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Refraction as a Function of Molecular Gravitation: Fresh Insights into the Nature of Space, Mass and Energy and a New Possibility in the Creation of Metamaterials

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I. Introduction

To many respected scientists today the force of gravity remains basically the force with significance only in the world of macroscopic phenomena. This paper challenges the perception by demonstrating significant microscopic effects of gravity at the atomic and molecular level. But the greatest challenge of this work to our cherished scientific worldview concerns (a) the nature and explanation of refraction, (b) the relationship between mass and space and (c) the relationship between energy and volume.

Despite centuries of serious scientific investigation what we have today as scientific explanation of refraction in material mediums is no more than a hodgepodge of learned but conflicting opinions. However, a shaky consensus is building along the line of thought which seeks to explain refraction in terms of interactions between incoming energy and the energy systems of the particles constituting the medium. Some have viewed this interaction as atomic absorption of a particular wavelength followed by the emission of a shorter wavelength with the same frequency; others see it as the interaction between incoming photons and the phonons in the medium producing a number of waves whose overall wavelength is shorter than, while its frequency remains the same as, that of the incident wave; a few others see it differently.

The bending of light in the vicinity of a massive body, on the other hand, is explained as resulting from a completely different phenomenon, namely, the curvature of space-time.

All these explanations become entirely untenable in view of the relationship, presented in this paper, between refraction and gravitation. According to this study, the effect of the gravitational field on length is the explanation for both refraction in material media and the bending of light by massive bodies.

In a radical departure from the current view of mass as *that which causes space-time curvature* this paper is a firm statement that there can be no space without mass. Space (which turns out to be no more than the cosmic gravitational field) is getting more and more depleted as more and more of the cosmic mass gets converted into energy; and this depletion of space, according to this paper, must manifest itself as the expansion of the universe - an expansion which takes place not as our universe conquers more and more of a supposed extra-cosmos space but as every piece of matter in it expands through **length dilation** in a weakening cosmic gravitational field. In a weakened cosmic gravitational field the distance between the earth and some distant galaxy increases (as we expect from the length dilation prediction of General Relativity) and this increase of distance between the earth and distant galaxies is what observers on earth see as receding galaxies.

Further, this work asserts that volume is the property of energy and that without energy the mass of the whole universe would occupy zero volume (such would be an ideal or perfect cosmic black hole);.atoms have volumes depending on the quantity of energy each has. The validity of this assertion is brought out by demonstrating (a) how volume changes in atomic bonding can be used to calculate bond energies of the atoms and (b) how the density of a substance can be calculated from its molecular weight and the sum of the Van de Waal volumes of the atoms constituting the molecule.

II. Refraction and Molecular Gravitation

It all began with my own observation that the refractive index of a medium, n, is directly proportional to the gravitational field set up by its molecules, i.e., **$n = kGm/r^2$** ,where k has the value of 1.30 x 10^{16}, G is the gravitational constant, m and r are the mass and the radius of the medium's molecule. Thus for water, whose molecular radius is 139 pm.[1] at 25 C, **$n = 1.3 \times 10^{16} \times 6.67 \times 10^{-11} \times 18 \times 1.66 \times 10^{-27} / (139 \times 10^{-12})^2 = 1.34$ (cf. 1.33),** using wavelength 581 nm. Similarly, for carbon disulfide, with a molecular radius of 258 pm (computed from carbon-sulfur bond length of 155 pm [2] and covalent radii for carbon and sulfur as 77 pm and 102 pm respectively) [3] and atomic weights for C and S being 12 and 32, $n = 1.3 \times 10^{16} \times 6.67 \times 10^{-11} \times 76 \times 1.66 \times 10^{-27} / (258 \times 10^{-12})^2 = 1.64$ (cf. 1.63)[4]

Diamond is made up units each of which consists of five atoms (four covalently bonded to a central one) all packed in a geometry which yields a sphere of radius 191 pm. This gives $n = 1.3 \times 10^{16} \times 6.67 \times 10^{-11} \times 60 \times 1.66 \times 10^{-27} / (191 \times 10^{-12})^2 = 2.37$ (cf. 2.41)[4]. (Deviations from the expected values, in brackets, are insignificant given the approximations in atomic radius tables)

More examples could be given.

III. Interpretation

My interpretation of this observation led to the following conclusions:

a) *Refraction through material mediums (e.g. water or glass) and the bending of star light by a massive body are caused by the same phenomenon, namely, gravitational length contraction*

Refraction in a medium of refractive index n occurs because in the gravitational field of the medium the wavelength of the radiation being observed contracts from l_0 in vacuum to l_0 / n in the medium, the frequency does not change because the observer and the clock are in n = 1. Thus for this observer the velocity becomes $fxl_0/n=c/n$. But if observer and clock were in the medium (were it possible for the observer to be in the intermolecular spaces of a glass slab, for instance) the frequency would increase to nf_0 due to gravitational time dilation; and the velocity of the radiation (for the observer in the medium) would be $nf_0 \times l_0/n = f_0 \times l_o = c$. In other words, the velocity of an electromagnetic wave is the same for all observers as long as the observer is in the refracting medium.

b) *There is a relationship between the volume of an atom or a molecule and the energy in that atom or molecule*

The observation that $n = kGm/r^2$ suggests that the circumference of the molecule, rather than any point inside it, is the crucial region for refraction; and the observation that, in general, n decreases with rising temperature suggests (in the light of $n = kGm/r^2$) that molecules (as we shall in deed show below) actually expand on absorbing energy. These two observations lead us to postulate that the volume of an atom or molecule is equal to the energy in it; in deed, I have been able to establish that the volume of a hydrogen atom represents electromagnetic energy at the rate of 5.15×10^{-26} J/pm^3.Thus when two hydrogen atoms are brought together to form a covalent bond their radii shrink from 120pm. to 37pm i.e. a total volume decrease of $2x4pi/3(120^3 - 37^3)$ representing energy release equal to $2 \times 4pi/3\ (120^3 - 37^3) \times 5.15 \times 10^{=26} \times 6.02 \times 10^{23} = 437$ kJ/mol. Notice that this energy is, in fact, the H-H bond energy[5]; notice, also, that this postulate is validated as it explains the Hydrogen Morse Curve very satisfactorily. In deed, the postulate affords us the possibility of constructing many formulations for important scientific quantitative analysis, e g.

(1) The covalent bond energy, BDE, between two atoms of the same element Y is given by $BDE = 2.6 \times 10^{-4}(Y^3 - (N/Z)^3y^3)$ kJ/mol. where Y, y, N and Z are , respectively, the vdw radius, covalent radius, nucleon and atomic number of the element. Thus, the vdw and covalent radii of carbon being 171 pm and 77 pm while its N and Z are 12 and 6, the C-C bond energy comes to **350 kJ/mol (cf. 348 kJ/mol.)** [5]. Similarly, for oxygen with N, Z and vdw radius as 16, 8 and 152 pm, and taking its covalent radius as 71.7 pm (rather than the more familiar 73 pm [6] for reasons to be given later), the O-O bond energy works out to **146 kJ/mol. (cf. 148`kJ/mol.)** [7]. Deviations from the expected values (bracketed) are insignificant for our illustrative purposes here. With minor modifications, this formula can be used to determine the bond energy between any two elements known to Chemistry.

(2) What science has hitherto defined as the *density of a substance* now turns out to be (for covalently bonded molecular substances) the ***ratio of molecular mass to the sum of Van de Waal radii of the atoms constituting the molecule.*** Thus for water (H2O with vdw radius for H and O as 120 pm and 152 pm respectively) we have, at 25C, $\text{density} = 18 \times 1.66 \times 10^{-27} / ((4pi/3\ (2 \times 120^3 + 152^3) \times 10^{-36}) = 1021$ kg /m^3 (cf. 1000 kg /m^3) Similarly, for ethanol (C_2H_5OH), $\text{density} = 46 \times 1.66 \times 10^{-27} / ((4pi/3\ (2 \times 170^3 + 6 \times 120^3 + 152^3) \times 10^{-36})) = 767$ kg /m^3 (cf. 789 kg /m^3. The slight but significant deviations from expected values are mainly due to intermolecular hydrogen bonding (in the case of water) and molecular polarity in the case of ethanol. Again, with minor modifications, this formula can be extended to determine the density of any substance.

c) *The gravitational field of the universe is not in space but it is itself space*

The fact that length contracts in a stronger, while expanding in a weaker, gravitational field can tell us a lot about the relationship between the gravitational field and what science calls space. To see this, we must answer the question: Why does length change in different gravitational fields? The question is most satisfactorily answered if we postulate that the gravitational field is space which means that an object entering a region of weaker gravitational field has to expand in search of space; conversely, an object entering a stronger gravitational field has to shrink since it now encloses (what we describe below as) ***higher density*** space. Let us explain: Consider a cube of side y placed in a region of n =1. If the gravitational field is increased to double n, each side of this cube will contract to y/2 shrinking the volume to $y^3/8$ which means we can now fit 8 cubes in the place of one just by doubling the n. Thus a volume of y^3 in a region of n = 1 is equivalent to a volume of $y^3/8$ in a region of n = 2. In other words, a region of higher gravitational field is *more spacious* than a region of lower gravitational field. Suppose, to give a further illustration, an atom is placed alone in a universe as big as our own. If the gravitational field in this universe is then decreased slowly towards zero, the atom will continue to expand until it fills the whole universe; at that point (when the field is only slightly above zero) space in that universe has become so little that a single atom will occupy the whole of it. Notice the implied distinction between *space* and *volume:* the amount of space enclosed by a particular volume depends on the density, n, of that space.

We are now in a position to explain many hitherto unsatisfactorily explained scientific observations, e.g.

(1) *Why a moving stick shrinks in length.* Increasing the velocity of the stick from 0 to v, relative to the observer, increases the mass of each molecule in the stick from m_0 to $m_0 / (1-v^2/c^2)^{1/2}$ (as we know from General Relativity). But this increase in mass will cause an increase in n from n_0 to $n_0 / (1-v^2/c^2)^{1/2}$ .Now we know, from the foregoing, that when n increases by a certain factor, length will contract by the reciprocal of that factor (e.g. when n is doubled, length is halved); so the radius of each molecule in the stick above, and therefore the length of the whole stick as we shall show below, will contract by the reciprocal of $(1-v^2/c^2)^{-1/2}$. Thus the new length of the stick l' is given by $l' = l_0 (1-v^2/c^2)^{1/2}$. In other words, the relativistic equation for length contraction, and in deed for time dilation, is now seen to be a corollary of the corresponding equation for mass increase.

(2) *Why the universe expands.* Cosmic mass is continually being lost through stellar mass-energy conversions; this means that cosmic n is continually falling due to this decrease in mass as well as due to the fact that the energy released occupies more and more of cosmic space. The decrease in cosmic n means an expansion of the distance between an observer on Earth and a star out there, hence the observed Dopplar red shifts. This immediately leads to a cosmogony: the primeval 'atom' was an enormous perfect black hole and the Big Bang was a sudden conversion of a chunk of this black hole mass into energy.

d) The fabric of the universe is made up of the gravitational and the electromagnetic fields moving at c relative to each other

From everything we have said so far, it is clear that the formula $n = kGm/r^2$ can be generalized into $n = kE$, where E is the gravitational field. Thus as E approaches infinity, i.e. as we approach the black hole situation, n approaches infinity. Notice that where the velocity of light is infinitely low (as in a perfect black hole), time also moves infinitely slowly just as it moves infinitely fast where the velocity of light is infinitely high. This tells us that time is no more than a consequence of the fact of the relative motion between the gravitational and the electromagnetic fields.

Since energy occupies space (space as gravitational field), we expect that once a particular region of the gravitational field is occupied by energy that region should be at zero gravity. This is what we see inside the atom or molecule: the region from the nucleus to the circumference of the molecule, which is occupied by molecular energy, has zero gravitational field. Notice that it is across this zero gravitational field where we expect gravitons to be flying past at c. This means that we must distinguish between a **field** (gravitational or electromagnetic) and the field's **quanta of propagation:** the field is, *more or less*, at rest relative to the observer [8] but gravitons or photons are propagating at c relative to the observer.

Granted, then, that an atom (between the nucleus and the circumference) is a quantity of electromagnetic energy occupying (and so reducing to zero) a particular region of the atomic gravitational field let us turn to investigate what happens when (i) an incoming photon strikes an atom (ii) when an atom enters a lower gravitational field *and it is not allowed to expand*.

(i) When an incoming photon hits an atom, two events are possible:

(1) If the photon is of a non-absorbable wavelength it will pass through the molecule at infinite velocity suffering refraction only in the intermolecular gravitational field – infinite velocity because in that region E is zero and so n = 0 and the velocity = infinity , i.e., on reaching a point on the atom's circumference, the photon *instantaneously* finds itself on the opposite side of the circumference; and this is what we should expect because, for the photon, there is no space (E = 0) inside the atom as this space has been occupied by the atom's energy .

(2)If the photon is absorbable, it gets absorbed and because there is no space inside the atom or molecule this absorbed photon must find space beyond the already occupied region causing the molecule to expand. If these absorbable photons come in such a rapid succession as to make the molecule a net absorber the molecule will expand as the temperature rises. This leads us to underline, as we demonstrate, the fact that (contrary to current scientific scholarly consensus) *thermal expansion of a substance is actually due to the thermal expansion of its constituent molecules*.

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Let us show this.

The average kinetic energy of a gaseous molecule is **fkT/2** (where f = degrees of freedom, T = absolute temperature and k is the Boltzmann constant. This energy (according to the energy / volume rate of 5.15 x 10-26, see above) represents **molecular volume = f kT/2 x 5.15x10^{-26} pm^3**. If this molecule now absorbs a quantity of energy equal to the molecular specific heat capacity, its temperature will rise to (T+1) and its volume will increase to **f k/2(T+1) x 5.15x10^{-26} pm^3**. Therefore the coefficient of thermal cubic expansion **B** is given by **B=5.15x10^{-26}xfk/2(T+1-T) / fkT/2 x 5.15x10^{-26} = 1/T** which is the expected value for any gas.

But we must now answer two very important questions: (i) we know that kinetic energy of a molecule is not the only energy the molecule has and this means that the molecule's *kinetic* volume (i.e. volume representing its kinetic energy) is only a fraction of the molecule's total volume. If this is so then how can the thermal coefficient of the molecule's kinetic volume be equal to the thermal coefficient of the molecule's total volume? (ii) And how can the thermal coefficient of each molecule be equal to the thermal coefficient of the bulk sample constituted by the molecules?

To answer both questions we must bear in mind the central thesis of this work, namely, the refractive index is directly proportional to Gm/r^2 where r is the molecular radius. So, if the molecule expands, r increases and n drops. If the n of each molecule in the sample drops by the same amount, the n in the whole intermolecular space will drop by this same amount. Therefore the whole sample constituted by these molecules will find itself in a region of decreased n with the result that its volume increases. It can be shown quantitatively that the thermal expansion coefficient of kinetic volume is in deed equal to that of both the volume of the whole molecule and the volume of the whole bulk sample.

(ii) When an atom enters a lower gravitational field it should (as we saw above) expand; but if this atom is *not allowed to expand* (as in our next illustration) it will be forced to shed away some of its energy in response to space decrease with the result that its volume shrinks.

Let us illustrate this. When two H-atoms are brought so close together that they touch each other let us realize that *at the point of touch* each of these atoms enters a zero gravitational field region and so it should begin to expand phenomenally but the bonding between these atoms (which starts as soon as they touch each other) prevents them from expanding; the result is that each atom gives up so much energy that its radius shrinks from 120 to 37 pm.

*e) The idea of **space-time curvature** must be replaced by that of **space density***

Mass does not curve space; rather mass (as the source of gravitational field) engenders or creates space; and in this space length and time will expand or contract depending on (a) the density, n, of this space (which varies inversely proportionally with distance from the centre of mass) and (b) the space density of the region of the observer. This explains why the idea of space-time curvature *actually works* as a model of scientific explanation and analysis.

Once we recognize that space is the cosmic gravitational field and that time is simply a consequence of the fact of the relative motion between this field and the electromagnetic one then we see immediately that the quantity *space density,* with n as its measure, is best suited to explain every physical phenomenon related to the effects of gravitation. I believe we should be able to show, in the light of everything said so far, that every motion in our universe is ultimately one and the same motion, namely, the relative motion between these two cosmic fields: the gravitational and the electromagnetic.

IV. Application

This link between the refractive index and molecular gravitation is certainly going to find extensive application in the whole enterprise of science and technology. I am already trying to figure out how it might be employed in the creation of Metamaterials.

V. Notes

(1) http:/www. chem 1.com/acad/sci/aboutwater.html
(2) http:/commons.wikipedia.org/wiki/FileCarbon_disulphide
(3) http:/www.wikipedia.org/wiki/Atomic radii of elements
(4) http://www.science.uwaterloo … bondl.html
(5) See (4) above.
(6) See (3) above
(7) See (4) above
(8) Observer and field at relative velocity << c