

EVANS / MORRIS RED SHIFTS FROM THE PLANCK DISTRIBUTION
IN BROAD BAND AND ATOMIC SPECTRA.

by

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ABSTRACT

Using a straightforward combination of the Planck distribution and the Beer Lambert law it is shown that fundamental quantum theory produces the Evans / Morris red shifts in all absorption spectra at any frequency of the electromagnetic spectrum. This finding is illustrated with the Debye and memory function theories of broad band absorption in liquids and similar, and by splittings induced in the spectrum of atomic hydrogen (H). The latter covers the entire range from the ultra violet to the microwave and lower frequencies. Fundamental quantum theory as used in this novel way shows that the initial probe frequency is red shifted and split into numerous lines as it propagates through the sample.

Keywords: ECE theory, Evans Morris red shifts, Debye and memory function theories, Schroedinger equation limit of the ECE wave equation, red shifted and split spectrum of atomic H.

UFT 306



1. INTRODUCTION

In recent papers of this series of three hundred and six papers and books of the UFT section of www.aias.us it has been shown {1 - 10} that fundamental quantum theory produces red shifts of an initial probe frequency in any absorbing sample. These shifts were first observed {1 - 10} by G. J. Evans and T. Morris at visible frequencies in condensed state samples such as liquids and glasses, and are recorded in comprehensive detail on the blog of www.aias.us. Experiments to observe these shifts took place over a span of approximately six years in two different laboratories. Visible frequency probe lasers were used and colour changes observed as the beam propagates through the sample. The experiments were repeatable and reproducible, and were immediately replicated by Dennis Davies as recorded on the blog of www.aias.us.

In Section 2 it is shown that the red shifts observed by Evans and Morris are due to fundamental quantum theory in which the well known intensities of the Beer Lambert law of absorption are described by the expression for intensity given by the fundamental Planck distribution. The theory is illustrated with the well known Debye and memory function theories of microwave and far infra red absorption in liquids and condensed matter in general. This theory is described in detail in Notes 306(1) and 306(2) accompanying UFT306 in the UFT Section of www.aias.us. As a probe of initial frequency ω_0 propagates through a molecular liquid for example the combination of the Planck distribution and Beer Lambert law means that its frequency becomes lower the further it propagates along a path length Z . This result could have been inferred by Planck in 1899 but the first signs of its existence were observed experimentally by Evans and Morris about six years ago (blog of www.aias.us). The entire spectrum is therefore red shifted along with fundamental optical properties such as photon linear velocity. It is shown in Section 2 and Notes 306(1) and 306(2) that the velocity

of a photon in a liquid is in general complex valued and always associated with photon mass. So any absorption spectrum at any frequency can be used to measure the photon mass. The latter is nowhere zero as in the obsolete standard model.

The same combination of the Planck distribution and the Beer Lambert law is applied to the spectrum of dilute gaseous atomic hydrogen (H) in Section 2 and Notes 306(3) to 306(6). It is well known that the wavefunctions of H can be calculated analytically from the non relativistic quantum limit of the ECE wave equation - the Schroedinger equation. The latter shows that the spectrum of H extends from the ultraviolet to the microwave and lower. It is shown in Section 2 that the absorption lines of the H spectrum are split and shifted to the red by fundamental quantum theory, the use of the Planck distribution in the Beer Lambert absorption law. Each line is split in a different way, defined by the well known quantum numbers and selection rules of the Schroedinger equation. All of these Evans / Morris shifts and splittings should be observable experimentally, and this is a new test of the quantum theory.

2. RED SHIFTS AND SPLITTINGS FROM THE QUANTUM THEORY.

Consider the nineteenth century Beer Lambert law for absorption {1 - 10}:

$$\frac{I}{I_0} = \exp(-\alpha Z) \quad (1)$$

where I_0 is the intensity in joules per square metre of radiation incident on a sample of path length Z . As the radiation propagates through the sample its intensity decreases to I and this process is characterized by the power absorption coefficient α . As shown in UFT300 and UFT304 the latter can be calculated from quantum theory, but the Beer Lambert law was known many years before the quantum theory was inferred in 1899 by Planck. The latter inferred that the intensity from his quantum theory is given by the well known Planck

distribution:

$$I = \frac{h\omega^3}{\pi^2 c^2} \left(\exp\left(\frac{h\omega}{kT}\right) - 1 \right)^{-1} \quad (2)$$

In Eq. (2) I is expressed in the S. I. Units of joules per square metre. Here ω is the angular frequency of the radiation, h the reduced Planck constant, k the Boltzmann constant and T the temperature. The assumption in Eq. (2) that the speed of light is c originates in the Rayleigh Jeans theory corrected by Planck. This is true only in a vacuum or dilute gas, and no longer true in condensed matter. It follows that:

$$I_0 = \frac{h\omega_0^3}{\pi^2 c^2} \left(\exp\left(\frac{h\omega_0}{kT}\right) - 1 \right)^{-1} \quad (3)$$

so the required ratio of intensities is:

$$\frac{I}{I_0} = \left(\frac{\omega}{\omega_0} \right)^3 \left(\frac{e^{y_0} - 1}{e^y - 1} \right) \quad (4)$$

where:

$$y_0 = \frac{h\omega_0}{kT}, \quad y = \frac{h\omega}{kT} \quad (5)$$

The speed of light fortuitously cancels in this ratio.

The fundamental combination of the Planck law and the Beer Lambert law is

therefore:

$$\frac{I}{I_0} = \left(\frac{\omega}{\omega_0} \right)^3 \left(\frac{e^{y_0} - 1}{e^y - 1} \right) = \exp(-\alpha Z) \quad (6)$$

and is a fundamental prediction of the quantum theory which immediately shows the existence of the Evans Morris red shifts, because for absorption:

$$\omega < \omega_0 \quad - (7)$$

In the Debye and memory function theories {1 - 10} the power absorption coefficient can be calculated theoretically as given below. In the theory of atomic spectra the integrated power absorption coefficient is well known to be:

$$A = \left(\frac{N}{V} \right) \frac{|\mu_{ji}|^2}{6 \epsilon_0 v \hbar} \quad - (8)$$

as in UFT300 and UFT304. In Eq. (8) there are N molecules in a volume V, μ_{ji} is the transition electric dipole moment, ϵ_0 the S. I. vacuum permittivity, v the speed of light in the sample, and \hbar the reduced Planck constant. In dilute gaseous H

$$v \sim c \quad - (9)$$

but in condensed matter, the speed of light is in general a complex quantity as discussed in UFT300 and UFT304, and is not c. So for atomic spectra, the quantum theory gives:

$$\left(\frac{\omega}{\omega_0} \right)^3 \left(\frac{e^{y_0} - 1}{e^y - 1} \right) = \exp \left(- \left(\frac{N}{V} \right) \frac{|\mu_{ji}|^2 Z}{6 \epsilon_0 v \hbar} \right) \quad - (10)$$

straightforwardly. In the high frequency approximation:

$$\hbar \omega \gg \hbar T, \hbar \omega_0 \gg \hbar T \quad - (11)$$

Eq. (6) becomes:

$$\frac{\omega}{\omega_0} = \exp \left(- \frac{2Z}{3} \right) \quad - (12)$$

In the low frequency approximation:

$$k \omega \ll k \tau, k \omega_0 \ll k \tau \quad - (13)$$

Eq. (6) becomes:

$$\frac{\omega}{\omega_0} = \exp\left(-\frac{\alpha Z}{2}\right) \quad - (14)$$

Now model the liquid state by the well known Debye theory of relaxation at the initial frequency ω_0 . The power absorption coefficient is given by:

$$d(\omega_0) = \frac{\omega_0 \epsilon''(\omega_0)}{n'(\omega_0) c} = \frac{\sqrt{2} \omega_0 \epsilon''(\omega_0)}{(\epsilon'(\omega_0) + (\epsilon'(\omega_0)^2 + \epsilon''(\omega_0)^2)^{1/2})^{1/2}} \quad - (15)$$

as in UFT300 and UFT304. Here $\epsilon''(\omega_0)$ is the dielectric loss, and n' is the real part of the complex refractive index:

$$\epsilon' - i\epsilon'' = (n' - in'')^2 = n'^2 - n''^2 - 2in'n'' \quad - (16)$$

where ϵ' is the real part of the complex permittivity. In the well known Debye theory:

$$\epsilon'(\omega_0) = \epsilon_\infty + \frac{(\epsilon_0 - \epsilon_\infty)}{1 + \omega_0^2 \tau^2}, \quad - (17)$$

$$\epsilon''(\omega_0) = (\epsilon_0 - \epsilon_\infty) \frac{\omega_0 \tau}{1 + \omega_0^2 \tau^2}, \quad - (18)$$

where ϵ_0 is the static permittivity and ϵ_∞ the infinite frequency permittivity, and

where τ is the Debye relaxation time characteristic of the material and frequency

independent.

As the beam propagates through a sample of path length Z , its frequency changes

to:

$$\omega = \omega_0 \exp\left(\frac{-d(\omega_0)Z}{2}\right) \quad - (19)$$

and this can be calculated for each inputted ω_0 and $d(\omega_0)$. So the entire spectrum is shifted to the red. This is the Evans / Morris shift in the Debye theory. The cosmological red shift is an example of an Evans / Morris shift in which the sample is inter stellar space over light years of propagation.

The basic optical equations are:

$$\frac{1}{v} = \frac{1}{c} (n' - in''), \quad - (20)$$

and:

$$\epsilon' = n'^2 - n''^2 \quad - (21)$$

$$\epsilon'' = 2n'n'' \quad - (22)$$

so the velocity of light in a material is in general complex valued and leads to the definition of the power absorption coefficient (α) as discussed in UFT304. Therefore:

$$\epsilon' = n'^2 - \frac{\epsilon''^2}{4n'^2} \quad - (23)$$

and so the real and imaginary parts of the refractive index are defined by:

$$n'^2 = \frac{1}{2} \left(\epsilon' + (\epsilon'^2 + \epsilon''^2)^{1/2} \right) \quad - (24)$$

and

$$n''^2 = \frac{4\epsilon''^2}{(\epsilon' + (\epsilon'^2 + \epsilon''^2)^{1/2})} \quad - (25)$$

respectively. Now define the complex velocity as:

$$v = v' + i v'' = \frac{c}{h' - i h''} \quad - (26)$$

so its real and imaginary parts are given by:

$$\frac{v'}{c} = \frac{h'}{h'^2 + h''^2} \quad - (27)$$

and

$$\frac{v''}{c} = \frac{h''}{h'^2 + h''^2} \quad - (28)$$

Therefore the real and imaginary parts of the photon velocity can be found from the Debye theory. The initial velocities are v_0' and v_0'' , and the velocities during the absorption process are v' and v'' . From the theory of complex numbers the squared modulus of the velocity is:

$$v_m^2 = |v v^*|^2 = v'^2 + v''^2 \quad - (29)$$

The photon mass is defined by the well known de Broglie / Einstein equation:

$$E = \hbar \omega = \gamma m c^2 \quad - (30)$$

in which the Lorentz factor can be defined by v_m :

$$\gamma = \left(1 - \frac{v_m^2}{c^2} \right)^{-1/2} \quad - (31)$$

Therefore the photon mass can be found from the Debye theory of relaxation. The initial photon mass is $m(\omega_0)$, and the photon mass during absorption is $m(\omega)$. Clearly, the photon mass is never zero.

It is well known that the Debye theory reaches its limitations in the far infra red, as described in detail in the early Omnia Opera papers on www.iais.us. The description of the

far infra red absorption of dipolar liquids needs the memory function theory developed in the early Omnia Opera. In the space of the Laplace variable:

$$p = -i\omega_0 \quad - (32)$$

the spectral function is described as:

$$\tilde{c}(p) = \frac{c(0)}{p + \frac{\kappa_0(0)}{p + \frac{\kappa_1(0)}{\dots}}} \quad - (33)$$

in a continued fraction of a hierarchy of memory function parameters: $\kappa_0(0)$, $\kappa_1(0)$, and so forth. The dielectric permittivity is:

$$\epsilon' = \epsilon_\infty + \frac{(\epsilon_0 - \epsilon_\infty)}{\omega_0} \text{Im} \tilde{c}(p) \quad - (34)$$

and the dielectric loss is:

$$\epsilon'' = (\epsilon_0 - \epsilon_\infty) \omega_0 \text{Re} \tilde{c}(p) \quad - (35)$$

The far infra red is adequately described by using the memory function:

$$\kappa_1(t) = \kappa_1(0) \exp(-\gamma t) \quad - (36)$$

whose Laplace transform is:

$$\kappa_1(p) = \frac{\kappa_1(0)}{p + \gamma} \quad - (37)$$

So the Evans Morris shifts and the photon mass can be found from the well known memory function theory of liquids.

The spectrum of H is given in wavenumbers from the Schroedinger equation as:

$$\bar{\nu} = 1.097373 \times 10^5 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \text{ cm}^{-1} \quad - (38)$$

and an example of a spectral series is given in the following table:

Transition	Lines	Wavenumber (cm^{-1})
$n' = 2$ to $n = 3$	3	15,241.4 (red, Hd)
$n' = 3$ to $n = 4$	5	5,334.4 (I.R.)
$n' = 4$ to $n = 5$	7	2,469.1 (I.R.)
$n' = 5$ to $n = 6$	9	1,338.8 (I.R.)
$n' = 6$ to $n = 7$	11	810.96 (I.R.)
$n' = 7$ to $n = 8$	13	524.54 (I.R.)
$n' = 8$ to $n = 9$	15	359.94 (F.I.R.)
$n' = 9$ to $n = 10$	17	257.41 (F.I.R.)
$n' = 10$ to $n = 11$	19	190.45 (F.I.R.)
$n' = 11$ to $n = 12$	21	144.91 (F.I.R.)
$n' = 12$ to $n = 13$	23	102.72 (F.I.R.)
$n' = 13$ to $n = 14$	25	81.52 (F.I.R.)
$n' = 50$ to $n = 51$	99	1.704 (microwave)

The selection rules for transitions are given from the Schroedinger equation as follows:

$$\text{any } \Delta n, \Delta l = \pm 1, \Delta m = 0, \pm 1 \quad - (39)$$

where n is the principal quantum number, and where:

$$l = 0, \dots, n-1 \quad - (40)$$

with

$$m = -l, \dots, l \quad - (41)$$

If the probe radiation is linearly polarized or amorphous:

$$\Delta m = 0 \quad - (42)$$

and if it is left or right circularly polarized the selection rules are

$$\Delta m = 1 \quad - (43)$$

and

$$\Delta m = -1 \quad - (44)$$

respectively. As described in detail on Note 306(4) the number of possible transitions in linear polarization is $2n' - 1$, and are given in the above table as "lines". Eq. (38) shows that the energy levels of the H atom do not depend on l and m , so in the absence of any other consideration, the lines in the table occur at the same frequency, given in the right hand side column of the table. This is the initial frequency of Eq. (10). As n' becomes larger the number of lines increases.

However, Eq. (10) means that the initially degenerate lines are split, because each line is generated by a different transition dipole moment of Eq. (10). As

the beam propagates through the sample the splittings become larger with longer Z. This is a direct prediction of the Planck distribution itself and therefore these Evans Morris shifts and splittings are a new test of the quantum theory. The latter predicts that the red Balmer line at $15,241.4 \text{ cm}^{-1}$ is split into three lines, all at a lower frequency. This splitting and shifting produces the colour changes observed by Evans and Morris in liquids. In H however the shifts and splittings are precisely defined. The far infra red line at 81.52 cm^{-1} is split into 25 and shifted to lower frequencies. The microwave line at 1.704 cm^{-1} is split into 99, all shifted to lower frequencies.

In left circular polarization of the probe radiation Notes 306(5) and 306(6) show that there are $n + 1$ lines in general. If left circularly polarized radiation is used, the red Balmer line is split into 5 by the Planck distribution used in the Beer Lambert law, i.e. split into 5 and red shifted by the Evans Morris effects. The far infra red line at 81.52 cm^{-1} is split into 170, all red shifted, and the microwave line at 1.704 cm^{-1} is split into 2,501 different lines in the microwave, all red shifted.

Clearly this is a severe new test of the quantum theory, because all these splittings must be observable experimentally and also be precisely described by the quantum theory in all polarizations. If this is not the case, the quantum theory fails at a basic level. If these shifts and splittings exist experimentally then a new and very useful type of spectroscopy emerges.

3. NUMERICAL ANALYSIS AND GRAPHICS.

Section by Dr. Horst Eckardt

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