<u>From Relativity to ECE in Seven Days based on Seven Crystal Spheres.</u>

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An introduction to the work of AIAS from an historical perspective.

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From Relativity to ECE in Seven Days based on Seven Crystal Spheres.

Preface.

Einstein is famous for his 1905 theory of special relativity and his 1915 theory of general relativity. It is also well known that Einstein was able to show that Max Planck's photon was actually real and in so doing became the father of quantum theory. However, Einstein has gone down in history as wasting the second half of his life trying to win an argument that started at the 1927 Solvay conference on the nature of quantum theory.

After Newton it was widely accepted that the universe operated like clockwork with time as the standard by which everything else was to be measured. Events such as the collisions between particles could be determined by feeding initial masses and velocities into the appropriate equations and the universe was therefore described as deterministic. However, Heisenberg came to believe that at the subatomic level events could not be determined accurately because probability was predominant in calculations so in effect experiments performed identically on different occasion could produce different results which it could be said were influenced by the throw of a dice. Thus two schools of thought emerged from the 1927 Solvay conference, Einstein's deterministic school and the 'Copenhagen' school of indeterminism based on probability. By the second half of the twentieth century physicists for some unfathomable reason saw indeterminism as the only game in town and came to regard Einstein's views as that of a scientific dinosaur. It then became a case of the 'Emperors Clothes' in physics where the 'Copenhagen convention' was sacrosanct and aspiring physicists criticised it at their peril. This led to the stagnation of physics and the ascendance of theories which flourished in the new physics of magic and spookiness that had previously been proven false by Newton. At the subatomic level physics regressed to the blinkered view of physics and astronomy that Galileo had fought so bravely against.

It is not widely known that Einstein was not isolated in his quest to return physics back into balance, but was supported and even surpassed by other titans of physics such as Schrödinger, De Broglie and Vigier. Vigier was chosen by Einstein to be his assistant but in the event ended up working with Einstein's staunch ally Prince Louis De Broglie in Paris for forty years. Eventually Vigier would continue to promote Einstein's and De Broglie's work with modern scientists through the formation of the Alpha Institute for Advanced Study (aias), which was formed in 1996 as a conduit for bringing Einstein's deterministic approach to physics back into the mainstream. Aias did just that in 2003 when the group succeeded in completing Einstein's life work by combining light, gravity and quantum electrodynamics into one grand unified field theory. The theory is called Einstein-Cartan-Evans or ECE theory and allows physics to be seen with fresh eyes and provides new equations as tools to bring about a new age of physics.

Introduction.

As far back as the seventeenth century, Galileo was thinking about problems raised by relativity with respect to two observers watching the same event. He considered how the path of a ball, falling from the mast of a ship as it was leaving harbor, would look to a person on the ship and an observer on the shore. He concluded that the ball would appear to fall vertically down to the person on the ship, but show a sideways motion, related to the ships speed to the observer on land.

In the nineteenth century scientists and mathematicians in a number of countries began pondering the effects of relativity on objects and observers traveling at high speed. As the century progressed, the importance of this strange area of physics was becoming clearer. James Clerk Maxwell produced equations showing light always moved away at the speed of light irrespective of the speed of an observer and in 1887 Michelson and Morley proved experimentally, that this was the case. George Fitzgerald suggested that at high speeds, close to the speed of light distance contracted and this explained what Maxwell, Michelson and Morley had found. Oliver's Heaviside experiments with electricity were confirming this and Lorentz produced a formula which could be used to calculate the degree of this contraction.

At the turn of the twentieth century, building on the work of these nineteenth century scientists and mathematicians, Einstein was able to formulate his great theory of special relativity. Einstein later extended special relativity (which describes how objects behave at speeds close to the speed of light), to general relativity which includes the effects of gravity on the motion of objects. Special relativity combined with general relativity, has been described by some, as the crowning achievement of nineteenth century physics.

Also, at the turn of the twentieth century, Einstein together with Planck started the quantum theory revolution. Quantum theory described light in terms of a wave particle duality and Bohr was able to describe how electrons behaved inside atoms. Quantum theory went on to be considered by many to be the most important theory of the twentieth century. However, Einstein came to have reservations about quantum theory, which disturbed him greatly.

By the time of the 1927 Solvay conference Bohr, Heisenberg and Pauli were convinced that an acausal indeterminacy held sway at the atomic level and Heisenberg's uncertainty principle was being accepted as the way forward in physics, as the so called Copenhagen convention. Einstein did not accept this however and worked until 1955 trying to combine electromagnetism with relativity and to show nature was after all deterministic. Einstein subsequently went down in history as wasting the last thirty years of his life on a hopeless venture, and that was that! Or was it?

As it turns out Einstein did not work in isolation as is commonly believed, but was supported in various ways by a team of superb scientists. Through them, Einstein's work continued away from the public eye and with time their theories have resurfaced. The subjective and acausal indeterminacy of Bohr and Heisenberg has also been proven false by experimentation, and these concepts are also extrinsic to objective and causal relativity - the great twentieth century debate in physics: causal deterministic (Planck, Einstein, de Broglie, Schrödinger, Bohm, Vigier and followers) versus Copenhagen (Bohr, Heisenberg, Pauli and followers). ECE theory shows that the causal deterministic school was correct.

ECE theory is short for Einstein-Cartan-Evans theory. Einstein showed that space was curved, while at the same time Elie Cartan, the great French mathematician, was attempting to show that electromagnetism was spinning spacetime or torsion. Myron Evans was able to 'dock' the two theories and in so doing completed Einstein's great work. ECE theory describes the standard model in terms of geometry. For each force there is a specific curvature of spacetime geometry and the equations which describe this geometry can be applied to any area of science. Thus, ECE theory could soon become recognized as the crowning achievement of the twenty first century.

The Alpha Institute for Advanced Study (AIAS) is an international think tank comprising physicists, engineers and scientists from all over the world and has been set up to promote ECE theory. ECE theory is a generally covariant unified field theory describing all of physics through geometry. ECE theory is simpler, yet more powerful than the standard model currently used in physics. The table below shows that ECE theory overcomes many theoretical problems encountered by the standard model and also describes experimental evidence in a far more convincing way.

The table shows ECE theory is a milestone in the development of theoretical physics. It shows lucidly that physics has now moved on from a viewpoint of the fundamentals, with ECE theory opening up the way for new advances in our understanding of the natural world and providing opportunities for technological breakthroughs. ECE theory is already being used to research and develop new technologies in the fields of motors, generators, instrumental chemical analysis, medical scanners and even antigravity devices.

Table of Differences between the Standard Model and ECE

ECE	Standard Model
All fields are objective, causal and generally covariant in both classical and quantum manifestations.	Only gravity is generally covariant, causal and objective and only in its classical limit
Torsion is considered	Neglects torsion
Quantum mechanics is objective and causal, just like gravity	Quantum mechanics and gravity cannot be unified.
Electrodynamics and gravity are two geometrical aspects of space-time, the former being torsion- and the latter curvature.	Electrodynamics and gravity are philosophically different.
No concepts, which have been disproven experimentally, are used. For example, Heisenberg Uncertainty Principle, strings, superstrings, Higgs mechanism, renormalization, asymptotic freedom, spontaneous symmetry breaking, dark matter, singularities such as the Big Bang and black hole theory and abstract internal space of Yang Mills gauge theory.	Contains several concepts which are experimentally unproven and/or do not exist in relativity theory.
Quantum electrodynamics is developed from simultaneous ECE wave equations and is generally covariant objective and causal.	Hugely over-elaborate and contains adjustable parameters.
All the wave equations are generally covariant, are derived from the tetrad postulate of geometry, and all are objective and causal.	Wave equations of physics such as the Dirac and Proca equations are postulates of special relativity unrelated to geometry, objectivity and causality
Photon mass and the Proca equation are derived geometrically	Photon mass is asserted to be zero, causing problems of several kinds
Inter-relation of fields is geometrical and can be developed relatively easily.	The inter-relation of fields cannot be developed.
Derives all of physics geometrically from two basic postulates	Cannot describe all of physics geometrically

In 1916 general relativity came of age, with the publication of the famous Einstein Hilbert field equation. This equation is covariant under any type of coordinate transformation, and is therefore said to be generally covariant. However this equation is restricted to gravitational theory. In order to develop it into a unified theory for all fields of physics, consideration of the Cartan torsion was needed.

In the early twenties, Elie Cartan suggested to Einstein that electromagnetic radiation was due to the torsion or twisting of spacetime. They corresponded extensively on the subject but were not able to construct the required unified field theory. In 1992, one hundred years after George Fitzgerald had recognized that length contracted as speeds close to that of light were encountered; M. W. Evans inferred the spin field of electromagnetism from the inverse Faraday Effect, the phenomenon of magnetization by a circularly polarized electromagnetic field.

The spin field was subsequently developed into a form of electrodynamics that could incorporate the spin field self-consistently ("O(3) electrodynamics"). The great Maxwell Heaviside theory was unable to do this because it is Lorentz covariant, but not generally covariant as required to unify fields logically within general relativity.

In the Spring of 2003, the field equations of gravitation and electromagnetism were unified into the Einstein Cartan Evans (ECE) field theory, which is based directly on Cartan (or differential) geometry. Shortly thereafter, the equations of the weak and strong fields were also unified with those of gravitation and electromagnetism, and the Dirac equation derived from the ECE wave equation. The equations of quantum mechanics and general relativity were unified in the same year (2003) through the use of the **tetrad postulate** of Cartan geometry, leading to the ECE Lemma and wave equation.

ECE theory has now been extensively developed in over a hundred scientific papers collected into a multi - volume monograph: M. W. Evans, "Generally Covariant Unified Field Theory" (Abramis, 2005 onwards), with three volumes published to date (www.aias.us and www.atomicprecision.com).

All the **wave equations and** first order **differential equations** of **physics**, come **from** the **tetrad postulate**, and the **field equations** from the **Bianchi identity**.

1905 was Einstein's 'miraculous year'. In this year Einstein had five short papers published which changed the face of physics. One paper was special relativity, another paper put quantum theory on a firm footing and the last paper introduced the world to his famous E=MC2 equation. Physics previous to this work can be referred to as classical physics and later developments can be referred to as quantum physics or quantum chemistry.

Nearly one hundred years later, 2003 became Myron Evan's 'miraculous' year. In this year Evans finally achieved what Einstein had endeavored to do from 1927 to the day he died, namely the unification of gravitation (general relativity) with electromagnetism. Evan's then unified the weak and strong nuclear forces with gravitation and electromagnetism. He then went on to derive the famous Dirac equation from first principles using his ECE theory. This allowed quantum theory to be united with special relativity, as was achieved last century, when the new subject area of quantum electrodynamics (QED) came into existence. Finally, Evans surpassed himself by unifying the equations of quantum electrodynamics with general relativity, thereby simplifying quantum electrodynamics (QED) and banishing forever some of the outlandish baggage which had become associated with quantum electrodynamics and which was interfering with the development of QED to the next level

In 1905 Einstein's ground breaking papers were greeted by silence. This was no doubt due to scientists being unable to take on board the scope and magnitude of Einstein's insights into physical problems of the day. Einstein had to carry on working as a patent officer (3rd class) in the Bern Patent Office for another five years, before the great Max Planck's assistant turned up at his workplace to end his isolation. From there Einstein became a professor of physics at the University of Zurich, before becoming a professor in Charles University, Prague and ultimately a professor in Berlin.

Myron Evan's miraculous year on the other hand did not go unnoticed, with the Swedish physicist Professor Bo Lehnert, quickly alerting the British establishment to what had been achieved. Evan's was quickly nominated as a worthy candidate for the Civil List and was supported by both The Royal Society and The Royal Society of Chemistry. In 2005, one hundred years after Einstein's miraculous year, Evans' achievements were discussed in Parliament and MP's voted overwhelmingly to reward Myron's great achievements with an appointment to the civil list. Myron Evans is the only scientist in Britain or the Commonwealth on the Civil List and acknowledges his thanks for this award on all his new publications.

Martin Caton, the M.P. for Gower supported Myron's nomination to the civil list and helped speed the process through.

The Alpha Institute for Advanced Study (AIAS) had been formed in 1996 to promote work in the field of chemical physics. The first webmaster of www.aias.us was Bob Grey of Rochester, New York who was followed by Sean MacLachlan of Boise, Idaho. Myron Evans was elected Director of the Alpha Institute for Advanced Study in 1998. AIAS became a vital conduit for promoting Evan's unified field theories. By December, 2005 Lar Felker from Reno, Nevada in the United States and Horst Eckardt from Munich, Germany had collaborated to produce a short introductory article entitled,
'Einstein, Cartan, Evans – Start of a New Age in Physics?
Which enabled interested parties worldwide to get a flavor of the power and technological potential of Evan's new unified field theory (ECE)? The article became the most popular item on the www.aias.us website and is now available in eight languages.

Lar Felker went on to write soon after, a textbook on ECE theory entitled,
'The Evans Equations of Unified Field Theory',
This was available as a free download on www.aias.us until May 2007, when it was published in print form by, Abramis Academic Publishing).

In 2006, A. D. DeBruhl had his book,
' The Ultimate Truth', Published in the United States. DeBruhl devotes a chapter of his book to ECE theory and on page 120 describes his view of the importance of Evan's miraculous year as,

"***Finally, over half a century after Einstein made his contributions of general and special relativity, Myron Evans, following in the tradition of Einstein, accomplished the impossible. Instead of trying to quantify gravity in terms of discrete packets of energy (quanta) to make it comply with the standard model, Evans took the opposite approach; He succeeded in describing the standard model in terms of geometry. In the Evans Grand Unified Field Theory particle exchange is not the fundamental unifying factor. Instead, for each force there is a specific curvature of spacetime or spacetime geometry. The resulting equations can be applied to any area of science and engineering. The impact on the computer, transportation, medical, power, and manufacturing industries will ultimately be as profound as the discovery of fire***".

Myron Wyn Evans was born in Craigcefnparc, near Swansea in Wales on May 26th 1950. Craigcefnparc is a small town in the South Wales coalfield where his father, along with most of the men folk of the town, earned a living underground in the mines. Myron's father was Edward Ivor Evans and his mother was Mary Evans. Edward worked not only as a coal miner, but also worked for the Mines' Rescue Service winning bronze, silver and gold medals. His mother was the daughter of a coal miner, Thomas Elim Havard Jones, Head Deacon of Elim Welsh Baptist Chapel, Craigcefnparc, descending from an eleventh century Norman family, the Havard or Harvard family. Myron attended Craigcefnparc Primary School from 1954 to 1961, before continuing his education at Pontardawe Grammar School until 1968.

Pontardawe Grammar School provided Myron with a fine education as it had done for many years to many children from this Swansea Valley town and its environs. The great world renowned actress Sian Philips was born in May 1934 in Bettws and was brought up as a Welsh speaker and attended Pontardawe Grammar School in her formative years. She made her radio debut at the age of only eleven and is famous for her portrayal of the evil Livia in 'I Claudius' and Queen Cassiopeia in 'Clash of the Titans.' Sian has had a glorious career in film and television and married Peter O'Toole, famed for his role in the film 'Lawrence of Arabia', with whom she had two daughters.

The school has also produced a world famous folk singer in the form of Mary Hopkin. Mary was born in May 1950 and was in the same class as Myron in this famous valley school. Mary was also a fluent Welsh speaker from Alltwen, near Pontardawe. She left in the lower sixth to start her career in singing and soon featured on the sixties talent spotting show 'Opportunity Knocks' which was hosted by the show business veteran Hughie Green. Luckily for Mary the sixties supermodel and icon 'Twiggy' was watching who contacted Paul McCartney on her behalf, leading to her signing for Apple Records.

Sir Goronwy Daniels was also from Pontardawe Grammar School, as is Hugh Llewelyn Davies, the rugby commentator. The school provided a formative discipline, which was especially beneficial for Myron, who came from a poor mining village (Craig Cefn Parc) whose school did not teach the full curriculum. The Welsh language was very much alive and used in the school and is still very strong in the Swansea Valley (Cwm Tawe).

At Pontardawe Grammar School Myron is proud to have played rugby once as full back against Gethin Edwards who was in the same class as Myron in the sixth form (1966-68). Gethin did not turn out to be a sporting legend, but his older brother Gareth who attended Pontardawe Technical School did! Gareth was the inside half of the great Welsh Rugby team of the late seventies which was full of stars from the world of Welsh Rugby. Considered great at that time, Gareth is now widely believed to be the greatest Welsh rugby player of all time, especially around the town of Pontardawe.

Myron as a boy also took the usual interest in the rough and ready village soccer and cricket and his father often took him to see 'The Swans'- Swansea Town, later called Swansea City. At the time they included Mel Charles, the younger brother of the great John Charles and also Herbie Williams.

Myron studied for his degree in chemistry at the University of Wales in Aberystwyth from 1968 to 1971 at the Edward Davies Chemical Laboratories and then continued there as a postgraduate student till 1974. At Aberystwyth Myron developed a love for athletics and started regular distance running when he was nineteen in order to keep fit. Eventually Myron took to using the university athletics track at Aberystwyth at weekends at first, then gradually every day. Initially his routine was ten thousand metres (25 laps) on a Saturday, and a five thousand on a Sunday. His times were nothing to write home about however, so he switched to sprinting over 100 and 200 metres, which he eventually did daily at the athletics field next to the Edward Davies Chemical Laboratories. Myron continued at the Edward Davies Chemical Laboratories (EDCL) for his Ph. D. with Professor **Mansel Davies (1913-1995)** as his supervisor from 1971 to 1974.

Professor **Mansel M. Davies** was born in Aberpennar (Mountain Ash), near Aberdare in South Wales and became a top quality scientist with a wide range of interests and a powerful searching personality, arriving in Aberystwyth University as a student in 1930. He enjoyed getting into debates, which could at times become heated; such was his passion and drive to interact with the world and all those about him. Mansel was a classless humanist, showing respect for all, be they top politicians or shop assistants and was keen to engage all with anecdotes acquired along his interesting and long life. Mansel wrote a number of books including (at the invitation of H. G. Wells) in 1947, 'An Outline of the Development of Science', which was translated into several languages including Welsh.

Mansel's research interests were intimately connected to the behavior of molecules. From 1938 to 1965 he worked on the development of high resolution infra red spectroscopy, which he applied to the elucidation of the nature of the hydrogen bond.

Between 1968 and 1977, Mansel worked with the National Physics laboratory's (NPL) John Chamberlain pioneering the development of Fourier transform infra red spectroscopy. Mansel collaborated with the Grubb Parson Company in the development of commercial infra-red instruments and one of these became an important research tool at the Edward Davies Chemical Laboratories and was used greatly by Myron Evans at the start of his research career. Myron's fifth research paper was published in 1974 and relates how, at Aberystwyth, the rotational velocity correlation function was introduced for the analysis of far infra red data of all kinds. This enabled a triple comparison to be made between data, theory and simulation and became a major theme running through Evans' work.

In 1985 Myron had the honor of meeting **David Whiffen FRS (1922 -2002)** who had joined the National Physics Laboratory in 1959. Whiffen had been interested in how electromagnetic radiation is absorbed by matter and what this reveals about the molecules involved. Whiffen had used electron-spin resonance spectrometry to find the resonance signal for a free radical in a crystal lattice before joining NPL. In 1968 Whiffen became a chemistry professor, then Dean and Vice Chancellor at Newcastle University where he developed the microwave and millimeter-wave spectroscopy of gases. Whiffen worked on the spin-flip laser project in which a semiconducting crystal in a strong magnetic field was to be used to provide a strong tunable infra-red source. If this had worked properly it would have allowed double resonance experiments to be carried out with simultaneous use of infra-red and microwave beams to excite a sample. Whiffen was impressed by Myron's work in the far infra-red and said it was the best since Debye. Whiffen got Myron an IBM Fellowship in 1985 at Newcastle University and went on to enjoy his retirement in Bridgewater, Somerset.

Mansel Davies was also involved with lattice energy studies of molecular crystals and from 1954 to 1975, the introduction of dielectric loss and relaxation as a means of probing molecular behavior. Mansel liked Cornell University and wrote **Peter Debye's (the 1936 Nobel Prize winner)** biography for the Royal Society of Chemistry. **Peter Debye (1884-1966)** was a Dutch chemist who in 1910 simplified the derivation of Planck's radiation formula. In 1911, when Einstein left Switzerland to become a professor at Charles University in Prague, Debye replaced him at Zurich University. In 1934 Debye became the director of physics at the Kaiser Wilhelm Institute which was renamed the Max Planck Institute in 1948. Debye left Germany in 1940 to work at Cornell University for the rest of his life. He made a major contribution to chemical physics from 1912 by applying the concept of dipole moments to the charge distribution in molecules. Debye relaxation is the dielectric relaxation response of an ideal noninteracting population of dipoles to an alternating external field

In 1976, Myron's twentieth paper described how, again at Aberystwyth, the memory function method was introduced to the far infra red. Here, the friction coefficient of the Langevin equation (Markovian process) is extended to a memory function hierarchy (non-Markovian process). The Langevin equation gives the Debye plateau in the far infra red and is unphysical, because the rotational velocity correlation function is undefined in the Debye relaxation process.

In 1976 at Mansel's request, Myron opened a Gordon conference at Holderness School, New Hampshire. Here Myron met a number of well known scientists including Harvard's J. H. Van Vleck and Brown University's Robert H. Cole who both made encouraging remarks. Myron also met Yale's Gibbs Theoretical Chemistry Professor, Lars Onsager and the Presidential Advisor John Deutch (Harvard University) at the conference dinner. **Lars Onsager (1903-1976)** was the Norwegian-American winner of the 1968 Nobel Prize for Chemistry for the Onsager reciprocal relations, which are a set of equations concerning diffusion and temperature which are used in thermodynamics. In 1925 Onsager improved the Debye-Hückel theory of electrolytic solutions by incorporating Brownian motion and became Debye's assistant at ETH Zurich until 1928 and went on at Yale to make improvements to the dipole theory of dielectrics. **John Hasbrouck Van Vleck (1899-1980)** was born in Connecticut and won the 1977 Nobel Prize for Physics for his contribution to the understanding of electrons in non-crystalline magnetic solids. Vleck told Myron that he thought his work was important, a complement that the 26 year old Welshman never forgot.

Myron was Mansel's third last student, followed by **Gareth J. Evans** (who became his close friend) and **Colin Reid**. Myron took up a Junior Research Fellowship at **Wolfson College Oxford** from 1974 to 1976 and along with his academic work continued to indulge his interest in athletics by training at Iffley Road, Oxford. One day soon before the old cinder track was to be replaced by a tartan track, Myron was training there when he happened to meet three old timers who had come to run around the track one last time for old time's sake. Amazingly Myron found out that the old timers were none other than Bannister, Brasher and Chattaway. They were running around one last time in honor of the old track where Bannister did 3 minutes 59.6 secs to become the first athlete to break the four minute mile barrier. Chattaway was a three miler. While at Oxford Mansel asked Myron to supervise both Gareth and Colin back at Aberystwyth. Mansel was a formative influence on Myron and encouraged him to publish in journals while still a student.

Myron's first paper infact was almost his last! It was on compressed gaseous cyanogen and required Myron to carry out a dangerous experiment on this most toxic and flammable gas. It was kept liquefied at liquid nitrogen temperatures prior to compression to up to about one hundred atmospheres and beyond. One evening, working late as usual, the safety office Dr Sam Graham heard the cyanogen bang in the pot, and as it started to bubble away Myron thought Dr Graham was going to keel over and sink at any time. Myron held his breath in more than one way. Dr Graham departed just in time as Myron quickly bolted up the gas in its pressure chamber and opened all the windows. This is paper one on the Omnia Opera, on the far infra red spectrum of compressed gaseous and liquid cyanogen and its quadrupole moment. Mansel typically chose it solely on the grounds of its quadrupole. The fact that he might lose both a student and a safety officer had eluded him!

Mansel was sometime Fellow of Peterhouse College, the oldest college in Cambridge, where **Sir John Meurig Thomas, Head of the Chemistry Department** in Aberystwyth later became Master. Mansel was an admirer of Lloyd-George and retired to Criccieth, where Lloyd-George had lived for long periods during his lifetime. Welsh speaking Lloyd-George was born in Manchester, but was relocated to Llanystumdwy when his father died at an early age. Lloyd-George retired back to his home village and there is a Memorial to him in Criccieth.

Mansel's cooperation with the NPL led to the loan of a far infra-red interferometer to EDCL, which Myron used at start of his Ph. D. with the help of Arnold Baise from Witwatersrand University in South Africa. This interferometer required the use of paper tape and a pack of cards and when in use the noise from the production of the tapes was deafening. Each pack had to be taken up to the Elliot 4130 computer half a mile away, which had a massive 48 kilobytes of memory for the whole College. As undergraduates Myron and chemistry students were introduced to the computer by Dr. Cecil Monk.

Myron returned to Aberystwyth from Wolfson College Oxford with a Ramsay Memorial Fellowship from 1976 to 1978 and a SERC Advanced Fellowship from 1978 to 1983. In these years Myron established his chemical physics research group with Gareth Evans, Colin Reid and Mauro Ferrario, together with visitors Ahmed Hasanein, Jozef Moscicki and Barbara Janik.

Colin Reid co-authored Myron's 67^{th} paper entitled, 'Zero-THz Absorption Profiles in Glassy Solutions, High Frequency Gamma Process and its Characterization' in Faraday II, 75(9), 1218 (1979). This ground breaking paper introduced the gamma process of the far infra red and shows that it is linked to the much lower frequency alpha and beta processes that were already known. Thus, the complete spectrum stretches over an immense twelve decades of frequency and its description is still a challenge to molecular simulation and theory.

By 1977, Evans' work in chemical physics was already being judged as substantial and consequently he was awarded his D. Sc by the University College of Wales, Aberystwyth. This was a great achievement, because Myron was awarded the D. Sc qualification only three years after obtaining his Ph. D. at the age of only twenty seven. This award in such a short time was a record and three years for the award of a D. Sc is a record in Britain to this very day! Aberystwyth's Principal **Sir Goronwy Daniel (1914-2003)** marked this award by inviting Myron to a reception, where he awarded was awarded the D Sc by Daniel himself.

Daniel was obviously very pleased at Myron's success, being a Swansea Valley man himself. Goronwy was born in Ystradgynlais (as was the present Archbishop of Canterbury) and also attended Pontardawe Grammar School. His sister was Miss Maud Daniel, who had taught both Myron and Goronwy English Literature and Latin at Pontardawe Grammar School, including 'Le Morte d'Arthur' by Sir Thomas Mallory. Goronwy was educated at the University College of Aberystwyth, where he obtained a first class degree in 1937, before taking his D. Phil at Oxford. Subsequently he became a diplomat and was knighted in 1969, the same year as he became Principal of Aberystwyth. He was also appointed Chairman of the Welsh Fourth Channel in 1982. Goronwy's wife Lady Daniel was the grand-daughter of David Lloyd-George, looking like a carbon copy of Lloyd- George with that broad intelligent brow.

Evan's success and recognition did not stop there however. In 1978 he was awarded the Harrison Memorial Prize, followed by the Meldola Medal in 1979. Both these medals are awarded by the Royal Society of Chemistry to identify their recipients as amongst the most capable young chemists in Britain. This brought great credit to Evans and the **Edward Davies Chemical Laboratories**.

At the turn of the century, Aberystwyth University's Chemistry Department was located in the Old College and was led by Professor J. J. Sudborough. Research in the department was already flourishing and as a result it needed to be rehoused into a large new purpose built facility. In 1903 the Davies family from Llandinam in Mid Wales provided funds for this purpose in memory of Edward Davies (1852-1898), who had been Treasurer at the College. Edward Davies's father David Davies (1818-1890) was a founder member of the University College of Wales and the Liberal MP for Cardiganshire. His business interests included railways, coal mines and dock-building and his resulting wealth was used to help establish the University for Wales at Aberystwyth.

The Edward Davies Chemical Laboratories was designed by Alfred W. S. Cross (1858-1932) and was opened in 1907 by Lord Asquith. It was built on top of a small hill, known as 'The Buarth' and has a fine view over Aberystwyth town, the harbor and Cardigan Bay. Behind it on a much larger hill (Penglais) is the National Library of Wales, which stands Parthenon-like overlooking the town. Above the library on Penglais hill is Aberystwyth University and both have amazing, stunning views over Cardigan Bay, Constitution Hill (with its cliff railway), the town and Pen Dinas Hill (with its large ancient hill fort and monument to the battle of Waterloo).

EDCL was the first purpose-built chemical laboratory in a British university and eventually it became so successful that a connecting new block was built on its right hand side. Fittingly, the extension was opened in 1963 by the third Lord Davies. The chemistry department became increasingly successful in the next fifteen years, reaching its zenith around 1978, before changes in staff and financial problems at the University and in the British Economy led to its demise and closure.

The Edward Davies Building fell into disuse after the chemistry department closed in 1988 and was nearly knocked down after lying vacant for some years. Luckily however Myron, along with Gareth Evans alerted CADW, which immediately conferred Grade II listed status on it before it could be destroyed. However, this did not apply to the new building which was knocked down and turned into student accommodation (Brynderw Hall of Residence). Meanwhile the number of students being admitted to Aberystwyth soared and improved university finances allowed the old building to become the home of the School of Art. EDCL is fine buildings for this purpose because with its ‘Wrenaissance’-style façade, displaying two wings and a central cupola, it does infact resemble a municipal art museum. The Edward Davies family can thus be proud of their legacy to Aberystwyth, with its years of work as a chemical laboratory and its new use as a school of art. It is also the spiritual home of The Alpha Institute for Advanced Study.

Aberystwyth is the oldest component of the University of Wales dating from 1872. **David Davies 1818-1890** not only gave a large proportion of the money required to establish the university, but also built the Cambrian Railways which links Aberystwyth to England via Shrewsbury and the line from Brecon in South Wales which connected to it at Newtown via Llanidloes. This was all achieved in the small time span from 1855 to 1870. He went on to discover and mine coal in the Rhondda Valley via the Ocean Coal Company and built Barry Docks, near Cardiff to export his coal around the world. These activities made Davies fabulously rich and a rival of the Marquis of Bute. The Marquis of Bute used his coal wealth to build up Cardiff to the premier town in Wales, to upgrade Cardiff Castle and to build the famous fairy-tale style castle, Castell Coch on the approach from the Merthyr Road. Davies meanwhile used his wealth to establish the first component of the University of Wales in Aberystwyth and as such invested in the people and future of Wales. From the Old College on Aberystwyth’s seafront ‘Great Oaks’ did grow with the university now dominating the town and other colleges being formed in Bangor, Swansea, Lampeter and Cardiff under the federal structure of the University of Wales.

The Edward Davies building was designed and used as a chemical laboratory for 81 years from 1907 to 1988, with its first Professor J. J. Sudborough quickly establishing an international reputation for organic chemistry. Professor Mansel Davies was associated with EDCL for 58 of these years, starting in 1930 as a student and had a personal chair created for him in 1968. Mansel started the process of turning the Aberystwyth Chemistry Department into a centre for chemical physics of international standing. The work of Myron and others was to complete this transformation.

While still working at Aberystwyth, Myron introduced the technique of field applied computer simulation. The first external field to be applied was a static electric field and it was found that the simulation produced the correct theoretical Langevin functions at all orders. Thus, the simulation could be used to produce a variety of results that could not be produced by experiment or theory. In later years, various other fields were used for computer simulation, the most revealing of which was a circularly polarized electromagnetic field related to the inverse Faraday Effect. Infact as it would turn out, the understanding of the inverse Faraday Effect would provide new information on the nature of the smallest part light, known as the photon. This new information would reveal the missing part of the puzzle, that had prevented Einstein from completing his life's work; the unification of gravity with electromagnetism.

The road to the unification of the forces of physics was started by Michael Faraday, who was a chemical physicist working at the Royal Institution in London. His practical skills and scientific insights led him to the discovery of electromagnetic induction and to the realization that electricity and magnetism were interrelated. He proposed that light was electromagnetic radiation, but his mathematical skills were not good enough to prove it. However, James Clerk Maxwell believed him and proved it mathematically. Einstein was inspired by Maxwell's equations and went on to formulate his theories of special relativity and general relativity.

Next Einstein tried to unify electromagnetism (light) with gravity. Elie Cartan, the French mathematician believed light was spinning spacetime and could describe it using his Cartan mathematics. Cartan and Einstein collaborated in the nineteen twenties trying to combine their two theories, but to no avail. As it turned out mathematics could not do this alone, because there was a part of the puzzle missing which was to be found in the realms of chemical physics.

The missing part of the puzzle leads us back to Michael Faraday and the Royal Institution. In 1845 Faraday experimented with the effect of magnetic fields on light. He found that if polarized light was passed through glass which was placed against the poles of an electromagnet, then the electromagnetic field caused the rotation of the polarized light. This magneto-optical effect became known as Faraday rotation, or more commonly as the Faraday Effect. There is also an inverse Faraday Effect. The inverse Faraday Effect is the magnetization of matter by an electromagnetic field at any frequency. The field must be circularly or elliptically polarized to produce the magnetization of matter.

The inverse Faraday Effect was inferred by Piekara and Kielich in the mid fifties using phenomenology in non-linear optics and re-inferred by Pershan at Harvard in the early sixties. However, the inverse Faraday Effect was not observed experimentally in liquids, solids and paramagnetic glasses in Harvard until the mid sixties.

In 1991 Myron took a year's leave from Cornell University's Theory Centre (founded by the 1992 Nobel Prize winner for Physics, **Ken Wilson**) to work with George Wagniere's group at the University of Zurich. The Schrödinger equation had emerged years earlier at the University of Zurich from discussions between **Erwin Schrödinger (1887-1961)** and Peter Debye, who had been trying to understand de Broglie's wave particle dualism. Schrödinger received the 1933 Nobel Prize for Physics for his great equation.

Myron continued his interest in athletics at Zurich and surprisingly enough produced his best time at 60 metres there, on the tartan track near Gerhardstrasse. Surprisingly Myron did not produce this personal best until he was over forty years old. Myron was also to achieve one of his greatest academic achievements while in Zurich, with breakthrough work on the nature of light.

While working at the Zurich University's new Irchel Campus, Evans (paper 347) used his technique of field applied computer simulation (developed at Aberystwyth in 1983) to simulate the inverse Faraday Effect, the magnetization of any type of matter by a circularly polarized electromagnetic field of any frequency. By 1992 (*The Elementary Static Magnetic Field of the Photon by M. W. Evans, Physica B, 182, 227, 237 (1992)*), Evans was able to see that **the inverse Faraday Effect signals the fact that there is a fundamental spin field connected with electromagnetic radiation** of any frequency. This confirmed that the electromagnetic field was indeed the Cartan torsion and that light was as Cartan and Einstein had believed 'spinning spacetime'. The **spin field** was the **missing part of the puzzle** and the quest to unify gravity with electromagnetism could now proceed to its final stages. The discovery of the spin field in November 1991 would lead over the next decade to the formulation of ECE theory in February 2003.

Myron's breakthrough at Zurich on the nature of light and the photon echoed Einstein's famous theoretical work at Zurich a century before.

Einstein attended Zurich Polytechnic from October 1896 to July 1900. Zurich polytechnic was a teachers' and technical college, which sported new state of the art science laboratories paid for by Werner Siemens. By 1911 the polytechnic was so well thought of that its status was elevated it and it was soon renamed ETH (Eidgenossische Technische Hochschule).

After graduating Einstein eventually found a well paid job, at the Bern Patent Office (where he worked until 1909) which was well suited to both his demeanor and talents. Einstein's father had owned his own electric lighting and generating company which had involved Albert in patent work and the practical design of electromagnetic devices. Albert found he was able to do his patent work in a fraction of his working day, leaving him free to surreptitiously work on his theories while still at his work desk. Michele Besso, Einstein's life long friend also worked at the patent office, giving Albert a sounding board for his theories.

During this time the great advances in theoretical physics were being made by applying statistical mechanics and kinetic theory to problems of radiation and thermodynamics. Professor Ludwig Boltzmann had produced influential work, showing how maths and statistics could be applied to problems involving molecules in physics and chemistry. In 1901 Einstein had his first paper published which described capillary action in terms of the attraction between large numbers of molecules. Einstein then spent time considering how statistical mechanics could be applied to molecules undergoing diffusion and other processes which paved the way for Einstein's miracle year.

Einstein's **miracle year** 1905, started with, '**On a Heuristic Point of View Concerning the production and transformation of light**', which explained the photoelectric effect and was to lead to quantum theory and Einstein's only Nobel prize.

Einstein's **second paper**; '**A New Determination of Molecular Dimensions'** used the processes of viscosity and diffusion to formulate two simultaneous equations for the unknown particle sizes and numbers of particles. Feeding in the data for the case of sugar dissolved in water and solving the simultaneous equations then produced Avogadro's number and the size of the molecules involved.

Einstein's **third paper** explained the phenomena of Brownian motion and effectively proved atoms and molecules existed. The British Civil List Scientist, Robert Brown had discovered in 1828 that pollen grains in water could be seen in a microscope altering their speeds and directions as if they were receiving random kicks from different directions. Einstein used statistical mechanics to show that invisible particles many orders of magnitude smaller at the size of molecules could randomly act together to produce the random kicks seen. Furthermore, Einstein showed that the distance that the pollen grains would move away from each starting position was proportional to the square root of the time between observations, which could be proved by simply observing the grains through a microscope.

Einstein's **fourth paper** changed our understanding of space and time and time and was entitled, **'On the Electrodynamics of moving bodies'**. This was Einstein's theory of special relativity.

Einstein's **fifth paper** developed from his fourth paper and was entitled**, Does the Inertia of a Body Depend on its Energy Content?** This introduced the world to Einstein's famous equation: - E=MC2.

So Einstein's studies in Zurich in time produced ground breaking advances in physics and chemistry. Myron's work in Zurich rekindled and intensified the search for a deeper understanding of the ways the forces and fields of physics were related. In particular Myron's work caught the eye of Jean-Pierre Vigier, who had collaborated with Einstein over a prolonged period. **Jean-Pierre Vigier (1920-2004)** had been invited to be Einstein's assistant in Princeton, but had been prevented from traveling there. However, he was still able to collaborate with Einstein through a Paris based research group which shared Einstein's belief in the deterministic viewpoint of physics and which had continued working towards the unification of light and gravity after Einstein's death in 1955.

Vigier's colleagues in Paris had included Louis de Broglie, with whom he worked for about forty years. **Louis de Broglie (1892-1987)** was one of France's greatest and most respected physicists and had become known to Einstein as far back as de Broglie's student days. Einstein had shown that light could exhibit particle properties as well as wave properties. De Broglie had suggested in his doctoral degree thesis that the same could be true for electrons, which his supervisors found a rather alarming concept. Luckily Einstein was visiting Paris at this time and was able to calm the situation by stating the idea was good and may even be true. Thus, Louis de Broglie was awarded his degree and a few years later, was awarded the Nobel Prize for his great insight. De Broglie became such a respected physicist, that he was invited to the 1927 Solvay conference, where he sided with Einstein and Schrödinger in the fierce debate on the 'deterministic' versus 'probabilistic' quantum theory. Jean Pierre Vigier had been thus well placed in Paris to become intimately acquainted with the arguments which had troubled Einstein so much.

Jean Pierre Vigier and Olivier Costa de Beauregard (1911-2007) both worked with Louis de Broglie at Institute Henri Poincaré and Universite Pierre et Marie Curie in Paris. Vigier was refused a visa to go to work with Einstein because he was a member of the French Communist Party. This was despite the fact that he had been awarded the Legion d'Honneur and had been a member of the general staff of the French Resistance in the Savoy Mountains.

At the end of 1992, Myron sent a paper to Vigier which after discussion was published in 'Foundations of Physics'. Myron did not have much of a chance to talk with Vigier, but wrote four books with him entitled, The Enigmatic Photon', with Vigier providing some ideas and Evans developing them and writing them up, for the universally respected Editor, Professor Alwyn van der Merwe (University of Denver, Colorado).

Vigier introduced Evans to photon mass (Einstein 1905), which was eventually incorporated into ECE theory. Vigier pointed out in 1993 that B(3) means finite photon mass and vice versa, and Evans worked this out self consistently from 1992 to present. Both B(3) and photon mass are incorporated into ECE geometrically, as Vigier pointed out had been intended by Einstein. By 1993 Vigier was allowed to enter the United States because the McCarthyist laws had been rescinded and he took the opportunity to attend a conference at Princeton. Vigier invited Myron to attend the conference, but this was not possible due to teaching commitments. However, Myron later co-organized the first Vigier Conference in Toronto in the summer of 1995, where they met for the first time and had a series of talks. Myron was told that de Broglie was "shouted down" at the 1927 conference and forced into accepting the Copenhagen interpretation. A session of the Toronto conference was dedicated to B(3) and Vigier was awarded an honorary degree there.

There were other physicists working with Einstein to show that the deterministic school of thought was correct. In Princeton in 1935, **E**instein and his two post doctoral assistants **P**odolsky and **R**osen conceived the famous **EPR** thought experiment, which was submitted by Podolsky to 'Physical Review' in March 1935. David Bohm a later assistant of Einstein extended the EPR thought experiment further while at Princeton, in his 1951 book on quantum theory. In 1957 Bohm went on to coauthor a paper with Yakir Aharonov to describe how the thought experiment could be tested in the laboratory. Bohm and Aharonov also inferred the famous effect that Chambers found at Bristol. Boris Podolsky went on to become a member of staff at the Physics Department of Xavier University, which held a famous conference in 1962 to continue the 'deterministic cause', with many renowned physicist attending from around the world. Professor John Hart organized the 1962 conference in support of determinism and worked closely with Myron for many years. The aias link with Xavier University continues through Dr. Ted Annis and Tom Widlar.

Schrödinger was thrilled with the EPR experiment and used it to provoke the likes of Teller, Pauli and Weyl, as was conveyed in his July 1935 letter to Einstein. Schrödinger was born and studied in Vienna and published, while at Zurich in 1926, a series of very important scientific papers, one of which included the world famous Schrödinger equation. Shortly after taking up a post at Magdalen College, Oxford Schrödinger shared the 1933 Nobel Prize with Paul Dirac. However, he did not get on too well at Oxford because he effectively had two wives, which was somewhat frowned upon. So in 1934 he found himself lecturing at Princeton and collaborating with Einstein, before moving back to Austria in 1936. In 1940 Schrödinger moved to Ireland to help establish the Institute for Advanced Studies in Dublin, worked on unified field theory there for seventeen years and fathered two children by different Irish women, before returning to Vienna in 1956 for his well earned retirement with his famous cat.

David Bohm (1917-1992) carried out research at Cal Tech before working with Robert Oppenheimer at the University of Berkeley. Bohm's calculations at Berkeley on the scattering of protons and deuterons in 1943 were relevant to the Manhattan Project and were classified before he could use them to obtain his Ph.D. Oppenheimer therefore had to write a letter to the University to certify he had met the requirement for his research degree. After the war Bohm worked at Princeton and collaborated with Einstein, before being suspended for having communist links. In 1950 Bohm fell fowl of McCarthyism with the Un-American Activities Committee having him arrested for refusing to testify, but was acquitted in 1951. At this point Bohm left America and developed the de Broglie-Bohm theory which asserts that sub atomic particles are accompanied by a wave known as the pilot wave which guides it through space in accord with the Schrödinger equation conveying a deterministic evolution through space-time. In 1957 Bohm moved to Bristol and in 1959 discovered with his student Aharonov, the Aharonov-Bohm Effect.

As already stated, Schrödinger spent much of his life working in Trinity College Dublin. Trinity College has a fine academic tradition and has a pivotal place in the development of relativity and unified field theory. Trinity College was founded by Queen Elizabeth the first in Tudor times and houses the famous fourteen hundred year old medieval monastic manuscript 'The Book of Kells' in its library. The book of Kells was looted by Norse Vikings and thrown into the sea, after its gold cover had been removed. Luckily it was eventually washed up to be preserved for future generations to appreciate. **William Hamilton (1805-1865)** worked at Trinity College on his vector and quaternion mathematics of spherical geometry. He was followed by **George Fitzgerald 1851-1901** who was to suggest that at speeds close to the speed of light, space and length contracts.

It is not well known that the Irish were the first to split the atom as a result of Dungarvan born Walton's collaborative work with Rutherford at Cambridge. **Ernest Thomas Sinton Walton (1903-1995)** is famed for earning Ireland's only Nobel Prize for science. Walton with **John Cockroft (1897-1967)** won the 1951 Nobel Prize for Physics for being the first team to split the atom using accelerated particles in the Cavendish Laboratory back in 1932. Walton had the great insight to replace the hammer and chisel traditionally used in atom smashing attempts, with a proton gun. Protons were accelerated and used to bombard nuclei. In 1932 Walton and Cockroft managed to split the lithium nucleus into helium by bombardment with high energy protons produced by their Cockroft-Walton voltage multiplying generator. Their generator employed diodes and capacitors to step up the voltages for their particle accelerator, so facilitating the splitting of nuclei by artificial means.

Walton was educated and carried out research at Trinity College, Dublin until 1927 when he moved to Trinity College, Cambridge to carry out research under the supervision of Rutherford. Walton returned to Trinity College, Dublin in 1934 and eventually became a professor until his retirement in 1974. Walton was still to be seen in Trinity College after his retirement in person and as a bust over the fire in the senior common room. Myron met Walton when he first visited Trinity College Dublin in 1976 to see Bill **Coffey** who introduced him to the great Ernest Walton in person in the senior common room. Walton was into his eighties at that time and displayed no trace of arrogance or vanity, as is often the case in scientists of real talent. Myron was very amused by Walton's account of the Rutherford group of which he was a part. He told Myron that bicycle parts would disappear mysteriously off the streets and College quads every time Rutherford had an idea, sometimes complete bicycles. These parts became apparatus for seven or eight Nobel Laureates, Walton included.

Trinity College's **Dr. William Coffey** has collaborated with Myron for many years and has developed Einstein's work on Brownian motion to much more detailed descriptions.

Trinity College was one of Myron's closest collaborative organizations while he was at Aberystwyth, both in geographical and scientific terms. This collaboration has continued to this very day. In 1980 Myron became co-Founder (with the National Physics Laboratory) and first Scientific Coordinator of The European Molecular Liquids Group (EMLG).

In 1983 while still at Aberystwyth, Myron produced his 147th paper, 'New Phenomenon of the Molecular Liquid State: **Interaction of Molecular Rotation and Translation**" in Phys. Rev. Lett., 50(5), 371 (1983), which relates the discovery at Aberystwyth of the mechanism in the molecule fixed frame through which molecular rotation and molecular translation influence each other. This had not been found using theory or experiment, only by computer simulation. This mechanism is important in general relativity (in a much broader context) because it governs the interaction of gravitation (translation) with any kind of spinning or rotating field (electromagnetic, weak, strong, fermionic etc.). This mechanism was seen to be all the more important when Myron discovered the **fundamental spin field of electromagnetic radiation** in 1991. The effect works its way through into the change of polarization of light deflected by a mass such as a white dwarf.

Myron left Aberystwyth in late 1983 to take up a University of Wales Fellowship at Bangor, which was followed by a Pilcher Senior Fellowship in Swansea in 1985. In October 1986, Myron reluctantly left the UK to take up an academic position in Kingston, New York. Myron had worked at the University of Wales for eighteen years and was sorry to end that connection, but grew to like New York State and Ithaca, the site of Cornell University which has one of the most beautiful campuses in the United States.

At Kingston, Myron met **Enrico Clementi** who had been nominated for a Nobel Prize by Mansel Davies and Clement Roothaan who was another visiting Professor. Clementi was working on the MOTECC Project for which Myron had his Professorship renewed for a further year.

From 1989 to 1992 Myron was a visiting professor at Cornell University with the middle year spent as a visiting professor at the University of Zurich. During this time period Myron did some of his most productive work and his researches concerning the Inverse Faraday Effect would lead eventually to the completion of Einstein's great work. At Cornell Myron met Harold Scheraga who had been appointed by Debye, and also Roald Hoffmann of the Woodward Hoffmann rules who had received the 1981 Nobel Prize for Chemistry.

The Cornell Theory Center had been finished and the staff had moved in to the striking curved building above one of the Ithaca gorges. The Clark Library is an especially appealing and links chemistry to physics. The B(3) field was actually inferred in 77 Lois Lane Common lands, looking out on the snow above six mile gorge, about November 1991, just a few weeks after Myron had returned from Zurich. This was a nice Community just outside Ithaca on the road to Binghamton and Myron was very happy there with his first wife, being the first time he had been able to buy a house. IBM had a unit in Cornell Theory Center, which used parallel processing around the IBM 3090-6S.

While working at Zurich from 1990 to 1991 Myron applied his computer simulation technique to the Inverse Faraday Effect and on his return to the Theory Center at Cornell, Myron soon realized that his Zurich results showed that **the inverse Faraday Effect signals the fact that there is a fundamental spin field connected with electromagnetic radiation** of any frequency. This confirmed that the electromagnetic field was indeed the Cartan torsion and that light was as Cartan and Einstein had believed 'spinning spacetime'. The **spin field** was the **missing part of the puzzle** and the quest to unify gravity with electromagnetism could now proceed to its final stages. Myron's work showed that circularly polarized light has a magnetic component in the direction of propagation which is now called the **B(3) field** and which produces magnetization in all materials. In order to apply this new knowledge to Einstein's work, Myron had to delve into the mysteries of spherical geometry, as Einstein and Cartan had done before him. The mathematics is difficult to understand, as Einstein found out when he began his search for his general theory of relativity. Einstein had managed to come up with his theory of special relativity using his thought experiments, but to extend this to include acceleration and gravity he had to spend ten years learning the maths he had never thought he would have a use for and on completing his great work he needed months of rest and nursing back to health. Likewise Myron would need to work for ten years on the problem and would need to collaborate with a number of superb mathematical physicists before ECE theory would emerge and Einstein's great work would be completed**!**

The spin field B(3) was a development in chemical physics. The equation for B(3) was developed at Cornell University and the University of North Carolina into the B Cyclic Theorem:

$$B(1) \times B(2) = iB(0)B(3)^*$$

in cyclic permutation. This is the Lorentz and generally covariant frame of reference ITSELF, in the complex circular basis (see for example Brian Silver, "Irreducible Tensorial Methods", published 1975, Cambridge). So B(3) is the frame of reference ITSELF within a factor A(0). Here cA(0) has the units of volts and is primordial in nature. In other words the field is the frame itself, as in gravitation.

Myron subsequently developed the spin field into a form of electrodynamics that could incorporate the spin field self-consistently "O(3) electrodynamics".

Myron began collaborating with Vigier in 1992, writing with him the series of books entitled ‘The Enigmatic Photon’ and organized with him the ‘Vigier Conference’ in Toronto in the summer of 1995. Thus, the collaborative mathematical venture to complete Einstein’s work using the new insights derived from the spin field had begun.

Vigier had worked extensively with Bo Lehnert and Nils Abramson, two Swedish Professors who work at KTH University in Stockholm and the three had published books and papers together. Myron also came into contact with Professor John Hart of Xavier University at this time and Bob Grey of Rochester. These collaborations led to the formation of The Alpha Institute for Advanced Study (AIAS) in 1996 to promote work in the field of chemical physics related to Einstein’s work and the nature of electromagnetic radiation. AIAS was thus formed to continue Einstein’s search for the grand unified field theory, his fabled ‘theory of everything’.

In 1982 Myron had been invited to be the editor of a special double edition of Advances in Chemical Physics (volumes 62 and 63) by the Series Editors Prigogine and Rice. **Ilya Prigogine (1917-2003)** was born in Moscow and studied chemistry in Brussels, where he became director of the International Solvay Institute before becoming Professor of Physics and Chemical Engineering at the University of Texas. Prigogine received the 1977 Nobel Prize for Chemistry for his contributions to non-equilibrium thermodynamics. **Stuart Rice** was born in **1932** in New York and is Professor Emeritus at the University of Chicago. He has been awarded both the National Medal of Science and the Congressional Medal of Honor by Bill Clinton.

This connection continued with Volume 119 in 2001, which described how far unified field theory had got at that time.

Bo Lehnert's article in Advances in Chemical Physics, vol. 119(2), Wiley Interscience, 2001 reviewed Lehnert's own theory and related it to other new theories which included many aspects of particle theory through the Proca equation. These theories included

- The Dirac theory of the electron.
- Einstein-Schrödinger-de Broglie-Vigier-Evans and the B(3) field.
- Lehnert vacuum charge current density theory.
- Bartlett-Harmuth-Vigier-Roy theory of vacuum conductivity and photon mass.
- Hertz-Chubykalo-Smirnov-Rueda theory of convective displacement current.

Bo Lehnert is a member of the Royal Swedish Academy and a King of Sweden Gold Medalist.

All Myron's Advances in Chemical Physics reviews are available on the Omnia Opera section of www.aias.us. "Modern Non Linear Optics" consists of the six volumes, Advances in Chemical Physics 85(1), 85(2), 85(3), 119(1), 119(2) and 119(3).

The Kielich Institute of Adam Mickiewicz University in Poznan was named after Stanislaw Kielich, who co-inferred the inverse Faraday Effect with Arkadeusz Piekara, and systematically developed non-linear optics in many directions. Mansel Davies introduced Kielich's work to the Royal Society of Chemistry of which the former was a Faraday Division Committee Member. The Faraday Division was formerly the Faraday Society.

Volume 119(3) of Advances in Chemical Physics was endorsed by the Royal Swedish Academy in recognition of Vigier's Omnia Opera, which is listed in that volume, with a portrait of Vigier as frontispiece. Vigier received an honorary degree from York University, Toronto at the first Vigier conference and would have received many more honorary degrees were it not for his intellectual adherence to the Einstein / de Broglie causality instead of the Copenhagen indeterminacy which dominated physics in the late twentieth century. Now the pendulum was swinging back again to causality, with the rigorously objective philosophy underpinning ECE.

Bo Lehnert summed up the impact of Myron's discovery of the spin field and its implications by stating, 'As a result of the theory by Evans, an axial magnetic field component $\boldsymbol{B}^{(3)}$ will exist in the direction of propagation of an individual photon. Regarding such a photon as an axis-symmetric wave packet of limited transverse section, it is inevitable that the packet should possess a three-dimensional magnetic field pattern, having an axial field component $\boldsymbol{B}^{(3)}$ and an associated angular momentum (spin). This fundamental contribution by Evans leads to a better understanding of the enigma of the photon than can be offered by conventional theory. Accordingly the results by Evans have inspired a number of scientists and research groups to perform further investigations along this line of approach. The research by Evans is thus of great importance to the scientific community and to the further development of modern physics and chemistry.'

Einstein had developed general relativity using German and Italian mathematics of curved surfaces advised to him by his fellow student from his days at ETH University, Marcel Grossmann. In 1911 on his return from his job at Charles University in Prague, Einstein was now a Professor at the University of Zurich, while Grossmann was a Professor of Mathematics at nearby ETH, Zurich. This allowed Einstein to access Grossmann's mathematical genius to make up for his own failure to capitalize on the learning opportunities offered to him in Mathematics at ETH, when he had been a student there.

In the early twenties, Elie Cartan had suggested to Einstein that electromagnetic radiation was due to the torsion or twisting of spacetime. They corresponded extensively on the subject but were not able to construct the required unified field theory. Einstein had shown that space is curved by massive objects as described by the 1915 Einstein Hilbert equation of general relativity. Cartan meanwhile had developed his differential Cartan geometry to describe light as torsion or spinning space time. After Myron's discovery of the spin field of electromagnetic radiation in 1991 and the formation of aias in 1996 it was seen that mathematics had to be developed to dock Einstein's curved space with Cartan's torsion of spinning spacetime.

Myron found in 2003, that Cartan's French differential geometry could be adapted to do the job. In the **Spring of 2003**, the field equations of gravitation and electromagnetism were unified into the Einstein Cartan Evans (ECE) field theory, which is based directly on Cartan (or differential) geometry. The breakthrough Paper was Myron's 599th: M. W. Evans, 'A Generally Covariant Wave Equation for Grand Unified Field Theory' in Foundations of Physics Letters, 16, 513 (2003). This paper from Craigcefnparc in South Wales (the nerve centre of aias) records the discovery of the wave equation that unifies wave (or quantum) mechanics and general relativity in an objective manner. This was a major aim of both Albert Einstein and Elie Cartan for many years. **Einstein's quest to unify gravity with light** had **finally** been **achieved** and **history had been made** by Evans and his Einstein Cartan Evans 'ECE' theory.

Shortly thereafter, the equations of the weak and strong fields were also unified with those of gravitation and electromagnetism, and the Dirac equation derived from the ECE wave equation. The equations of quantum mechanics and general relativity were unified in the same year (2003) through the use of the **tetrad postulate** of Cartan geometry, leading to the ECE Lemma and wave equation.

Dirac's equation allowed quantum theory to be united with special relativity last century, when the new subject area of quantum electrodynamics (QED) came into existence. In 1927, Einstein's quantum theory was being taken over by the Copenhagen school of scientists, such as Heisenberg, who regarded it as complete and governed by probability only. They believed at the subatomic level uncertainty held sway and particles were linked by 'spooky action at a distance'. Einstein however believed quantum theory was incomplete and the role of probability would diminish as the theory firmed up. However the Copenhagen school came to dominate physics as the twentieth century progressed and eventually was regarded as the only game in town. This one sided view opened the door for more outlandish ideas and eventually led to string theory and other theories which could not be tested experimentally and which contained equations that could be 'cooked' to produce results to give the impression that they were the best theories to develop.

The Schrödinger equation was discovered by Schrödinger and Debye at the University of Zurich as they struggled to understand the de Broglie wave particle dualism and was inspired by their search to visualize the internal workings of the atom. Heisenberg on the other hand used his superb mathematical abilities to formulate the Heisenberg equation as an equation to emulate Schrödinger's great equation. However, Heisenberg's copy cat equation did not develop from an insight into the workings of nature but was derived from abstract mathematical juggling of data. At this point Heisenberg broke away from Baconian scientific principles with his declaration of mathematical independence from experiment using 'uncertainty' as his battle cry. Bohr became his first convert to mathematical independence and the Bohr Heisenberg indeterminacy was foisted on the physics world at the Solvay Conference in 1927.

Heisenberg was very able, a formidable proponent, and appointed a full professor at the age of 26. Peter Atkins points out in his book, "Molecular Quantum Mechanics" (Oxford University Press, 1983) that the Heisenberg uncertainty should really be called indeterminacy. Indeterminacy means that things are no longer causal; this immediately introduces considerable confusion as to what is physics, or natural philosophy. Indeterminacy really means that some things are intrinsically unknowable, not statistically uncertain, but absolutely unknowable. The casual determinists Einstein, de Broglie and Schrödinger (and many others) rejected this outright as is well known. Boltzmann had spent much of his life trying to convince lesser scientists that atoms existed. Planck had introduced the photon as merely a mathematical necessity to solve a problem. Einstein meanwhile used his vision of an underlying reality to prove atoms existed and established the photon as real. Heisenberg's indeterminism kicked the photon back into touch and back into the domain of abstract mathematics. No wonder Boltzmann spent so much of his life in a sanitarium!

Paul Dirac's 1928 equation was introduced to describe the motion of an electron in the atom for the one electron case. Hitherto the path of the electron did not match up to mathematical description. Dirac realized that because electrons moved at extreme speed, close to the speed of light in the atom a relativistic correction was needed. Dirac achieved this correction by unifying quantum mechanics with special relativity to create quantum electrodynamics (QED), which then needed extension to the many electron case of atoms beyond hydrogen.

In time the clarity that the Dirac equation brought to the field of QED was lost in abstract mathematics as a generation of mathematical physicists followed Heisenberg's lead in developing exotic equations free from the rigor derived from experimental verification. Eventually Richard Feynman gate crashed the party with his Feynman diagrams which described QED again in terms of an underlying reality. Neils Bohr was furious with Feynman for turning the 'Copenhagen Convention' on its head and led the verbal Feynman bashing which ensued. However, Feynman's logic was compelling and a truce followed when the abstract mathematicians were allowed to put their heads back in the sand with the thought that the underlying reality indicated by Feynman diagrams could be regarded merely as a mathematical convenience to get things moving again. So for the next fifty years mathematical indulgence was the order of the day and physics was allowed to drift from its experimental tether leading to string theory, dark matter, dark energy and other doomed dead end contrivances.

Eventually Myron tried to improve the situation by tightened up the Heisenberg equation by introducing general relativity, notably the quantum of action density, h bar / V. This intervention is described in Lar Felker's new book, "The Evans Equations of Unified Field Theory" (Abramis Academic, Suffolk, 2007). The new ECE theory was used by Evans to unify the equations of quantum electrodynamics with general relativity, thereby simplifying quantum electrodynamics (QED) and negating the need for outlandish theories, such as string theory. In addition because ECE theory unifies quantum electrodynamics with the more powerful general relativity rather than weaker special relativity, new opportunities have been opened up to look afresh at old problems in science to see what new information can be gleaned.

The spin field B(3) was not inferred until 1992, and the inverse Faraday effect itself was unknown prior to the mid fifties. The whole structure of the Maxwell Heaviside theory had to be developed from 1992 to present (in ECE and precursor theories) to unify electromagnetism with gravitation.

'The Spinning and Curving of Spacetime: The Electromagnetic and Gravitational Fields in the Evans Unified Field Theory', (*Found. Phys. Lett., 18, 431 (2005))* which was Myron's 663rd paper from Craigcefnparc records the development of the field equations of electrodynamics within ECE theory, a major advance from the standard model in which the electromagnetic field is still the nineteenth century entity of Maxwell, Heaviside, Lorentz and Poincaré. In ECE theory the electromagnetic field is a field of general relativity, unified with all other fields geometrically.

The essential difference between special relativity and general relativity applied to classical electrodynamics is that in the former theory (Maxwell and Heaviside) the field is an entity (introduced by Faraday) superimposed on a fixed frame. Whereas, when general relativity replaces special relativity, the electromagnetic field is the frame itself and the frame itself is dynamic, needing the spin connection. The spin connection makes all the difference, introducing many new effects not present in Maxwell-Heaviside theory and explains many phenomena not explicable by MH. The spin connection makes the theory of classical electrodynamics philosophically consistent with the theory of gravitation.

The debates between ECE and the standard model revolve around this revolutionary approach to the subject. To resolve these debates, www.aias.us offers a Table of many experimental advantages of ECE over the standard model. The standard model has lost the debate comprehensively according to Bacon's philosophy. In other words we are making truly significant advances in relativistic physics for the first time in ninety years!

Honors and awards of the Aberystwyth group (Gareth Evans, Colin Reid and Myron Evans).

Awards for **Dr. Gareth Evans**
Mathews Prize of the University of Wales
Ph. D. 1977
Post Doctoral Fellowship
University of Wales Fellowship
S.E.R.C. Advanced Fellowship
Author of over a hundred scientific papers and books
Discoverer of the ‘Evans’ crystal growth effects.
Awards for **Dr. Colin Read**
Masters degree 1978
Doctoral Degree 1980
Post Doctoral Fellowship
Member of the Mass Spectrometry Unit at UW Swansea
Author of over fifty scientific papers
Co-discoverer with Myron Evans of the far infra red gamma process.

Honors and awards of the Aberystwyth group (Gareth Evans, Colin Reid and Myron Evans).

Awards for **Dr. Myron Evans**
Mathews Prize (1969)
Top first (1971, generally considered the best undergraduate degree of UW Aberystwyth)
Dr Samuel Williams studentship (1971)
Ph. D. (1974, considered by Mansel Davies to be one of the two best he had supervised)
SRC Post Doctoral Fellowship, Oxford University (1974-76)
ICI European Fellowship (1974)
Canadian NRC Fellowship (1974, open international competition)
Elected Junior Research Fellow of Wolfson College Oxford (1975)
Ramsay Memorial Fellowship, University College London (1976-78)
Chemistry Lecturer, University College Swansea (1978)
SERC Advanced Fellowship (1978-83), University of Wales, Aberystwyth)
D. Sc. (1978, for major contributions to knowledge and youngest recipient of Britain and the Commonwealth).
Royal Society of Chemistry Harrison Memorial Prize (1978, open competition, major award).
Royal Society of Chemistry Meldola Medal (1979, major award).
First EMLG Scientific Coordinator and co-Founder (1980, National Physical laboratory).
Visiting Scientist, University of Pisa (1980)
Two University of Wales Fellowships (1983).

Honors and awards of the Aberystwyth group (Gareth Evans, Colin Reid and Myron Evans).

Awards for **Dr. Myron Evans** (continued)
University of Wales Pilcher Senior Fellowship (1985, open inter-subject competition).
Two Leverhulme Trust Fellowships (both in open inter-subject competition).
IBM Fellowship (1985, open competition).
IBM Visiting Professorship (1985).
Honorary Fellowship University of London (1987).
Honorary Fellowship University of Lancaster (1987).
Visiting Professor Cornell (1989-92), Zurich (1990-1991), Penn State (1991), York University Toronto (1995) and Indian Statistical Institute (1995).
Professorship UNCC
Professor, Institute of Basic Research (1995- to date)
Director AIAS (1998 to present)
Civil List Pension 2005 in recognition of distinguished service to Britain in science, a British High Honor akin to Order of Merit and Appointment by Parliament.
Many Editions of Marquis Who's Who in America, the World and Science and Engineering.
Author of about seven hundred and fifty scientific papers and books. Website www.aias.us where a complete list is available.
Naturalized a US citizen in 2000, British citizen by birthright, born and resident in Craigcefnparc.

Honors and awards of the Aberystwyth group (Gareth Evans, Colin Reid and Myron Evans).

Fields of Interest and Discoveries **Dr. Myron Evans** (continued)
Explanation of the far infra red region of the spectrum in terms of molecular dynamics.
Co-pioneer of computer simulation
Co-discoverer with Colin Reid of the far infra red gamma process.
Development of field applied computer simulation.
Various discoveries in molecular dynamics using computer simulation.
Development of group theoretical statistical mechanics.
Discoverer of the fundamental spin field of electromagnetic radiation.
Development of electrodynamics using gauge theory, generally covariant unified field theory, which has made an unprecedented impact (2003 to present, www.aias.us activity feedback).
Book of poetry (2005).
Permanent exhibition of photographic prints UW Swansea Library.
President of the Alpha Institute for Advanced Study, 2007.
Chairman of the Santilli-Galilei Association, 2007.
Industrial Post: - Director and Chairman of Steriwave Plc, 2007.
Santilli-Galilei Gold Medal, 2008.
Websites: www.aias.us, www.atomicprecision.com, www.bbc.co.uk/wales/mid/halloffame/alumni/

From Relativity to ECE in Seven Days based on Seven Crystal Spheres.

Early Astronomy, The Days of the Week and the Crystal Spheres.

In ancient times man began studying the oldest science of astronomy. Monuments such as Stonehenge show that the length of the year had been determined and that the longest and shortest days were considered important. December 25th was considered as the beginning of the New Year, because on this day the morning sunrise was determined to be earlier than the day before. The Babylonians were so advanced with their astronomy, that they learned how to predict eclipses.

The Egyptians based much of their religion on astronomy and it was known by Egyptian priests that six weeks after Sirius reappeared in the morning sky, the Nile could be predicted to flood. They were very interested in the Northern stars that never set (the indestructibles). The most important of these stars was the North Star (Polaris) which stays still in the sky with the others stars rotating around it every 24 hours (this provides proof that the Earth is rotating). The most important constellation (star pattern) in the sky was Orion which takes on the easily identifiable shape of a man and which the Egyptians revered as the god Osiris. If the three stars of Orion's belt are followed in a line downwards to the left it points to Sirius, the brightest star in the sky. Three small shafts were incorporated into the great pyramid, originating in the king's and the queen's chambers and pointing towards the central star of Orion's belt, to Sirius and to Polaris.

Astronomical measurements were already being routinely taken of the stars by the Babylonians and seven planets (if we include the Sun and the Moon) were known to be moving through the fixed patterns of the stars. These planets were thought to revolve on seven invisible crystal spheres which were stacked one inside the other, in the same way as 'Russian dolls'. The order of the spheres away from the Earth was thought to be Moon, Mercury, Venus, Sun, Mars, Jupiter and Saturn. This explains the speed of the planets against the star background and led to the 'Geocentric' view of the universe.

The seven planetary gods of the seven crystal spheres became the seven days of the week. This relationship between the planets, gods and days of the week spread throughout Western Europe.

Day of Week	Planet	Greek	Latin
Sunday	**Sun**	Helios	Sol
Monday	**Moon**	Selina	Luna
Tuesday	**Mars**	Ares	Mars
Wednesday	**Mercury**	Hermes	Mercurius
Thursday	**Jupiter**	Zeus	Iuppiter
Friday	**Venus**	Aphrodite	Venus
Saturday	**Saturn**	Kronos	Saturnus

When the Romans came to Britain the Roman days of the week came with them and were incorporated into and preserved by the Welsh language. Astronomy and alchemy were closely related in ancient times and it was thought that the metals found in the earth had a heavenly source related to the appropriate planet.

Day of Week	Day in Welsh	Translation of Welsh	Alchemic Connection.
Sunday	Dydd Sul	**Sun**	Gold
Monday	Dydd Llun	**Moon**	Silver
Tuesday	Dydd Mawrth	**Mars**	Iron
Wednesday	Dydd Mercher	**Mercury**	Mercury
Thursday	Dydd Iau	**Jupiter**	Tin
Friday	Dydd Gwener	**Venus**	Copper
Saturday	Dydd Sadwrn	**Saturn**	Lead

From Relativity to ECE in Seven Days based on Seven Crystal Spheres.

Sunday **Sun** **Testing ECE theory and Relativity.**

1. **The Sun and Navigation, the Rise of Baconian Science, the Royal Society and the Voyages of Discovery.**
2. **The Royal Institution, the Nature of the Atom and the Rise of the Cavendish Laboratory.**
3. **Alchemy, the Philosophers Stone and the Rise of the Edward Davies Chemical Laboratories.**
4. **The Age and Power of the Sun.**
5. **Testing Relativity and ECE Theory with the Sun and the Bending of Light.**
6. **The French Connection.**
7. **Visualizing atoms at the Edward Davies Chemical Laboratories.**
8. **The Sun, Cosmology, Fred Hoyle and the Steady State Theory.**
9. **Across the Universe.**

1. The Sun and Navigation, the Rise of Baconian Science, the Royal Society and the Voyages of Discovery.

There are twelve signs of the zodiac, which roughly cover the twelve months of the year and which mark the constellation that the Sun is in on the day that a person is born. This means that on a person's birthday the constellation that is their star sign cannot be seen because it is blotted out by the daytime Sun. However six months later, the Sun has moved the opposite part of the sky, so the relevant star sign is at its most favorable position to see in the sky at midnight. The twelve star signs form a circle around the sky called the ecliptic, which is due to the orbit of the Earth around the Sun.

All the planets in the solar system orbit in a plane which is the same as the Earth's within a few degrees. This means that they follow a similar path around the sky to that of the Sun and so are confined to the constellations that form the zodiac. Thus, in horoscopes it could be said, 'that this month Jupiter moves into Virgo'. However, this could only be true if Jupiter was actually just about to move into the constellation of Virgo as seen from the Earth. Jupiter would then be confined to the constellation of Virgo for around a year, because it takes twelve years to orbit the Sun, so twelve years to find its way around the twelve star signs of the zodiac.

In the sky it is seen that there are summer and winter constellations with Orion signaling the onset of winter and Leo showing we are moving into spring. The constellations that change with the seasons are found within a wide band around the sky, roughly corresponding to the tropics of Cancer and Capricorn on world maps being projected upwards onto the sky. The patterns of the stars seen on the canvas of the sky changes from night to night, but is seen to be on a loop that repeats itself every 365 days. The constellations are seen to be in the same position earlier every night by four minutes or two hours every month, so that after twelve months they are in the same position 24 hours earlier so the loop has been completed. The name to this repetitive shift of the stellar background with time as measured by the local time of the observer is called the year. It is caused by the Earth orbiting the sun. When the Sun reaches its highest point in the sky it is twelve noon and occurs every twenty four hours. However, each day the Earth moves around its orbit slightly, which means the line of sight from the observer through the Sun to the stellar background has changed by an amount equivalent to four minutes of the Earth's rotation time. Thus, **the measurement of time is relative.** You can measure time by the Sun as we usually do or by the position of the stars. If we forget about the Sun and measure time by the time it takes the stars to be at the same point above us as they were the day before we are measuring 'star time', which is called sidereal time. The difference is due to the orbit of the Earth around the Sun, but could also be said, to be due to the orbit of the Sun around the Earth. Galileo found that stating that the Sun not the Earth is the centre of our universe in such matters could be construed to be a statement tantamount to heresy.

Beyond the confines of the constellations marked by the zodiac signs are the northern stars above the Earth and the southern stars beneath. The further an observer goes north in the northern hemisphere the fewer of the southern stars he can see, because they never rise above the horizon. However, as he moves further north it is found that some northern stars never set below the horizon. These stars that never set are said to be circumpolar. It is also seen that as the stars move around the sky, one star never moves. This star is Polaris in the constellation of Ursa Minor and is better known as the North Star. To an observer stood on the North Pole, Polaris would be directly above him with all the stars moving around it. Constellations close to the horizon would never set but simply skim around the horizon as the Earth night progressed. It could be quite obvious to the observer that it was infact the earth spinning rather than the stars moving around the Earth.

It is easy for an observer to work out his latitude in the northern hemisphere. The observer has only to determine the angle between the horizon and the North Star and that is the observer's latitude! Moving north or south is seen to affect the altitude of the North Star correspondingly, so that at the equator the North Star would lie on the horizon, whereas at pole it had been directly overhead. If a traveler measured the distance due south he had traveled along the Earth's surface when going from the pole to the equator, this would be ninety degrees around the Earth and the circumference of the world could be calculated simply by multiplying by four. Similar calculations had been done in ancient times and it was known that the earth was round. However, through religious dogma and conflicts this information was lost to the European powers and it was assumed the Earth was flat. The trade in spice between Europe and the eastern powers was a rich source of revenue for those who controlled the flow of the spices. Thus, the Italian Christopher Columbus was able to gain funding from the Spanish to see if indeed the earth was round and if the Spice Islands could be found by sailing around the back of the world.

The astronomer and navigator **Christopher Columbus (1451-1506)** set out on the first of his four famous voyages in August 1492 and in October noticed that his compass needle was no longer pointing at the North Star, but was starting to point to the north west of it. Columbus was thus the first person to recognize that magnets point to a point on the Earth which is now called magnetic north. Before October was out Columbus had discovered the Bahamas, followed by Cuba and Haiti and headed for home reaching Lisbon in March 1493.

Bartholomew Dias explored the Coast of Africa for Portugal and in 1488 discovered the Cape of Good Hope which gave the route to India for Vasco da Gama (1460-1524) to reach in 1498.

In 1494 the pope gave the rights to the eastern trade routes to the Portuguese and the western routes to the Spanish. However, the English, French and Dutch were not going to be kept out of world exploration by this agreement and stepped up their own efforts to find new trade routes.

In 1497 the English sent an expedition from Bristol on the Matthew led by the Italian **John Cabot (Giovanni da Verrazzano 1450-1498)** over to North America to look for the North West Passage to the Spice Islands. He did not find the route to the pacific, but landed in Newfoundland giving England the claim to Canada. It is thought that one of Cabot's backers, Richard Ameryk gave his name to America.

Ferdinand Magellan (1480-1521) led the expedition that finally found the route west for the Spanish via the Magellan straits in South America. Magellan did not survive the voyage, but the one ship and eighteen men who did, then led by

Juan Sebastian Elcano, became the first expedition to circumnavigate the world. Magellan also saw two irregular nearby galaxies which now bear his name, the smaller and the larger Megallanic clouds.

England became an increasingly outward looking country in this time frame and developed its sea faring tradition which paved the way for its trade and exploration around the globe. **Sir Walter Raleigh (1552-1618)** was active in attempts to establish colonies in Virginia and North Carolina and supposedly was the first person to plant potatoes in Ireland and famously had a bucketful of water thrown over him by a servant who had not seen anyone smoking Virginia tobacco before. **Sir Francis Drake (1540-1596)** led the first British circumnavigation of the world, fighting the Spanish as he went and arriving back in 1580, in the Golden Hind, which was only the first time this feat had been achieved since Magellan's voyage back in 1520.

In 1497 at Bologna University, **Nicolaus Copernicus (1473-1543**) began his astronomical observations, which he would continue to make throughout his life as a hobby. Copernicus built on the work of the Ancient Greek philosopher **Aristarchus** from the island of Samos, who was the first to put forward the heliocentric theory. Aristarchus had also calculated the distance between the Earth and the Sun, as well as the distance between the Earth and Moon by geometrical methods that though perfectly sound, were way off because of the severe limitations imposed by the technology of the day in measuring angles. Copernicus's observations of the position and movement of the planets over time were however much more accurate and his mathematical analysis of them produced scientific evidence supporting Aristarchus' belief that the Earth was not at the centre of the universe. Copernicus's book **'On the Revolutions of Heavenly Spheres'** was published on the day he died in Poland in **1543** and marked a shift from Aristotelian science to the modern scientific method which uses experimental work to validate scientific conclusions.

Britain's ability to embrace and exploit new scientific ideas had its foundations in these Tudor years. Key figures such as Leonard and Thomas Digges, **John Dee (1527-1608)**, Thomas Gresham and Francis Bacon had the intellect, financial capability and connections to government that would provide the scientific foundation to put Britain at the forefront of scientific advances for centuries to come. Copernicus's ideas were soon taken up by this group and publicized by Leonard and Thomas Digges in England.

Leonard Digges (1520-1559) secretly invented the telescope which was used by the Royal Navy and for spying on political enemies. Leonard Digges and his son Thomas **(1546-1595)** produced an almanac in English which let the ordinary Englishman marvel at the implications of Copernicus's ideas. Furthermore they used their telescopes to observe the heavens before Galileo and realized that the stars were not at a set distance, but were at differing distances moving off to infinity.

The rich merchant **Thomas Gresham (1519-1579)** left a large sum of money to establish **Gresham College** in London, which opened its doors in **1598** and was the first community college in Britain catering for citizens who wanted to improve their knowledge of science and mathematics. Logarithms were introduced to the public at Gresham College as a way of replacing complicated multiplication processes by adding numbers from a table of logarithms. Navigation was also taught, along with astronomy. **Christopher Wren** became the Gresham Professor of Astronomy and a host of enthusiasts started meeting there, many of whom were to become well known names, such as Robert Boyle.

Francis Bacon was Gresham's brother-in-law and shared his desire to promote experimental science. **Francis Bacon (1561-1626)** was born at York House in the Strand in London, son of Sir Nicholas Bacon, Keeper of the Great Seal to Elizabeth 1st Tudor. Francis Bacon saw the need for science to move away from Aristotelian methods of inquiry, which did not involve testing theories experimentally and campaigned for 'Baconian' science to take its place. Thus, through the work of these far sighted gentlemen and the meeting place provided at Gresham College the stage was set for the formation of **The Royal Society** in **1660**, which was followed in 1798 by the formation of the Royal Institution which was to become the place where more scientific discoveries were made than anywhere on Earth. The Royal Institution also became the location of the most famous scientific lecture theatre in the world.

Tycho Brahe (1546-1601) in Copenhagen was another leading experimental and observational astronomer who worked at the turn of the seventeenth century. Tycho had a supernova named after him and made such accurate observations of the planets, that Kepler was later able to use them to prove the planets move around the Sun in ellipses. However Tycho was not known for keeping his thoughts to himself. As a young man he had lost the bridge of his nose in a duel with swords and surprisingly wore his copper nose covering with pride, as a kind of badge of honor to his outspokenness. Tycho's was able to show that a chance comet changed its distance as it passed the Earth in such a way that the supposed solid crystal spheres on which the planets moved could not exist. Tycho's revelation was greeted with fury by the Danish King who effectively sent him into exile for his troubles. Tycho's treatment for his scientific insight in astronomy and physics no doubt sent a warning to Galileo and to physicists down the centuries, but it is in the nature of true minded scientists to bring scientific advances into the public domain. In this respect Galileo could be regarded as the 'Patron Saint of Scientific Truth'.

Galileo pioneered the use of observation and experiment to move scientific arguments forward. Before Galileo few scientists had moved on from the Aristotelian method of investigation, where assumptions were made and developed until conclusions manifested themselves. The use of scientific observation and experiment was used by Galileo to move science away from being an abstract talking shop bogged down by circular arguments and into a new age of reason and discovery, paving the way for the scientific revolution that has made our modern world possible. Copernicus had shown the way forward with his astronomical observations and calculations which were able to prove the planets go round the Sun. However, Copernicus was wise enough to see that the powers that be in society have a vested interest in maintaining the status quo and often see radical thinking as a threat to their power base. Therefore it may not be a coincidence that Copernicus's book outlining his theories was not published until the day he died.

When the simple refracting telescope reached Galileo in 1609, he used his experimental and mathematical genius to design his own Galilean telescope which had greater magnification and resolution than the instrument he had purchased. Glass making in Venice at the time was well advanced and since spectacles were in common use at this time he was easily able to find lenses to experiment with. As time went on Galileo was able to improve the design of his telescope to produce ever better telescopes. Infact, the term telescope was even coined by Galileo.

In 1610, Galileo was ready to turn his improved telescope to the heavens and within a few months had revolutionized astronomy. He saw the Moon had craters, mountains and flat areas. He called the flat areas seas, but pointed out that the seas could infact simply be flat areas of rock. He also noted that the Sun was rotating as shown by Sunspots, which also revealed the Sun was not the perfect sphere without blemishes that had been believed previously. The planet Venus was seen to have phases which provided crucial evidence that Venus was orbiting the Sun and not Earth, as Copernicus had asserted. Saturn was seen to have an odd shape, due possibly to a ring around it. One of Galileo's most far reaching discoveries was that Jupiter had four large moons which could be seen orbiting the gas giant every few days. This was proof that not every celestial body went around the Earth. In a few months Galileo had published his popular book 'The Starry Messenger' which was quickly sold out and read avidly throughout Italy and making Galileo famous throughout the known world.

Galileo went on to make other great scientific discoveries, but was advised by the Church not to promote Copernicus's idea that the Earth was not the centre of the universe. This advice was later turned into a court injunction to make sure Galileo did not destabilize church beliefs. Years later however, Galileo had the ear of the new pope in matters concerning scientific advances. The Pope advised Galileo not to promote Copernicus's beliefs, but gave him permission to write a book entitled, 'The Dialogue of the Two World Systems' with the title being thought up by the pope himself. However a couple of years later in 1633, when the book was published, the pope now feared that Galileo's ideas were dangerous to the stability of the country and ordered that Galileo be put on trial heresy. Eventually the seventy year old Galileo was forced to admit that he was guilty of heresy and was ordered not to leave his house for the last ten years of his life.

In 1642 the year that Galileo died, Isaac Newton was born. The instability feared by the pope was actually being played out in England around the time of Newton's birth with the Stuart King being confronted by Parliament which led to civil war. Puritanism was in the ascendance in the land and one of its great protagonists Oliver Cromwell eventually led the roundhead army to victory. England had now strong links to North America and the puritans known as the Pilgrim Fathers were annually in the summer months transporting their supporters to America for a better life where they could practice their religion in peace in the British colony. Their high regard for education led to them forming their own university which was in large part funded by a puritan by the name of Harvard. Harvard did not survive in the colony for very long but is generosity led in large part to the formation of Harvard University.

Despite the civil war England had become an outward looking nation embracing the wider world and was well placed to benefit from an upsurge in scientific and technological advances, which would turn Britain, the small island nation, into a world superpower. Oliver Cromwell was a devout Puritan and as Lord Protector had started passing laws which were interfering with the common peoples attempts to enjoy their lives as good as they were able. Cromwell even went so far as to ban Christmas! Thus, on his death the nation was ready for the restoration of the monarchy.

Over time more scientists and mathematicians came over to Bacon's way of thinking and this led Gresham scholars to seek a forum where scientists, mathematicians and engineers could meet to discuss how experimental investigation could be used as a means to take science and technology into the modern age. Thus the Gresham group succeeded in 1660, at beginning of the reign of Charles (II), with the formation the Royal Society which was given its Royal Charter from the King in 1662.

The Royal Society's first meeting took place in November 1660 and the proceedings of the society were published from 1665 in the world's oldest Journal 'philosophical Transactions'. This forum quickly started promoting the development of mathematics, astronomy, biology, physics and chemistry through their discussions and enthusiasm and by embracing experimental science as proposed by Francis Bacon.

At Oxford University the chemical physicist Robert Boyle had taken on an assistant called **Robert Hooke (1635-1703)**. Hooke was to take a leading role in the development of the Royal Society in its early years and became its Curator of Experiments in 1662. Hooke had already formulated his famous Hooke's Law of elasticity and soon used it to develop the balance spring, which was then used as a timing mechanism in watches. Hooke was a scientific all rounder making important observations in astronomy, physics and biology and was gifted in the art of drawing, making him into a kind of British Leonardo. By 1665 Hooke had obtained a microscope and had used his artistic gift to make fabulous drawings of the microscopic world. He recognized the existence of cells in plants and infact coined the term. He went on to publish a great scientific best seller called Micrographia, which enthralled the people of London. In 1665 Hooke became the Gresham Professor of Geometry where Wren worked. After the great fire of London the two men helped to rebuild London, with Hooke as surveyor of London and assistant to Wren. Hooke designed the 'Monument' to the fire of London and built it with an opening on top to house a lens, which facilitated it being used as a telescope or transit instrument when an observer down below used a suitable lens as an eyepiece. Hooke used the Monument to observe a star in the constellation of Draco on nights six months apart, so that the diameter of the Earth's orbit could be used to look for stellar parallax. Hooke did not discern any parallax showing that the stars were much further away than previously thought.

As the European sea powers started to develop global links an accurate way for determining longitude was sought. In Britain the task was passed by the King onto the Royal Society and John Flamsteed. **John Flamsteed (1646-1719)** became the first Astronomer Royal in 1675 and the Royal Greenwich Observatory was founded the same year to be his home and workplace. A year later he also became a Fellow of the Royal Society. John Flamsteed and his collaborators at the Royal Greenwich Observatory were given the task of measuring the positions of stars to an accuracy that could allow longitude to be determined at sea so that navigation around the globe could be facilitated. In 1725 Flamsteed's star catalogue 'Historia Coelestis Britannica' was published and listed the positions to 3,000 stars to the greatest accuracy so far achieved, surpassing the work of even Tycho Brahe.

Meanwhile Edmund Halley and Isaac Newton were on the case and were constantly banging on Flamsteed's door for the latest star positions. Newton was using his new law of universal gravitation to attempt to predict the position of the Moon, however even for Newton this was not a simple task because not only the gravitational effects of the Sun and Earth have to be taken into account, but also changing distance between the Earth and Moon during the month and variation in distances with the Sun during the year.

It is easy for an observer to work out his latitude in the northern hemisphere. The observer only has to determine the angle between the horizon and the North Star and that is the observer's latitude! However longitude presented a most formidable problem which took a hundred years to solve. Flamsteed's work led to the lunar method of longitude determination, in which a ship's position could be determined by finding the time at Greenwich by observing the position of the Moon against the starry background or angle with the Sun and then comparing it with the local time for the ship. The ship could find its local time by reference to when the Sun was highest in the sky being midday which could be determined using a sextant, as were the angles between the Moon, Sun and reference stars. By 1762 it was becoming clear that the German astronomer Tobias Mayer was able to produce tables of the Moon's time and position accurate enough to finally allow navigators to work out their longitude to half a degree or about twenty miles. Mayer's widow was awarded a large prize by the Board of Longitude and from 1767 nautical almanacs were published containing the data needed for global navigation to proceed. This opened the way for the great voyages of discovery by Cook, Darwin and Flinders on the Endeavour, Investigator and the Beagle where the world would become the laboratory for the study of biology, botany and geology.

Captain Cook (1728- 1779) led the famous voyage to Tahiti to observe the transit of Venus as part of a great international effort to use the transit to finally work out the size and scale of the Solar System. The expedition set off in 1768 as the first of three voyages by Cook and returned in 1771 with the astronomical measurements and a host of newly discovered plants. Not only had the Endeavour called at Tahiti, but also at previously unknown islands in addition to New Zealand and Australia. The success of the ships botanist Joseph Banks, who had largely funded the voyage, was celebrated on landing in Australia by Cook naming that point Botany Bay.

The observations made by Cook in Tahiti of the 1769 transit of Venus was part of the worlds first major international scientific collaboration and enabled the distance in miles to the Sun to be calculated. The size of the solar system was already known in terms of, astronomical units (1AU= the distance from the Earth to the Sun), but the observation of the transit of Venus was needed to determine the number of miles corresponding to one astronomical unit. In 1781 two years after Captain Cook was killed by natives on Hawaii, **William Herschel (1738-1822),** discovered the planet Uranus and this meant the solar system was now double the size previously calculated. Herschel was placed on the Civil List in 1782 for his discovery, becoming the second of the historically important Civil List Scientists. The size of the solar system increased again when **John Couch Adams (1819-92)** enabled Neptune to be discovered through his mathematical predictions of its expected position based on perturbations in the orbit of Uranus caused by Neptune's gravitational pull. Adams was similarly rewarded as Herschel, becoming the tenth of the fourteen Civil List scientists to date.

Robert Brown (1773-1858) was the Scottish botanist on the **Matthew Flinders Expedition (1801-1803)** to New Holland (now called Western Australia) aboard the Investigator, where he discovered several thousand new plant species. Interestingly, Brown also discovered and named the nucleus found in cells and discovered that pollen grains in water have a strange, almost life-like motion that is now called Brownian motion after him. Brown was put on the Civil List for his endeavors and Einstein used Brownian motion in 1905 to show physicists that atoms actually existed. This shows, surprisingly that the use of Baconian principles to find thing out in the nineteenth century had put chemistry some hundred years in advance of physicists with regards to the atom. Soon after the formation of the Royal Institution in 1798, the Civil List scientist **John Dalton** was giving lectures on atomic theory while at the same time physicists were bogged down in meaningless discussions on the meaning of life and were busy later victimizing the physicist Ludwig Boltzmann for formulating equations which showed atoms could be treated statistically to great effect. Soon yet another Civil List scientist, **Michael Faraday** working at the Royal Institution would join the battle to characterize atoms using electricity to give the relative weights of atoms and also showing that atoms have a characteristic combining power or valency.

Charles Darwin sailed around the world on the five year long second voyage of the **Beagle** from **1831-1836** via South America, Tahiti and Australia. He spent a third of this time at sea and two thirds on land explorations as a geologist studying the geology of the lands, together with plants, animals and fossils. This voyage led Darwin to write his controversial book 'On the Origin of the Species (by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life)' in which he presented evidence for the theory of natural selection. However, he did not publish his ideas initially, because he was well aware that it would cause a furor amongst traditional biologist who believed in creationism and so chose to bide his time in order to develop his knowledge so that his eventual book would be able to stand up to ridicule. However, when he found out **Alfred Wallace (1823-1913)**, who was soon to become a Civil List scientist, had independently come up with similar ideas and had published an article in a journal in 1856 and was about to have a book published on evolution, based on his own fieldwork in the Amazon and Malay Archipelago, Darwin reluctantly bit the bullet and raced to complete and have published his epochal book in 1859. Darwin's theory did not come as a bolt from the blue however, since other scientists centuries before had reasons to suspect a kind of evolution had been taking place. Robert Hooke the first Curator at the Royal Society had realized that many fossils contained the remains of extinct species and Darwin's own grandfather Erasmus had been thinking along similar lines to Charles.

The mathematical genius of the first of the Civil List Scientists, Isaac Newton together with his universal law of gravitation had enabled expeditions and trading vessels to explore and circumnavigate the globe and by the time of Darwin's voyage in the Beagle the age of discovery by sea was coming to an end. **Sir George Airy (1801-1892)** followed in Newton's footsteps both by becoming the Lucasian Professor at Cambridge University and by being appointed as Civil List Scientist. Airy was appointed Astronomer Royal in 1835 and in 1854 succeeded in determining the mean density of the Earth using gravity measurements above ground and the bottom of the Harton mine. In 1851 Airy established a new Prime Meridian at Greenwich which was accepted in 1854 as the Prime Meridian for the world, so showing the world's quest for longitude was now complete.

It was important for navigators to be able to measure the position of the Sun in relation to the Moon and to be able to recognize and locate the fifty seven stars used for navigation. This meant that the best ships navigators had to have a good knowledge of observational astronomy and scientific instruments such as the sextant were developed and refined to allow better and better measurements of the

Sun, Moon and stars. With the invention of the telescope it became possible to observe the Sun's surface in more detail than ever before. The Sun is too bright to be observed directly through a telescope unless a very dark almost opaque filter is used to avoid the observer being blinded. Solar telescope do not need to have large diameter object glasses to collect every scrap of light as astronomical telescopes do, so can be quite small. What is needed is magnification to see the surface in more detail and a suitable filter to give the contrast needed to bring out the surface detail. Galileo tackled the problem by using his telescope as a projector. The image of the Sun was projected from the eyepiece onto a piece of card and the magnification could be played with by changing the distance between the card and the eyepiece.

Galileo was the first person to realize the Sun had an active surface and rotated. Having built himself a telescope, he pointed it at the Sun but was careful not to look through it knowing that would cause injury to his sight. Instead, he projected the image from the eyepiece onto a card and was then able to draw daily what he saw. Galileo saw that there were groups of dark spots on the Sun that we now call Sunspots. These spots were seen to drift westward across the Sun's disc day after day, disappearing around the western edge (limb), to be replaced by new Sunspots appearing from the eastern limb. Galileo was able to conclude that the Sun rotates in around a month, with the Sun's equator rotating faster than the poles.

Since Galileo's time, sunspots have been meticulously recorded. The Royal Greenwich observatory has records of them going back hundreds of years. The spots show an eleven year cycle in which spots increase to a maximum and then slowly fall to a minimum. At solar maximum sunspot activity is greatest and the spots which are due to magnetic fields in the Sun can become violent and result in solar flares which can reach the Earth and produce the famous Auroras at the poles.

Sunspot activity is known to affect the weather slightly. When the sun is at solar maximum, the temperature can be slightly higher indicating that the Sun is more active. Going back through the sunspot records it was found that there was a time when sunspots were not seen on the sun for many years. It was found that these years corresponded to the mini ice age when the Thames regularly froze in winter allowing Londoners to hold fairs on the Thames, shown in scenes painted by contemporary artists.

In the nineteenth century the rate of progress in the different areas of science would quicken so that there would be more and more scope for students to become involved in useful and fascinating scientific research. The Royal Institution was formed in 1799 to extend the work of the Royal Society by providing a location for scientists to meet and to work and to expound the wonders of science to the public at large. James Clerk Maxwell a regular visitor to the Royal Institution appreciated how experimental investigations were needed to support theoretical work, as was clearly happening at the Royal Institution. In the middle of the nineteenth century Maxwell was appointed head of the new Cavendish Laboratory and was able to apply what he had seen at the Royal Institution, to the design of what would become the world's most famous physics laboratory.

Towards the end of the century, chemistry was taking off as a subject at the first university in Wales, at the seaside town of Aberystwyth and would outgrow the Old College building to be relocated in the Assembly Rooms in Laura Place before a purpose built laboratory complex was built for it known as the Edward Davies Chemical Laboratories. The Edward Davies Chemical Laboratories would collaborate with the Royal Institution and the Cavendish over the coming years to develop chemical physics in order to solve many interesting problems. To obtain a better understanding of the Sun and the stars and our place in the universe it was necessary to delve into the world of the atom and the nature of light. The experiments at these three laboratories and the insights of scientists who worked in them would have a profound effect on our understanding of these topics. To understand what the Sun is made of we need to look into the world of chemistry and the nature of atoms. We need to know how many different kinds of atoms there are and how these tiny microscopic particles interact together. Captain Cook's observations of the transit of Venus helped the distance of the Sun to be determined as about 93 million miles. At this vast distance it could be assumed that it would be impossible to study the chemical composition of the Sun. However light that reaches us from the Sun carries all the information we need with it. It was the job of nineteenth century chemists and physicists to study the atom and nature of light on Earth to enable us to understand the nature of the Sun, stars and ultimately the universe at large. The establishment of the Royal Institution at the turn of the nineteenth century would provide the location, the laboratory and the meeting place for such studies to take place and for the impetus to inspire other scientists to carry on this great quest at new university laboratories that would be built as a result of the boom in science and technology during that century. The first scientists who worked at the Royal Institution would have the responsibility of establishing the reputation of the Royal Institution and of selecting important areas of research for study. The first of the institutions scientists would be active in the fields of light and the separation of atomic elements using electricity, in the guise of the great Thomas Young and Humphry Davy. Soon they would be joined in their endeavors by the greatest experimental scientist of all time, the scientific titan Michael Faraday, who would found the electricity industry and pave the way to our understanding of light and electromagnetism, opening a doorway to view and understand the universe.

2. The Royal Institution, the Nature of the Atom and the Rise of the Cavendish Laboratory.

The Royal Institution was established in 1799 by the great Count Rumford, with the aid of Captain Cook's wealthy ship's botanist **Sir Joseph Banks (1743-1820)**, who had moved on to become the President of the Royal Society. Banks had been elected a Fellow of the Royal Society in 1766, following his return from a voyage to Newfoundland, where he had studied the plants and animals. Robert Brown the botanist on the Flinders expedition was for a while the librarian and curator of Bank's collections. Banks promoted many scientific voyages and was behind the voyage of the Bounty on which Captain Bligh caused the famous mutiny. As President of the Royal Society (1778-1820), Banks was a guiding light in the development of British science in the formative years of the nineteenth century.

Count Rumford was the 'James Bond' character of his day, moving in government circles, being an inventor and scientist, advisor on military matters and military hardware, a mercenary, womanizer and spy. Rumford was born in America and left after helping Britain in the War of Independence. Eventually he was accused of spying against Britain for a European power and left for France, where he married the widow of the great French chemist Lavoisier. **Antoine Lavoisier (1743-1794)** had named oxygen in 1778 and hydrogen in 1783 and recognized mass was conserved in chemical reactions. He went on to create a list of substances that could not be broken down. This list contained the chemical elements and was a step on the way to the conception of the periodic table. Lavoisier was not popular in revolutionary France, having been a rich aristocratic tax collector and was dispatched by Guillotine in 1794.

The Royal Institution was established with Thomas Young as professor and Humphry Davy as Assistant Lecturer and with both undertaking research and giving talks to the public and interested parties. Thomas Young soon came up with his Young's slit experiment which brought the wave theory of light back into play. Davy meanwhile built the world's biggest battery and used it to separate many metallic elements such as sodium and potassium for the first time. The public were enthralled by Davy's lectures and in 1813 Faraday joined him as an assistant. Davy took Faraday with him on a long scientific tour of the continent meeting Rumford and his French wife in Paris.

In Naples Davy used 'The Great Lens' to burn diamond with sunlight. The waste gas produced was carbon dioxide and this experiment showed that diamond was pure carbon. Amazingly physicists a century later could not accept this fact, which had been proven with a simple experiment. Diamond is made of only one kind of atom, but physicists in the nineteenth century could not accept the existence of atoms (except for Boltzmann of course) in the way chemists did. In the early years of the Royal Institution Davy had done much to promote atomic chemistry by his experiments which separated or characterized the nature of atoms

Pioneering work on atomic theory was carried out early in the nineteenth century by the civil list chemical physicist John Dalton who also produced work on meteorology and the nature of colour vision. **John Dalton (1766-1844)** lectured on his theories about atoms at the Royal Institution as early as 1803 and 1804 and on the 'Atomic Theory of Vapours' in 1834.

Finding evidence for the existence and nature of atoms in chemistry is not rocket science! Once reasonably accurate chemical balances were available, it was possible for anybody to carry out simple experiments to work out the weights of atoms relative to one another. Magnesium ribbon can be burned in a crucible to produce magnesium oxide. The mass of the magnesium used is increased by the mass of oxygen atoms which are added from the air to form the oxide. By taking the initial mass from the final mass you find the mass of oxygen which combines with the magnesium. So if you use 24 grams of magnesium you find it combines with 16 grams of oxygen. Here it can be seen magnesium atoms are one and a half times the mass of oxygen. By carrying out similar experiments with other elements you can find the relative atomic masses of all the elements. Hydrogen is found to be the lightest atom and by comparing the masses of all atoms to hydrogen you can list all the different atoms of all the elements in order of their mass. So hydrogen the lightest element has a relative atomic mass (Ar) of 1. Helium the second lightest element has an Ar of 4, carbon 12, oxygen 16, magnesium 24 and so on.

Once batteries had been invented and were commonly available it was possible for anybody to do simple experiments to give the combining power of each atom. For instance if two carbon rods are connected to a battery and placed inside inverted test tubes in salt water, the salt water is split apart by the current into oxygen and hydrogen. The hydrogen collected in the first test tube has twice the volume of the oxygen collected in the second test tube indicating water is made of two parts hydrogen to one part oxygen and has the formula H20. The hydrogen can be identified simply by placing a lighted splint at the mouth of the tube to produce the familiar pop and the oxygen is identified by allowing it to rekindle a glowing splint.

Michael Faraday is the father of the electricity industry, having invented the electric motor and electromagnetic induction, which is the method of mass producing mains alternating electricity by rotating magnets inside coils of wire. Soon after inventing the method of producing electricity by electromagnetic induction, Faraday was carrying out experiments in the early 1830's into 'electrolysis', a term that Faraday coined. Faraday also coined the terms anion, anode, cathode, cation, electrode, electrolyse, electrolyte and ion and also founded the electroplating industry. Faraday's work led him to formulate his laws of electrolysis, which shows the mass of a metal deposited or mass of an element liberated by electrolysis depends on the mass of the metal or element relative to hydrogen and the amount of charge or electricity normally carried by that element when melted or dissolved in its ionic form. Thus, simple experiments with electrolytes give the masses of different atoms and their chemical combining power or valency. Thus, the way was made ready for **Dmitri Mendeleev (1834-1907)** to formulate the periodic table of elements.

Dmitri Mendeleev was born in Siberia and had sixteen brothers and sisters, with whom he moved to St. Petersburg in 1849. Mendeleev became Chemistry Professor at the University of St. Petersburg in 1863 and set about transforming his chemistry department into a notable centre for chemical research. In 1905, he was awarded the Copley Medal which is the highest award given by the Royal Society and has also had a radioactive element named after him. Interestingly Mendeleev experimented with vodka and water, resulting in a Russian law that vodka has to be made with 40% alcohol by volume!

In 1869, Mendeleev gave a lecture to the Russian Chemical Society which showed how the periodic table of elements could be formulated by reference to valency and atomic weights (relative atomic mass). He showed that the list of the known elements in order of weight could be arranged in rows called periods and as each period became filled, heavier atoms could be added in new rows by matching repeating chemical patterns in heavier atoms to those already lay down. The vertical patterns (groups) produced in this table were governed by the valency of the atoms and could be used to predict the chemistry of one member of the group by knowing how other members of that group behaved. Mendeleev table left gaps where matches could not yet be found, with the assumption that these gaps would be filled as new elements were discovered. Mendeleev gave the Faraday Lecture on 'The Periodic Law of the Chemical Elements' at the Royal Institution in 1889 to

Fellows of the Chemical Society. In his Faraday address Mendeleev acknowledged the ground breaking work of Lavoisier and Dalton and recognized the importance of the use of the spectroscope to identify elements both on Earth and in the Sun and stars.

Mendeleev was an expert on spectroscopy and had written a book in 1861 on the subject, while researching into its use in Heidelberg. Contemporary researchers with Mendeleev at Heidelberg were Bunsen and Kirchhoff who pioneered the technique of emission spectroscopy. In chemical analysis, the flame test is used to show the presence of metallic elements by putting samples into a Bunsen burner flame to look for characteristic colours. A lilac flame indicates potassium, yellow flame sodium, and brick red flame lithium and so on. The spectroscope greatly extends this technique and was pioneered by **Robert Wilhelm Bunsen (1811-1899)** who received the Copley Medal in 1860 and **Gustav Kirchhoff (1824-1877)**. Bunsen invented the Bunsen burner in 1865 by improving the design of a burner of Michael Faraday's design. At Heidelberg, Bunsen and Kirchhoff discovered cesium in 1860 and rubidium in 1861through spectroscopic analysis, so completing the discovery of the metals of the first group of the periodic table. In 1861, while studying the chemical composition of the Sun through its spectrum they found cesium and rubidium to be present.

Kirchhoff formulated **three laws** of **spectroscopy**. His second law states that a hot gas produces light with **spectral lines** at **discrete wavelengths** which depend on the **energy levels** of the **atoms** in the gas. Study of these wavelengths and lines by other scientists would soon **reveal** how **electrons** are **arranged in atoms**. However, at this time electrons had not yet been discovered, but as might be expected Michael Faraday the world's greatest experimenter had done the groundwork experiments which would facilitate their discovery.

In 1835 Faraday did some of the first experiments on plasmas, involving electrical discharges of gases at low pressure in evacuated glass tubes. These discharges can be seen in tubes containing noble gases such as neon, which are used in neon signs. The glow in cathode ray tubes was due to electrons colliding with gas atoms and emitting some of their energy as visible light or other forms of electromagnetic radiation. Faraday found the nature of the discharge in the evacuated cathode ray tubes depended on the pressure and discovered the Faraday dark space discharge near the cathode. At the end of the century further experiments with cathode ray tubes would lead in 1995 to the discovery of **X-rays** by **Wilhelm Conrad Röntgen (1845-1923)** in Germany. Röntgen was awarded the Copley Medal in 1896 and the first ever Nobel Prize for Physics in 1901.

In his later years Faraday believed that electricity, magnetism and light were all manifestations of the force of electromagnetism which was not believed by other leading scientists. However, James Clerk Maxwell believed in Faraday's insights and eventually was able to prove the relationship mathematically. Maxwell frequently visited Faraday at the Royal Institution which gave Maxwell an overview of how Baconian science was most productive when theoretical work could be supported by experiments carried out in state of the art laboratories. This knowledge was put to fine use when Maxwell became the first Director (1871-1879) of the new Cavendish Laboratory at Cambridge where he was able to work hard on the design of the laboratories, giving Cambridge the first purpose built physics laboratory in the world. Before Maxwell's time physics in Cambridge and indeed throughout the world depended on students developing their ideas alone in their own college rooms, as Isaac Newton did, largely unsupervised and learning from their professors by helping out with experiments, much in the way as Michael Faraday had interacted with Davy. At this time science was often a hobby for the rich and as such the experimenter was often able to build his own laboratory for his experimentation. Thus the civil list scientist **James Prescott Joule** had a chemistry laboratory built for him by his father who had made his money brewing beer. Maxwell included lecture rooms in his plans so theoretical research and teaching could take place, with students undertaking applied projects in the cutting edge areas of physics.

Lord Rayleigh (1842-1919) followed Maxwell as Director of the Cavendish Laboratory for five years from 1879 and just like Joule, as a man of means, had his own working laboratory at his family home. Rayleigh provided some of his own money to bring the Cavendish Laboratory up to his own standards, which shows that at this time university laboratories were not the well equipped places seen by modern science students in Britain and the rest of the world. Under Rayleigh the workshops were expanded and an organized practical course for science was set up, which at last broke the Aristotelian stranglehold on student scientific studies and replaced them with Baconian experimental based learning. This approach spread to become the standard method of science teaching throughout the world. With his contributions to the Cavendish Laboratory complete, Rayleigh returned to work at his own laboratory at Terling, where he carried out the ground braking work on the noble gases, which earned him the 1904 Nobel Prize for Physics.

Eventually **Joseph John Thomson (1856-1940)** took over as the third Director of the Cavendish Laboratory and his special area of interest was cathode ray tubes. Thomson was born in Manchester and studied at the University of

Manchester before moving on to Cambridge. At the Cavendish Laboratory, Thomson designed a cathode ray vacuum tube which contained a fluorescent screen and which he used to show cathode rays could be deflected by magnetic fields or by electric charge and used the deflection to find the charge to mass ratio of the particles present. The charge to mass ratio was one thousand times greater than that of an atom, showing that the particles were very light and with a negative charge. Thomson had found out that electrons have a particle nature and for this great practical demonstration of the existence of the electron, Thomson was awarded the 1906 Nobel Prize for Physics.

Thomson's cathode ray tube design was some years later adapted to measure the masses of atoms by first ionizing them and thus the mass spectrometer was developed. Furthermore some years later, Thomson's son George, inspired by De Broglie, was awarded the 1937 Nobel Prize for Physics for showing that electrons could be shown to exhibit a wave nature. The wave nature of the electron had infact been detected by an experiment, devised by Michael Faraday as his last experiment in 1862 at the Royal Institution and completed in 1896 by **Pieter Zeeman (1865-1943)** at the University of Leiden. This effect then became known as Zeeman splitting

For his last experiment, Faraday was attempting to investigate the relationship between light and magnetism by looking for a change in width or position of the two lines in the yellow/orange spectrum produced by a sodium vapor lamp in the presence of a strong magnet. The experiment was unsuccessful however, because the spectroscopes of the time used prisms for the dispersion of the light and were thus not capable of showing the effect being looked for. In 1881, concave diffraction gratings were used to replace the prisms and so the discovery was there for the first enterprising scientist who repeated Faraday's experiment. Pieter Zeeman was that lucky scientist who learned of the experiment by reading Maxwell's book on Faraday's life and carried it out in 1896. The effect became known as Zeeman splitting and gave Lorentz and Zeeman the 1902 Nobel Prize for Physics.

J. J. Thomson went onto propose the plum pudding model of the atom, suggesting that atoms are tiny spheres with much smaller electrons embedded in it like fruit in a Christmas pudding. Thomson became the President of the Royal Society from 1916-1920 and was also appointed to the Order of Merit in 1912.

By the end of the nineteenth century, Faraday had created the need for more physicists, scientists and engineers by his inventions of the electric motor and electric generator. Joseph Wilson Swan had invented the light bulb in 1860 and inventors soon started pushing the pace of technology with the invention of other devices. By the end of the century the great Tesla was on the case with a prolific output of creativity which helped to found the electric industry. Even Einstein's father Hermann was making money in the electric industry by designing electrical generators and gaining contracts for his company to light Munich. Young Albert was also involved in this industry during his formative years at the turn of the century, which helped him gain his job in the patent office after he left university. Unfortunately for the Einstein family the Siemens Company gained the later contracts for lighting Munich which put them in financial meltdown and caused them to move to Italy. The great success of the Siemens Company allowed it to finance the refurbishment of Zurich ETH University's physics laboratories into a state of the art facility from which Einstein benefited during his undergraduate studies. Even with the boost in the need for physics teachers and physicists across Europe, class sizes in new laboratories were quite small. Einstein only had six students in his class at ETH catering for future teachers of physics. At the Cavendish Laboratory numbers were similarly low and there was a need to attract more students.

In 1894 Cambridge was able to boost its intake of physicists by accepting research students from overseas for the first time. The New Zealander Ernest Rutherford had just won a scholarship that enabled him to continue his studies abroad and so he came to England to work with J. J. Thomson at the Cavendish Laboratory from 1895-1898. Rutherford was interested in radio transmission and detection and while at the Cavendish held the world record for its useful transmission distance Rutherford was to become one of the world's greatest scientists of all time.

Becquerel had just discovered that uranium salts were radioactive and this provided Rutherford for his topic to study at the Cavendish. Rutherford quickly used his experimental flare working with uranium and thorium to establish there were two distinct types of radioactivity, which he called alpha and beta. In 1898 Rutherford moved to McGill University in Canada to be its Physics Professor. Here he was to team up with the chemist Frederick Soddy, with whom he was to make marvelous discoveries on the nature of radioactivity and the nature of the atom. Eventually he would return to the Cavendish Laboratory as a Nobel Laureate and take on the role of its Director from Thomson.

3. Alchemy, the Philosophers Stone and the Rise of the Edward Davies Chemical Laboratories.

Physics and chemistry often advance side by side with advances in the one subject clarifying and having spin offs in the other subject. This was the case for developments in the understanding of the nature of light, the structure of the atom and of the atomic nucleus. A major chemical input in this vein was provided by the Chemistry Department of the University of Wales, Aberystwyth which developed into the Edward Davies Chemical Laboratories and produced great work in the field of chemical physics for over one hundred years before its untimely demise in the early nineteen eighties. Universities had been established for hundreds of years in Ireland, Scotland and England before Wales became an economic powerhouse in the nineteenth century on the back of coal, iron and steel production in the South Wales valleys. Powerful industrialists then took the opportunity to establish the first university in Wales in the seaside town of Aberystwyth on the Cambrian Coast in 1872. The first department to flourish was the chemistry department, which quickly outgrew its allocated space in the Old College and soon outgrew its new accommodation in the nearby Laura Place building, so the Davies family of Llandinam made money available for the purpose built Edward Davies Chemical Laboratories on a nearby small hill known as the Buarth. The Edward Davies Chemical Laboratories were opened by Lord Asquith the Chancellor of the Exchequer in 1907, the year before he became the Liberal Prime Minister of the United Kingdom. In 1908 Asquith as Prime Minister introduced pensions and led Britain through the War until Lloyd George took over. Asquith's great-granddaughter is the actress Helena Bonham Carter.

By the nineteen sixties even the EDCL had become too small to accommodate the ever increasing demands on it, so at that time an extension was built that doubled the available space by building an adjoining building onto its right hand side. Over the years chemistry at Aberystwyth would sustain developments in the field of chemistry and physics at Cambridge, the Royal Institution and elsewhere.

Before the Edward Davies Chemical Laboratories were built, chemistry at Aberystwyth was taught in the Laura Place building, which later was used for many years as the students union building as a centre for student's recreational activities. While chemistry was being taught there, Aberystwyth University attracted a most gifted young chemist as a student who went on to work with great scientists in the United Kingdom and Canada, with whom he made fabulous chemical discoveries.

That student was one **Frederick Soddy** and he would go on to win the **1921 Nobel Prize for Chemistry** after being nominated by Ernest Rutherford.

Frederick Soddy won the 1921 Nobel Prize for Chemistry the same year as Einstein won the Nobel Prize for Physics. However, they did not meet at the awards ceremony because Einstein was awarded the 1921 Nobel Prize for physics a year late in 1922. It had been intended to award Einstein the 1921 Nobel Prize for his theory of general relativity, but one of Einstein's enemies managed to put a spanner in the works, by pointing out that one of the two British teams which observed the 1919 solar eclipse which proved Einstein's theory, had produced results which were not convincing. To overcome this problem, Einstein was awarded the 1921 Nobel Prize a year later for his explanation of the photoelectric effect, in the same year that Neils Bohr was awarded the 1922 Nobel Prize for the 'Bohr atom'. Einstein's explanation of the photoelectric effect in terms of light quanta, made Einstein along with Max Planck, the father of quantum theory. Bohr subsequently used Einstein's ideas of light quanta to explain the emission spectrum of the hydrogen atom in terms of the arrangement of electrons into shells within the atom. Even Bohr did not meet Einstein at the Nobel Prize awards ceremony, because Einstein was touring Japan in December 1922 and was given his prize in Sweden at a special ceremony after his return. Einstein had been confident for years that he would win the Nobel Prize and amazingly it had been agreed in court in 1919, as part of his divorce settlement, that the money from the Nobel Prize would go to the wife he was then divorcing!

Frederick Soddy (1877-1956) was a chemist educated at the University College of Wales, Aberystwyth and Oxford University. After undertaking research at Oxford (1898-1900), Soddy took up a position as a demonstrator from 1901 to 1903 at McGill University in Montreal, Canada. Here, Soddy used his chemical knowledge and practical skills to support Rutherford in his quest to determine the nature and causes of radioactivity. Their collaboration was able to show that radioactivity was due to the fabled process of transmutation (one chemical element changing into another), which had been believed in by alchemists (including Isaac Newton) for hundreds of years and was the focus of their quest to turn base lead into fabulous gold. Radioactivity was due to the decay of unstable chemical elements into more stable elements by the emission of alpha and beta particles and was accompanied by the emission of gamma radiation. Soddy and Rutherford worked together on the thorium series of radioactive disintegrations, uranium and radium with radioactive samples of radium and uranium being sent to them by the Curies back in France.

Soddy's success with Rutherford did not go unnoticed back in Aberystwyth and the Edward Davies Chemical Laboratories, where a laboratory was eventually built in his honor. The EDCL Soddy Laboratory was built behind the original building and was a radio-isotope laboratory financed by a grant to Dr Cecil Monk who came from Birkbeck College London. There was also a later extension from the Soddy lab to an organic chemistry teaching lab built by Dr Samuel Graham.

After Soddy returned to England in 1903, he first worked at University College London before moving on to Glasgow University to continue his endeavors. There he was able to use his chemical skills to show that there had to be heavy particles in the nucleus of an atom which were not charged as protons are and which do little to affect the elements chemical properties. Soddy was therefore the first person to realize that there were different forms of an element which differed only in their mass numbers. Soddy decided to coin the term isotopes for different forms of an element differing in their mass number, a term suggested to him by a Scottish female relative. The existence of isotopes was later confirmed by workers at the Cavendish Laboratory in Cambridge, where Rutherford had taken over as Director and whose research group had developed J. J. Thomson's design for a mass spectrometer into an accurate method of weighing atoms. This illustrates how chemistry and physics can approach a problem from two different angles and produce complementary results, which independently verify discovery.

In 1903 Soddy returned to England from McGill University in Canada, to work with Sir William Ramsay at University College London and was able to verify that the decay of Radium produced helium. In 1868 the French astronomer Pierre Janssen had detected the hitherto unknown element helium in the spectrum of the Sun during a total solar eclipse in India. Helium having been discovered on the Sun before being found on Earth was named after the Greek word for Sun. In 1885 **William Ramsay (1852-1916)** the Scottish chemist isolated helium on Earth by adding acid to the mineral cleveite. Ramsay went onto discover the noble gases argon, neon, krypton and xenon for which he was awarded the 1904 Nobel Prize. Soddy meanwhile went to work at Glasgow University from 1904 to1914, where he proved that uranium decays to produce radium and that elements could have different isotopes. Soddy went on to get the 1921 Nobel Prize for Chemistry for his researches into radioactive decay and in particular for his theory of isotopes.

Ramsay's 1904 Nobel Prize was Britain's first Nobel Prize in any subject and this achievement was recognized in 1920 by the establishment of a British Ramsay Fellowship, which is administered by the Ramsay Memorial Fellowship Trust which was constituted in 1920 for this purpose. The trust aims to promote chemistry by encouraging individual ability at the highest level. The British Ramsay Fellowships are awarded annually to distinguished chemists who are regarded as an elite group having been nominated by an Advisory Council of British Chemistry Professors, so they may conduct their research at a University in the United Kingdom. In 1976 Myron Evans was given this prestigious award to allow him to continue his ground breaking work at the Edward Davies Chemical Laboratory during the period 1976-1978. Soddy helped Ramsay at University College London the year before he won his Nobel Prize and Myron's Award showed that chemistry at Aberystwyth was still in the Vanguard of chemical research many years after Soddy, the 1921 Nobel Prize winner had learned his craft there.

Ramsay's frequently worked with John Strutt (also known as Lord Rayleigh) who had formerly been a guiding light and Director of the Cavendish Laboratory (1879-1884). Their work is a prime example of how a physicist working together with a chemist can produce ground breaking discoveries in the mould of Rutherford and Soddy and is a signal to theoretical physicists that an appreciation of the real world as seen through the eyes of chemists helps to identify and define problems requiring study. After his spell as Director of the Cavendish Laboratory, Lord Rayleigh OM (1902) continued his experimental work at his family home before serving as the Royal Institution's Professor of Natural Philosophy (1887-1905) and subsequently as President of the Royal Society (1905-08). It was at the Royal Institution that Rayleigh and Ramsay would collaborate in their studies and particularly with those concerning the noble gases. It was Rayleigh the physicist who found in 1894 that nitrogen isolated from the air had a different density from nitrogen made via chemical synthesis. Rayleigh as Professor at the Royal Institution pointed out this density discrepancy at one of his lectures and by good fortune Ramsay the chemist was there in the audience to take up the challenge. Before the year was out Ramsay had identified argon gas as the element in air causing the discrepancy and went on to isolate helium and radon and to discover the other noble gases neon, krypton and xenon. Thus, Rayleigh the physicist was awarded the 1904 Nobel Prize for Physics for his discovery of argon and Ramsay the chemist was awarded the 1904 Nobel Prize for Chemistry for his discovery of the 'inert gaseous elements of the air'. Taking into account their collaboration with Frederick Soddy, we see a prime example of how workers from the Edward Davies

Chemical Laboratories, the Cavendish and the Royal Institution have interacted to take forward science in the last hundred years or so.

Ramsay’s work on the noble gases established these ‘inert gases’ as the last group of the periodic table and with the discovery of the electron it was becoming easier to link patterns of reactivity in the periodic table with the arrangement of groups and electronic charge. **Kirchhoff’s second law of** Emission spectroscopy had revealed atoms had discrete energy levels associated with them that were revealed by the wavelength of the emitted light and at the beginning of the twentieth century chemists and physicists were gaining insights into how electrons fitted into atoms. At the Edward Davies Chemical Laboratories the chemist Charles R. Bury and at Manchester, the theoretical Danish physicist would soon be able to reveal their insights into the arrangements of electrons in atoms. C. R. Bury was Mansel Davies' Masters Supervisor at EDCL, and inferred a form of the Bohr atom about the same time as Bohr. So Mansel always called it the Bohr Bury atom.

Mansel Davies’s field was infra red and dielectrics and worked at the Edward Davies Chemical Laboratories from the nineteen thirties to the nineteen eighties. In Mansel's office there was a photograph of Bertrand Russell and a statue of Michael Faraday, as well as one of the first infra red spectra ever taken - in the thirties when he was doing a Ph. D. at Cambridge, where he became Fellow of Peterhouse, Cambridge. Later, Sir John Meurig Thomas who was Head of the Edward Davies Chemical Laboratories in the seventies would go on to be Master of Peterhouse, which as the oldest Cambridge College is called simply Peterhouse, not Peterhouse College.

4. The Age and Power of the Sun.

The formation of the Royal Institution gave chemistry and physics the boost needed to answer the burning questions of the day. How old was the Earth? Why did the Sun continue to burn constantly for such a prolonged period? Bishops believed the Earth to be only thousands of years old, whereas geology indicated the world was very old. Darwin believed in the evolution of man in a process that took many millions of years, but this required the Sun to support life over a much longer period than could be supported by physical arguments.

In the second half of the nineteenth century the chemical composition of the Sun was becoming known, however its source of energy was still an enigma. If it was composed of best quality Welsh steam coal it could only 'burn' for a few million years, yet geologists were finding evidence in the rocks that the Earth was at least tens of millions of years old and it was reasonable to assume the Sun was at least as old as the Earth. For a long time astronomers and geologists had disagreed on the age of the Earth. The fossil records being found by geologists were causing them to believe the Earth had been around for much longer than astronomers believed.

Soddy and Rutherford discovered during their time at McGill University that different radioactive elements have different half lives in which time half a particular isotope would have transmuted into other elements. Some half lives were fleeting, whereas others were millions or even billions of years in duration. The vast energy involved in nuclear reactions and the new understanding of nuclear half life gained by Soddy and Rutherford was to have far reaching implications to man's understanding of his place in the universe and the age of both the Sun and the Earth. In 1904 Rutherford visited the Royal Institution where he was able to assert that radioactivity was the secret of the longevity of the Sun.

The Sun is of course our ultimate source of energy. It has been responsible for the evolution of life on earth through its billion year plus stability of energy output. Monuments such as Stonehenge show ancient men knew that the Sun was important to the maintenance of life on Earth. However, it was difficult to explain how the sun, being made primarily of hydrogen and helium could produce energy at such a prolific rate for such a long time through chemical reactions. In 1904, Rutherford introduced the world to the potential of radioactivity as a form of power. A year later, Einstein published his famous equation, E= MC2 and the conundrum was solved.

Rutherford was also able to show some years later, that radioactivity could be used as a means of dating the Earth. Rutherford argued that uranium crystals formed in rocks when the Earth was young would slowly turn into lead through radioactive disintegration. Since the half life of the radioactive Uranium 235 isotope was known all that needed to be found was the proportion of uranium to lead in modern rock samples. This measurement was subsequently carried out and proved the Earth to be a few billion years old.

The Sun is four and a half billion years old and half way through its life cycle. Every billion years the Sun warms up by ten percent, so that in another billion years, life on Earth could find it difficult to cope with the increasing temperature of the planet. Thus far, the increase in the radiation output from the Sun has been cancelled out by a reduction in the greenhouse effect, as carbon dioxide levels have fallen from the high levels found in the atmosphere of the early Earth. The regular cycle of ice ages, is a relatively recent development in the Earth's history, resulting from the global cooling caused by the continued reduction of carbon dioxide in the atmosphere. However, carbon dioxide levels are now down to a fraction of a percent, so this mechanism will no longer be able to compensate for the increase in radiation output from the Sun of the next couple of billion years. Furthermore, as the Sun comes towards the end of its nine billion year cycle, the Sun will suffer an enormous increase in size as its core shrinks and the Sun becomes a red giant. The Sun will swell up at this point, to almost reach the orbit of the Earth. The Earth will end up being well and truly cooked, rather than simmered.

George Ellery Hale (1868-1938) invented the spectroheliograph, an instrument which is used to study spectral lines by collecting light from the Sun in a telescope and then focusing the light onto a diffraction grating which is then dispersed and passed through a narrow slit for analysis. Hale was a famous American solar astronomer and the designer and builder of large telescopes. In particular he built telescopes on Mount Wilson and used his newly built solar telescope to observe sunspots with his spectroheliograph to make discoveries on the nature of sunspots. Wilson saw with his spectroheliograph, that as the spectral lines of the Sun surface moved to a region occupied by sunspots, the spectral lines split showing a phenomenon known as Zeeman splitting. Zeeman splitting occurs when light from a source is exposed to a strong magnetic field and Hale's spectral data for sunspots showed that sunspots were intimately linked to magnetic fields. Sunspots are actually produced as pairs with opposite magnetic polarity.

Zeeman splitting was discovered by **Pieter Zeeman (1865-1943)**. Zeeman was Lorentz's assistant at the University of Leiden and in1893 completed his thesis on the Kerr Effect. The Kerr effect is similar to the Faraday Effect and involves the reflection of light reflected from a magnetized surface experiencing changes in polarization and reflectivity. In 1896 when looking at how magnetic fields affected spectral lines from a light source, Zeeman found that a spectral line is split into several lines by the presence of a magnetic field. Hendrik Lorentz heard of Zeeman's discovery and used it to show that Lorentz's own predictions of the polarization of light emitted in a magnetic field were confirmed. Lorentz was able to show that Zeeman splitting could show that negatively charged particles a thousand times smaller than an atom were in oscillation. In other words Lorentz and Zeeman had discovered the existence of electrons before atoms had been proven to exist. Their work on Zeeman splitting gave Lorentz and Zeeman the 1902 Nobel Prize for Physics.

Spectroscopy is a most useful method in chemistry for the analysis of molecules and compounds. Absorption spectroscopy is when light of a range of wavelengths is passed through a chemical sample and then on to a detector. Light can be absorbed by molecules in a number of ways which can be used as a chemical fingerprint or to reveal insights into the nature of the motion and structure of atoms and molecules. The wavelength of the light absorbed gives us directly the energy change occurring in the atom or molecule simply by dividing Planck's constant by the wavelength.

E = h/ wavelength or
E = h x frequency.

Absorption spectroscopy is complemented by emission spectroscopy, where atoms or molecules are 'excited' in order to study the wavelength (or frequency) of light emitted due to the process induced in the atom or molecules being studied.

This relationship was studied by Bohr who used it to work out the permitted energy levels of electrons inside atoms. The nature of the spectral lines of different elements revealed that electrons can only have certain discrete energies when inside an atom. Electrons are only allowed to have certain 'quantities' of energy while inside an atom and therefore said to be 'quantized'. Thus, Bohr analysis of electronic spectra greatly extended the use of quantum theory which had been pioneered by Einstein and Planck.

Rutherford left McGill University to become a professor at the University of Manchester. Rutherford worked on the development of the Geiger counter with Hans Geiger. Geiger and Marsdon, another researcher in Rutherford's group used a phosphorescent screen to show that when alpha particles were used to bombard gold leaf, a small number came straight back. Rutherford concluded in 1911 that most of the mass of an atom was contained in a tiny nucleus with the bulk of the volume of the atom being taken up by electrons in orbit around it.

Rutherford's fame as the greatest experimental nuclear physicist attracted Neils Bohr to Manchester to learn from the master. This move from Denmark paid off when Bohr was able to figure out the electronic structure of the hydrogen atom from spectroscopic data. Bohr was then able to return to Copenhagen in 1916 where a glittering career awaited him and where the Niels Bohr Institute was to become the 'other' great centre for nuclear physics. However in Copenhagen researchers did not keep to the Baconian principles used to such great effect by Rutherford and Soddy. The Cavendish would continue to use experimentation as a means of driving theory forward and this approach would in time lead to the nuclear power industry and to nuclear weapons, showing the power of applied physics. The Copenhagen group's return to Aristotelian science would however stifle theoretical physics for the rest of the twentieth century with its theoretical dogma known as the Copenhagen Convention.

The Copenhagen Convention of the twentieth century could in the twenty-first century become known as the Copenhagen Conspiracy, in which theoretical physicists led by Heisenberg and Bohr took physics away from Baconian principles and into the domain of mathematics freed from the need to keep theories in step with experiment. Bohr analyzed the spectrum of the hydrogen atom to produce the Bohr model of the atom's electronic shells, but claimed the insight came out of thin air rather than building on advances made by experimental physicists and chemists. Heisenberg claims to have come up with the matrix mechanics description of the atom independently of the insights of the atom provided by Prince Louis De Broglie and Erwin Schrödinger. However, it could be argued that Heisenberg was jealous and upset by Erwin Schrödinger's insight at producing the great Schrödinger equation and this is what motivated his drive to produce an alternative mathematical description. Heisenberg produced his copy cat Heisenberg equation using his great mathematical skills and then set off to Munich to heckle Schrödinger as he gave a lecture to an audience of keen scientists. Schrödinger's audience sent Heisenberg away with a flea in his ear, so he returned to Copenhagen to cry on Bohr's shoulder. It could be argued that the duo realized that their greatest asset was mathematical ability, but other teams' great experimental work and insights could keep the Copenhagen team continually in eclipse. By claiming that it was impossible to visualize an atom except mathematically and by invoking the Heisenberg uncertainty principle, the Copenhagen conspiracy came into being as a way to suppress experimentalists and common sense and to hand theoretical physics to mathematicians and accountants. The amazing thing about the Copenhagen Conspiracy was that Bohr and his mathematical protégés were able to sell it to physicists at the 1927 Solvay conference, leading to the standard model and the stagnation of free thought in physics for the next eighty years! Thus, theoretical physics returned to the Aristotelian method of scientific enquiry that the Royal Society had been set up to replace.

So the Copenhagen Conspiracy lasted for eighty years through Bohr's, Heisenberg's and Pauli 'unknowable atom' doctrine. And they would have got away with it still if it wasn't for those meddling chemical physicists! Foremost amongst the pesky chemical physicists were workers at The Royal Institution, The Cavendish Laboratory and The Edward Davies Chemical Laboratories who continued to carry out experiments which gave ever greater insights into the nature of the atom.

We can see therefore that Bacon's principle of carrying out experiments to support assumptions about the nature of atoms was most fruitful in the nineteenth century with chemists such as Davy, Faraday, Dalton and Lavoisier finding the relative masses and combining power of atoms to provide the foundations for the periodic table. In contrast at this time physicists were still using Aristotle's methods of investigations restricted to abstract untested arguments, which allowed them to maintain the 'party line' that atoms do not exist. Einstein proved to physicists in 1905 that atoms exist by looking at Brownian motion indicating that physicists at that time were around one hundred years behind chemists in atomic theory due to physicists continued use of Aristotelian methods of inquiry.

Einstein displayed the interest in philosophical discussions shared by physicists of his era and while in Bern formed his own mini philosophical society with a couple of his friends. His philosophical society was called the

Olympia Academy and met regularly to eat sausages and poke fun at other 'learned societies'.

The physicists at the Niels Bohr Institute were thrilled by Bohr's 1922 Nobel Prize as proof of the power of mathematics to solve problems in physics. However, over jus a few years they began to believe that mathematics could go it alone in physics and could dispense with the need to link their researches to experiment. In so doing they turned away from the Baconian principles that had caused a revolution in science in the last centuries and returned to the Aristotelian method of science based on assumptions and conclusions, free from the tether of experimental rigor and validation.

Flushed with their success in explaining the movement of electrons in the hydrogen atom, the Copenhagen advocates went onto confront Einstein and his supporters with their views that only mathematics could used to portray the nature of the atom. Bohr's merry throng unilaterally decided that at the atomic level, probability and chance ruled and it was impossible to visualize an atom, because the atom was unknowable. This doctrine became known as the Copenhagen convention and was used to confront Einstein at the 1927 Solvay Conference.

Einstein was to spend much of his time and effort trying to convince his skeptics that the Copenhagen school of thought was wrong but to no avail. Their battles with Einstein only served to give them the prestige they needed to hoodwink the general public and grant committees of their worthiness.

Meanwhile real science continued to be the order of the day at the Cavendish Laboratory was able to show time and time again that the atom was knowable and more and more about its structure was being found out by the use of subtle and inspired experimentation. Rutherford's protégés went onto get Nobel Prize after Nobel Prize for their copious insights and experimental proofs of the nature of the atom.

Meanwhile chemistry was to prove that Schrödinger wave equation was vastly more useful that its copy-cat Heisenberg matrix mechanics.

5.Testing Relativity and ECE Theory with the Sun and the Bending of Light.

Rutherford's daughter Eileen married **Ralph Fowler (1889-1944)** in 1921. Fowler lectured mathematics from 1920 at Cambridge University and wrote an important book on stellar spectra, temperatures and pressures. Fowler worked with Dirac at Cambridge, introducing him to quantum theory in 1923 and collaborating with him on the statistical mechanics of white dwarf stars. Fowler also worked with the great English astronomer Arthur Eddington.

Arthur Stanley Eddington (1882-1944) replaced Darwin's son as the Plumian Professor of Astronomy in 1913 and became the director of the Cambridge Observatory in 1914. Eddington showed that the matter in stars is ionized due to the high temperatures involved and that the pull of gravity on the matter is balanced by the gas and radiation pressure. Eddington showed that the gas pressure required to balance the star's gravity indicates that the core temperatures of stars must be millions of degrees. He went on to support the idea that a star's energy is produced by the nuclear fusion of hydrogen into helium.

The equation E= MC2 demonstrates that light has mass and as such should be deflected by a gravitational field. In 1911 Einstein calculated the deflection of light from a star caused by proximity to the sun. He took into account that time is slowed down by a strong gravitational field and this effect would increase the deflection.

In 1914 a German astronomical expedition set off to observe the total eclipse of the Sun in the Crimea. However, the World War started and the team was arrested by the Russians before they could observe it. Luckily for the team however, they were soon released on an exchange of prisoners. If the team had been successful they would not have proved Einstein right, because he had not yet calculated the deflection expected for the light beam correctly. Later he realized that gravity also bends space as well as slowing down time, making the path the light takes longer and doubling the angle of deflection in his initial calculations. Why Einstein decided that the angle should be exactly doubled is not clear and so must be put down to his great scientific insight or otherwise to an educated guess to allow his calculations to continue and to provide a figure that could be tested experimentally. Either way Einstein was correct in his assumption as has been shown by the NASA Cassini probe, which is now able to show that the deflection is indeed twice the Newtonian value experimentally to a very high precision.

General relativity came from the equivalence principle in which acceleration and gravity were considered to be equivalent by considering an observer in a box. The observer could be in a lift or in a spaceship. If the observer felt the pull of gravity in the box then this could simply be the pull of gravity on the stationary lift. However, if he was in a spaceship he could be feeling the ship accelerating at a rate corresponding to the Earth's gravity 'g'. Similarly, if the spaceship was stationary the observer would become weightless, but if the box was actually a lift with the cable snapped he would also feel weightless and would not be aware the box was falling with an acceleration of 'g' because he to would be accelerating at the same rate as the box.

Einstein conceived the bending of light and space by gravity from this thought experiment. If light enters through a window in the box inside the rocket as it accelerates upwards, then the box would move up as the light crossed to the other side, causing the observer to see the light bending as it crossed the box. The bending of the light would naturally be greater if the acceleration was greater. Einstein's great insight was then to realize that the effect would be equivalent to an observer held stationary in a gravitational field inside the lift. The greater the gravitational field the greater the bending. Einstein had conceived general relativity, extending special relativity of objects moving at high speeds close to the speed of light to include the effects of gravity and acceleration also. Einstein only needed now to put his ideas into mathematical form to produce his famous Einstein equation. However, this involved cutting edge mathematics and Einstein had been a 'lazy dog' in this respect as a student in ETH University in Zurich, opting to take the easier mathematic options despite being capable of taking the much harder mathematical courses. Luckily, the mathematical genius Marcel Grossmann was in Einstein’s class at ETH University so Einstein was able to pick his brains on the nature of the mathematics required to describe curved space. The mathematics Einstein was advised to study was that of Riemann and Noether. Albert Einstein then went to derive his Einstein field equation from the second Bianchi identity without torsion (**Riemann** geometry) and the Noether Theorem.

In 1915, Einstein introduced the world to General Relativity. The ideas were fantastic so needed to gain support through experiment if this new theory of gravity was to be believed. The bending of light by the gravity of the sun as it passed close by was the test. In May 1919, Arthur Eddington the British astronomer led an expedition to the Island of Principe off the coast of Africa to observe the total eclipse of the sun, while a second British expedition set off to Sobral in Brazil. Photographs were taken during totality to see if bright stars close to the sun had shifted their position. At the same total eclipse measurements were also recorded by the expedition in Sobral in Brazil. At the time of totality the Sun was in the constellation of Taurus the bull. The Bull's head in Taurus is marked by a 'V' shaped cluster of reasonably bright stars with the much brighter and nearer star aldebran marking the bull's eye.

As it turns out some of the results for the bending of light recorded on the Brazil photographic plates were in better agreement with Newtonian theory, while Eddington's measurements were supportive of Einstein. After consulting with the Astronomer Royal and J. J. Thomson (President of the Royal Society) it was decided to disregard results from Brazil, so in November 1919 Eddington was able to state that Einstein's theory of relativity had passed this test of validity. Einstein then became a world wide celebrity. The experiment for calculating the bending of light close by the sun does not now need a total eclipse. In October each year two quasar radio sources pass close to the sun and the apparent changes in the angle between them can be followed by radio telescope in broad daylight.

Einstein-Cartan-Evans (ECE) theory takes the prediction of the deflection of light a step further by predicting that the light will also twist. The polarization of the light is predicted to change as it passes close to massive objects such as white dwarfs with strong gravitational fields. This can be seen in M. W. Evans, "Generally Covariant Unified Field Theory" (volume three, Abramis, Oct. 2006), where the dielectric theory is developed, and "ECE Theory of Gravity Induced Polarization Changes" on the www.aias.us homepage.

In ECE theory, the essential new thing is the homogeneous current j, which adds a term on the right hand side of the Faraday Law of induction. This results in various optical effects such as changes of polarization, observed in a white dwarf as in the paper.

ECE theory reduces to Einstein-Hilbert theory when the Cartan torsion vanishes, so producing all that Eddington saw. Calculations were helped by Freeman Dyson, who later moved to the Princeton Institute of Advanced Studies. The accuracy of the light bending now is 1: 100,000 (NASA Cassini, 2003 onwards), proving EH. The extra effects of ECE come from the well known Cartan torsion, which is entirely missing in EH. The homogeneous current j gives the way in which torsion affects EH.

In 2004 Kerry Pendergast was awarded a Royal Society Partnership Grant in relation to an astronomical project entitled 'Daylight Astronomy'. As part of the award Kerry was invited to a special evening viewing of the Royal Society's

Summer Exhibition which highlights groundbreaking projects in education and industry. Impressively Jodrell Bank was there describing their discovery of a double pulsar in a binary orbit in which both pulsar beams would over time eclipse each other in their orbits as seen from earth. This allowed an unparalleled opportunity to study the bending of space and the slowing of time in giant gravitational fields and was dubbed the test bed of relativity theory. Later Kerry reflected that this double pulsar was just the ticket for taking forward the Eddington Experiment and general relativity to the 21st century, since it could be used to test and study the prediction made by ECE theory that the polarized light beam would not only bend around a high gravitational field, but would also tilt. In 2007 Kerry was invited for the day to Jodrell Bank and took the opportunity to discuss the problem with two professors there. They described the experiment as 'cute'. It is only a matter of time before workers at Jodrell Bank or elsewhere get around to carrying out this experiment which has the capability of proving ECE theory beyond doubt and could well lead to a Nobel Prize for the first team to accomplish the task.

Jodrell Bank is a hamlet of houses twelve miles from Manchester named after a Cheshire archer who fought with the Black Prince. A field in Jodrell Bank was originally used by botanists from Manchester University to test genetically modified crops prior to the Second World War. Just before the Second World War, Bernard Lovell was studying cosmic rays at the University, which are very high energy rays which probably originate from supernovae. Lovell was called up just a few days before the outbreak of war to help develop radar and soon found that there were sporadic echoes shown on radars screens that did not come from aircraft and whose source was a mystery. Lovell believed the source of the sporadic radar signal was due to cosmic rays and after the war sought to continue studying them with radar equipment outside the physics department in Manchester. However, trams were an annoying source of interference so Lovell set up his equipment at the university's field at Jodrell Bank, where he soon found the signals were coming from shooting stars. Lovell's experiments interested Manchester University sufficiently, that land was bought at Jodrell Bank in the forties and buildings erected in the late forties and early fifties, together with what was by far the world's largest radio telescope which was two hundred and eighteen feet across and made from wire mesh hung from poles in the ground which reflected radio waves to a mast one hundred and fifty feet above the ground. As the Earth turned the radio telescope was able to pick up signals in a band in a full circle around the Earth, but because the mast could be pivoted the band of signals could be widened to give a radio window on a wider band of the sky. In particular this radio map of the sky was wide enough to pick up the Andromeda Galaxy, so that it was seen that radio signals could be received beyond our own galaxy.

Lovell decided that it would be much better if the world's biggest radio telescope at Jodrell Bank was fully stearable, so all the sky in the northern hemisphere could be radio mapped. He gave the job to Chares Husband a bridge engineer to realize his dream and so the mark 1 Bernard Lovell telescope was born

The first four pulsars were discovered by Jocelyn Bell Burnell, while a post graduate student at Cambridge University and led to her supervisor Antony Hewish being given the 1974 Nobel Prize for Physics. Fred Hoyle had been a great inspiration to Jocelyn and he was annoyed that Jocelyn had not been given a Nobel citation with her supervisor. But Fred Hoyle himself had done great work on the evolution of elements in stars and had coined the term 'Big Bang' only to see others get the Nobel Prize for what many would say was Hoyle's work! Hewish was professor of radio astronomy at the Cavendish Laboratory from 1971-89 and pioneered the observation of scintillations which led to Jocelyn discovery of pulsars. Jocelyn discovered the first pulsar in 1967 and the pulses beamed to Earth were arriving with such precision that it was considered possible that the pulses were from an alien civilization trying to contact us.

The Hulse Taylor binary pulsar was discovered 21,000 light years away in the constellation of Hercules using the Arecibo antenna in 1974, giving the discoverers the 1993 Nobel Prize for Physics. The binary pulsar is in orbit with another star, with both components having a mass 1.4 times that of the Sun and the binary nature of the pulsar being given away by the 7.75 hour periodic variations in the arrival times of the radio pulses, which corresponds with the time taken for the system to complete one orbit. Its discoverer Russell **Alan Hulse (1950-)** was born in New York and went to the Bronx High School of Science and did his degree at the Cooper Union, the privately funded college in Manhattan where Thomas Edison had been a student and where Lincoln made his famous Cooper Union Address in 1860 which led to him becoming President. Hulse continued with his education at the University of Massachusetts Amherst where he gained his Ph.D in 1975.

The orbit of the binary pulsar is elliptical (Eccentricity 0.61713) with a semi major axis of 1,950,100 km and with the distances from the centre of mass varying from 1.1 (746,600 km) to 4.8 (3,153,600 km) solar radii with corresponding orbital velocities of 450 km/sec and 110 km/sec respectively. The neutron star component rotates seventeen times every second giving a pulse to the Earth every 59 milliseconds and the periastron advances (perihelion advance for a star) by 4.2 degrees a year.

The double pulsar was discovered by Jodrell Bank in 2003. The rotation times are 2.8 seconds for one and in the millisecond range for the other and their orbit get smaller by 7mm a day as predicted. The 2.8 second pulsar has a mass of 1.25 and the 23 millisecond pulsar has a mass of 1.34 solar masses. They orbit each other every 2.4 hours with an orbit slightly smaller than the diameter of our Sun and are traveling at 0.01 the speed of light. The 7 mm decrease per revolution is due in ECE to T / R not being quite constant. In fact in ECE theory, T / R replaces the universal constant G / c squared for a given M. The "ECE Paradox" is that the EH equation does not obey the Bianchi identity, and as with all paradoxes this is leading to wholly new information - notably that gravitation is not quite universal in the sense that G / c squared is not quite constant. This shows up in binary pulsars and also in the Pioneer anomalies now perplexing NASA. In paper 106 the orbit of a binary pulsar is described without using gravitational radiation, which has never been directly observed.

David Hilbert (1862-1943) independently inferred the EH field equation in 1915 using the Lagrangian method. A Lagrangian is a function that summarizes the dynamics of the system and is named after **Joseph-Louis Lagrange (1736-1813)** who was born in Turin and worked in France, Italy and Prussia. Lagrange was one of the greatest mathematicians of the eighteenth century and made contributions to number theory as well as celestial mechanics. Lagrange followed **Leonhard Paul Euler (1707-1783)** as director of mathematics at the Prussian Academy of Sciences in Berlin on the recommendation of **Jean le Rond d'Alembert (1717-1783).** His students included Joseph Fourier and Simeon Poisson

Hilbert was a late starter in the 'general relativity' stakes. In June 1915 in Göttingen Einstein gave lectures on how he was going to get to the equations of relativity. Hilbert was present at these lectures and Einstein gave him the run down of how he was going to finally solve the problem. Soon after Einstein realized he had wasted several years in his quest by not following up work with Grossman on Riemann tensors.

Hilbert meanwhile set out to beat Einstein to the post by finding the equations first. Einstein was horrified when he found out that Hilbert had joined the race. Einstein became very worried that Hilbert would beat him to the punch and worked furiously to complete his ‘Einstein equation’ even to the point of risking his health.

In November 1915 both physicists completed the tasks within days of each other. Einstein was however burnt out with the exhaustion of running the race and pictures taken of Einstein in early 1915 and early 1916 show the youthful looking Einstein had changed to the older looking Einstein that we are all familiar with. Einstein was so exhausted that he had to spend the early months of 1916 being nursed back to health by his partner Elsa Einstein. This great contest in mathematical physics has parallels to Ali's famous 'Rumble in the Jungle fight', which exhausted Ali and Foreman so much that it could have cost either boxer their lives. Hilbert however thrived on the competition and took the view that General Relativity was inherently Einstein's theory and that he (Hilbert) had only worked on the final mathematical steps to the finish.

Albert Einstein inferred the EH field equation from the second Bianchi identity without torsion (**Riemann** geometry) and the Noether Theorem. **Amalie Emmy Noether (1882-1935)** was the world's first widely renowned mathematical female genius.

ECE theory replaces Riemann geometry with the much more powerful Cartan geometry, which allows not only the bending of spacetime to be taken into account, but also the effect of the twisting or torsion of spacetime, allowing all the forces of physics to be described in terms of geometry. When light grazes the Sun the slowing down of time causes the light to bend. Additionally the bending of space by the Sun's gravity causes the light beam to bend also. Nevertheless, even in ECE theory there is no explanation as to why the slowing time of light in a gravitational field and the bending of light should both produce the same degree of bending, so that the angle of deflection is double the angle calculated by Einstein for Newtonian gravitational theory. However, Myron has proposed that:-

R = omega T as another form of the null geodesic condition and believes this will explain why the light deflection is twice the Newtonian value whenever light (electromagnetic radiation) is deflected by gravity, i.e. by light grazing an object of any mass M.

"There is no doubt from NASA Cassini that the deflection of light in the Eddington type experiment is twice the prediction of the Newtonian theory to 0.001% or thereabouts. It is now known however (papers 93 to 105 of ECE theory on www.aias.us) that the use of the Christoffel symbol is incompatible with the Bianchi identity of Cartan. The version of the Bianchi identity used by Einstein omits the torsion, which is unfortunately an irretrievable flaw. This showed up in the Hodge dual of the Bianchi identity, and it turns out that we cannot just set T = 0 in the Bianchi identity. Therefore in paper 103 onwards an attempt has been initiated to make the great Einsteinian theory fully compatible with the Cartan torsion. The conditions for the observed deflection have been defined and work is currently (Feb. 15th 2008) in progress in paper 105. This work can account for the Pioneer anomaly while the Einstein Hilbert theory cannot, because it cannot adjust M. The problem is that the so called "Schwarzschild metric" used routinely in astronomy is not the one devised in 1916 by Schwarzschild himself in two exact solutions. Prof. Stephen Crothers, Vice President elect of the Myron Evans University, has shown this definitively (see www.aias.us). In paper 105 a first attempt will be made to explain the true origin of the so called Schwarzschild metric. Also, ECE theory predicts in a simple way that the polarization of light is changed by gravitation, and also all the optical and electrodynamical properties, whereas the Einstein Hilbert theory is a pure kinematic theory based on the mass of the photon being attracted by an object of mass M. For further well known limitations of the Einstein theory see www.santilli-galilei.com. "

6. The French Connection.

Lavoisier made important contributions to chemistry, working as a hobby scientist in Paris. Lavoisier experimentally proved that mass is conserved in chemical reactions, named oxygen and made a list of the substances that could not be broken further chemically. However, Lavoisier's day job was collecting taxes from the poor people of France. This did not make him popular with Parisians and his head was first under the guillotine when the revolution came!

Pierre Simon de Laplace (1749-1827) was more successful than Lavoisier in revolutionary France, being able to change with the times. Whereas Lavoisier had done important work in chemistry, Laplace made groundbreaking advances in mathematics and physics. Laplace was the Isaac Newton of France and was able to advance Newton's work sufficiently to remove the need for a divine intervention in the equilibrium of the solar system, which had been believed in by Newton. Napoleon even had a conversation with Laplace on the subject and was impressed that Laplace could dispense with the almighty in matters concerning the movement of heavenly bodies, showing that both men were great supporters of the cause of **deterministic physics**. Laplace's insights were published in his five volume work Mécanique Céleste (1799-1825), which was translated into English by the Civil List Scientist **Mary Fairfax-Somerville (1780-1872).** Mary Fairfax-Somerville was a Scottish science writer, mathematician and astronomer who had Somerville College Oxford named after her. Laplace's work covered diverse aspects of physics and mathematics and in some respects his work updating Newton's insights created the subject of physics in its modern incarnation.

Meanwhile in London, Count Rumford had decided that British science would benefit from a new meeting place for experimental work, debate and public lectures. Rumford played a vital role in the setting up of the Royal Institution and soon Sir Humphry Davy was separating the group 1 and group 2 metallic elements using the world's biggest battery in the basement of the building. Unfortunately for Rumford, his penchant for spying for foreign governments did not endear him to the British establishment and he wisely relocated his scientific endeavors to Paris, where he married Lavoisier's widow. Napoleon was a great lover of science and so Davy and Faraday were welcomed to Paris to meet with Rumford for scientific and social purposes even though Britain and France were at War! By the end of the nineteenth century Paris would be the centre of research into radioactivity, with Becquerel and the Curies making the vital discoveries that led to the foundation of the nuclear power industry that is today a vital source of energy in France.

Pierre Curie (1859-1906) was a gifted scientist who was born in Paris and worked at the Sorbonne. In 1880 Pierre discovered the piezoelectric effect where compressed crystals create a voltage (and vice versa) and is the effect used in digital circuits such as quartz digital watches. The crystal distorts when the voltage from the battery is applied and as the crystal returns to its original shape its natural resonance frequency generates the voltage that is used as the timing pulse in the RLC circuit. Pierre also did important work on paramagnetism and temperature (Curie's Law) and showed ferromagnetic materials lost their magnetism at a temperature known as the Curie point. Maria Sklodowska began her studies in Paris in 1891 and was interested in the magnetic properties of steel, an interest which brought her to the notice of Pierre. In 1895 Pierre married Marie and it is their work with radioactivity (a term they coined) that made them famous, along with Marie's academic advisor Henri Becquerel.

The German physicist **Wilhelm Conrad Röntgen (1845-1923)** (who like Einstein had studied at ETH Zurich), discovered X-rays in 1895 while working with cathode ray tubes at the University of Würzburg. This discovery gave Röntgen the first ever Nobel Prize for Physics in 1901. It was when Becquerel was working in Paris on the phosphorescence phenomena described by Röntgen that radioactivity was discovered.

Antoine Henri Becquerel (1852-1908) was born in Paris and studied science at the École Polytechnique. After taking up the chair of physics at Muséum National d'Histoire Naturelle, he discovered radioactivity while delving into the phosphorescence of uranium salts first seen by Röntgen. He found that the Uranium salts were able to fog photographic plates with a contact print of a Maltese cross through thick black paper which could not be penetrated by strong sunlight. The SI unit of radiation is named after Becquerel for this discovery. Henri was Marie Curie's academic advisor and this connection set the Curies on the path to fame and glory in their legendary investigation into the nature of radioactivity. Their work gave Henri, Pierre and Marie the 1903 Nobel Prize for Physics.

Pierre observed that heat continued to emanate from radium for extended periods without diminishing and realized that radioactivity was a new type of energy, which is now called nuclear energy.

Radium has a half-life of 1,602 years and therefore a large enough mass of radium could be used to boil water to turn turbines to produce electricity for a thousand years without the need to refuel. However, as larger masses of radioisotopes are assembled, the radioactivity shoots up and the ‘atomic pile’ would become a potential atomic bomb. In practice it is the uranium-235 isotope has been used both for atomic energy and for atomic weapons.

The Curies’ ground breaking work involved the processing of a few tons of the uranium rich mineral pitchblende, starting in 1898 and taking several years to complete. Marie’s work could be compared with the traditional view of a witch stirring away, busily working on the mixture in her cauldron. In this case the cauldron began to glow in the dark as the radioactive nuclides began to be concentrated. In 1898 it became obvious that the pitchblende contained two previously unknown elements, which they called polonium and radium. Both elements were far more radioactive than the uranium which was producing them. The Curies soon became aware that radium has a strong effect on living tissue. Pierre used to carry a sample of radium around with him in his trousers pocket and he found that his leg started to become inflamed and sore. They found that radium damaged healthy living tissue, but could also be used to deliberately kill cancerous lumps. Thus, radiation therapy came into use as a medical treatment.

In 1906 Pierre was tragically mowed down and killed in a Paris street by a horse drawn wagon carrying military supplies. Marie was heartbroken, but bravely carried on with her research efforts. As time went on she struck up a relationship with a family friend Paul Langevin who had been one of Pierre’s doctoral students. Langevin was in a somewhat unhappy marriage with a bad tempered wife who sometimes could become quite violent towards him.

Paul Langevin (1872-1946) did his initial studies in Paris before undertaking further studies in the Cavendish Laboratory under J. J. Thomson, giving the Curies an invaluable link to the Cavendish Laboratory and Ernest Rutherford. The Curies would go on to supply the radioactive isotopes to Rutherford and Soddy during their days at McGill University in Canada, which allowed vital breakthrough to be made into the nature of radioactivity and the study of radioisotope half-lives. Langevin returned to Paris in 1902 to obtain his doctorate from Pierre.

Langevin is famous for the ‘Langevin Equation’ which is a stochastic differential equation used to describe Brownian motion. In 1905 Einstein used a diffusion equation to produce the Avogadro number from the Brownian motion, proving that pollen particles are moving due to interaction with much smaller particles called molecules. This is similar to a Langevin equation approach. Later, diffusion equations were developed by Smoluchowski, Fokker, Planck and Kramers. In the seventies there was strong interest in this at the Dublin Institute for Advanced Studies, clearly following the research guidance of people like Schrödinger and Synge at DIAS. Myron tested out these very complicated equations in the far infra red, using the Elliot 4130 and CDC 7600. This can all be traced back to those first years of the twentieth century which were so important to physics.

Myron developed the Langevin equation for the far infra red using memory function methods in his Ph. D. Work (see early Omnia Opera papers on www.aias.us). This work was later extensively developed with Bill Coffey at Trinity College Dublin and Paolo Grigolini in Pisa. The Debye bell shaped dielectric loss is produced from the rotational Langevin equation, but gives the Debye plateau in the far infra red. This was first recognized and named at the EDCL by Myron's Ph. D. supervisor, Professor Mansel Davies. The friction coefficient of the Langevin equation was developed into a continued fraction of memory functions. Gareth Evans, Colin Reid and Myron used this method extensively in the far infra red, giving a first explanation of the far infra red spectra of materials. Myron added computer simulation to this technique in 1975, using one of the very first simulation methods developed by the Konrad Singer group at Royal Holloway College, and the Oxford Group of Prof. Sir John Rowlinson where he worked from 1974 to 1976. With the greatly improved power of modern computers it should be possible to simulate millions of molecules now and the far infra red described with ever greater refinement using the basic methods worked out in the seventies by Myron's EDCL "Hall of Fame" group (BBC Mid Wales link on www.aias.us).

Marie's relationship flourished as time went on and they went so far as to secretly take an apartment together. In 1911 at the first Solvay Conference in Brussels both Marie and Paul were present along with rising star Albert Einstein. Einstein was worried that Marie could end up costing Langevin his marriage, but thought all would probably turn out fine. However, during the conference Marie was awarded the 1911 Nobel Prize for Chemistry which was widely acclaimed around the world. At the same time Langevin's wife was supplying Parisian newspapers with details of Paul's affair with Marie. So Marie's conference week was full of triumph and ridicule. Before the year was out, poor old Marie was in a state of depression.

Langevin like Pierre and Marie studied magnetism in detail, which led to Paul giving its explanation in terms of electrons in atoms. He also went on to apply Pierre's piezoelectric effect to the ultrasonic detection of submarines. Langevin's greatest student was Marie's daughter Irène Joliot-Curie.

Irène Joliot-Curie (1897-1956) was born in Paris and studied at the Sorbonne. For her doctorate Irène studied the emission of alpha particles from polonium, one of the two elements discovered by her parents. Langevin had tutored Irène when she was six with a group of the Curie's friends for a couple of years and also became her supervisor for her doctorate, which was completed in 1926. During this time she shared her knowledge with the chemical engineer **Frédéric Joliot** who she married in 1926. Irène and Frédéric Joliot-Curie experimented with the transmutation of the chemical elements which gave them the 1935 Nobel Prize for Chemistry for their discovery of artificial radioactivity. Thus, the Curie dynasty was awarded a record total of three Nobel Prizes which must be one of the greatest achievements in the history of science!

Irène and Frédéric Joliot-Curie daughter **Dr. Hélène Langevin-Joliot** was born in 1927 and also became an expert in radioactivity and is currently a professor of nuclear physics in Paris. The Curie link with the Langevins has been continued into the twenty-first century with Hélène marrying Paul Langevin's grandson Michel Langevin, who naturally enough is yet another nuclear physicist.

Pierre Curie has gone down in history by having the Curie named after himself in 1910, which is a unit of radioactivity. Pierre and Marie were awarded the Davy medal in 1903, an honor which is shared by Sir John Meurig Thomas the former Head of the Edward Davies Chemical Laboratories who was awarded the Medal in 1994. The Curies were frequent visitors to the Royal Institution in London and Pierre gave a lecture there on radioactivity in 1903. John Meurig Thomas left Aberystwyth in 1978 to become Head of Physical Chemistry at Cambridge University and in 1986, was appointed Director of the Royal Institution until 1991. As Director of the Royal Institution Professor Thomas lived in Michael Faraday's apartment at the Royal Institution and pursued his interests in solid state chemistry by working in Michael Faraday's own laboratory of which John was then Director. Professor Thomas or JMT as he was known in Aberystwyth carried on Michael Faraday's tradition of Christmas Lectures, by giving the Christmas Lectures himself on 'Crystals' in 1987 with the lectures being screened on the British television channel BBC 2. During his time as Director of the Royal Institution, John also researched and wrote a book on Michael Faraday's life entitled 'Michael Faraday and the Royal Institution: The Genius of Man and Place' which highlighted the great impact Faraday had made in shaping the research and public discourses that had taken place there.

Also working in France throughout most of the twentieth century, was Prince Louis de Broglie who during the First World War worked at the top of the Eiffel Tower as a radio operator. After the war Broglie realized that electrons in atoms had a wave nature. An idea which he conveyed to Einstein when he sent him his doctoral thesis, Einstein was thrilled and worked to make sure Broglie was awarded his doctorate for his revolutionary insight into the working of the atom!

Schrödinger was also thrilled to learn of Broglie's ideas and his discussions with Debye led him to formulate the famous and supremely influential Schrödinger Equation. They were trying to understand Broglie's, then new wave particle dualism, when Schrödinger worked out how to put these ideas into mathematical form. This was one of the greatest feats of the twentieth century

Prince Louis de Broglie built himself a laboratory in Paris and worked there for the rest of his life. Vigier collaborated in Paris with Louis de Broglie for about forty years and subsequently collaborated with Myron in the production of the series of monographs entitled 'The Enigmatic Photon' at the end of the twentieth century, which paved the way for ECE theory at the start of the new millennium.

7. Visualizing Atoms at the EDCL.

The existence of atoms was first considered by the ancient Greeks and taken further by the Civil List Scientist John Dalton, who believed each element consisted of different types of atoms. Ludwig Boltzmann came up with equations which could describe the motion of atomic particles and molecules statistically and thus pressure could be described as the action of billions of particles or solid spheres undergoing collisions. The Civil List Scientist Michael Faraday working at the Royal Institution founded the electricity industry and his experiments into electrochemistry gave further insights into the nature of atoms through his laws of electrolysis. Faraday's work showed that atoms were associated with positive and negative charges and cations and anions. This showed that different atoms have differing combining powers or 'valencies' and helped with the arranging of the list of known atoms into the periodic table. Further crucial evidence for arranging elements in the periodic table was being gleaned from the technique of atomic spectroscopy and Niels Bohr eventually used it to describe the arrangement of electrons into shells within atoms. In 1927 however Bohr and his colleagues announced to the world at the Solvay Conference that atoms were 'unknowable' and could not be visualized. The bulk of theoretical physicists then agreed with them and the course of theoretical physics followed the 'Copenhagen Convention' into a mathematical abyss which is still being developed today by these mathematical gifted, but visually blind physicists who fail to follow Baconian principles in their search for ever greater slices of the world's physics budget! Einstein and the other small band of deterministic physicists at the 1927 Solvay conference did what they could to convince the 'Copenhagen School' of the errors that were being made, but to no avail and these scientists then announced to the world that probability and chance was the way forward at the subatomic level and the rest his history.

Einstein and Prince Louis De Broglie traveled together to Paris after the conference and both would continue to try to put the 'physics train' back on track. Einstein's efforts are well documented, but in the main only served to give publicity and 'street cred' to the partially sighted community of theoretical physicists who doggedly followed the belief that atoms were most definitely unknowable and certainly could not be visualized. Prince Louise De Broglie had been given a rough ride at the conference and had been shouted down by the partially sighted group of physicists and was even told in no uncertain terms to 'shut-up' by Wolfgang Pauli, who was well know for his eloquent use of the English Language! In the event it was De Broglie's work that would eventually lead to the direct visualization of atoms and ionic lattices and much of this ground breaking work would be carried out in the nineteen seventies at the Edward Davies Chemical Laboratories which was then at the zenith of its existence under the stewardship of Sir John Meurig Thomas..

The visualization of atoms can be regarded as more than merely a process of imaging, but can be extended to the understanding of how electrons, neutrons and protons are arranged within atoms and how they move and are influenced by different forces at the subatomic level. The visualization process then continues at the atomic level by considering how atoms interact with one another and join together and undergo rearrangements in their associations as is studied by chemists. Chemical physicists are concerned with how different forms of light interact with atoms in solids, liquids and gases causing the atoms and molecules to undergo various motions such as translation, oscillations, rotations and vibrations and this was the type of work that EDCL scientists had specialized in during the twentieth century. In addition, with the advent of supercomputing, in the late seventies it was starting to become possible to simulate the action of atoms and molecules in computer simulation work which was being pioneered by Myron Evans. So in the seventies EDCL had two independent research groups both working on ways to visualize atoms and both groups would go onto achieve great recognition for their work.

The best optical microscopes are not capable of imaging atoms, because they simply do not have sufficient magnifying power and resolution. Furthermore, such microscopes will never be able to visualize atoms, because visible light has only a medium wavelength in the electromagnetic spectrum and this limits optical microscopes to medium magnification and resolutions. While ordinary light microscopes are limited to a magnification of around a thousand times, the limit for microscopes using oil emersion at the eye piece and the extreme end of the visible spectrum as a light source, the limit is a magnification of around twelve hundred times. However, the use of shorter but invisible wavelengths opens up the possibility of much greater magnifications so the use of short wavelength X-radiation could be used to produce the magnification required to image atoms and their positions in ionic lattices. This is not possible however, because X-rays cannot be focused. The X-ray beam would undergo diffraction by atoms in a crystal to produce a diffraction pattern which could be recorded on a photographic film wrapped around the sample, but it would not be possible to focus the diffraction pattern back into an image because X-rays cannot be focused. Nevertheless, the diffraction pattern could be used to find the distances apart the atoms or ions were in a crystal lattice using Bragg’s Law.

Bragg's Law was devised by **William Lawrence Bragg (1890-1971)** who at the age of 25 became the youngest ever person to receive a Nobel Prize! He built on the work of **Max Theodor Felix von Laue (1879-1960)** who discovered X-rays could be diffracted by crystals and was consequently awarded the 1914 Nobel Prize for Physics. The work of these two great scientists was revolutionary and brought X-ray crystallography into being as the preeminent tool of the day for 'seeing' atoms in crystals. A great tool of Baconian science that appears to have passed by theoretical physicists such as Pauli, Heisenberg and Bohr!

X-rays are diffracted by the outermost electrons and 'see' electrons as an electron cloud. In amorphous solids the diffraction of X-rays is too weak to produce a useful signal from one electron cloud, but in crystals the atoms, ions or molecules have a highly ordered repeated pattern known as a lattice. These lattices reinforce the signal by allowing constructive interference to take place between the diffracted X-rays so that the diffraction pattern produced by a small crystal, say a millimeter across can easily be recorded by a photographic film. Even though X-rays cannot be focused, computers can now be used to transform the diffraction pattern into a kind of contour map of the electron density around the nuclei in the crystals, giving information about the number of electrons in the electron cloud surrounding the atom and by inference the position of the nucleus in the centre of each 'hill' of electron density.

X-ray crystallography is a difficult subject to master, because it is a truly mind bending pursuit. The diffraction pattern produced is the reciprocal of the real space it represents. Points on the diffraction pattern that are close together represent atoms or ions that are actually far apart in the real world and points that are far apart in the diffraction represent atoms or ions that lie next to each other in the real crystal lattice. The crystallographer has to think therefore, in terms of reciprocal space! Symmetry plays a key role and so the crystallographer has also to take into account the operation of such relationships as reflection symmetry and rotational symmetry. So the interpretation of diffraction patterns is not recommended practical work for students with a hangover!

Laue worked at several universities; including Göttingen where he met the mathematician David Hilbert who had a great influence on him, with both men making a contribution to relativity. In 1902 Laue studied in Berlin under Max Planck and in later years both men played a role in the reconstruction of German science as recognition of their anti-Nazi stance in years gone by. Laue obtained his doctorate for his work on interference phenomena in plane-parallel plates. Laue became a friend of Einstein in Berlin and took over some of Einstein's duties when he became the deputy director of the Kaiser-Wilhelm Institute in 1922. Laue became the Director of the Institute when Einstein did not return there in 1933 (after Hitler became Chancellor) until 1948, except for the period 1935-1939 when Debye was the Director.

William Lawrence Bragg was born in Australia and followed in Rutherford's footsteps by moving to England, where he too had J. J. Thompson as his advisor and made great discoveries at the Cavendish Laboratory and the University of Manchester. The University of Manchester only strictly speaking came into being in 2004 when the Victoria University of Manchester merged with UMIST (University of Manchester Institute of Science and Technology). UMIST had been founded in 1824 by the Civil List Scientist John Dalton with the help of wealthy industrialists and businessmen. UMIST and the Victoria University of Manchester combined to form the largest single-campus university in Britain, with forty thousand students. W. L. Bragg worked at the Victoria University of Manchester from 1919-1937, the Cavendish Laboratory from 1938-1953 and at the Royal Institution from 1953-1966, becoming Companion of Honor in 1967.

William Lawrence Bragg's father William Henry Bragg had been Professor of Mathematics and Physics in Adelaide before returning to England to take an appointment at the University of Leeds. In 1912 working at the Cavendish Laboratory W. L. Bragg discovered Bragg's law for calculating the position of atoms in a crystal from the diffraction of X-rays. His father W. H. Bragg then developed the X-ray spectrometer back in Leeds, earning the father and son duo the 1915 Nobel Prize for physics. Both father and son followed in the footsteps of Michael Faraday by becoming Fullerian Professors of the Royal Institution, an honor also shared by EDCL's Sir John Meurig Thomas.

In 1948 Lawrence Bragg became interested in determining the shape and structure of proteins and biological molecules and subsequently as Director of the Cavendish Laboratory was able to promote the work of Francis Crick and James D. Watson which led to them discovering the structure of life's most important molecule DNA. The discovery was made possible by the use of Bragg's technique of X-ray crystallography at King's College London by Maurice Wilkins. Wilkins, Crick and Watson received the 1962 Nobel Prize for Medicine for their landmark achievement in science, which shows clearly that Bohr and Heisenberg were clearly wrong in their belief that atoms were unknowable and could not be visualized. Much of the work in recognizing the double helix structure was carried out using cardboard models to help visualize the unknown structure and known chemical interactions between groups of atoms were considered when putting the pieces of the jigsaw together!

As already stated, X-rays cannot be focused so cannot be used to image crystal lattices directly. However, Prince Louis De Broglie advocated in his Ph.D thesis that just as light waves can exhibit particle properties, so can electrons exhibit wave properties. As electrons are accelerated faster and faster to approach a fraction of the speed of light, they display the characteristics of waves and the faster they travel the shorter their wavelength becomes. Thus, high speed electrons can be used in high resolution electron microscopes to actually image atoms in crystal lattices, because they can be made to possess the required wavelength for the resolution and magnification needed and unlike X-rays the charged electrons can be focused using electromagnets as lenses. In the seventies the ground breaking work to image crystal lattices, using the new technique of high resolution electron microscopy was being pioneered at the Edward Davies Chemical Laboratories at Aberystwyth under the leadership of John Meurig Thomas. This work was being carried out in parallel with Mansel Davies's group which was using far infra red spectroscopy to study how molecules translated, rotated and oscillated in solids, liquids and gases.

In 1969 the EDCL's credentials as an internationally renowned centre for chemical physics took a leap forward, when John Meurig Thomas (J.M.T.) arrived from Bangor to become the Head of Department. **John Meurig Thomas** was born in 1932 in Llanelli, in South Wales. He attended his local University of Swansea, where he obtained his degree in 1954 and PhD in 1958. He went on from there to lecture and research in Bangor University for ten years, before Aberystwyth was to benefit from his prolific and ground breaking research in solid state chemistry.

In Bangor Thomas became friends with and collaborated with fellow chemist **John O. Williams** and physicist **Gareth Roberts.** Roberts familiarized Thomas and Williams with important aspects of solid state physics and they in turn familiarized Roberts with important aspects of solid state chemistry. This shared knowledge allowed the three to see important routes forward in the field of solid state chemical physics. Williams known as J.O. came to Aberystwyth with J.M.T. and Roberts went on to the Department of Physics and Applied Electronics in Durham University, where a glittering career awaited him.

Within a few years the strength of the Aberystwyth Chemistry Department in solid state chemistry was so well established, that it became well known to workers in related fields in Oxford University. Professor John Stuart Anderson was about to retire and was looking for just such a department to continue his research. He relocated to Aberystwyth in 1975, bringing with him his vast experience and a high resolution electron microscope. A talented expert in applied high resolution electron microscopy, John L. Hutchison also agreed to come to Aberystwyth at this time with Professor Anderson (J.S.A.) and together they boosted the talent and capability of the Aberystwyth Chemistry Department to yet greater heights.

With the arrival of JSA, the EDCL now sported two top quality high resolution lattice imaging electron microscopes, one made by Philips and the other by siemens. One was equipped with EDAX, the energy dispersive analysis of X-rays, which allowed the chemical composition of that part of the crystal which was having its lattice imaged to be instantly analyzed and viewed simultaneously on a display monitor above the microscope.

Another member of staff, John Adams had brought an X-ray machine to the Department for use in X-ray crystallography. Here an X-ray diffraction pattern is produced by shining an X-ray beam over a large section of the crystal and the pattern recorded photographically. The diffraction pattern gives the distances between the atoms in the crystal, just by measuring their relative distances recorded as spots on the image. However, it is more complicated than that, because in a diffraction pattern a larger separation of the spots means the atoms are actually closer together in the lattice. It is not possible to focus X-rays to produce an image of the lattice from the diffraction pattern however, but using computers an averaged image over the relatively large section of the crystal being irradiated can be computer generated.

During this time a revolution was taking place in solid state chemistry, with the power and capability of very expensive high resolution electron microscopes vastly outperforming the traditional, relatively cheap, and stalwart of crystallography X-ray diffraction. **With newly available high resolution electron microscopes of the type used at Aberystwyth in the seventies, it was becoming possible to 'see' the lattice of a crystal directly for the first time** and not averaged out over a large section of the crystal, but over a width of some tens of angstroms and a resolution of around two angstroms. EDCL had both the equipment and the personnel to drive these advantages home and this turned EDCL into a world leading laboratory in the field of solid state chemistry.

8. The Sun, Cosmology, Fred Hoyle and the Steady State Theory.

Fred Hoyle **(1915-2001)** was an English astronomer from Yorkshire, who founded the Institute of Astronomy at Cambridge University and was also an honorary professor at Cardiff University from 1975, where the 'panspermia theory' that life on Earth is in part due to the transport of viable cells from space, has been developed by Professor Chandra Wickramasinghe. Micro-organisms have now been detected as high as forty-one kilometres up in the stratosphere. Hoyle developed the theory of the structure of star and made key advances in the understanding of how chemical elements in stars are formed by nuclear reactions.

In the 1950's Hoyle proposed the Steady-State theory as an alternative to the notion that the Universe began with a 'Big Bang' some 13.8 billion years ago. Infact, the term 'Big Bang' was coined by Hoyle as a snipe at the expanding universe theory. The battle between the two theories took place in the fifties and sixties, before the discovery of the cosmological background radiation in 1964, delivered Hoyle's theory a knockout punch. However, Hoyle's theory has not been dead but only dormant and new ideas are being developed which could offer an alternative explanation for the cosmic background radiation. One idea is that light of galactic origin, is absorbed by iron 'whiskers' produced by supernovae and then reemitted as microwaves.

The steady state theory hinges on the creation of matter between galaxies over time. As galaxies move apart new galaxies evolve to fill the space in between them. Just as a river flows, but the river remains the same, the universe could be considered to be expanding, but unchanging. A problem with this theory today is that the Hubble Telescope's deep field picture shows that the most distant and oldest galaxies are different to galaxies in our neighborhood.

Hoyle believed that solutions to major unsolved problems were best solved by exploring radical hypotheses, whilst at the same time showing due reference to well-attested scientific tools and methods. This was because if scientific breakthroughs were always orthodox in nature, they would already have been discovered. This view is shared by the staff of aias, and is the key to the development of objective and deterministic science. Hoyle frequently condemned the enormous social pressures that are brought to bear on scientists to conform and sneered at the modern practices of peer review conducted by journals, believing them to produce unconstructive conformism and to present a barrier to the development of novel theories. At aias this stagnation has been overcome by the use of the internet to publish ground breaking articles quickly to a wide readership, before publishing them as collected articles in book form.

In 1929 Edwin Hubble started work at the newly completed telescope at Mount Wilson in California. The telescope he was about to use was the world's most modern and biggest.

Many people have pondered the question, 'Are there any other universe apart from our own?' At the time the known universe was the Milky Way galaxy, which contained some nebulae which had a characteristic spiral shape and which were thought to be gas clouds within the Milky Way. In 1923, Edwin made his first great discovery. While looking at the spiral Andromeda nebula, known as M31 with the world's biggest telescope, he was able to see that the gas nebula was not made of gas, but was actually made of stars. Thus, the spiral nebulae that were already discovered at that time could infact, be regarded as other universes at a great distance from the Milky Way. Therefore these other universe became classified as galaxies and it became known that our Milky Way was only one of a great number of other galaxies, some of which like our own had a characteristic spiral shape.

Monday **Moon** **General Relativity.**

The sun exerts a gravitational force on all the planets in the solar system, but at the same time the planets exert their own gravitational force on the Sun. This planetary gravitational force causes the Sun to wobble as the planet orbit around it. The Sun wobbles around the point at the centre of mass of the solar system, which is called the barycentre. However, because the Sun contributes the vast majority of the mass to the solar system, the barycentre is located within the body of the Sun. This wobble has been detected around other stars, which leads us to believe many stars have planets around them. So far two hundred planets have been detected around other stars using this method.

The Moon and the Earth orbit around a centre of mass, which is much closer to the Earth, because the Earth is significantly more massive. This causes the Earth to wobble as the Moon orbits around it. The interaction of the gravitational fields of the Earth and the Moon can be described in Newtonian terms by stating:-

Gravity is a fundamental force in astronomy and cosmology.
All objects have gravity, so gravity is everywhere in space.
The gravity felt by two objects depends on:-

1. Their masses (the bigger the masses the bigger the force felt).
2. Their separation (the closer the objects the bigger the force felt).
3. The reduction in gravity with distance follows the inverse square law, so gravity reduces rapidly with distance. Doubling the distance gives only a quarter of the gravity.

$$\text{Gravitational force} = \frac{\text{G x Mass of Earth x Mass of Moon}}{\text{Distance between Earth and Moon squared}}$$

Before Galileo's time it was assumed that heavy objects fell to Earth faster than light objects. The Feather and Guinea experiment shows that this is not the case. The acceleration due to gravity is the same for light objects and heavy objects. Consider astronauts arriving and entering a space station orbiting the Earth. The density of the space station increases when the astronauts are inside the space station, but this does not affect the orbital speed or diameter of the orbit of the space station.

The bending of space as described by Einstein gives an alternative explanation to the elliptical path of the planets, which was formulated Newton after Kepler deduced his laws of planetary motion from observational data. Both Newton's and Einstein's explanations of planetary motion can closely predict the orbits of the planets, even though their theories are radically different.

General relativity tells us that massive bodies cause space and time to warp and this is what gives rise to Newton's force of gravity. Objects moving close to this warped space follow the best straight line they can, which becomes more curved when close to a massive body or when the body is more massive. The resulting curved path is what gives rise to orbital motion. The mass, volume or density of the moving object does not affect the diameter of the object's orbit around the massive body. It is only the objects speed through the curved space that determines the objects orbit.

Tuesday **Mars** **War of the Worlds: God Does Not Play Dice!**

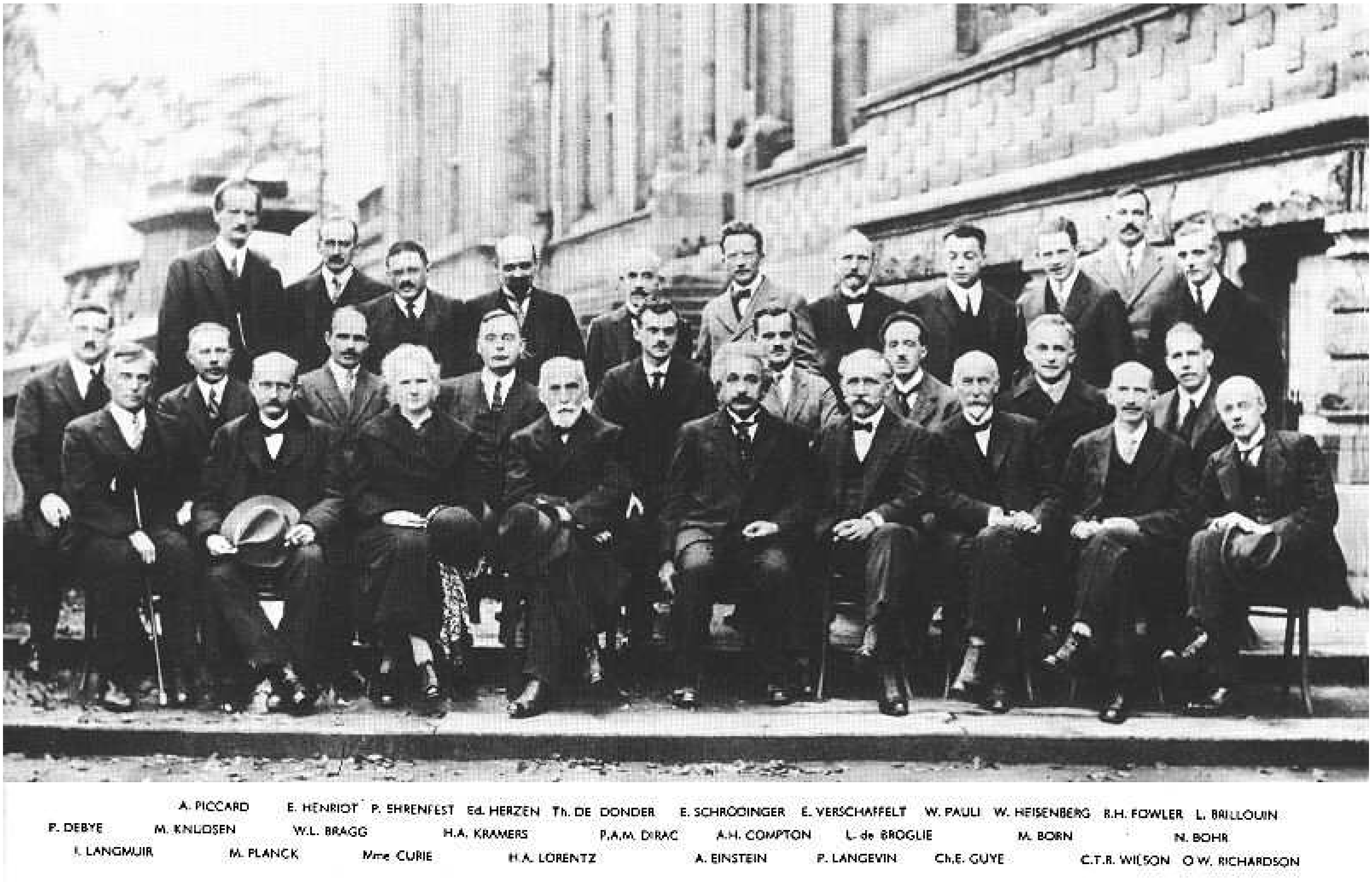
At its brightest, Mars is the fourth brightest celestial object in the sky and its famous reddish hue is clear to see. However, Mars's brightness (magnitude) varies greatly over a two year cycle with Mars spending much of the time looking like a fairly insignificant star. This is because Mars is much smaller than the Earth and its distance at closest approach (opposition) is dwarfed by its distance when it is on the far side of the Sun. Mars orbits the Sun in slightly less than two years in which time it does one complete circuit of the ecliptic. This means that Mars spends around two months in each of the constellations that make up the signs of the zodiac.

The American astronomer Percival Lowell was fascinated by Mars at the end of the nineteenth century and used his great wealth to establish an observatory in Flagstaff, Arizona. He produced detailed maps of Mars, which indicated that Mars had polar ice caps with canals from them to carry water to other parts of the planet. Lowell's belief that Mars had canals for irrigation inspired H. G. Wells to write his famous book 'The War of the Worlds'.

In 1927 in Brussels, Belgium, there started a 'War of the Words' in theoretical physics, when the greatest physicists of the time met to discuss differences of opinion in quantum theory at the Solvay Conference. Since Newton's time the world was thought to run like clockwork and the motion of particles could be determined by calculation (the deterministic point of view). However, a group of younger physicists had come to believe that on the atomic scale motions became blurred and uncertain and the motions of small particles could only be described by equations giving probability. Einstein could never believe the new implications of quantum physics and on many occasions would proclaim, "I cannot believe God plays dice'.

The causal and objective physics of Einstein, **Prince Louis de Broglie**, and **Erwin Schrödinger** came into conflict with the "uncertainty" of **Neils Bohr**, **Heisenberg** and **Pauli**. This became the 'War of the worlds' in theoretical physics, which has continued from the time of the Solvay Conference to this very day. The 1927 Heisenberg uncertainty principle, which upset Einstein so much, is today accepted by the scientific establishment, but a number of groups are now challenging its validity.

The 1927 Solvay Conference in Belgium was the Venue for 'The Clash of the Titans' in the World of Physics.



Back Row.

A. Piccard. E. Henriot. **P. Ehrenfest**. Ed. Herzen. Th. De. Donder **E. Schrödinger**. E. Verschaffelt. W. Pauli. **Werner Heisenberg**. R. H. Fowler. L. Brillouin

Middle Row.

Peter Debye. M. Knuosen. W. L. Bragg. H. A. Kramers. **Paul Dirac.** A. H. Compton. **Louis de Broglie.** M. Born. **Neils Bohr.**

Front Row.

I. Langmuir. **Max Planck.** Madame Curie.
Hendrik A. **Lorentz (Chairman). Albert Einstein.**
P. Langevin. Ch. E. Guye. C. T. R. Wilson. O. W. Richardson.

The Heisenberg Uncertainty Principle has been tested experimentally by Croca et al (J. R. Croca "Towards a Non-Linear Quantum Physics" (World Scientific, 2003)) using several different reproducible experiments. It was found experimentally, using microscopy for example that the Principle is in error by many orders of magnitude.

Myron Evans has addressed this theoretically with two papers, in volumes one and two, and used the concept of h bar / V, i.e. introduced the quantum of action or quantum of angular momentum density. General relativity has to do with densities of quantities.

Also work by Afshar and at Northeastern University was referenced in those papers (work reported in "Science" about 2004).

There is also work at Konstanz University which refutes the Heisenberg Principle experimentally.

Thus, at least four independent groups disagree with the uncertainty principle.

The 'uncertainty problem' can be illustrated by a number of elegant experiments which produce surprising and strange results. Perhaps, the most famous of these is the 'single photon Young's slits experiment'.

When a pair of narrow slits is opened close together, an interference pattern is produced when light is simultaneously sent through both slits. If the light is sent through the slits one photon at a time, there cannot be any interference because there is not a second photon present to interfere with. However, interference still occurs, suggesting the photons have some strange awareness of each other over time and distance.

This is one of the profound questions of wave particle dualism. Myron Evans addressed it with ECE theory in volume three; chapter ten, "Wave mechanics and ECE Theory" (paper 54 on www.aias.us). In ECE the wave and particle co-exist, being part of the same wave equation (pp. 167 ff. of volume three)

(d'Alembertian + kT) A sup a sub mu = 0 ------------ (1)

When the electromagnetic field is free of any other fields (notably but not exclusively the gravitational field) then:

kT = (mc / h bar) squared ------------ (2)

where m is the photon mass. So the photon mass m and the wave A sup a sub mu appear in the same equation (1). Evans goes on to discuss the two-slit experiment on pp. 168 ff. in analogy with the **Aharonov** Bohm effect and quantum entanglement. Evans states p169 (or it can be read at www.aias.us in paper 54). The basic explanation is that the "local" part of the photon (the "particulate" part) is described in shorthand notation by d ^ A and the "non-local" wave part by omega ^ A. The entity that passes through one aperture on the one photon level is always accompanied by omega ^ A, and thus by A, which is a wave. The mass is defined by equation (2) in terms of the T (essentially a mass density). So the ingredient missing from the standard model is the spin connection omega, which is also responsible for the Aharonov Bohm, Sagnac, Faraday disk and topological phase effects, and indeed all phases in electrodynamics.

In the standard model the photon is either a wave or a particle by the Bohr Heisenberg uncertainty. The latter has been shown experimentally to be incorrect by nine orders of magnitude (J. D. Croca, "Towards a Non-Linear Quantum Physics", World Scientific, 2003).

The uncertainty problem is discussed in more detail in volume three of:

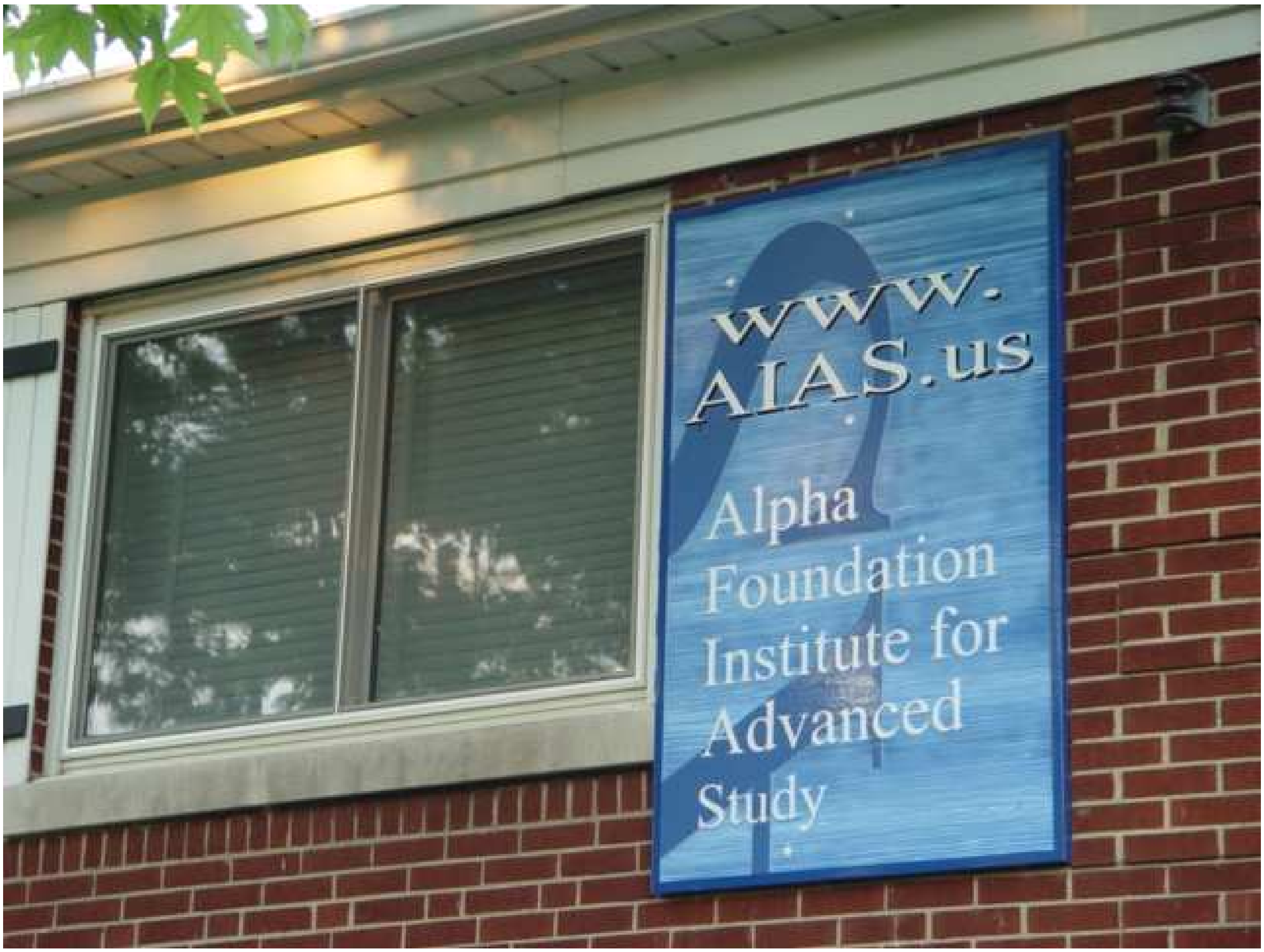
M. W. Evans, "Generally Covariant Unified Field Theory" (Abramis 2005 and 2006), available in paperback at 19.95 pounds or $36 US.

Einstein was really troubled by the uncertain and probabilistic aspects of quantum theory and endeavored to devise ‘thought’ experiments to prove the universe was deterministic after all. His last and most famous thought experiment is the **EPR** experiment. **AIAS Professor John Hart** (1924-2007) organized a week long conference in 1962 which attracted physicists from around the world to **Xavier University** to explore the **E**instein-**P**odolsky-**R**osen Effect and the theory of quantum mechanics. This International Quantum Mechanics Conference drew **Paul Dirac** and **Eugene Wigner** (both Nobel Prize winners), **Yakir Aharonov** and **Nathan Rosen**, who with **Boris Podolsky**, then a **Xavier physics professor**, and Albert Einstein had developed the theory that was shaking the world of physics.

The EPR experiment concerns the communication of a pair of quantum particles over time and distance. If the pair of particles must be in one of two opposite states when one is observed, then when the state of the first particle is observed the other would need, according to Neils Bohr, to instantly take on the opposite state. However, Einstein considered the situation where the two particles had been separated by a great distance. In this case when the first particle was observed and its state determined there would not be time for the other particle to instantly take on the other state because nothing can travel faster than the speed of light. The experiment has actually been carried out in Geneva in recent years using pairs of photons created by shining a laser through a non-linear crystal. After creation, each photon was then sent through two separate optic fiber networks in opposite directions. Experimenters claim this experiment shows Einstein is wrong, however if the photons are created as a pair of opposites, then why should it be a surprise if once the state of the first photon is observed the other is found instantly to have the opposite state?

Professor John Hart lived here, on the Xavier University campus.

The organizer of the 1962 EPR conference, Professor John B. Hart was Chair of Physics at Xavier University, Cincinnati, Ohio, USA where he taught for fifty years. He served in the pacific as an officer in the US Navy in the Second World War on destroyer escorts. He was an executive officer, communications officer and anti-submarine warfare officer and continued in the U.S. Naval Reserve for 26 years until his retirement as a lieutenant commander. As a reservist he taught navigation at reserve officer training schools in Rhode Island and California and was also commanding officer of the U.S. Naval Research Reserve Unit that met at Xavier and of the local Naval Reserve Training Center.



John Hart became a founding member and Professor of AIAS and was regarded as 'The Father of the House'. His home is on the Xavier campus, which proudly displays the AIAS logo on a large sign on the front of the building. Many of his students became leading figures in their own right in astrophysics, medicine and nano-technology. He was always enthusiastic in the pursuit of what he deemed to be the ultimate truth, and was a friend of **Paul Dirac** and **Eugene Wigner** among many others.

Eugene Paul Wigner (190-1995) was a Hungarian physicist and mathematician regarded as having an intellect similar to Einstein's. In 1921 while studying chemical engineering at the Technical University in Berlin, he attended colloquia of the German Physical Society where he came into contact with Planck, Pauli, Heisenberg and Einstein. In 1930 Wigner started working at Princeton and became an American citizen in 1936. While at Princeton, Wigner introduced his sister Manci to Paul Dirac, who were then married. Wigner supported Einstein in the need for the Manhattan Project and became director of research and development at Oak Ridge in 1946, before returning to Princeton
In 1963 E. P. Wigner was given the Nobel Prize for his great contributions to the theory of the atomic nucleus and elementary particles through his symmetry principles. Wigner's student John Bardeen became the only person to win two Nobel Prizes for physics. Bardeen won the 1956 prize for the transistor (with Shockley and Brattain), which was followed by the 1972 prize for the BCS theory of superconductivity.

The photograph above, taken at the 1962 Xavier conference organized by John Hart, shows Wigner drinking coffee in the background while his brother in law Paul Dirac (left) discusses the issues of the day with Boris Podolsky (right).

The photograph below shows Nathan Rosen and Xavier Professor Boris Podolsky collaborating with Paul Dirac at the 1962 conference at Xavier University

Nathan Rosen Paul Dirac Boris Podolsky

Podolsky and Rosen had been assistants to Einstein at Princeton, where together they had produced the famous 1935 paper entitled 'Can Quantum Mechanical Description of Physical Reality Be Considered Complete?' Published in Physical Review, the paper introduced the world to the 'EPR Paradox' that has been used ever since to put the 'Copenhagen School' on the defensive.

Nathan Rosen (1909-1995) was Einstein's assistant at Princeton's Institute for Advanced Studies, between 1935 and 1945.

The photograph below shows a collection of the great physicists who attended the Xavier conference, working in the Altar room. Yakir Aharonov working with David Bohm inferred the famous effect that Chambers found at Bristol.

Paul	Boris		Eugene	Yakir
Dirac	Podolsky	W. Furry	Wigner	Aharonov

In 1928, Paul Dirac (1902-1984) mathematically predicted the existence of the positron. The positron is an electron with positive instead negative charge, demonstrating that sub-atomic particles have opposites, which we now call antimatter. The existence of the positron was confirmed in 1932, when it was discovered in cosmic radiation. When antimatter and normal matter meet they annihilate each other with an incredibly large release of energy. This is believed to have happened shortly after the big bang. Gene Roddenberry the creator of Star Trek, used antimatter-matter annihilations as his energy source for the propulsion of the Starship Enterprise. Paul Dirac's prediction of antimatter has thus found its way into popular science fiction.

There is no explanation for matter antimatter annihilation in special relativity - it is an axiom of special relativistic quantum mechanics proposed by Dirac, the axiom is that antimatter exists, and that antimatter and matter cannot co-exist. In ECE theory (generally relativistic quantum mechanics) there is a more fundamental explanation for this axiom - whenever matter and antimatter are brought together, there is spin connection resonance energy which overwhelms the Coulomb law.

Antimatter is not only a thing of science fiction, since it can be manufactured and put to good use. It has found a medical application for many years in positron emission tomography (PET). When matter and antimatter particles collide, they annihilate each other producing gamma rays. These gamma rays can be used to look inside the body, without the need for invasive surgery. Particle accelerators make the radioactive substances that emit the positrons needed for the PET scanning and these are injected into the patient. Gamma rays are produced when positrons, emitted from the injected radioactive isotope, annihilate a nearby electron. The gamma rays are detected by a rotating scanner and converted into electrical signals to produce an image. The scanning process is repeated to give a series of thin images of the body, which can be combined to give a 3D image.

In 1928, Paul Dirac formulated the Dirac equation, which describes the behavior of electrons moving at speeds close to the speed of light and linked quantum theory to relativity. Einstein thought of the Dirac equation as the most perfectly logical expression of quantum mechanics because of its natural incorporation of spin and special relativity into wave mechanics.

In 2003, the Dirac equation was derived from the ECE wave equation. The equations of quantum mechanics and general relativity were then unified, through the use of the tetrad postulate of Cartan geometry, leading to the ECE Lemma and wave equation.

The derivation of the Dirac equation from the ECE equation leads naturally to the Dirac matrices and Dirac algebra via the d'Alembertian operator. The latter comes from the tetrad postulate of geometry, so Dirac is understood geometrically using general relativity. Dirac's great achievements include his equation of special relativistic quantum mechanics, the Dirac sea vacuum, the antiparticle, and quantum electrodynamics. There is also the Dirac phase concept which Myron Evans generalized using ECE theory in volume one.

Dirac received the Nobel Prize, and Order of Merit, (O.M.), and was elected F.R.S. There is also a memorial of him in Westminster Abbey. He has been described as "the purest soul in physics", being quiet by nature and deeply scholarly.

Antimatter was proposed by Dirac to avoid the cascade to infinite negative energy. The vacuum was proposed to be the Dirac Sea, filled with paired off negative energy electrons. A gap in this pairing would produce a positively charged electron, the positron (proposed by Weyl, Dirac initially thought it might be a proton but Weyl pointed out that it to have equal mass to the electron). The positron is produced from the electron by the charge conjugation operator, C. It was proposed that matter and anti-matter annihilate each other to produce energy; an example being that an electron annihilating a positron to produce two photons.

However, the observable universe is matter, and anti-matter is observed only fleetingly. There is no explanation for this in the standard model, i.e. why the universe and anti-universe do not annihilate. This is because the original matter antimatter axiom was not based on anything except the need to remove negative energy. In ECE theory there is an explanation for matter antimatter asymmetry in that spin connection resonance is not normally operative. Nearly everything we observe in the universe of matter is never in spin connection resonance (SCR). Similarly nearly everything in the antiuniverse is off resonance. So the two universes do not mutually annihilate. This is not just a shift in axiom; it is based on the geometrical principles of general relativity. When we are in SCR we obtain energy from spacetime as in paper 61. So bringing together a particle and antiparticle results in spin connection resonance, generating energy. So SCR plays a central role in particle physics of all kinds. This is general relativity as proposed by Einstein, but developed for all particles and fields in ECE theory.

The ratio of the velocity of an object in air to the speed of sound is called its Mach number. The Mach number is named after Ernst Mach (1838-1916) an Austrian physicist and philosopher born in the Czech Republic. His work on the Doppler Effect and acoustics earned Mach a chair at Charles University in Prague in1867. Mach’s principle, stating that the inertial forces experienced by a body in nonuniform motion are determined by the quantity and distribution of matter in the universe, influenced Einstein thinking when developing his theory of general relativity.

Mach had also contemplated the behavior of light and the ether, providing a background for Einstein to consider when formulating his special theory of relativity. Einstein himself later worked at Charles University for one year, after leaving Zurich, Switzerland and before moving to take up a professorship in Berlin. Developments in ECE theory are regularly followed by students in Prague. Karel Jelinek, of Charles University is working on an experiment in radiation induced fermion resonance (RFR), which through ECE theory could produce a revolutionary breakthrough in instrumental chemical analysis.

If and when fully developed RFR would be of use in analytical labs and medical labs of all kinds, including forensic laboratories. Paper 84 has developed the chemical shift theory of RFR - which for analytical labs is its most important feature.

For pure physics the important feature is the existence of the resonance line, which is due to the B(3) spin field in ECE physics. This is therefore a feature of general relativity. Detecting the RFR resonance line is in fact the easiest way of detecting the inverse Faraday Effect (IFE), and the method can be extended to other optical effects such as inverse magnetochiral birefringence. The latter is a much smaller effect than the IFE and was first detected by the Wagniere group in the University of Zurich.

Non-linear optics is now a very highly developed subject area, and there are many possibilities. Crowell and Evans have shown there are effects of quantum electrodynamics (QED) in RFR. The theory given in paper 84 is at the semi-classical level designed to show the existence of the RFR chemical shift. Magnetless MRI may be developed by using an inhomogeneous CPRF beam instead of an inhomogeneous magnet. Here, a magnetless Stern Gerlach experiment is required as the first step. An inhomogeneous CPRF beam should separate an electron beam into left and and right half integral spins.

In the ESR and NMR of complicated molecules the spectrum is frequently not completely resolved because the chemically shifted lines are too close to each other. The fine and hyperfine structure overlap. In RFR the main chemically shifted lines can be spaced much further apart than in ESR and NMR, so the fine and hyperfine structure can be full resolved without overlapping. There are many advanced electronic and computational techniques already available which can help in the development of RFR and FT RFR (Fourier transform RFR).

In the Prague experiment, one line is being sought for the basic unshielded electron resonance line in an electron beam. RFR can be thought of as the resonance equivalent of IFE (magnetization by a circularly polarized electromagnetic field). ESR and NMR are the resonance equivalents of magnetization by a permanent magnet. In both cases resonance occurs between the spin states of the Pauli matrix.

Chemical shift is the main spectral feature of RFR, as in ESR and NMR. The fine and hyperfine detail are also present and due to various spin-spin interactions. Tom Kennedy and his group at NRL have demonstrated high resolution in a hybrid technique where a circularly polarized laser is used to align spins (see references in the book by Crowell and Evans on the Omnia Opera of www.aias.us). RFR would take this a step further and dispense with magnets entirely, while also giving a much higher resolution. The entirely new feature of RFR is that the resonance lines can be understood on the classical level using the Pauli matrix in the pump beam Hamiltonian:

H = - i (e squared / (2m)) sigma dot A x A*

A photon is absorbed from the probe beam and resonance occurs between the states of sigma. The chemical shift Hamiltonian is:

H (shift) = - i (e squared / (2m) sigma dot (A + A sub N) x (A* + A sub N)

Where, A sub N, is due to dipole-dipole interaction as found in chemical shift theory in ESR or NMR. Here A is complex valued (e.e. plane wave) while A sub N is real valued. These Hamiltonians are the result of the minimal prescription:

p goes to p + A + A sub N

and Clifford algebra, given in full detail in paper 83. The A sub N is site specific, i.e. different for each nucleus as in the ethanol and propanol examples given in previous notes. In ethanol there are three chemically shifted lines and in propanol four.

In the electron beam there is one resonance line, which is not chemically shifted and which is not split. RFR can be used for all materials: gases, liquids, liquid crystals, polymers, amorphous gels, colloids, semiconductors, superconductors, metals and plasma. In each case RFR may be used for electron spins or for proton spins. The main electron resonance line must first be found in an electron beam, and then the main proton resonance line must be found in a proton beam. If hydrogen is then used in the third experiment, with one proton and one electron, there is to be expected a chemically shifted electron resonance line split by electron proton coupling, and also a chemically shifted proton resonance line split by electron proton coupling.

In ethanol for example there are three main chemically shifted lines, because there are three types of H atoms, three on the CH3 part, two on the CH2 part, and one in the OH part of the C2H5OH molecule. So the intensity ratio is 3:2:1. Ethanol is:

H3C - CH2OH

Propanol is

H3C - CH2 - CH2OH

and there are four lines, in the ratio 3 : 2: 2 : 1.

In RFR these lines can be resolved a long way apart, and fine and hyperfine detail picked up easily. In conventional NMR the only way to do this is to make a very strong magnet that has to be very homogeneous and cooled down to liquid nitrogen or liquid helium. This is increasingly expensive. In RFR, magnets are dispensed with completely and replaced by a radio frequency pump beam which is circularly polarized.

In the original Stern Gerlach experiment a beam of silver ions was used, silver having one valence electron. The beam was separated into spin up and spin down components by an inhomogeneous magnetic field, thus proving the existence of electron spin. MRI is a development of this experiment using inhomogeneous magnets. Magnetless MRI can be developed by using an inhomogeneous CPRF beam (ICPRF beam). It is better to use a modern electron beam generator than a beam of silver ions. The ICPRF beam separates the electron beam into spin up and spin down components. For spin up:

Energy = (eA(r)) squared / (2m)

for spin down:

Energy = -(eA(r) squared / (2m)

and there are forces in opposite directions due to the inhomogeneity of the pump beam. These forces move the spin up and spin down electrons in opposite directions. Magnetless MRI uses this property along with RFR chemical shifts and splittings. Here A(r) denotes the fact that A depends on r, i.e. is inhomogeneous. One way of making such an ICPRF beam is to focus it as it mixes with the electron beam. Such a magnetless MRI device would lead to a multi billion dollar industry as would magnetless NMR, and to a lesser extent, magnetless ESR.

It is well known that Japan, Taiwan and South Korea are quick at developing new ideas into products, as are the USA, Canada and some parts of the European Union. In this case the end product would be a portable and magnetless MRI unit which could be used to scan patients for tumors etc. Magnetless ESR and NMR would be used all over the world in analytical laboratories.

Wednesday **Mercury** **Perihelion Advance, Vulcan And Double Pulsars.**

Mercury is never far from the Sun and so can never be seen against a darkened sky, except at time of total eclipse of the sun. It is thus confined to the twilight zone that surrounds the Sun. The Romans saw Mercury as a god of trade as can be seen with its similarity to the word ‘merchant’.

Planets orbit the Sun in elliptical orbits and the time taken to complete one orbit is one year for that planet. The nearest point to the Sun in a planets orbit is called the perihelion. The perihelion of a planet can slowly rotate over a long time due to the gravitational effects of other nearby planets in an effect called precession. After taking into account the influence of other planets on the precession of Mercury, Mercury still shows a perihelion advance of 43 arc seconds per century.

General relativity tells us that massive bodies cause space and time to warp and this is what gives rise to Newton’s force of gravity. Objects moving close to this warped space follow the best straight line they can, which becomes more curved when close to a massive body or when the body is more massive. The resulting curved path is what gives rise to orbital motion. The mass, volume or density of the moving object does not affect the diameter of the object’s orbit around the massive body. It is only the objects speed through the curved space that determines the objects orbit.

In general relativity the attraction between the two bodies does not actually exist. Instead a property of massive objects is that they distort space and cause it to curve. The orbit is then caused by the object trying to continue in a straight line, but that line has become curved due to the warping of space-time. When Mercury is closer to the Sun in its orbit time slows down slightly and space becomes more curved. This causes a delay in Mercury passing through this part of its orbit (perihelion), which causes the perihelion to shift or precess. This effect was a test between Einstein's and Newton's theories and speeded the acceptance of Einstein's genius.

The bending of space as described by Einstein gives an alternative explanation to the elliptical path of the planets, which was formulated Newton after Kepler deduced his laws of planetary motion from observational data. Both Newton's and Einstein's explanations of planetary motion can closely predict the orbits of the planets, even though their theories are radically different. However, with Mercury the perihelion advance in its orbit after the perturbing effects of other planets was taken into effect, could only be explained in terms of Einstein's theory of relativity. Mercury is closest planet, so experiences the greatest gravitational effects from the Sun. This results in the slowing down of time and the curvature of space working together to cause Mercury to be thirty miles away from its position at perihelion after each orbit compared to that predicted by Newton.

In 1859 the French mathematician Urbain Le Verrier suggested that the perihelion advance discrepancy was due to the gravitational effect of an undiscovered planet nearer to the Sun than Mercury. Verrier had just discovered Neptune by using calculus to determine where the planet that was perturbing Uranus's orbit would be found. He is credited with this discovery along with John Coach Adams, both of whom worked independently along similar lines. Verrier called this as yet undiscovered planet Vulcan, after the God of fire and volcanoes. However, the planet Vulcan did not exist, even though a number of astronomers claimed to have observed it. The perihelion advance of Mercury subsequently provided more proof that Einstein's theories of relativity could supplant the Newtonian view of gravitation.

The perihelion advance of Mercury is small and difficult to measure, because the gravity of the Sun is not that great in cosmic terms. However, there are much more massive and dense objects elsewhere in the galaxy that have a much greater power to curve space. In 1974 Joseph Taylor from the University of Massachusetts discovered the pulsar 1913 + 16 while using the Arecibo radio telescope. This pulsar was found to have a dense companion which could be a neutron star. These two objects form a binary pair in mutual orbit. The pulsar in this pair shows a perihelion advance of four degrees a year. The discovery of this first binary pair of neutron stars led to the award of the Nobel Prize in 1993.

The first double pulsar system was discovered a couple of years ago and is regularly observed by Jodrell Bank and other great radio telescopes. The discovery of the first double pulsar system recently is very useful for testing general relativity and gravitational waves. The two neutron stars in this system are less than the diameter of our sun apart and will merge in the future.

Thursday **Jupiter** **The Speed of Light, Special Relativity and Warp Drive.**

Jupiter (or Zeus) in mythology is the King of the Gods. Jupiter is the biggest planet in the solar system and is five astronomical units from the Sun. This means when Jupiter is at its closest to the Earth (at opposition) it is four astronomical units away and six astronomical units away, when it is on the opposite side of the Sun. Jupiter takes twelve years to orbit the Sun, so moves into a different sign of the zodiac each year.

Jupiter was one of the first objects to be observed by Galileo once he had made a telescope. When Jupiter is observed in a telescope it is seen as a disc like object against a background of point like stars. The disc is evidence that Jupiter is a planet and not a star. In January 1610 when Galileo first observed Jupiter, he noticed that Jupiter was accompanied by four star-like objects which could be seen to move from one side of Jupiter to the other and back over a period of days. It became obvious to Galileo that these star like objects were actually in orbit around Jupiter. He had discovered the four giant (Galilean) moons of Jupiter. The orbit of the Galilean moons around Jupiter is easy to observe through a telescope and can even be clearly seen with binoculars.

Galileo quickly published his findings in a book called ‘The Starry Messenger’, which quickly sold out. At the time the conventional wisdom was that the Earth was at the centre of the universe and all celestial objects revolved around it (The Geocentric Model). Copernicus had already given the world the heliocentric theory that it was the Sun, not the Earth at the centre of the universe with all the planets including the Earth in orbit around it. Galileo’s observations supported the heliocentric model, which did not go down well with the pope and the leaders of the Catholic Church in Italy. In time and under threat of torture, Galileo had to throw his support around the geocentric model of the solar system. Galileo was not allowed to leave his house for the last ten years of his life, because the pope considered his views on the solar system to be a threat to the stability of the church. In fact, Galileo was not declared innocent of heresy by the Vatican until 1992.

The four Galilean moons are amongst the biggest moons in the solar system, with Ganymede and Callisto being bigger than the planet Mercury. They are Io, Europa, Ganymede, and Callisto. Io is the most volcanically active world in the solar system, due to the strong tidal forces caused by Jupiter's gravity. Europa is an ice covered water world, which also experiences strong tidal effects from Jupiter. The effects are smaller though, because Europa is further out from Jupiter than Io. The effects of Jupiter's gravity are believed to be enough to provide an energy source for Europa, which may have promoted conditions that could have spawned life. Ganymede and Callisto are both giant moons, with Ganymede being the biggest moon in the solar system. As the moons orbit Jupiter they can be seen to transit (pass in front of the planet) and to be occulted (pass behind the planet). The moons can also be eclipsed when they pass into Jupiter's shadow.

In 1637 Galileo proposed a method to measure the speed of light by covering and uncovering lamps separated by a distance with an assistant measuring the time intervals. In 1667 the Academia del Cimento in Florence, carried out the experiment and were able to state that light traveled extremely quickly and at least ten times faster than the speed of sound. For Galileo's experiment to obtain a value for the speed of light, a vast distance between the timed uncovering and the observer was needed. Within eight years this became possible by using Jupiter's moons coming out of eclipse, as the source of the uncovered light.

In 1675, the Dutch astronomer Ole Roemer noticed that the times of the eclipses of Jupiter's moons, were affected by the position of the Earth in its orbit around the Sun in relation to Jupiter. When Jupiter was at opposition, at its closest approach to the Earth, the position of the satellites was ahead of the predicted times. This showed that the time taken for light to cross the Earth's orbit could be determined by the variations in the eclipses of Jupiter's moons, due to the Earth's position. The timings work best with the moon Io, because it is one of the smaller Galilean moons and being the nearest to Jupiter is the fastest to emerge from eclipse. The time and distance could then be used to calculate the speed of light. Using the accepted diameter of the Earth's orbit of the time, the speed of light was calculated as 200, 000 km/s.

In 1849 the French physicist Hippolyte Louis Fizeau used a rapidly rotating toothed wheel to reduce the need for vast distances to be used for speed of light experiments. Light was shone through the teeth of a first wheel, through a second wheel five miles away and reflected back along its path through the same gap. With the toothed wheels rotating at hundreds of times a second, time intervals of fractions of a second could be measured. This method gave a better value for the speed of light as 313, 300 km/s. In 1926 Leon Foucault's improved method using rotating mirrors, achieved a figure of 299, 796 km/s for the speed of light.

In the second half of the nineteenth century, the full importance of the speed of light to physics, astronomy and cosmology was starting to be appreciated. Maxwell's equations asserted that the speed of light could not be exceeded and light would always move away from an observer at the speed of light, no matter how fast the observer was moving. Oliver Heaviside's experiments with electricity were also throwing up important results.

In 1887 **Albert Abraham Michelson** (1852-1931) and **Edward Morley** (1838-1923), carried out the famous Michelson-Morley experiment. An observer on Earth travels at 30 km per second in the direction of the Earth's orbit and Michelson and Morley designed an experiment to measure the effect on the speed of light. They expected to find light traveled faster when assisted by the Earth and slower in the opposite direction, but were perplexed to find the speed of the observer and apparatus had no effect.

In 1892 **George Fitzgerald** (1851-1901) working at Trinity College, Dublin explained the results of the Michelson-Morley experiment by suggesting that as objects approached the speed of light, their length in the direction of motion would become progressively shorter and this could account for the constancy of the speed of light seen by a moving observer. Heaviside's new equations and experiments helped Fitzgerald come to this conclusion.

Fitzgerald's qualitative hypothesis was adopted almost immediately by **Hendrik Lorentz** (1853-1928) who set about making it mathematically precise. In 1904, Hendrik Lorentz produced the Lorentz transform which could quantify the contraction of length at high speeds. **Jules Poincaré** (1854-1912) the great French mathematician and physicist was able to see the importance of Lorentz transformations to the synchronization of time and relativity. The scene was set for Einstein to formulate his theory of special relativity, which he did in 1905.

1905 is known as Einstein's miraculous year. In 1905 Albert Einstein, while working at the patent office in Bern, Switzerland, published ground breaking papers on **Brownian motion**, the **photoelectric effect**, **special relativity** and the famous equation **E= MC2**.

Robert Brown (1773-1858) was the Scottish botanist on the Matthew Flinders Expedition (1801-1803) to New Holland (now called Western Australia) aboard the Investigator, where he discovered several thousand new plant species. Interestingly, Brown also discovered and named the nucleus found in cells. Brown noticed that tiny particles, such as pollen grains in water or dust in air lit up in a beam of light, are in random motion even though the air or the water appears still. This random motion is called **Brownian motion**. Robert Brown's contributions to botany and cell biology, together with his discovery of Brownian motion, led to his appointment to the Civil List.

Brown was not able to explain Brownian motion, but in 1905 Einstein was. Einstein stated that the random motion of tiny pollen grains is due to collisions with even smaller fast moving water particles. Einstein derived Avogadro's number from a diffusion experiment enabling him to calculate the approximate sizes of atoms and molecules and thereby providing important proof for their existence and derived Avogadro's number

Myron Evans worked on Brownian motion at Aberystwyth and Oxford and this led to two separate awards from the Royal Society of Chemistry in the same year. These were the Harrison Memorial Prize and Meldola Medal and were awarded for an extension of the Brownian motion theory called Mori theory (See the early papers of Evan's Omnia Opera and the monograph "Molecular Dynamics" which is available on www.aias.us). Myron Evans has worked on Brownian motion with Gareth Evans, Bill Coffey and Paolo Grigolini. The overview description in Evan's Omnia Opera also gives an account of this work, and one or two of Evan's "top ten papers" is on the subject. Evans and his colleagues worked on the Smoluchowski, Fokker Planck and Kramer's equations, and also on the Euler Langevin equation. Mori theory extends the friction coefficient of the Langevin equation into a memory function and continued fraction. Evans and his team tested this with far infra red data obtained at Aberystwyth. Later this work developed into the Pisa Algorithm (see Omnia Opera). Evans used a combination of simulation, theory and data. The "collection of positive opinion" on www.aias.us shows this work had great impact, for example the letter from Max Maglashan of University College London, of which Evans was Ramsay Memorial Fellow (1974 to 1976) based at Aberystwyth.

Einstein's 1905 paper on the **photoelectric effect** had relevance to the first paper on quantum theory by the great German physicist Max Planck.

Prior to 1900 it was believed light energy could only be emitted in a continuous wave. In 1900 **Max Planck** (1858-1947) conceived the formula E= hf, which states energy equals the frequency of the emitted light times a constant h (named after Planck, as Planck's constant). The intriguing thing about this formula was that it only worked with integer values, which implied that the emitted light was not continuous, but released in packets of energy now known as photons of light. Planck's revolutionary 1900 paper was entitled, 'On the Theory of the Law of Energy Distribution in the Continuous Spectrum'. This paper suggested that light should now be seen as having a wave particle duality.

Einstein's 1905 paper, **'On a Heuristic Viewpoint Concerning the Production and Transformation of Light'**, concerning the photoelectric effect was to reinforce Planck's view that light was both a wave and particle in nature. The photoelectric effect concerns the emission of electrons by a metal sheet when light strikes it. The emission of electrons can only occur if the frequency of the incident light is above a threshold value, which is specific to each metal. Einstein asserted that light is composed of particles of light called quanta or photons whose energy is given by the frequency of the light. As the frequency of light increases, so does the energy carried by individual photons. Individual photons colliding with individual electrons can knock the electrons out of the metal surface, but only if the photon can provide the electron with a minimum amount of energy (the work function) to overcome the electrostatic disruption of the metal's surface. Thus, the energy of emitted electrons was dependent on the frequency of the incident light, but not its intensity. Therefore high intensity, low frequency light beams could not cause 'photoelectrons' to be emitted, but low intensity, high frequency could!

Einstein's paper on the photoelectric effect paved the way for the introduction of the photon to the motion of light. A photon of light is a packet or particle of light, traveling at the speed of light and carrying a quantity of energy governed by its frequency. The energy of a photon is its frequency multiplied by Planck's constant. Einstein's 1905 paper on the photoelectric effect provided proof for Planck's exotic quantum theory. Quantum theory is considered as one of the greatest theories of the twentieth century and gave Planck the 1918 and Einstein the 1922 Nobel Prize for Physics.

Max Planck and Einstein met at Planck's home many times. Planck was also visited socially at home by many famous scientists, including Otto Hahn and Lise Meitner. The work of Einstein and Meitner influenced the creation of the atomic bomb in World War 2. Heisenberg (another great proponent of quantum theory) also worked on the atomic bomb and atomic energy during the war having failed to leave Germany, as many great physicists had done. Infact, at the outbreak of War Heisenberg had been arrested and interrogated by the Gestapo and was only released because he was already so famous. Both World Wars were to cost Planck a son. In 1914, his oldest son Karl was killed in action at Verdun and in 1945 his youngest son was executed for his part in the failed 1944 attempt to assassinate Hitler.

Einstein's paper on **special relativity** was published in the German Journal, 'Annalen der Physik' and was entitled, **'On the Electrodynamics of Moving Bodies'**. Max Planck was the editor of the Journal, who had the foresight to sanction the publication of Einstein's historic paper.

Einstein's theory of special relativity states firstly, that all laws of science are the same in all frames of reference. Secondly it states that the speed of light in a vacuum is constant and independent of the speed of the observer. Special relativity also asserts that, the mass of an object increases as its speed increases and becomes infinite at the speed of light, so that nothing can move faster the speed of light in a vacuum.

The distance between stars is so great that if man is to undertake interstellar travel, even at high speeds, then it would take many lifetimes to explore our galactic neighborhood. In science fiction warp drive is brought into play to allow our heroes to reach alien worlds and races by traveling faster than the speed of light. Warp factor one would then correspond to the ship reaching the speed of light, which would allow the astronauts to reach the nearest star in 4.3 years. However there is very little evidence that warp drive will ever be possible.

Einstein's theory of special relativity is concerned with high speed travel, especially speeds close to the speed of light. As speeds get closer to the speed of light there are two important effects which are important to our interstellar travelers. Firstly, at speeds close to the speed of light our astronauts would find that time slows down for them compared with the Earth they left behind. Secondly, distance in the direction they are traveling would be reduced and at the speed of light this distance would decrease to zero. Thus, it would theoretically be possible to reach any point in the galaxy in less than a human lifetime without the need to travel at faster than light, fictional warp speeds.

There are problems for astronauts traveling at speeds close to that of light. Since time slows down for them relative to the Earth, their high speed motion acts as a time machine propelling them onto the future. The faster they go and the longer they travel, the further they are propelled into the future. This is a one way trip. When they return to Earth millions of years may have passed even though they are not much older themselves. It will be impossible to return back to their own time, because high speed travel only allows astronauts to move forward in time at a slower rate of ageing.

The ability to move forward in time would however have medical uses. In America people are known to have their bodies cryogenically frozen in the hope that medical advances will enable them to live again. With the ability to move forward in time, this cryogenic freezing would be unnecessary. If someone was waiting for a medical cure to be developed he could take a journey on a fast moving spacecraft and return to the Earth at a time in the future when the needed medical breakthrough was likely to have occurred. This possibility could encourage some of the world's richest people to fund the development of suitably fast space vehicles.

Saturday. **Saturn.** Electromagnetism and the Civil List Scientists.

Saturn was the furthest known planet until the invention of the telescope. It is in orbit ten astronomical units from the Sun. This means that at opposition when it is at its closest approach (at its highest at midnight), it will be nine AU from the Earth and when on the far side of the Sun it will be eleven AU away from the Earth. This means that Saturn's brightness and apparent size, varies less at different times of the year, than the other planets which were known in ancient times. Saturn takes thirty years to orbit the Sun spending around two and a half years in each of the twelve signs of the zodiac.

When Galileo pointed his telescope at Saturn in 1610 he could tell there was something strange about it, but was not quite able to tell that Saturn was surrounded by a ring. In 1659 the Dutch astronomer Christiaan Huygens identified the ring around Saturn and was able to state that the apparent size of the ring depended on its angle to the Earth. The Cassini division is the name given to the gap in the rings discovered by G. D. Cassini in 1675. Thus the probe that visited Saturn recently was called Cassini-Huygens. The mother ship Cassini went into orbit around Saturn and the Lander descended onto the surface of Saturn's largest moon Titan, which has the thickest atmosphere of any Moon in the Solar System.

William Herschel discovered Uranus in 1781 from his garden in Bath using a telescope he had made himself. For this discovery he was put on the civil list. Other objects were candidates for being new planets. When a star the size of our Sun dies, it loses its outer layers to form a planetary nebula with a white dwarf in the middle. In low resolution telescopes, some planetary nebulae display a planet like disc. This is why William Herschel coined the tem 'planetary nebula'. Eventually spectroscopic analysis was able to show their true nature. In 1802 Herschel also coined the term 'asteroid' for large space rocks. The word asteroid means 'star like' in Greek.

William Herschel made numerous contributions to astronomy and made the world's biggest and best telescopes. He looked at the 'proper motion' of nearby stars and was able to conclude that the Solar System is moving towards the constellation of Hercules. He also developed theories concerning stellar evolution, which inspired Darwin to form his famous theory on the evolution of living things.

Darwin was not the only scientist to come up with the theory of evolution. **Alfred Russell Wallace** (1823-1913), O.M., F.R.S. was born in Usk in Wales. He independently formulated the theory of natural selection. Charles Darwin had already written his book, 'On the Origin of Species by Natural Selection', but feared publishing knowing that it would lead to heated debate and controversy. However, when Wallace sent him a copy of his similar book (which was ready for publication), Darwin decided to publish his own book as well. Wallace was not forgotten however and was honored with a Civil List pension in 1881 following nominations by Darwin and Huxley.

William Herschel's son John was also a great astronomer and scientist. John did pioneering work in photography and went on to coin the terms 'photograph' and 'positive' and 'negative' images. Photography when applied to astronomy opened the way for artistic and inspiring images and gave a means of increasing the power and usefulness of telescopes.

The movement of Uranus indicated that there must be another planet further out. **John Couch Adams** the English mathematician was able to predict the position of this unknown planet, which was subsequently discovered in 1846. For this achievement John Couch Adams was placed on the civil list. The success of discovering Neptune by calculation, led to the establishment of a mathematics prize at St John's College, Cambridge. The topic for the 1857 prize was 'the motion of Saturn's rings'.

James Clerk Maxwell (1831-79) won the prize by showing Saturn's rings could not be solid, because they would not be stable. Maxwell predicted the rings were likely to be made of a myriad of boulder-sized particles individually orbiting Saturn arranged in a series of narrow rings. Maxwell was soon to apply his mathematical genius to unify the fields of electricity, light and magnetism by building on the work of great experimenters of the first half of the nineteenth century.

The invention of batteries at the dawn of the nineteenth century gave scientists a new tool they could use to investigate nature, which led to new subject areas in physics, chemistry and technology. However, there is evidence that batteries were in reality invented and in use over two thousand years ago in Persia. In 1938 the German archaeologist Wilhelm Konig (in what sounds like a plot from Indiana Jones), unearthed a five inch long clay jar near Baghdad, which contained a copper cylinder encasing an iron rod. The object can be shown to work as a battery and may have been used for electroplating, although its purpose is not actually known for sure. This intriguing object is now kept in the Baghdad museum.

By 1800 Alessandro Volta had invented a battery from silver and zinc dipped in a salt solution. Thus experiments could start on discovering the nature and applications of electric currents. Sir Humphry Davy (1778-1829) from Cornwall used giant batteries to pioneer experiments into electrolysis. Between 1807 and 1808, Davy used electrolysis to isolate sodium, potassium, barium, calcium, magnesium and strontium for the first time and became the father of electrochemistry.

Davy became very famous for his scientific experiments and started to give lectures to the public. In 1812 **Michael Faraday** (1791-1867) was lucky enough to obtain tickets for the last four of Davy’s public lectures, and subsequently persuaded Davy to take him on as a laboratory assistant. In October 1813, Davy and his wife were given passports (amazingly enough) by Napoleon to tour the continent for scientific purposes and did so with Faraday. The scientific duo visited a number of leading scientists in France and Italy and ground breaking experiments were carried out before they returned home in April 1815. On their return Faraday worked as a chemical assistant at the Royal Institution until 1821.

In 1820, Hans Christian Ørsted’s discovery that electric currents affected compasses facilitated research into electromagnetism. Hans Christian Ørsted also wrote poetry and as such was one of the first people to appreciate and encourage the great Hans Christian Anderson with his endeavors.

The fact that electricity could cause a compass needle (a magnet) to move, allowed Michael Faraday to realize that the energy change, electrical to movement was possible, which is the principle of the electric motor. Faraday came to believe that as electricity flowed through a wire, invisible magnetic waves were created which moved forward helically around the wire in the same direction of flow as the electric current. These invisible magnetic lines of force could be revealed by sending a current through a vertical wire, which was embedded in a horizontal piece of thin wood covered in iron filings. When tapped the filings produced a pattern of concentric circles showing the position of the field. By then surrounding the wire by small ‘plotting’ compasses, the direction of the lines of force around the wire could be seen. It could also been shown that reversing the direction of the current through the wire caused the direction of the compasses and magnetic lines of force also to be reversed. In 1821 Faraday was able to publish his design for the world’s first electric motor.

Faraday had shown with the electric motor electrical energy could be converted into movement energy. **James Joule** (1818-1889) was actively experimenting with energy changes. Joule started in1840 by looking how heat was produced when a current flowed through a resistor and was able to formulate Joule's Law. In the same year Joule establishing the principle of the conservation of energy and went on to formulate the first law of thermodynamics. Surprisingly, Joule was only a hobby scientist and did not go to university because he was busy working at his rich father's brewery. The brewing trade however made him very astute at making accurate measurements which he was able to apply to his experiments with heat. His father was so impressed by James's great interest in heat that he built him his own laboratory near the brewery. His efforts did not go unnoticed and he was duly placed on the civil list.

Having paved the way for the construction of electric motors, Faraday went on in 1831, to discover the principles of electromagnetic induction. The motor is a device that changes electrical energy into movement. Electrical generators on the other hand change movement energy into electricity. A motor can be made to produce movement or electricity depending on how it is used. If a small motor is connected to a battery, it can be made to turn a propeller. If on the other hand, it is connected to an ammeter, it can be made to produce electricity by causing the propeller to turn by blowing air at it from a hair drier. Thus spinning a magnet inside a coil of wire can induce electricity in a coil and sending electricity into the same coil of wire can cause the magnet to spin.

Furthermore, if two coils of wire are wound around a common soft iron core, a magnetic field in the first coil can induce a magnetic field in the second coil. So, a constantly changing alternating current passed though the first coil induces a constantly changing alternating current in the secondary coil. By altering the ratios of the turns in the two coils, the voltages and currents in the secondary coil could be transformed, to higher or lower values as desired. Thus, with electrical transformers and generators, Faraday had paved the way for electricity to change our lives. In 1836, Faraday was placed on the civil list for his great insights into the nature of electromagnetism.

In 1845 Faraday experimented with the effect of magnetic fields on light. He found that if polarized light was passed through glass which was placed against the poles of an electromagnet, then the electromagnetic field caused the rotation of the polarized light. This magneto-optical effect is now known as Faraday rotation, or more commonly as the Faraday Effect. Faraday rotation is used in astronomy to measure magnetic fields. Radio waves passing through the ionosphere also experience Faraday rotation, which is frequency dependent. At UHF radio frequencies the rotation is around one and a half complete rotations. At higher frequencies the degree of rotation diminishes.

As already mentioned, in 1845 Faraday experimented with the effect of magnetic fields on light to discover the Faraday rotation known as the Faraday Effect. There is also an inverse Faraday Effect. The inverse Faraday Effect is the magnetization of matter by an electromagnetic field at any frequency. The field must be circularly or elliptically polarized. The effect occurs in one electron for example (www.aias.us). It was inferred by Piekara and Kielich in the mid fifties using phenomenology in non-linear optics. The effect is now known to be caused by the ECE spin field:

$$B(3) = - i\, g\, A(1) \times A(2)$$

where

$$g = \text{kappa} / A(0).$$

Here A(1) is the complex conjugate of the potential A(2), kappa is a wave number and A(0) the magnitude of A(1) = A(2)*. The ECE spin field B(3) was inferred in M. W. Evans Physica B, 182, 227 and 237 (1992) and shows the spin connection at work in electrodynamics. The B(3) spin field is fundamental to unified field theory because it shows that the electromagnetic field is a spinning frame of reference.

The inverse Faraday Effect was re-inferred by Pershan from Harvard in the early sixties and first observed experimentally in liquids, solids and paramagnetic glasses by van der Ziel, Pershan and Malmstrom from Harvard in the mid sixties. It was observed in plasma by Deschamps, Fitaire and Lagoutte in the late sixties. Since then it has become routinely observable and B(3) fields of many Tesla have been observed, for example, using VULCAN at Rutherford / Appleton.

Michael Faraday, the father of classical electrodynamics, believed all forms of light were composed of electromagnetic waves moving at the speed of light. The Faraday Effect provided the first experimental evidence that light and magnetism were related and inspired Faraday to champion his views to the public, which he did in 1846, with his lecture, 'Thoughts on Ray Vibrations'. However, his views on the nature of light were not widely accepted. James Clerk Maxwell (1831-79) the great physicist and mathematician did believe Faraday's ideas however and set about proving them.

The German Wilhelm Weber was also on the case. In 1858 Weber had measured the ratio of magnetic to electric forces and when Maxwell fed Weber's ratio result into his own equations, a velocity equal to the speed of light appeared.

In 1868 Maxwell managed to reduce his mathematical ideas concerning light, into the four Maxwell equations, which unified electricity and magnetism as a wave traveling in the ether at the speed of light. Maxwell's equations of electromagnetism mathematically confirmed what Faraday had been saying about the nature of light for the many years and forever changed our views on the nature of light.

In addition in 1864, Maxwell was able to state that visible light was only one form of light within an electromagnetic spectrum which included invisible forms of light of longer and shorter wavelengths. In the next thirty years radio, X and gamma rays would be discovered and added to the electromagnetic spectrum. Herschel had already discovered infrared light in 1800, when he saw that a thermometer placed beyond the red end of light from a prism indicated it was being heated by a previously unknown form of light

Infrared telescopes such as UKIRT (United Kingdom Infra Red Telescope) observe objects that are relatively cold such as dust clouds (nebulae) containing stars at the start of their lives. Infrared light can penetrate dust clouds because it has wavelengths longer than visible light. This is similar to red light being able to penetrate fog better than white light. The biggest and best telescope in the world operating in the far infrared is in Hawaii and is named in honor of James Clerk Maxwell or JCMT for short.

Maxwell's great mathematical ability was appreciated from his earliest days in Cambridge and in 1852; he was invited to become an apostle. The Apostles were a secret society (founded in 1820) composed of the twelve students who were considered to have the greatest intellect of those currently at Cambridge. On leaving, the apostles became Angels and met in secret every few years, at a Cambridge College. Many angels such as Bertrand Russell went on to work in the media, government and church. Maynard Keynes and the Bloomsbury group were well known before the First World War. The apostles came to the attention of the public again in 1951, with the exposure of the Cambridge spy ring. Anthony Blunt (MI5) and Guy Burgess (MI6) were both spies passing information to the soviets.

Maxwell's equations predicted that light would always move away from an observer at the speed of light, no matter how fast the observer was moving. When Einstein was a student he was intrigued by Maxwell's equations and their implications. This stimulated him to formulate his great theory of special relativity.

The theory proposed by Maxwell was developed using William Hamilton's quanternions. Quanternions are a non-commutative extension of complex numbers, which were subsequently converted into vector form by Oliver Heaviside, to produce the Maxwell Heaviside (MH) theory. Sir William Rowan Hamilton (1805-1865) was a great Irish mathematician and physicist. His work later became relevant to quantum physics, where the 'Hamiltonian' bears his name.

Oliver Heaviside (1850 to1925) from Camden town, London, made major contributions to physics and mathematics. In 1885 he presented Maxwell's equations in their present form, which is why they can be referred to as the Maxwell Heaviside equations and field theory. He also developed the operational calculus, the theory of vectors, the Heaviside step function, the Heaviside equation of telegraphy, and (in 1889) the basic equation for the motion of charge in a magnetic field. He developed m.k.s. units, the use of complex numbers for circuit theory, and the modern theory of Laplace transforms through his powerful operational calculus method. He deduced the denominator root (1 - (v/c) squared) fifteen years before Einstein in his studies of the speed of light in circuits.

In 1896 Oliver Heaviside was awarded a Civil List pension on the recommendation of Rayleigh, Kelvin, Fitzgerald and others. He is one of the greatest physicists and mathematicians in history and deserves to be better known.

Heaviside also proposed that the vector potential A in classical electrodynamics be an abstract entity, only the fields E and B are physical in that view. The latter is the opposite of the view of Faraday and Maxwell, who considered the potential (electrotonic state of Faraday) to be physical. The Heaviside point of view evolved into the gauge principle in the twentieth century, mainly through the ideas of Weyl. This principle states that the action is invariant under the gauge transformation of any field. This appeared to be effective until Evans proposed the ECE spin field B(3) in Physica B, 182, 227 and 237 (1992). The B(3) field implies an O(3) gauge invariance for electrodynamics as in the work Evans did from about 1992 to 2003 (see collected papers on www.aias.us).

In paper 71 an invariance principle was introduced with the intention of replacing the gauge principle. In papers 71 and 72 some applications were developed of the invariance principle. In paper 73 some details of its advantages over the gauge principle will be developed.

Evans proposed the invariance principle in paper 71 because it is based directly on an invariant of ECE theory and Cartan geometry - the tetrad postulate. The latter is frame invariant (the covariant derivative of the tetrad always vanishes in all frames of reference). It was shown from this property that the tetrad field (i.e. all fields) must include a phase alpha which cannot depend on distance and time and therefore is "global" in the rather vague but received terminology which Evans follows for convenience - "local" and "global". The local and global connection can be used to explain effects of quantum entanglement showing that the Heisenberg uncertainty principle is wrong and that Einstein was correct to assert that nature is deterministic and ‘God does not play dice’.

In 2005 Myron W. Evans followed in the footsteps of William Herschel, Robert Brown, John Couch Adams, Michael Faraday, Alfred Wallace and Oliver Heaviside by being awarded a civil list pension. At the present time, Myron Evans is the only scientist in Britain or the Commonwealth to hold this high honor.

Civil List Scientists.

Scientist.	Award	Accomplishments.
Isaac Newton 1642-1727	**1696 1699.**	Laws of motion and gravitation. Newtonian telescope and light theory. Warden of the Mint in 1696. Master of the Mint in 1699.
William Herschel 1738-1832	**1782**	Astronomer Royal to George III. Discoverer of Uranus and infrared radiation.
Sir James Ivory 1765-1842	**1831**	Scottish mathematician.
John Dalton 1766-1844	**1833**	Law of partial pressures. Atomic theory : - Each element is composed of different types of atoms.
Robert Brown 1773-1858	**Circa 1858**	Brownian motion. Recognized the importance of and named the cell nucleus.
Mary Fairfax-Somerville 1780-1872	**1835**	Scottish science writer, mathematician and astronomer. Somerville College Oxford named after her. Translated Laplace's "Celestial Mechanics".
Michael Faraday 1791-1867	**1836 1858**	Laws of induction. Laws of electrolysis. 1858 Grace and favor house, Queen Victoria.
Sir George Airy 1801- 1892	**1835**	Northumberland, Astronomer Royal. Established prime meridian at Greenwich. Airy Crater defines prime meridian on Mars.
James Prescott Joule 1818-1889	**1878**	First Law of Thermodynamics, Principle of the Conservation of Energy, Joule's Law, speed of gas molecules.
John Couch Adams 1819-1892	**1861**	Mathematically predicted the position of Neptune facilitating its discovery.
Alfred Wallace 1823-1913	**1881**	Wrote a book on evolution, which led to Darwin publishing his own book.
Oliver Heaviside 1850-1925	**1896**	Maxwell-Heaviside equations and theory. Mathematician, physicist and engineer.
William F. Denning 1848-1931	**1904**	Denning of Somerset, astronomer, comet hunter and science writer.
Myron Evans Born 1950	**2005**	Completed Einstein's work, by docking the curved space of relativity with Cartan's torsion of electromagnetism.

The physicists and mathematical physicists have generally been awarded O.M or C. H., comparable high honors to the Civil List. However the latter requires an Act of Parliament and is also an Appointment.

Order of Merit Natural Scientists.

Scientist.	Award	Accomplishments.
Lord Rayleigh (John Strutt) 1842-1919	**?**	Theory of waves. Cavendish Professor. 1904 Nobel prize for discovery of argon.
Lord Kelvin (William Thomson) 1824-1907	**1902**	Kelvin temperature scale. Mathematics of thermodynamics and electricity.
Ernest Rutherford 1871-1937	**1925**	1908 Nobel prize for chemistry for investigations into disintegrations of elements and radioactive substances
Arthur Eddington 1882-1944		Eddington's light bending result in the 1919 eclipse proved relativity.
William Henry Bragg 1862-1942		1915 Nobel Prize for x-ray diffraction and crystallography.
Paul Dirac 1902-1984		Dirac equations and prediction of antimatter. Nobel Prize for physics in 1933. Quantum theory.
George Porter 1920-2002		Evidence for free radicals. President of the Royal Society. 1967 Nobel Prize for Chemistry. Flash photolysis.
Dorothy Hodgkin 1910-1995	**1965**	Protein crystallography. 1964 Nobel Prize for chemistry.
Sir Michael Atiyah Born 1929	**1992**	Mathematical advances. Former President of the Royal Society.
Sir Roger Penrose Born 1931	**2000**	Mathematical physics, general relativity and cosmology.
Sir Andrew Huxley Born 1917	**1983**	Nobel Prize for medicine and physiology in 1963 for work on nerve impulses.
Sir Frederick Sanger Born 1918	**1986**	1958 Nobel prize for chemistry for structure of insulin. 1980 Nobel Prize for chemistry for gene sequencing. Only four people have won two Nobel Prizes.
Sir Aaron Klug Born 1926	**1995**	1982 Nobel prize for chemistry for x-ray crystallography applied to biochemistry.
James Black 1924	**2000**	Nobel Prize for medicine and physiology in 1988 for revolutionary method for discovering and evaluating medicines.
Lord May of Oxford Born 1936	**2002**	Ecologist. Former President of the Royal Society.

The Order of Merit is based on the Prussian Pour le Merite (“The Blue Max") and was introduced by Edward VII. The Order of Merit is limited to the Sovereign and twenty four others and is the prerogative of the Sovereign without Ministerial advice. It is awarded to people from all walks of life. Prime Ministers, who were awarded the Order of Merit, were for example: Lloyd-George, Churchill and Attlee.

The Companion of Honor was introduced in 1917 by George V. Stephen Hawking, Sydney Brenner and Frederick Sanger are the only natural scientist who are currently companions of honor (Sovereign and up to 65 others).

The Civil List pension is for distinguished contributions to Britain, in literature, the arts, humanities and science (by Parliament upon recommendation of the Prime Minister and in science, the Royal Society).There are about 25 members of the Civil List at present, with Myron Evans being the only scientist.

The six natural scientists, currently with British high honors are:-
Sir Michael Atiyah, Stephen Hawking, Frederick Sanger, Sir James Lovelock
Sydney Brenner, Roger Penrose and Myron Evans.

Music of the Spheres.

Civil List Poets.

Poet.	Award	Accomplishments.
Lord Byron 1788-1824		Romantic era poet, supporter of Greek independence.
William Wordsworth 1770-1850	**1842**	Fervent revolutionary as a young man, Romantic era poet, famous poem to Tintern Abbey in Gwent.
Lord Tennyson 1809-1892		The Charge of the light Brigade. The Lady of Shalot. Made a Baron by Queen Victoria in 1884. The first English writer to be raised to the peerage. Coined the phrase, 'it is better to have loved and lost'
George Moore		Romantic era Irish poet - sometimes called the national poet of Ireland.
Frances Browne, Blind Poetess of Donegal		Nineteenth century poetess much loved in her (Victorian) era.
W. S. Graham		Born in Glasgow, leading twentieth century poet
Vernon Watkins		Leading metaphysical poet of the twentieth century, friend and advisor of Dylan Thomas, these two are known as "The Swansea Poets" and are commemorated in the Glyn Vivian Gallery. Also a Memorial to Vernon Watkins overlooking Hunt's Bay in Gower. Born in Maesteg, educated in Cambridge, also an artist.
George Gordon Lord Byron	**1850**	Thomas Moore, sometimes known as the Irish national poet, was born in Dublin, the son of a grocer, and educated at Trinity College Dublin. (I mistakenly wrote "George Moore".) He was a friend of Byron and Shelley, and wrote "Irish Melodies" (1807 onwards in ten volumes) and "Letters and Journals of Lord Byron" (1830).
Hugh MacDiarmaid (Christopher Murray Grieve).	**1950**	Leading Scots and English language poet of the twentieth century, co-founder of the Scottish Nationalist Party with Compton-Mackenzie and Campbell-Bannerman. Hugh MacDiarmaid was a leading twentieth century poet and Scottish national figure and revived the Scots language.

From Relativity to ECE in Seven Days based on Seven Crystal Spheres.

Summary.

The Experimentally Tested and Philosophical Advantages of ECE over the Standard Theory.

These advantages are based on the principles of Francis Bacon (test against data) and William of Ockham (the simpler the better). The major advantage of ECE is that it relies on the original principles of the theory of general relativity, without any extraneous input. More detail is provided in the 76 papers of ECE on www.aias.us and the papers of Myron Evan's Omnia Opera back to 1992.

1) **The inverse Faraday Effect.**
This is described by the spinning of spacetime and the B(3) field from first principles. In the standard model the effect cannot be described self consistently and cannot be described without an ad hoc conjugate product A x A* of special relativity.

2) **The Aharonov Bohm effects.**
These are described self consistently through the spin connection using the principles of general relativity. The standard model description (special relativity) is confused, elaborate and in some respects erroneous. So the standard model does not give a satisfactory description of the Aharonov Bohm effects.

3) **The polarization change in light deflected by gravitation.**
This is not described in the standard model because of its neglect of torsion. Similarly, all optical effects of light deflected by gravitation.

4) **The Faraday disk generator.**
This is described in ECE through the Cartan torsion, and in the standard model cannot be described satisfactorily.

5) **The Sagnac Effect and Ring Laser Gyro.**
These are described by the Cartan torsion in ECE, and cannot be described by the Maxwell Heaviside field theory of the standard model.

6) The Velocity Curve of a Spiral Galaxy.

This is described by a constant torsion mcv which originates in a constant Cartan torsion of spacetime. It cannot be described in the standard model without the ad hoc introduction "dark matter".

7) The Topological Phases such as the Berry phase.

These are derived from the first principles of general relativity. In the standard model their description is incomplete because it is confined to special relativity.

8) The Electromagnetic Phase.

This is described self consistently with the B(3) spin field using general relativity. In the standard model the phase is incompletely described.

9) Snell's law, Reflection, Refraction, Diffraction, Interferometry and Related Optical effects.

These can only be described correctly with ECE theory. In the standard model the theory of reflection for example, does not fit with parity inversion due to the neglect of the B(3) spin field.

10) Improvements to the Heisenberg Uncertainty Principle.

In the standard model, various experiments show that this is incorrect by up to nine orders of magnitude. In ECE it is improved by the introduction of action density, giving qualitative agreement with data.

11) The Unification of Quantum Mechanics and General Relativity.

This is achieved straightforwardly in ECE theory with geometry. In the standard model no such unification has been achieved. The Dirac, Proca and similar wave equations are limits of the ECE wave equation. So ECE allows the description of the effect of gravitation on such equations. This is not possible in the standard model.

12) Description of Particle Exchange from General Relativity, for example Exchange of Photon and Electron.

This is achieved with simultaneous ECE equations without having to use renormalization. In the standard model it is incomplete (special relativity) and requires a hugely elaborate renormalization procedure.

13) The Theory of Photon Mass.

The Proca equation is derived straightforwardly from geometry using the ECE hypothesis that the potential is proportional to the tetrad. In the standard model the theory of the Proca equation conflicts diametrically with the gauge principle.

14) Replacement of the Gauge Principle by the Invariance Principle of ECE.

This allows a return to the original principle of general relativity without the introduction of an ad hoc abstract internal space as in gauge theory. Weaknesses of gauge theory are removed in ECE theory.

15) Description of the Electroweak Field without the Higgs Mechanism.

This becomes possible by solving simultaneous ECE wave equations without the ad hoc Higgs mechanism, which is extraneous to Einstein's theory of general relativity.

16) Description of Neutrino Mass and Oscillations.

This becomes possible straightforwardly in ECE, but with great difficulty in the standard model because neutrino mass was long thought to be zero, in conflict with Einstein's general relativity.

17) The Generally Covariant Description of the Laws of Electrodynamics.

This is a straightforward consequence of Cartan's structure equations and identities. In the standard model such a description is not possible, because electrodynamics is not generally covariant, i.e. is the Maxwell Heaviside theory of Lorentz covariant special relativity.

18) Derivation of the Quark Gluon Model from General Relativity.

This has been achieved in ECE theory using the SU(3) representation space in Cartan geometry. In the standard model it is still a theory of special relativity with ad hoc infinities that have to be removed by renormalization.

19) Derivation of Quantum Electrodynamics from General Relativity.

This is achieved in ECE using the ECE wave equation and the ECE hypothesis, potential proportional to tetrad. In so doing a minimum particle volume is defined that makes renormalization obsolete - there are no point particles in nature.

20) The Origin of Particle Spin is traced in ECE Theory to Geometry.
Particle spin is successfully incorporated into general relativity by geometry. This is not possible in the standard model due to neglect of torsion.

21) A New Cosmology is developed in ECE Theory and has been tested experimentally.
This has several advantages over the standard model due to the incorporation of Cartan torsion. The latter is part of Riemann geometry. The cosmology used by Einstein and Hilbert neglects the torsion because it assumes a symmetric Christoffel connection.

22) ECE Shows that there are no Singularities in Nature, so there is no Big Bang in Nature.
The concept has been replaced in ECE by an oscillatory universe without singularities. The scholar Stephen Crothers has shown that Big Bang is due to erroneous mathematics of the standard model. These errors are not repeated in ECE.

23) The Red Shift is explained in ECE as a Simple Optical Effect.
This shows why there can be different red shifts for equidistant objects (data of Halton Arp). The standard model has no explanation for this and none for many other observations of astronomy.

24) The Concept of Spacetime Resonance in Classical Electrodynamics is Introduced in ECE theory, and Named "Spin Connection Resonance".
This concept is missing entirely from the standard model because electrodynamics therein is special relativity (flat Minkowski metric).

25) Spin Connection Resonance is Due to Spinning Spacetime (the Cartan torsion), and is the reason why electric power can be obtained from spacetime as observed experimentally by several groups in industry. This is of great potential importance for energy acquisition. The standard model has no explanation.

26) Counter Gravitational Spin Connection Resonance has been developed in ECE Theory, which shows that counter gravitation is feasible. The standard model has no explanation.

27) **The Recent Discovery of the Gravitational Equivalent of the Faraday Law of Induction** is explained straightforwardly in ECE theory through the first Cartan structure equation. The standard model has no explanation for such an effect, which is important for counter gravitational technology and is many orders of magnitude greater than that expected from Einstein Hilbert theory and the Lense Thirring theory. Again this is due to the neglect of torsion in the standard model.

28) **Quantum Entanglement and the Single Photon Young Experiment** have been explained in ECE using the concept of the spin connection of Cartan torsion applied to electrodynamics and quantum electrodynamics. The standard model fails because of the failure of the Bohr Heisenberg indeterminacy.

29) **The Equations of Superconductivity** have been derived from general relativity using geometry. Similarly the equations of semiconductor and plasma theory, and the whole of classical electrodynamics. This cannot be done in the standard model.

30) **The Equations of Quantum Field Theory** have been derived from general relativity without the use of ad hoc "dimensions" (string theory). It has been admitted by leading string theorists that string theory cannot be tested experimentally.