60(3) : Absorption in Atoms and Molecules

This process depends on an interaction Hamiltonian:

$$H = -\underline{\mu} \cdot \underline{E} \quad -(1)$$

where $\underline{\mu}$ is the transition dipole moment and $\underline{E}$ is the electric component of the electromagnetic field. The electric field strength is:

$$\underline{E}^a = -\frac{\partial \underline{A}^a}{\partial t} - \underline{\nabla}\phi^a - c\omega^{0a}{}_b \underline{A}^b + \underline{\omega}^a{}_b \phi^b \quad -(2)$$

$$\underline{\nabla} \cdot \underline{E}^a = \rho^a / \epsilon_0 \quad -(3)$$

The interaction of the e/m field with the atom or molecule is therefore governed by the resonance equation:

$$-\underline{\nabla} \cdot \frac{\partial \underline{A}^a}{\partial t} - \nabla^2 \phi^a - c\,\underline{\nabla} \cdot \left(\omega^{0a}{}_b \underline{A}^b\right) + \underline{\nabla} \cdot \left(\underline{\omega}^a{}_b \phi^b\right) = \rho^a / \epsilon_0 \quad -(4)$$

The transition dipole moment $\underline{\mu}$ is defined by the charge density ρ^a of an electron in an orbital. For a plane wave in the standard model eq. (4) reduces to:

$$\nabla^2 \phi^a = -\rho^a / \epsilon_0 \quad -(5)$$

and orbital angular momentum is imparted to the electron from the field (photon). Eq. (5) is a Poisson equation with no resonance.

2) In eq. (4):

$$\underline{\nabla} \cdot \left(\phi^b \underline{\omega}^a{}_b\right) = \left(\underline{\nabla} \cdot \underline{\omega}^a{}_b\right)\phi^b + \underline{\omega}^a{}_b \cdot \underline{\nabla}\,\phi^b \quad -(6)$$

and

$$\underline{\nabla} \cdot \left(\omega^{0a}{}_b \underline{A}^b\right) = \left(\underline{\nabla} \cdot \underline{A}^b\right)\omega^{0a}{}_b + \underline{A}^b \cdot \underline{\nabla}\,\omega^{0a}{}_b \quad -(7)$$

If the vector potential is regarded as being a plane wave in the first approximation ~~then~~ $\underline{\omega}^a{}_b$ is dual to $\underline{A}^c$, so in this approximation:

$$\underline{\nabla} \cdot \frac{\partial \underline{A}^a}{\partial t} \sim \underline{\nabla} \cdot \underline{A}^b \sim \underline{\nabla} \cdot \underline{\omega}^a{}_b \sim 0 \quad -(8)$$

and eq. (4) becomes:

$$-\nabla^2 \phi^a - c\left(\underline{\nabla}\,\omega^{0a}{}_b\right) \cdot \underline{A}^b + \underline{\omega}^a{}_b \cdot \underline{\nabla}\,\phi^b = \rho^a / \epsilon_0 \quad -(9)$$

Now assume that $c\underline{A}^b$ is equal to $\underline{\phi}^b$, and that $\underline{\omega}^a{}_b$ is negative to obtain:

$$\boxed{\nabla^2 \phi^a + \left(\underline{\nabla}\,\omega^{0a}{}_b\right) \cdot \underline{\phi}^b + \underline{\omega}^a{}_b \cdot \underline{\nabla}\,\phi^b = \rho^a / \epsilon_0} \quad -(10)$$

This is

$$\boxed{\nabla^2 \phi^a + g\,\underline{\phi}^c \cdot \underline{\nabla}\,\phi^b + g\,\underline{\nabla}\,\phi^c \cdot \underline{\phi}^b = \rho^a / \epsilon_0} \quad -(11)$$

where g is a constant. Eq. (11) is an unharmonic oscillator