

THE EVANS / MORRIS SHIFTS DUE TO ABSORPTION AND EMISSION

by

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ABSTRACT

The Beer Lambert laws for absorption and emission are derived from first principles and the Evans / Morris red shift and blue shift derived by using the Planck distribution for intensity, corrected for higher order infinitesimals left out of consideration by Rayleigh. It is concluded that the Evans / Morris red shift is due to stimulated absorption, and that the Evans / Morris blue shift is due to stimulated and spontaneous emission. Therefore any absorption or emission spectrum is always accompanied by a pattern of Evans / Morris shifts at any frequency of the electromagnetic spectrum.

Keywords: ECE theory, Evans / Morris shifts, Beer Lambert laws for absorption and emission.

UFT 300

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## 1. INTRODUCTION

In recent papers of this series of three hundred papers to date {1 - 10} on the development of Einstein Cartan Evans unified field theory, various theories of the Evans / Morris shifts have been developed. The Evans / Morris shifts are colour changes brought about by the propagation of laser light in liquids and solids. These are reproducible and repeatable shifts in frequency of visible laser light and are described in the blog or diary of [www.aias.us](http://www.aias.us) in many colour photographs. There can be shifts to lower frequency (red shifts), and those to higher frequency (blue shifts). Several types of theory of reflection and refraction have been applied to try to explain them in immediately preceding papers. In the course of development of the theory it was shown that Snell's laws are incompatible with conservation of momentum on the one photon level. It was also found that the frequencies of the incident, refracted and reflected light are in general different. They cannot be the same as in the standard physics. Reflection and refraction with monochromatic radiation were developed with the average energy of a Planck oscillator. During the course of extending this theory to polychromatic radiation a correction was given of the Rayleigh Jeans density of states for higher order infinitesimals left out of consideration by Rayleigh. This is a large correction that necessitates the re assessment of experiments designed to test the law. A Compton type theory of reflection and refraction was developed and the existence of photon mass incorporated in the theory.

In Section 2 a new theory of the Evans / Morris shifts is developed based directly on the most fundamental concepts of optics: the Planck distribution and the Beer Lambert law. It is concluded that the Evans /Morris red shifts are due to stimulated absorption and that the Evans / Morris blue shifts are due to stimulated and spontaneous emission. Any absorption spectrum at any frequencies of the electromagnetic spectrum generates a concomitant and

characteristic pattern of Evans / Morris red shifts. Conversely, any emission spectrum generates a pattern of Evans / Morris blue shifts. These conclusions are wholly new to optics and spectroscopy.

As usual this paper should be read in conjunction with its background notes (notes to UFT300 on [www.aias.us](http://www.aias.us)). Note 300(1) describes a combination of conservation of intensity in reflection and refraction with the Planck distribution. The refracting medium is described with a Beer Lambert law for monochromatic absorption together with Snell's laws. The absorption of the refracting medium is described with the Debye theory. The results of this note are described in Section 3. It is found that large shifts occur above the Debye frequency, defined as the inverse of the Debye relaxation time. Note 300(2) deals with the conservation of polychromatic intensity and incorporates the correction to the Rayleigh Jeans law found in UFT291. New equations are found for conservation of polychromatic intensity, assuming that the intensity of the incident beam is the sum of the intensities of the refracted and reflected beams. Note 300(3) gives some examples of spectra for the calculation of Evans Morris shifts using the intensity conservation method of Note 300(2). Section 2 is based on Notes 300(4) and 300(5), developing a combination of the Planck distribution and the Beer Lambert law for absorption (Note 300(4)) and emission (Note 300(5)).

## 2. BEER LAMBERT LAWS AND PLANCK DISTRIBUTION.

The Beer Lambert law for absorption means that the initial intensity decreases exponentially in an absorbing sample:

$$I = I_0 \exp(-\alpha l) \quad (1)$$

Here  $I_0$  is the initial intensity,  $I$  the absorbed intensity,  $\alpha$  the power absorption coefficient and  $l$  the path length. The law can be derived theoretically by using the Einstein B

coefficient for stimulated absorption. The Beer Lambert law is combined with the Planck distribution in this Section to give the result, in the given approximation:

$$\omega = \omega_0 \exp\left(-\frac{d_e l}{\lambda}\right) - (2)$$

where  $\omega_0$  is the initial angular frequency of the incident beam, and where  $\omega$  is its angular frequency in the sample. The angular frequency  $\omega$  in the sample depends on the power absorption coefficient and the path length as observed experimentally by Evans and Morris (photographs on the blog of [www.aias.us](http://www.aias.us)). So the Evans / Morris red shifts are given immediately by the well known Beer Lambert law for stimulated absorption. This means that the Evans Morris red shifts accompany any absorption spectrum at any frequency of the electromagnetic spectrum, and this is a result of the fundamental laws of quantum optics.

Similarly it is shown in this section that the Evans Morris blue shifts are given by:

$$\omega = \omega_0 \exp\left(\frac{d_e l}{\lambda}\right) - (3)$$

where  $d_e$  is the power emission coefficient for stimulated and spontaneous emission described by the well known Einstein B and A coefficients respectively. So the Evans / Morris blue shifts accompany any emission spectrum in any part of the electromagnetic spectrum. This is again the result of the most fundamental known laws of quantum optics.

In the obsolete physics there are no frequency shifts at all, and this dogma is in clear contradiction to the most fundamental quantum theory. It is refuted theoretically in immediately preceding papers and experimentally by the Evans / Morris effects.

Consider an electromagnetic beam of energy density  $U / V$  in joules per unit volume. Its energy flux density is:

$$\underline{\Phi} = c \frac{U}{V} - (4)$$

in watts per square metre (joules per second per square metre). Sometimes in the literature the flux density is known as the intensity, but in deriving the Beer Lambert law for polychromatic radiation a different definition of intensity as joules per square metre is used:

$$I = c\rho \quad - (5)$$

where  $\rho$  is the Rayleigh Jeans density of states defined as the energy density in the range  $\omega$  to  $\omega + d\omega$ .

The volume of radiation is defined as:

$$V = Al \quad - (6)$$

where A is its area and where

$$l = c\Delta t \quad - (7)$$

is the path length traversed by light propagating at c in an interval of time  $\Delta t$ . So the definition (7) is valid only in the vacuum or in air but is used in the standard derivation of the Beer Lambert law for stimulated absorption {1 - 10}. The total electromagnetic energy is:

$$U = \left(\frac{U}{V}\right)V = \left(\frac{U}{V}\right)Al. \quad - (8)$$

The infinitesimal of flux density in the range from  $\omega$  to  $\omega + d\omega$  is defined as:

$$d\Phi = c\rho d\omega = I(\omega) d\omega. \quad - (9)$$

From Eq. (9) the density of states is:

$$\rho(\omega) = \frac{1}{V} \frac{dU}{d\omega} \quad - (10)$$

so the intensity of polychromatic radiation is defined as:

$$I(\omega) = \frac{c}{V} \frac{dU}{d\omega} \quad - (11)$$

in units of joules per square metre, i.e. energy per unit area of the beam.

This is the definition of intensity used in the Beer Lambert law.

In the uncorrected Planck distribution:

$$P = \frac{1}{\sqrt{\pi}} \frac{dU}{d\omega} = \frac{\frac{8\pi\omega^3}{c^3}}{\pi^2 c^3} \left( \exp\left(\frac{h\omega}{kT}\right) - 1 \right)^{-1},$$

so the intensity is:

$$I = \frac{\frac{8\pi\omega^3}{c^3}}{\pi^2 c^3} \left( \exp\left(\frac{h\omega}{kT}\right) - 1 \right)^{-1} \quad -(12)$$

$$I = \frac{8\pi\omega^3}{3\pi^2 c^3} \left( \exp\left(\frac{h\omega}{kT}\right) - 1 \right)^{-1} \quad -(13)$$

In the corrected Rayleigh Jeans law of UFT291:

$$I = \frac{10}{3} \frac{\frac{8\pi\omega^3}{c^3}}{\pi^2 c^3} \left( \exp\left(\frac{h\omega}{kT}\right) - 1 \right)^{-1}. \quad -(14)$$

If:

$$\frac{h\omega}{kT} \ll 1 \quad -(15)$$

then:

$$I \sim \frac{10}{3} \frac{kT\omega^3}{\pi^2 c^3} \quad -(16)$$

and it follows immediately that:

$$\left(\frac{\omega}{\omega_0}\right)^2 = \exp(-\alpha l) \quad -(17)$$

i. e.

$$\frac{\omega}{\omega_0} = \exp\left(-\frac{\alpha l}{2}\right) \quad -(18)$$

which is the Evans / Morris red shift Q. E. D.

In order to derive the Beer Lambert law theoretically consider the number of

molecules per unit volume able to absorb light at frequencies in the range  $\omega$  to  $\omega + d\omega$  so that the total number of molecules in a given volume  $V$  is:

$$\frac{N}{V} = \int \frac{n(\omega)}{V} d\omega \quad - (19)$$

This is known as the number density. Note that  $n(\omega)$  has the units of time because  $N$  is unitless. Each photon in the beam has quantized energy  $\hbar\omega$  and quantized momentum magnitude  $\hbar\omega/c$ .

The rate at which one molecule absorbs a photon is given by the Einstein coefficient of stimulated absorption:

$$W_{if} = B_{if} \rho \quad - (20)$$

from a quantized state  $i$  to a state  $f$  within the molecule. Note that  $W$  has units of  $s^{-1}$ .

The rate of change of energy density per unit volume in the range  $\omega$  to  $\omega + d\omega$  is:

$$\frac{1}{V} \frac{dU}{dt} = -\hbar\omega W_{if} \frac{n(\omega)}{V} d\omega \quad - (21)$$

and dividing both sides by the infinitesimal of frequency gives:

$$\frac{dp}{dt} = -\frac{n(\omega)}{V} \hbar\omega B_{if} \rho \quad - (22)$$

This is an equation for the rate of decrease of the Rayleigh Jeans density of states as the photons are absorbed by molecules. Energy is lost from the electromagnetic beam and transferred to the molecules.

Note carefully that total energy and total momentum are conserved.

The initial electromagnetic energy entering the sample volume is:

$$E_i = \overline{I}(x) A dt \quad - (23)$$

and the electromagnetic energy leaving the sample is:

$$E_f = \Phi(x + dl) A dt - (24)$$

The principle of conservation of energy means that the energy lost by the beam is transferred to the material of the sample volume:

$$d\Phi = \Phi(x + dl) - \Phi(x) = \frac{A dl}{V} dU - (25)$$

and it follows that:

$$\frac{1}{V} \frac{dU}{dt} = \frac{d\Phi}{dl} - (26)$$

Eq. (26) is true for each frequency component of the beam, so for frequencies in the range  $\omega$  to  $\omega + d\omega$ :

$$\frac{dU}{V} = \rho(\omega) d\omega - (27)$$

and

$$d\Phi = I(\omega) d\omega - (28)$$

so:

$$\frac{d}{dt} (\rho(\omega) d\omega) = \frac{d}{dl} (I(\omega) d\omega) - (29)$$

and

$$\frac{dp}{dt} = \frac{dI}{dl} - (30)$$

The rate of change of the density of states with time is equal to the rate of change

of beam intensity with sample length.

From Eqs. (22) and (30):

$$\frac{dI}{dl} = -\frac{n(\omega)}{V} \frac{\hbar\omega}{c} B_{if} I = -\left(\frac{n(\omega)}{V} \frac{\hbar\omega}{c} B_{if}\right) I \quad (31)$$

Note carefully that the magnitude of the photon momentum:

$$K = \frac{\hbar\omega}{c} \quad (32)$$

appears in this equation. The equation can therefore be developed with photon mass theory.

From Eq. (31):

$$\frac{dI}{I} = -\alpha(\omega) dl \quad (33)$$

where the power absorption coefficient is:

$$\alpha(\omega) = \frac{n(\omega)}{V} \frac{\hbar\omega}{c} B_{if} \quad (34)$$

in units of inverse metres. Eq. (33) is the Beer Lambert law Q. E. D.:

$$I = I_0 \exp(-\alpha l) \quad (35)$$

More precisely, Eq. (35) is the Beer Lambert law for stimulated absorption.

Using Eq. (14) it becomes:

$$\left(\frac{\omega}{\omega_0}\right)^3 \left(\exp\left(\frac{\hbar\omega_0}{kT}\right) - 1\right) \left(\exp\left(\frac{\hbar\omega}{kT}\right) - 1\right)^{-1} = \exp(-\alpha l) \quad (36)$$

and in the approximations:

$$\frac{\hbar\omega}{kT} \ll 1 \quad (37)$$

$$\frac{\hbar\omega_0}{kT} \ll 1 \quad (38)$$

the Evans Morris red shifts are derived from fundamental physics, Q. E. D. :

$$\frac{\omega}{\omega_0} = \exp\left(-\frac{\alpha l}{2}\right). \quad (39)$$

Stimulated emission is defined by:

$$\bar{W}_{fi} = B_{fi}\rho \quad (40)$$

so:

$$W_{fi} = \bar{W}_{fi} \quad (41)$$

and stimulated emission of a photon is the opposite process to stimulated absorption of a photon. However, thermal equilibrium between electromagnetic radiation and matter requires consideration of spontaneous emission defined by the Einstein A coefficient:

$$A_{fi} = \bar{W}_{fi}. \quad (42)$$

The total rate of emission of photons from molecules is:

$$\bar{W}_{fi} = B_{fi}\rho + A_{fi}. \quad (43)$$

If there are  $N_i$  molecules in state i and  $N_f$  molecules in state f the total rate of absorption is  $N_i W_{if}$  and the total rate of emission is  $N_f \bar{W}_{fi}$ . At equilibrium these rates are equal:

$$N_f (A_{fi} + B_{fi}\rho) = N_i B_{if}\rho. \quad (44)$$

At thermal equilibrium

$$\frac{N_i}{N_f} = \exp\left(\frac{\hbar\omega}{kT}\right) \quad (45)$$

which is the Boltzmann distribution where k is Boltzmann's constant and T is the

temperature. It follows that the density of states is:

$$\rho = \left( \frac{A_{gi}}{B_{gi}} \right) \left( \exp\left(\frac{\hbar\omega}{kT}\right) - 1 \right)^{-1} \quad (46)$$

However the uncorrected Planck distribution gives the density of states as:

$$\rho = \frac{\hbar\omega^3}{\pi^2 c^3} \left( \exp\left(\frac{\hbar\omega}{kT}\right) - 1 \right)^{-1} \quad (47)$$

The result (47) is derived from assuming that:

$$\frac{dN}{V} = \frac{\omega^3}{\pi^2 c^3} d\omega \quad (48)$$

so that the infinitesimal of energy density is:

$$\frac{dU}{V} = \langle E \rangle \frac{dN}{V} \quad (49)$$

where:

$$\langle E \rangle = \hbar\omega \left( \exp\left(\frac{\hbar\omega}{kT}\right) - 1 \right)^{-1} \quad (50)$$

is the mean energy of the Planck oscillator as in immediately preceding papers on the Evans / Morris effects.

So:

$$\frac{dU}{V} = \frac{\hbar\omega^3 d\omega}{\pi^2 c^3 (e^\gamma - 1)} \quad (51)$$

where:

$$\gamma = \frac{\hbar\omega}{kT} \quad (52)$$

and:

$$\rho = \frac{1}{\pi} \frac{d\bar{U}}{d\omega} = \frac{\hbar\omega^3}{\pi^2 c^3} (e^{\gamma} - 1)^{-1} - (53)$$

which is Eq. (47).

However as shown in UFT291 the correct Eq. (48) is:

$$\frac{dN}{\pi} = \frac{\omega^3}{\pi^2 c^3} d\omega + \frac{\omega}{\pi^2 c^3} (d\omega)^3 + \frac{(d\omega)^3}{3\pi^2 c^3} = \frac{10}{3} \frac{\omega^3}{\pi^2 c^3} d\omega - (54)$$

so  $\rho$  is corrected to:

$$\rho = \frac{10\hbar\omega^3}{3\pi^2 c^3} (e^{\gamma} - 1)^{-1} - (55)$$

and:

$$A_{fi} = \left( \frac{10\hbar\omega^3}{3\pi^2 c^3} \right) B_{fi} - (56)$$

Therefore the total rate of emission of photons is:

$$W_{fi} = B_{fi} \left( \rho + \frac{10\hbar\omega^3}{3\pi^2 c^3} \right) - (57)$$

and increases sharply with frequency. In the process of emission of radiation from molecules,

the electromagnetic beam gains energy as it passes through the sample, so the sign of Eq.

(22) is changed. Total energy is conserved and the energy lost by the molecules through

loss of photons results in a gain of electromagnetic or radiation energy. So:

$$\frac{dp}{dt} = \frac{n(\omega)}{\pi} \hbar\omega B_{fi} \left( \rho + \frac{10\hbar\omega^3}{3\pi^2 c^3} \right) - (58)$$

From Eqs. (30) and (58):

$$\frac{dI}{dl} = \frac{n(\omega)}{\pi} \hbar\omega B_{fi} \left( \rho + \frac{10\hbar\omega^3}{3\pi^2 c^3} \right) - (59)$$

From Eqs. (55) and (59):

$$\frac{10\hbar\omega^3}{3\pi^2 c^3} = \rho(e^\gamma - 1) \quad (60)$$

so:

$$\frac{dI}{dl} = \frac{n(\omega)}{\sqrt{V}} \frac{\hbar\omega}{c} B_{fi} \exp\left(\frac{\hbar\omega}{kT}\right) I \quad (61)$$

and:

$$\frac{dI}{I} = d_e dl \quad (62)$$

where the power emission coefficient is:

$$d_e = \frac{n(\omega)}{\sqrt{V}} \frac{\hbar\omega}{c} B_{fi} \exp\left(\frac{\hbar\omega}{kT}\right) \quad (63)$$

From Eqs. (34), (41) and (63):

$$d_e = \exp\left(\frac{\hbar\omega}{kT}\right) d(\omega). \quad (64)$$

From Eqs. (45) and (64):

$$d_e = \left(\frac{N_i}{N_f}\right) d(\omega) \quad (65)$$

and the Beer Lambert law for emission is:

$$I = I_0 \exp(d_e l). \quad (66)$$

From Eqs. (5) and (66):

$$\rho = \rho_0 \exp(d_e l) \quad (67)$$

i. e. from Eq. (55):

$$\left(\frac{\omega}{\omega_0}\right)^3 \left(\frac{e^y - 1}{e^y + 1}\right) = \exp(d\ell), \quad -(68)$$

$$y_0 = \frac{k\omega_0}{kT}, \quad y = \frac{k\omega}{kT} \quad -(69)$$

If:

$$k\omega_0 \ll kT \quad -(70)$$

and

$$k\omega_0 \ll kT \quad -(71)$$

then:

$$\left(\frac{\omega}{\omega_0}\right)^2 = \exp(d\ell) \quad -(72)$$

i. e. :

$$\frac{\omega}{\omega_0} = \exp\left(\frac{d\ell}{2}\right) \quad -(73)$$

where:

$$d_e = d(\omega) \exp\left(\frac{k\omega}{kT}\right) = \frac{N_i}{N_f} d(\omega). \quad -(74)$$

This is the Evans / Morris blue shift, Q. E. D.

In the same approximation the Evans / Morris red shift is:

$$\frac{\omega}{\omega_0} = \exp\left(-\frac{d(\omega)\ell}{2}\right) \quad -(75)$$

so the two types of shift are closely related.

# The Evans/Morris shifts due to absorption and emission

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## 3 Numerical analysis and discussion

The energy density is given by Eq.(51):

$$\frac{dU}{V} = \frac{\hbar\omega^3}{\pi^2 c^3} \frac{d\omega}{\exp(\frac{\hbar\omega}{kT}) - 1}. \quad (76)$$

Evaluation of the integral with the abbreviation

$$a = \frac{\hbar}{kT} \quad (77)$$

leads to

$$\begin{aligned} & \int \frac{\omega^3}{e^{a\omega} - 1} d\omega \\ &= \frac{6}{a^4} \left( \text{li}_4(e^{a\omega}) - a\omega \text{li}_3(e^{a\omega}) + \frac{a^2 \omega^2 \text{li}_2(e^{a\omega})}{2} + \frac{a^3 \omega^3 \log(1 - e^{a\omega})}{6} \right) \\ & - \frac{\omega^4}{4} \end{aligned} \quad (78)$$

where  $\text{li}_n(x)$  are the polylogarithmic functions of order  $n$  for a complex argument  $x$ . From this result it cannot be seen that a simple, real-valued result comes out for the definite integral

$$\int_0^\infty \frac{\omega^3}{e^{a\omega} - 1} d\omega \quad (79)$$

because the polylogarithmic functions do not converge to zero for large arguments. Instead of investigating Eq.(78) further we introduce the substitution

$$y = \frac{\hbar\omega}{kT} \quad (80)$$

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which leads to

$$\int \frac{\omega^3}{e^{a\omega} - 1} d\omega = \left( \frac{kT}{\hbar} \right)^4 \int \frac{y^3}{e^y - 1} dy . \quad (81)$$

The integral over the whole frequency range is independent of the temperature and can be evaluated as a general constant. It is called *Bose-Einstein integral* with value

$$\int_0^\infty \frac{y^3}{e^y - 1} dy = \frac{\pi^4}{15} \approx 6.49 . \quad (82)$$

The factor gives the  $T^4$  dependence of the Planck distribution. In cases where the frequency range is restricted it would rather be interesting to evaluate

$$\int_{y(\omega_1)}^{y(\omega_2)} \frac{y^3}{e^y - 1} dy \quad (83)$$

in the frequency range between  $\omega_1$  and  $\omega_2$  which leads to smaller values which have to be determined numerically. To give an impression on the effects we have evaluated the integral (82) numerically as a function of the upper limit:

$$f(y_2) := \int_0^{y_2} \frac{y^3}{e^y - 1} dy . \quad (84)$$

The result is shown in Fig. 1. The frequencies on the  $y_2$  axis depend on the temperature and have to be determined from Eq.(80). The integral function converges to 6.49 for large  $y_2$ 's as expected. The integral values for a frequency interval  $[\omega_1, \omega_2]$  can be computed simply by the difference  $f(y_2) - f(y_1)$ .

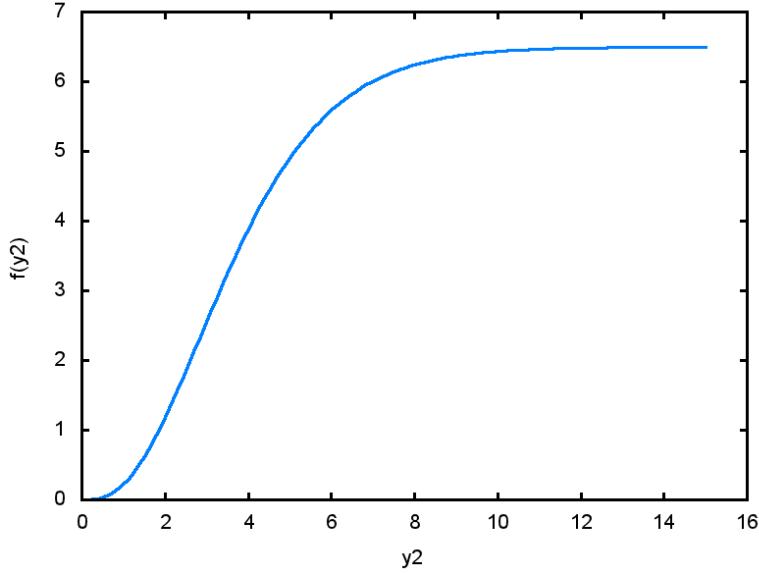


Figure 1: Graph of the integral function (84).

### 3. NUMERICAL ANALYSIS AND DISCUSSION

Section by Dr. Horst Eckardt

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