3 Ho(4): Effect of the Vacuum on the Dipole Magnetic Flux Density

Consider the magnetic vector potential:

$$\underline{A}_0 = \frac{\mu_0}{4\pi} \frac{\underline{m} \times \underline{r}}{r^3} \quad -(1)$$

Then the usual magnetic flux density of the standard model is

$$\underline{B}_0 = \underline{\nabla} \times \underline{A} \quad -(2)$$

In ECE2 theory:

$$\underline{B} = \underline{\nabla} \times \underline{A} - \underline{\omega} \times \underline{A} \quad -(3)$$

where $\underline{\omega}$ is the vector spin connection. Here:

$$\underline{B}(\text{vac}) = -\underline{\omega} \times \underline{A} \quad -(4)$$

is the vacuum correction of $\underline{B}$.

So ECE2 theory automatically considers the vacuum correction:

$$\underline{B} = \underline{B}_0 + \underline{B}(\text{vac}) \quad -(5)$$

From vector analysis:

$$\underline{B}_0 = -\frac{\mu_0}{4\pi} \underline{m} \nabla^2 \left(\frac{1}{r} \right) + \frac{\mu_0}{4\pi r^3} \left(3 \underline{m} \cdot \frac{\underline{r}\,\underline{r}}{r^2} - \underline{m} \right) \quad -(6)$$

in which

$$\underline{m} = m_X \underline{i} + m_Y \underline{j} + m_Z \underline{k} \quad -(7)$$

is the magnetic dipole moment and

$$\underline{r} = X \underline{i} + Y \underline{j} + Z \underline{k} \quad -(8)$$

Therefore it follows that:

) If we use: $\nabla^2\left(\frac{1}{r}\right) = 0$ — (9)

e_2:

$$B_0 = \frac{\mu_0}{4\pi}\left[\frac{3(m_X X + m_Y Y + m_Z Z)}{(X^2+Y^2+Z^2)^{5/2}}\left(X\underline{i} + Y\underline{j} + Z\underline{k}\right) - \frac{\left(m_X\underline{i} + m_Y\underline{j} + m_Z\underline{k}\right)}{(X^2+Y^2+Z^2)^{3/2}}\right] \quad -(10)$$

so the scalar components of $\underline{B}_0$ are: —(11)

$$B_{0X} = \left[\frac{3(m_X X + m_Y Y + m_Z Z)X}{(X^2+Y^2+Z^2)^{5/2}} - \frac{m_X}{(X^2+Y^2+Z^2)^{3/2}}\right].$$

$$B_{0Y} = \left[\frac{3(m_X X + m_Y Y + m_Z Z)Y}{(X^2+Y^2+Z^2)^{5/2}} - \frac{m_Y}{(X^2+Y^2+Z^2)^{3/2}}\right] - (12)$$

$$B_{0Z} = \left[\frac{3(m_X X + m_Y Y + m_Z Z)Z}{(X^2+Y^2+Z^2)^{5/2}} - \frac{m_Z}{(X^2+Y^2+Z^2)^{3/2}}\right] - (13)$$

The isotropically averaged effect of the vacuum on for example the X component is given by the tensorial Taylor series:

$$\langle \Delta B_{ox} \rangle = \Big\langle \frac{1}{2!}\left(\delta X \frac{\partial}{\partial X} + \delta Y \frac{\partial}{\partial Y} + \delta Z \frac{\partial}{\partial Z}\right)\left(\delta X \frac{\partial B_{ox}}{\partial X} + \delta Y \frac{\partial B_{oY}}{\partial Y} + \delta Z \frac{\partial B_{oZ}}{\partial Z}\right) + \frac{1}{4!}\left(\delta X \frac{\partial}{\partial X} + \delta Y \frac{\partial}{\partial Y} + \delta Z \frac{\partial}{\partial Z}\right)\left[\left(\delta X \frac{\partial}{\partial X} + \delta Y \frac{\partial}{\partial Y} + \delta Z \frac{\partial}{\partial Z}\right)\left[\left(\delta X \frac{\partial}{\partial X} + \delta Y \frac{\partial}{\partial Y} + \delta Z \frac{\partial}{\partial Z}\right)\left(\delta X \frac{\partial B_{ox}}{\partial X} + \delta Y \frac{\partial B_{ox}}{\partial Y} + \delta Z \frac{\partial B_{ox}}{\partial Z}\right)\right]\right] \Big\rangle \quad -(14)$$

$+ \ldots$

In three dimensions:

$$\langle \Delta \underline{B}_o \rangle = \langle \Delta B_{ox} \rangle \underline{i} + \langle \Delta B_{oY} \rangle \underline{j} + \langle \Delta B_{oZ} \rangle \underline{k} \quad -(15)$$

However, from eq. (5):

$$\langle \Delta \underline{B}_o \rangle = \underline{B} - \underline{B}_o = \langle \underline{B}(vac) \rangle \quad -(16)$$

$$= -\underline{\omega} \times \underline{A}_o$$

So the isotropically averaged vacuum magnetic flux density is:

$$\langle \underline{B}(vac) \rangle = \langle \Delta B_{ox} \rangle \underline{i} + \langle \Delta B_{oY} \rangle \underline{j} + \langle \Delta B_{oZ} \rangle \underline{k} \quad -(17)$$

$$= -\underline{\omega} \times \underline{A}_o$$

So the spin connection vector $\underline{\omega}$ can be found.