329(7): The Vector and Scalar Potentials in ECE2 Theory

In ECE2 theory (UFT317), the magnetic flux density is defined by:

$$\underline{B} = \underline{\nabla} \times \underline{W} = \underline{\nabla} \times \underline{A} + 2\underline{\omega} \times \underline{A} \quad -(1)$$

where W^μ has the same units as A^μ. So the minimal prescription used in the previous notes for UFT329 is replaced by a minimal prescription that includes the spin connection. The simplest procedure is to use

$$p^\mu \rightarrow p^\mu - eW^\mu \quad -(2)$$

where

$$W^\mu = (\phi_W, c\underline{W}) \quad -(3)$$

and

$$\underline{B} = \underline{\nabla} \times \underline{W} \quad -(4)$$

$$= W^{(0)} \underline{R}(\text{spin})$$

The electric field in ECE2 is defined by:

$$\underline{E} = -\underline{\nabla}\phi_W - \frac{\partial \underline{W}}{\partial t} \quad -(5)$$

so the scalar potential of electromagnetism is defined by ϕ_W.

) Here the relevant hamiltonian is defined by:

$$H_{01}\phi = -\frac{H_0}{4m^2c^2}\,\underline{\sigma}\cdot(\underline{p}-e\underline{W})\,\underline{\sigma}\cdot(\underline{p}-e\underline{W})\phi \quad -(6)$$

which gives the ESR and NMR term:

$$H_{01}\phi = -\frac{H_0}{4m^2c^2}\,\underline{\sigma}\cdot(-i\hbar\underline{\nabla}-e\underline{W})\,\underline{\sigma}\cdot(\underline{p}-e\underline{W})\phi \quad -(7)$$

where

$$\underline{p} = \gamma m\underline{v_0} \quad -(8)$$

So the new ESR hamiltonian is:

$$H_{ESR}\phi = -\frac{ie\hbar H_0}{4m^2c^2}\,\underline{\sigma}\cdot\underline{\nabla}\,\underline{\sigma}\cdot\underline{W}\phi \quad -(9)$$

so

$$\mathrm{Re}(H_{ESR})\phi = \frac{e\hbar H_0}{4m^2c^2}\,\underline{\sigma}\cdot\underline{\nabla}\times\underline{W}\phi \quad -(10)$$

$$= \frac{e\hbar H_0}{4m^2c^2}\,\underline{\sigma}\cdot\underline{B}\phi$$

$$= \frac{e\hbar H_0 W^{(0)}}{4m^2c^2}\,\underline{\sigma}\cdot\underline{R}(\text{spin})\phi$$

So ESR and NMR originate in $\underline{R}(\text{spin})$.