278(1): ECE Theory of the Evans Morris Effects

Consider the inhomogeneous ECE equation:

$$\underline{\nabla} \times \underline{B}^a - \frac{1}{c^2}\frac{\partial \underline{E}^a}{\partial t} = \mu_0 \underline{J}^a \quad -(1)$$

where $\underline{B}^a$ is the magnetic flux density, $\underline{E}^a$ is the electric field strength and $\underline{J}^a$ the current density. By definition:

$$\underline{B}^a = \mu_0(\underline{H}^a + \underline{M}^a), \quad \underline{E}^a = \frac{1}{\epsilon_0}(\underline{D}^a - \underline{P}^a) \quad -(2)$$

where $\underline{H}^a$ is the magnetic field strength, $\underline{M}^a$ is the magnetization and $\underline{P}^a$ the polarization. $\underline{D}^a$ is the electric displacement. The structure of eq. (1) is fully worked out in papers of this year.

For each index a:

$$\underline{\nabla} \times (\mu_0(\underline{H} + \underline{M})) - \frac{1}{\epsilon_0 c^2}\frac{\partial}{\partial t}(\underline{D} - \underline{P}) = \mu_0 \underline{J} \quad -(3)$$

So:

$$\underline{\nabla} \times \underline{H} - \frac{\partial \underline{D}}{\partial t} = \underline{J} - \left(\underline{\nabla} \times \underline{M} + \frac{\partial \underline{P}}{\partial t}\right) \quad -(4)$$

If:

$$\underline{J} = \underline{\nabla} \times \underline{M} + \frac{\partial \underline{P}}{\partial t} \quad -(5)$$

then:

$$\underline{\nabla} \times \underline{H} - \frac{\partial \underline{D}}{\partial t} = \underline{0} \quad -(6)$$

By definition:

$$\underline{D} = \epsilon_0 \epsilon_r \underline{E} = \epsilon \underline{E} \quad -(7)$$

and

$$\underline{B} = \mu_0 \mu_r \underline{H} = \mu \underline{H} \quad -(8)$$

where:

$$\epsilon_r = \frac{\epsilon}{\epsilon_0}, \quad \mu_r = \frac{\mu}{\mu_0} \quad -(9)$$

are the relative permittivity and permeability.

Therefore eq. (6) is:

$$\underline{\nabla} \times \underline{B} - \frac{\mu_r \epsilon_r}{c^2} \frac{\partial \underline{E}}{\partial t} = \underline{0} \quad -(10)$$

The phase velocity is:

$$v = \frac{c}{(\mu_r \epsilon_r)^{1/2}} \quad -(11)$$

$$= \frac{\omega}{\kappa}$$

In free space:

$$c = \frac{\omega}{\kappa} \quad -(12)$$

so in the medium (e.g. a liquid):

$$\frac{\omega}{\kappa} \longrightarrow \frac{1}{(\mu_r \epsilon_r)^{1/2}} \left(\frac{\omega}{\kappa}\right) \quad -(13)$$

The angular frequency red shift may be defined by:

$$\boxed{\omega \longrightarrow \frac{\omega}{\epsilon_r^{\,1/2}}} \quad -(14)$$

which is one possible solution of eq. (13).
The velocity is changed to:

$$v = \frac{c}{(\mu_r \epsilon_r)^{1/2}} \quad -(15)$$

The refractive index is:

$$n = \frac{c}{v} \quad -(16)$$

$$= (\mu_r \epsilon_r)^{1/2}$$

Eq. (14) is accompanied by:

$$\boxed{\kappa \rightarrow \mu_r^{\,1/2} \kappa} \quad -(17)$$

Eqs (14) and (17) are possible solutions of eq. (13).