EVANS / MORRIS SHIFTS AND SPLITTINGS IN SCATTERING THEORY.

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ABSTRACT

It is shown that scattering theory can be described in terms of a generalized Beer Lambert law which for electromagnetic scattering can be compared with the Planck distribution to give the newly discovered Evans / Morris shifts and splittings in scattering theory. The results are exemplified by Compton, Rayleigh and Raman scattering but apply to any kind of electromagnetic scattering. If the Planck distribution is modified appropriately they also apply to particle scattering.

Keywords: ECE theory, Evans / Morris shifts and splittings, scattering theory.

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1. INTRODUCTION

Recently in this series {1 - 12}, a new and rigorous test of the quantum theory has been proposed using a simple combination of the Planck distribution and the Bouguer Law (known as the Beer Lambert Law). This work was catalyzed by the experimental discovery by G. J. Evans and T. Morris of colour shifts at visible frequencies in various processes in which light interacts with the condensed state of matter. These results are given in the diary or blog of www.aias.us and are archived with this website in the National digital collection in the British Library from the National Library of Wales (www.webarchive.org.uk). In the immediately preceding paper (UFT308 and background notes on www.aias.us) a new and rigorous test of the quantum theory was devised with the well known rotational spectrum in the far infra red and microwave of a dipolar diatomic molecule. A probe laser tuned to one of the rotational absorption lines is shifted to a lower frequency and split by fundamental quantum theory. The shift to lower frequency is the Evans / Morris red shift. So the probe laser frequency is changed and emerges from the sample at a lower frequency. Note carefully that this is the direct result of the Planck distribution itself and was first discussed in UFT49 in the context of the cosmological red shift and Assis theory. The extent of the frequency shift depends on the usual Beer Lambert law and is therefore governed by the product of the power absorption coefficient and the sample path length. The power absorption coefficient is calculated as usual with the transition dipole moment so in general the original frequency is shifted in different ways so the emergent radiation is a spectrum. Each possible transition dipole moment gives its own shift, so the energy degeneracy of the rotational absorption line is lifted. This spectrum can be calculated precisely with the methods of quantum mechanics and is easily observable with for example a Michelson interferometer whose source is the emergent radiation.

In Section 2 a similar test of the quantum theory is devised using scattering theory and exemplified using Compton, Rayleigh and Raman scattering. As usual this paper should be read with its background notes, posted as the notes to UFT309 on www.aias.us. Note 309(1) discusses general scattering theory expressed as a Beer Lambert law and applies the method to the usual theory of Compton scattering. It is shown that the well known frequency shifts of Compton scattering are Evans / Morris shifts. The latter are therefore observed directly in Compton scattering (greatly developed for photon mass in UFT158 ff.). Note 309(2) shows that the Planck distribution used in Rayleigh scattering theory shifts the scattered frequency. The latter is no longer the same in general as the incident frequency as in the well known theory of elastic Rayleigh scattering. This shift occurs in the usual broadening of the Rayleigh line. This is a direct test of the quantum theory produced in this case by a simple combination of the usual Planck distribution and the usual Rayleigh scattering theory. Note carefully that nothing else is assumed. Evidently this combination of fundamental theories has not been considered hitherto and immediately produces rigorous tests of the basics of the quantum theory. Note 309(3) extends Note 309(2) to inelastic Raman scattering. Another test of the quantum theory is produced by combining the usual Raman scattering theory with the usual Planck distribution. Each Raman line is shifted by the Planck distribution, for example the Stokes Raman and anti Stokes Raman rotational spectral lines. Note 309(4) gives the condition for the usual Rayleigh scattering, where the incident and scattering frequency is the same. This is the only case in which there is no shift, because the incident and scattered flux densities are the same, so the incident and scattered frequencies from the Planck distribution are the same. Finally Note 309(5) illustrates the theory with a simple derivation of the Beer Lambert law for use in Raman scattering, and illustrates the way in which the transition induced dipole moment is calculated with perturbation theory.

With reference to Note 309(1) scattering theory in general can be described by the generalized Beer Lambert law:

$$\frac{dI}{dZ} = -Q \cdot I \qquad -(1)$$

where I is a flux of particles of any kind, Z the sample path length, and Q is a parameter that is defined by the type of scattering experiment being considered. For example, in conventional Compton scattering (UFT158 ff) of an assumed massless photon from an initially stationary electron:

$$\frac{\omega}{\omega_0} = 1 - \frac{\hbar\omega}{mc^2}\left(1 - \cos\theta\right) - (2)$$

where ω_0 is the incoming angular frequency and ω the scattered angular frequency of the photon, $\hbar$ is the reduced Planck constant, m the mass of the electron, c the vacuum velocity of light and θ the scattering angle. In the usual Planck distribution the average energy of an oscillator is:

$$\langle \hbar\omega \rangle = \frac{\hbar\omega}{e^{y} - 1} \qquad -(3)$$

where:

$$y = \frac{\hbar\omega}{kT}. \qquad -(4)$$

Here k is the Boltzmann constant and T the temperature. In Compton scattering theory it is assumed that the one photon scatters off one electron, so:

$$\langle \hbar\omega \rangle = \hbar\omega. \qquad -(5)$$

This is equivalent so assuming that:

$$\hbar\omega = kT \log_e 2. - (6)$$

If it is assumed that the volume V occupied by the quantum of energy $\hbar\omega$ is the same as the volume V_0 occupied by ω_0 then:

$$\frac{\Phi}{\Phi_0} = \frac{\omega}{\omega_0} \quad -(7)$$

where the electromagnetic flux density in watts per square metre is defined by:

$$\Phi = c\frac{E}{V}. \quad -(8)$$

Therefore the shift of ω_0 to lower frequency ω is given directly by the Planck distribution as follows:

$$\frac{\Phi}{\Phi_0} = \frac{\omega}{\omega_0} = 1 - \frac{\hbar\omega}{mc^2}(1-\cos\theta). \quad -(9)$$

The Evans / Morris effect is ubiquitous and the Compton effect is one example of it.

In elastic Rayleigh scattering theory an incoming electromagnetic field induces an electric dipole which produces dipole radiation at the same frequency as that of the initial electromagnetic frequency. However, Rayleigh scattering theory must be developed with consideration of the fundamental Planck distribution. It becomes clear as follows that inelastic Rayleigh scattering can occur in general and Evans / Morris type shifts can occur in Rayleigh scattering. These shifts can be looked for experimentally as broadenings of the Rayleigh line.

Consider the Planck distribution for monochomatic radiation as in Note 309(2). The electromagnetic flux density in watts per square metre is:

$$\Phi = c\frac{U}{V} \quad -(10)$$

where U is the energy of the electromagnetic field and V the volume occupied by the radiation. For an assumed two states of polarization the Rayleigh theory gives:

$$\frac{N}{V} = \frac{1}{3}\frac{\omega^3}{c^3\pi^2} \quad -(11)$$

Note that the $\underline{B}^{(3)}$ field of ECE theory produces and additional contribution. The mean energy of the Planck oscillator is given by Eq. (3), so the flux density for monochromatic radiation is:

$$\underline{\Phi} = c\frac{U}{V} = c\langle\hbar\omega\rangle\frac{N}{V} \quad -(12)$$

$$= \frac{\hbar\omega^4}{3c^2\pi^2}\left(\frac{1}{e^y - 1}\right)$$

The ratio of flux densities is:

$$\frac{\underline{\Phi}}{\underline{\Phi}_0} = \left(\frac{\omega}{\omega_0}\right)^4\left(\frac{e^{y_0} - 1}{e^y - 1}\right). \quad -(13)$$

For high temperatures or low frequencies:

$$\hbar\omega << kT \quad -(14)$$

so the ratio is approximated by:

$$\frac{\underline{\Phi}}{\underline{\Phi}_0} = \left(\frac{\omega}{\omega_0}\right)^3. \quad -(15)$$

In the usual theory of Rayleigh scattering as in Note 309(2) the same ratio is given by:

$$\frac{\underline{\Phi}}{\underline{\Phi}_0} = \left(\frac{\alpha\sin\phi\,\omega_0^2}{4\pi\epsilon_0 c^2 R}\right)^2 \quad -(16)$$

where α is the polarizability, R is the distance of the detector from the scattering atom or molecule, ϕ is a well defined scattering angle, ϵ_0 is the S. I. vacuum permittivity and ω_0 is the frequency of the incoming electromagnetic radiation. In the usual theory of elastic Rayleigh scattering this frequency does not change. The incoming flux density is:

$$\Phi_0 = \frac{1}{2} c \epsilon_0 E_0^2 = c\frac{U}{V} \quad -(17)$$

where E_0^2 is the square modulus of the electric field strength in volt m^{-1} of the incoming electromagnetic field. The scattered flux density is given by dipole radiation theory:

$$\Phi = \left(\frac{\mu^2 \sin^2 \phi}{32 \pi^2 c^3 \epsilon_0 R^2} \right) \omega_0^4 \quad -(18)$$

where $\underline{\mu}$ is the radiating electric dipole moment. In Rayleigh scattering this is the induced dipole moment:

$$\underline{\mu} = \alpha \underline{E_0} \quad -(19)$$

where α is the polarizability, in general a tensor. The Planck distribution asserts that if the incoming and scattered frequencies are the same, the incoming and scattered flux densities are also the same, so according to the Planck theory:

$$\Phi = \Phi_0 . \quad -(20)$$

From Eq. (16) and (20) the angular frequency must be:

$$\omega_0 = \left(\frac{16 \pi c^2 \epsilon_0 R}{\alpha \sin \phi} \right)^{1/2} . \quad -(21)$$

This result can be tested experimentally and is another rigorous test of the quantum theory.

More generally, by comparing Eq. (13) from the Planck theory with Eq. (16) from the Rayleigh theory:

$$\frac{\Phi}{\Phi_0} = \left(\frac{\omega}{\omega_0}\right)^4 \left(\frac{e^{y_0} - 1}{e^{y} - 1}\right) = \left(\frac{\alpha \sin\phi\, \omega_0^2}{4\pi\epsilon_0 c^2 R}\right) \quad -(22)$$

and in general, the quantum theory predicts the existence of a frequency change given in the high temperature or low frequency approximation by:

$$\frac{\omega}{\omega_0} = \left(\frac{\alpha \sin\phi\, \omega_0^2}{4\pi\epsilon_0 c^2 R}\right)^{1/3}. \quad -(23)$$

This is an Evans / Morris type shift and is a new kind of inelastic Rayleigh scattering where the scattered frequency ω is not the same as the incoming frequency ω_0. In fact this effect is observed routinely in the well known broadening of the Rayleigh scattering.

In the classical treatment of inelastic Raman scattering the incoming frequency of the electromagnetic field is shifted in the scattered radiation, which is in general quantized. The polarizability is considered to be:

$$\alpha = \alpha_0 + \Delta\alpha \cos\omega t. \quad -(24)$$

So the induced dipole moment is:

$$\begin{aligned} \mu = |\underline{\mu}| &= (\alpha_0 + \Delta\alpha \cos\omega t)\, E_0 \cos\omega_0 t \\ &= \alpha_0 E_0 \cos\omega_0 t + \frac{1}{2} E_0 \Delta\alpha \left(\cos((\omega_0+\omega)t) + \cos((\omega_0-\omega)t)\right) \end{aligned} \quad -(25)$$

In the usual development the first term gives Rayleigh scattering at the incoming frequency, ω_0, the second term gives anti Stokes scattering at the frequency $\omega_0 + \omega$, and the third term gives Stokes scattering at the frequency $\omega_0 - \omega$. It is observed experimentally that the scattered radiation is quantized, so there are several frequencies ω. This is known as Raman scattering. The scattered Stokes flux density is:

$$\Phi(\text{Stokes}) = \frac{1}{4}\left(\frac{E_0^2(\Delta\alpha)^2\sin^2\phi}{32\pi^2c^3\epsilon_0R^2}\right)(\omega_0-\omega)^4 \quad -(26)$$

and the scattered anti Stokes flux density is:

$$\Phi(\text{anti-Stokes}) = \frac{1}{4}\left(\frac{E_0^2(\Delta\alpha)^2\sin^2\phi}{32\pi^2c^3\epsilon_0R^2}\right)(\omega_0+\omega)^4 \quad -(27)$$

The incoming flux density is given by Eq. (17).

The ratios of flux densities are as follows. In Stokes scattering:

$$\frac{\Phi}{\Phi_0}(\text{Stokes}) = \left(\frac{\Delta\alpha\sin\phi}{8\pi\epsilon_0c^2R}\right)^2(\omega_0-\omega)^4. \quad -(28)$$

In anti Stokes scattering:

$$\frac{\Phi}{\Phi_0}(\text{anti-Stokes}) = \left(\frac{\Delta\alpha\sin\phi}{8\pi\epsilon_0c^2R}\right)^2(\omega_0+\omega)^4, \quad -(29)$$

and in Rayleigh scattering:

$$\frac{\Phi}{\Phi_0}(\text{Rayleigh}) = \left(\frac{\alpha_0\sin\phi}{4\pi\epsilon_0c^2R}\right)^2\omega_0^4. \quad -(30)$$

In the Planck theory in the high temperature or low frequency approximation the same ratio is:

$$\frac{\Phi}{\Phi_0}(\text{Planck}) = \left(\frac{\omega_P}{\omega_0}\right)^3 \quad -(31)$$

where ω_0 is the incoming frequency, and where ω_P is the scattered frequency of the Planck theory, denoted ω_p . In this case the Evans / Morris shifts are defined by the Raman scattering spectrum. It is clear that ω_p is not the same as ω_0 .

Finally Note 309(5) gives a simple derivation of the Beer Lambert law that can be adopted for Raman scattering using the generalized Beer Lambert law (1). In this case Raman scattering is described by:

$$\frac{\Phi}{\Phi_0} = \exp\left(-A_s R\right) \quad -(32)$$

where A_S is named the power scattering coefficient defined in direct analogy with absorption theory as:

$$A_s = \left(\frac{N}{V}\right) \frac{|\mu_{if}|^2}{6\epsilon_0 c \hbar} \quad -(33)$$

where μ_{if} is the transition induced dipole moment as in Note 309(5). The expectation value of this transition induced dipole moment is:

$$\langle \mu_Z \rangle = E_Z \int \psi^* \alpha_{ZZ} \psi \, d\tau \quad -(34)$$

where from perturbation theory:

$$\alpha_{ZZ} = -2 \sum_n{}' \left[\frac{\langle 0|\mu_Z|n\rangle\langle n|\mu_Z|0\rangle}{E_0 - E_n} \right]. \quad -(35)$$

Therefore a variety of novel frequency shifts and splittings are expected from the equation:

$$\frac{\Phi}{\Phi_0} = \left(\frac{\omega}{\omega_0}\right)^4 \left(\frac{e^{y_0} - 1}{e^{y} - 1}\right) = \exp\left(-A_s R\right), \quad -(36)$$

in direct analogy with absorption theory. This is another severe test of quantum theory.

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REFERENCES.

{1} M. W. Evans, H. Eckardt, D. W. Lindstrom and S. J. Crothers, "Principles of ECE Theory" (open source on www.aias.us as UFT281 to UFT288, and in book format, in prep.)

{2} M. W. Evans, ed., J. Found. Phys. Chem., (open source on www.aias.us and CISP 2011).

{3} M. W. Evans, Ed. "Definitive Refutations of the Einsteinian General Relativity" (special issue of ref. (2), open source on www.aias.us).

{4} M .W. Evans, S. J. Crothers, H. Eckardt and K. Pendergast, "Criticisms of the Einstein Field Equation" (open source on www.aias.us, UFT301, and CISP 2010).

{5} M .W. Evans, H. Eckardt and D. W. Lindstrom, "Generally Covariant Unified Field Theory" (Abramis 2005 to 2011 and open source on www.aias.us) in seven volumes.

{6} H. Eckardt, "The ECE Engineering Model" (UFT303 on www.aias.us).

{7} L. Felker, "The Evans Equations of Unified Field Theory" (UFT301 on www.aias.us and Abramis 2007).

{8} M .W. Evans and L. B. Crowell, "Classical and Quantum Electrodynamics and the B(3) Field" (World Scientific 2001).

{9} M .W. Evans and S. Kielich, Eds., "Modern Non Linear Optics" (Wiley Interscience, New York, 1992, 1993, 1997, 2001) in two editions and six volumes.

{10} M. W. Evans and J.-P. Vigier, "The Enigmatic Photon" (Kluwer, 1994 to 2002 and open source on www.aias.us) in five volumes softback and five volumes hardback.

{11} M. W. Evans, "Collected Scientometrics of ECE Theory" (UFT307 on www.aias.us).

{12} M. W. Evans and A. A. Hasanein, "The Photomagneton in Quantum Field Theory"

(World Scientific 1994 and partially on www.aias.us)