ENERGY COMPRESSIBILITY

Astrophysics and Variable Speed of Light (VSL) Theories

Part 1: Compressible Flow and Relativity

$$c^2 = c_o^2 - V^2/n$$

$$\mathbf{A} \rightarrow \mathrm{B}$$

(+n) (-n)

INTRODUCTION

This Website presents a new, physically based, variable speed of light (VSL) theory which is an application of standard compressible fluid flow theory.
The theory treats energy flows and associated transformations of matter as being *compressible.*

Several recent approaches towards solving major problems in cosmology and astrophysics connected with comic inflation, dark matter and dark energy have involved abandoning the currently accepted fixed value for the speed of light **c** in space (3×10^8 m/s). Such theories are called **Variable Speed of Light Theories (VSL)**. Currently, most of these proposals are still in the stage of *ad hoc* speculation.

However**, compressible** energy flow theory**,** is an application of well established, standard gas dynamics and aerodynamic theory [1,2] and is therefore based on a century of scientific and engineering results. **It introduces the necessary VSL condition as a physically-based formulation**, instead of a tentative, ad hoc VSL proposal.

First, we outline the basic concept of energy compressibility and show its relationship to the variable speed of light, and to relativity.

Then, because the compressible energy flow equation contains a parameter (**n)** which represents the number of ways the energy of the system is divided, and which can have either positive or negative integral values, the theory introduces the possibility of a **binary universe** [$A \rightarrow B$] in which transformations of matter can take place involving release of radiant energy.

THE NATURE OF ENERGY

The name energy is derived from a Greek root relating to work or relating to activity [Gk. *energeia; energes* from *en*-on + *ergon*- work].

The precise scientific concept of energy in science emerged only quite late in the 19th century. Previously, the idea was implicit in Galileo's concept of mechanics, and later it was called by Huygens *vis viva* or living force. Energy is still today a somewhat subtle concept [3]. This is probably due to the fact that it emerges from the mechanics of motion, not as a directly observable entity, but only as a calculated quantity $\frac{1}{2} mV^2$ which is conserved or unchanged in magnitude during physical motions (V). This conserved or unchanging quantity which is involved in the mechanical motions of a material body of mass **m** is named **kinetic energy** usually denoted by T: **[K.E. = T = ½ mV^2].**

A second kind or category of energy is stored energy or **potential energy.** The sum of these two kinds of energy, kinetic and potential, is the total mechanical energy E of the system, and this is the quantity that is conserved. Of course, in a complete treatment of the subject other kinds of energy such as electrostatic and electromagnetic energies, gravitational energy, chemical energy, surface free energy, and so on must be included, but in our present thermodynamic approach the mechanical energy will suffice.

Since energy is always conserved in any physical change, it is obviously a powerful and fundamental scientific concept. As so it is a curious fact that the science of mechanics can actually be formulated (

in terms of force and momentum) without ever bringing in the concept of energy at all. However, alternatively, it is also possible to formulate mechanics entirely from the concept of energy, and this approach, the Hamiltonian formulation, results in the most general and powerful formulation of the science of mechanics. It is little wonder that energy appears as a fundamental but still subtle concept.

It should also be pointed out that the concept of compressibility is applied here only to energy flows between material particles, or to energy flows within the various physical *fields,* such as the electromagnetic field, the gravitational field, the quantum field and so on. There is no question of postulating the separate physical existence of an energy field *per se.*

COMPRESSIBLE ENERGY FLOW: A Fundamental, Variable Speed of Light (VSL) Theory

The standard, kinematical, steady flow, compressible energy equation is [1,2]:

$$c^2 = c_o^2 - V^2/n \qquad \textbf{(1)}$$

where **c** is the **variable compressive wave speed in a fluid**, c_o is the usual constant, or static wave speed of the fluid in the absence of any **relative flow V,** and **n** has values 1,2,3….. Here **n** specifies the number of ways the energy of the compressible flow is divided. In a material gas, such as air, for example, **n** is equal to 5 (three space motions for the air molecules in the x, y, and z directions, plus one motion each for their rotation and vibration).

[In engineering and thermodynamics, the ratio of the specific heats **k** = c_p/c_p is often used instead of n. The relationships between n and k are: n = 2/(k **-** 1) and k = (n + 2) /n].

Next, we extend the compressible energy flow concept from a material fluid to the flow of light i.e. to a flow of photons. The question of whether this is justified will be dealt with later, where it will be shown that compressibility at the critical or Mach 1 flow speed (where V = c = c*; V/c* = 1 = M) brings about physical changes that convert longitudinal, compressive wave motions (e.g. acoustic type, compressible waves) into the necessary transverse wave motion, such as must apply to a flow of photons of light in a compressible electromagnetic field, and which will justify the extension of the compressible energy theory to the case of light and other electromagnetic phenomena. It is also perhaps worth pointing out that an incompressible medium would have an infinite wave speed; consequently any finite wave speed, such as the speed of light in space, suggests that compressibility may be involved.

For **isothermal flow**, that is for flow with constant temperature, n is equal to infinity. This makes the term V^2/n in Eqn.1 equal to zero and so c always just equals c_o. This means that for isothermal flow, relative motion (V) has no effect on the wave speed c.

For one-dimensional energy or particle flows, such as in a linear accelerator, **n** equals 1. For uniform motions such as in the Michelson-Morley experiment which will be discussed in detail below, **n** appears to be equal to 9. For accelerated flows n appears to have values between 1 and 8.

The **critical wave speed** c* occurs when the flow speed V equals the wave speed. This is called the **Mach 1 speed**; V = c =c* and V/c = V*/c* = M = 1. Speeds less than the critical speed are **subcritical** (in gases they are called subsonic). Speeds greater than the critical speed c* or V* are called **supercritical** (in gases, supersonic). At the critical speed the physical behaviour of the medium alters, becoming stiff or quasi-solid so to speak. In supercritical flow the wave equations alter to resemble those governing vibrating strings or membranes.

The **maximum flow speed** is the escape to a vacuum V_{max}, which is given by **$V_{mav} = \sqrt{n}\, c_o$** . Therefore, for any value of n greater than unity the escape flow speed V_{max} is greater than the maximum wave speed c_o by the amount $\sqrt{n}$.

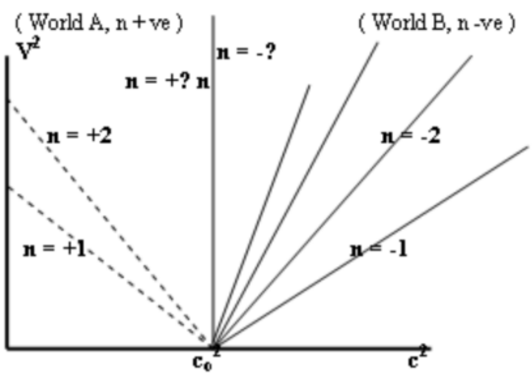
We see that, once compressibility occurs in a flow, then the wave speed c is no longer a constant but varies with the relative flow velocity V. When V is zero the wave speed has its maximum or static value c_o. As V increases, the wave speed c diminishes from the maximum wave speed c_o in an amount given by Equation 1, and vice versa. . When the flow speed V equals the maximum or escape speed V_{max} , the wave speed c has decreased to zero.

For unsteady energy flow, such as in a wave pulse, we have an additional term added to Equation 1:

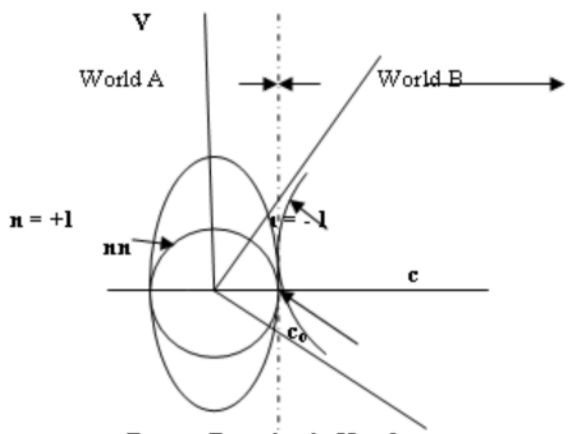
$$\mathbf{c^2 = c_o^2 - V^2/n - 2cV/n} \qquad \mathbf{(2)}$$

The extra energy term, interaction energy, or 2cV term in Eqn. 2 may indicate the physical basis for the **wave/particle duality** of quantum physics..

The plot of the energy equation $c^2 = c_o^2 - V^2/n$ (±n) is as follows:



Energy Equation in V² and c²
(n positive = World A; n negative = World B)



Energy Equation in V and c
(n positive = elliptical and World A; n negative = hyperbolic and World B)

(Note that in World B there is no upper limit to either V or c).

The first physically based, variable speed of light theory appeared in 1979, and work has continued since then **[Power, 4, 5, 6, 7, 8, 9, 10, 11]. O**ther VSL theories have been advanced, mostly *ad hoc* proposals designed to solve various cosmological problems that have arisen with general relativity **[Moffatt, Magueijo, Barrow,Youm [12,13,14,15].**

LONGITUDINAL COMPRESSIVE WAVES AND TRANSVERSE ELECTROMAGNETIC WAVES

There are innumerable, striking, insightful analogies between compressible flow and nearly all parts of physics. However, if these are to be more than interesting similarities, we must establish that the compressible wave speed c in Eqn. 1 corresponds physically to the speed of a **transverse,** electromagnetic wave, for example light waves at speed c. This transverse wave nature of electromagnetic disturbances was a fatal problem for the validity of the old 'ether medium' theory in the early 20th century.

With **compressible** flow, however, we can now invoke the physical transformation that takes place at the critical or Mach 1 speed ($c = V = V^*$; $V^*/c = M = 1$), where the flow physically transforms to a shock discontinuity whose longitudinal compression physically restricts all vibration to the transverse direction only. Essentially, the uniformly moving electron emits no electromagnetic waves; once acceleration or vibration of the electron sets in, electromagnetic waves (photons) are emitted. These, on the present compressibility theory, are now compression wave/particles with only lateral or transverse wave motions physically permitted. The photons then travel at the compressive local wave speed c. In space, with no relative flow V, c becomes the static wave speed c_o equal to 3×10^8 m/s. In the presence of matter and when there is relative motion we have two different possibilities:

a) Steady relative motion: $c = c_o [1- (1/n) (V/c_o)^2]^{1/2;}$;

b) Unsteady, pulsed, or accelerated relative flow: $c = c_o [1 \pm (1/n) (V/c_o)]$

Steady motions, since they involve a second order term in the ratio $V/c_{o,}$ affect the speed of light appreciably only for large velocities. Even the orbital speed of the earth at 30 km/s affects the speed of light by not more than one part in a billion or so.

Unsteady motions or accelerations, since they involve a first order term in the ratio V/c_o, can detectibly affect the speed of light for relative flow speeds which are a factor of 10^4 smaller than steady motions, i/e down to a meter per second and less..

The complete evaluation of the concept of compressibility against all the experimental facts on the nature and speed of light is obviously a very considerable task. A full theoretical treatment of development of transverse wave motion in critical, compressible flow requires advanced gas dynamics and electromagnetic theory. It will be of interest to see how many of the varied electromagnetic phenomena can be encompassed by compressibility considerations, and what unexpected new insights may emerge. Many close analogies between electromagnetic and hydrodynamic phenomena have, of course, long been known [16].

COMPRESSIBLE ENERGY FLOW AND RELATIVITY

The concept of relativity in physics can have several meanings. We have (a) *physical* relativity and (b) *reference coordinate* relativity. Physical relativity can be illustrated in the case of the of air flow past the wing of an airplane. Here only the relative speed of the air past the wing is physically relevant. It does not matter to the physical pressure forces whether the air is blowing past the airplane wing on the ground, or if the wing is moving through the air in flight. Only the relative air flow V past the wing determines the physical pressure effects of lift and drag on the wing. This is the meaning of relative motion V in the theory of compressible fluid flow.

When we come to the flow of light we must also distinguish physical from coordinate relativity, and in each case we must avoid uncritical assumptions about the physically relevant speed.

The compressible flow velocity V in Equation 1 is a physically relative flow. One might suspect therefore that compressibility of flow has something to say about the theory of relativity, and this is indeed so. If we put the mass m into Eqn. 1 explicitly, we have

$$(m)c^2 = (m)c_o^2 - (m)\ V^2/n = E$$

which has the form of the familiar special relativity mass/energy relationship $E = mc^2$, but now with a variable wave speed c and a kinetic energy term V^2/n·.

In compressible flow, the physical behavior of the flow in terms of pressure, density, temperature, wave speed, and so on does not depend on whether the flow is moving past a material body or whether the body is moving through the compressible field. Both are relative motions and will have the same physical effects.

When we turn to measurements of the speed of light in space, we shall find, if we assume that light is a compressibility effect, that we will have to adjust our light speed for any motion or speed of our measuring apparatus through space, since by Equation 1 any relative motion V will alter the speed of light c.

This problem with light arose very soon after the nature of light as an electromagnetic wave was discovered in the late nineteenth century. The addition of the speed of light **c** to the velocity **V** of a light measuring instrument, for example, an interferometer mounted on the earth which is moving through space at V = 30 km/s around the sun, was soon found to be a big problem. Compressible flow was then not at all well understood, and so the addition of velocities was made using only the classical or so-called Galilean method. How this attempt failed, and how the solution embodied in Einstein's special relativity theory came to gradually be adopted, will now be discussed.

1. The New Problem with Addition of Velocities

The classical or "Galilean" addition of velocities is algebraically straightforward. To take a nineteenth century example , of the kind used by Einstein to demonstrate the classical addition of velocities, if a train is moving through a railroad station at V_t = 20 mph and a passenger on the train is walking through the railroad car toward the engine at V_p= 3 mph, then his speed over- the- ground as seen by the stationmaster is simply the sum of the velocities, 20 + 3 = 23 mph or [$V_t + V_p = 23$]. The Galilean transformations between one inertial coordinate frame and another moving relative to it at velocity V are expressed as follows:

$$x = x' + vt$$

$$y = y'$$

$$z = z'$$

$$t = t'$$

$$u_x = u_x' + V \quad \text{(Classical direct addition of velocities)}$$

Turning to the case where light waves are involved with the motion of material bodies, researchers at first reasoned that, since light was now thought to be a wave, then the light wave must be moving in some sort of universal wave medium or 'electromagnetic ether', just as sound waves move in the material medium, air. Measurements of the speed of light in an apparatus such as an interferometer on the earth's surface should then show an addition of light velocity **c** to the velocity of the earth through space V_o of 30 km/s ($c + V_o$) along that direction, but, at right angles to the motion the speed of light, would remain unaltered at c. The effect on the speed of light of this difference ($c + V_o$) versus c, although very small- it being only about one part in a billion - could be measured in a sensitive interferometer designed by the American physicist **Michelson.** The effect of the difference in velocities along the orbital motion and at right angles to it should show up in the interferometer as a tiny displacement or 'shift' in the position of the light interference fringes as the instrument was rotated through a 90 degree angle. The equation for the expected fringe shift δ calculated on direct addition of velocities is:

$$\delta = [2(V/c)^2]\, l / \lambda$$

where l is the optical path length (in Miller's instrument l was 32 m and λ the wavelength of the light used was 5.7×10^7 m) , V is the relative motion of the earth in orbit 30 km/s, and c is 3×10^8 m/s, the speed of light in space.

For the dimensions of the instrument used by Miller, for example, the expected fringe shift should have been 1.12 fringes. The tests, however, showed that only about 1/9 th of the expected shift predicted by the classical addition of velocities actually occurred. Expressed in terms of velocity through space, this small observed shift corresponded to about 1/3 of the expected orbital velocity of the earth i.e. to only about 10 km/sec versus 30 km/sec. What was wrong?

Several decades of great debate and repetition of the Michelson experiment followed. The result was always the same. The expected, classically calculated fringe shifts were never observed. Either the much smaller than expected fringe shifts that were observed had to be explained, or they had to be discarded as experimental error and some other theory of light propagation through space devised.

2. The Fitzgerald/Lorentz Solution to the Problem of Addition of Velocities

Fitzgerald and **Lorentz** independently (on the assumption that the small observed fringe shifts were actually just experimental noise and should be taken as a zero shift) proposed that the orbital motion of the earth through space somehow compressed or contracted the electrons of the interferometer itself along the direction of the motion in just the right amount to mask the predicted fringe shift completely. This purely *ad hoc* solution to the problem produced the Fitzgerald/Lorentz contraction factor γ, which can be expressed as .

$$l'/ l = [1 - (V/c)^2]^{1/2} \text{, or}$$

$$l/ l' = [1 - (V/c)^2]^{-1/2} = \gamma$$

where l is the length of the instrument at rest, and l′ is the (contracted) length when moving at velocity V. c is the speed of light through space (3×10^8 m/s). In terms of the Michelson interferometer, l would be the length of the optical arm at right angles to the earth's motion and **l′** would be the length of the contracted arm along the direction of the orbital motion through space around the sun. When the instrument is rotated through 90 degrees the lengths would become interchanged. By applying this correction factor to the velocity additions in the two different directions the fringe shift predictions became zero.

Of course, this meant discarding the small observed fringe shifts and treating them as being zero. However, they were certainly very small, and could be considered as being within the experimental error of most of the instruments of the day. Lorentz expanded his theory and derived corresponding corrections to length and time measurements in relatively moving systems which would be in accord with a nil effect of the Michelson/Morley experiments.

It is important to note that the Fitzgerald/Lorentz explanation, although somewhat odd, is still a physical one. They proposed this physical contraction of as body's length in order to nullify or exactly cancel out the classical addition of velocities which was giving a far too large fringe shift prediction. Still, the solution somehow seemed artificial, since when one tried to measure the orbital motion of the earth through the electromagnetic ether or through space, the proposed physical contraction effect intervened to just exactly cancel the effect of the motion and made it impossible to observe. Was motion real and precisely calculable, or was it just apparent and relative? On another view, the new contraction factor was just a sort of fudge factor which served to reconcile a bad prediction with observation.

3. Einstein's Special Relativity Solution

In 1905 **Einstein** proposed a radical solution that succeeded in deriving the Fitzgerald /Lorentz contraction factor, not from the proposed physical contraction, but from two apparently contradictory physical propositions. This theoretical derivation, although seemingly irrational, gave the same contraction factor that Fitzgerald/Lorentz had proposed, and so it quieted the intellectual uneasiness of many physicists with the unexpected results of the Michelson/Morley type experiments.

What Einstein essentially did was this. He argued that, since we cannot detect motion through space (i.e. if we take the Michelson-Morley type attempts at motion detection as showing no motion at all) therefore all motions are relative. Thus two uniformly moving systems have the same laws of motion. Both are equally valid, and the same laws of nature, such as simple addition of velocity, should apply in each. Next, he assumed that all measurements are made with light signals or by other electromagnetic observations. Thus the constant and finite speed of light comes into the matter, and the second of his two propositions emerges, namely the <u>constancy of the speed of light for all observers even those moving relatively to each other</u>.

When his two postulates are combined, the Fitzgerald /Lorentz contraction factor automatically emerges from his theory. In addition to producing the desired contraction factor Einstein's derivation also gave reconciling equations for length and time which were identical to the Lorentz transformations, and so this added to their credibility as revealing a fundamental discovery of some mysterious complexity in nature itself.

To take a simple, but still accurate, illustration using the addition of velocities and his constant light speed assumption, we have in one system the speed of light as c (and so its squared value is c^2). In another system moving uniformly with respect to the first system at the velocity V, we have the speed of light as seen from the stationary system to be $[c^2 - V^2]^{1/2}$ Now, according to Einstein's relativity assumption there is no preferred reference measurement frame and one value is as good as the other. Moreover the speed of light must actually be the same for all observers, and so we are obliged to set the values for each of them as equal

$$c^2 = [\, c^2 - V^2 \,]$$

This is an obvious algebraic impossibility ,and so to reconcile the numerical incompatibility, Einstein then introduced a factor γ which would automatically make them equal, so that there would be no algebraic contradiction and calculations adding the speed of light to the full speed of material bodies could still be made between moving systems with no arithmetic error, as follows

$$c^2 = \gamma^2 \, [c^2 - V^2]$$

And, dividing by c^2, we get the value of his adjustment or ‘transformation’ factor γ

$$\gamma = [1 - (V/c)^2 \,]^{-1/2}$$

We see that this is the Fitzgerald/ Lorentz contraction factor which has now emerged automatically from Einstein’s two assumptions. He then went on to apply this correction factor to length, time, and to all of the subsidiary or related physical quantities of velocity mass, work, energy and so on:

$$1/\gamma = [1 - (V/c)^2 \,]^{1/2} = l' / l = dt' / dt = W/W_o = E_o / E = m_o / m \text{ etc.}$$

However much Einstein succeeded in reconciling an assumed zero result of the Michelson-Morley experiment with retaining the classical addition of velocities, his procedure of equating things that are clearly unequal seemed to most scientists to be somehow unreasonable, and therefore only to be accepted because it was required **by the nature of physical reality itself**, that is to say, that it was imposed or **required by the experimental facts**.

However, in actual fact, the Michelson-Morley experiments never produced a zero observed fringe shift; there was always a small shift of about 1/10 of the classically expected value, but it was never zero. So now today, if the small residual fringe shifts of all Michelson/Morley experiments can be explained by a sound physical theory, then the abandonment of strict rationality would no longer be an experimentally based requirement, and would now be scientifically unjustified.
For the review of the Michelson-Morley experiments see **APPENDIX A** ***Compressible Photon Flow and The Results of Michelson-Morley Type Experiments***

It may be well to point out here that, from the point of view of compressibility theory and its Equation 1, the correct procedure is not the addition of **velocities** but, instead, it is the **addition of energies.** This is perhaps why Einstein, in effect, in order to derive his special relativity contraction factor γ, had to equate not two unequal velocities c and (c - V) but the squares of the velocities, i.e. two **energies (** assuming unit mass**)** c^2 and $(c^2 - V^2)$ to get his $c^2 = \gamma^2 \, (c^2 - V^2)$.

4. Historical scientific quotations on the relativity problem

At this point, to properly set the historical background, we shall turn to some comments by scientists over the years on this theory of relativity.

1. *Special Relativity*, **A.P. French**, Norton, New York, 1968

"In the first encounter with Einstein's relativity, one may get impressions like these:

There is a lot of algebraic wizardry - much of it bewildering. One can learn to do some of the tricks, but it doesn't make much physical sense. Such feelings are very natural. No matter how long one has lived with the results of special relativity, there is something very non-intuitive about it… But relativity does make good sense and is not in a separate compartment from Galileo-Newton".

2. *Space, Time and Matter.* **Hermann Weyl.** Dover, New York, 1952

"Although conditions were such that, numerically, even only 1 per cent of the displacement of the fringes expected by Michelson could not have escaped detection, no trace of it was to be found when the experiments was performed.

In fact, not only the Michelson-Morley experiment but a whole series of further experiments designed to demonstrate that the motion of the earth through space around the sun has an influence on combined mechanical and electromagnetic phenomena, have led to a nul result..

We are to abandon our belief in the objective meaning of simultaneity; it was the great achievement of Einstein in the field of the theory of knowledge that he banished the dogma from our minds and this is what leads us to rank his name with that of Copernicus."

3. *The Emperor's New Mind.* **Roger Penrose.** Vintage 1990.

"It may seem outrageous to introduce such a strange concept of time-measure, at variance with our intuitive notions. However, there is now an enormous amount of experimental evidence in favor of it."

4. *A Brief History of Time*. **Stephen Hawking**. Bantam Books, 1988.

"The special theory of relativity was very successful in explaining that the speed of light appears the same to all observers (as shown by the Michelson-Morley experiment) and in describing what happens when things move a speeds close to the speed of light."

5. *Introduction to the Theory of Relativity.* **Peter Gabriel Bergmann. Dover, 1942.**

" The Lorentz transformation equations do away with the classical notions of space and time. The experiment of Michelson and Morley has been repeated many times under varying conditions. All these new experiments have confirmed the original results, with the exception of those which were carried out by D.C. Miller. It is very difficult to decide why Miller's experiments show an effect which appears to indicate an 'ether drift' of about 10 km/sec. However, since all the evidence of other experiments points to the accuracy of the Lorentz transformation equations, it is reasonable to assume that Miller's results were caused by systematic experimental error which has not yet been discovered. "

6. *Theory of Relativity.* **Wolfgang Pauli**. Preface 18 Nov. 1956 Inn Dover . 1981.

"There is a point of view according to which relativity theory is the endpoint of classical physics , which means

physics in the style of Newton-Faraday-Maxwell, governed by the 'deterministic" form of causality in space and time.

By its epistemological analysis of the consequence of the finiteness of the velocity of light (and with it all signal velocities) the theory of special relativity was the first step away from naïve visualization. The concept of the state of motion of the luminiferous ether, as the hypothetical medium was called earlier, had to be given up , not only because it turned out to be unobservable, but because itt became superfluous as an element in mathematical formalism, the group-theoretical properties of which would only be disturbed by it."

7. *Special Relativity* . **Albert Shadowitz**. Dover. 1968

" ..the correctness of the Michelson-Morley experiment. This experiment, however, had been performed very carefully. It duplicated, with much greater accuracy, the results of an earlier experiment carried out by Michelson alone in 1881. Also, when the experiment was repeated by others the same results were obtained. The velocity was always the same, for all observers, in all directions. There was no way out: the Michelson-Morley experiment was correct. It violated common sense by stating that the velocity of light in a vacuum, c, was the same for all observers. But it was true.

(Einstein's) second axiom was that c, the velocity of electromagnetic waves in a vacuum, was indeed a constant for all observers. At the time it was made, his was a very bold step, for the experimental evidence in favor of this was not then overwhelming, as it is today. Then as now, it was contrary to common sense. This axiom accepted the experimental evidence as fact."

8. *Space and Time.* **Hermann Minkowski**. 108. In the Principle of Relativity, a collection by Dover, New York 1952.

"The views of space and time which I wish to lay before you have sprung from the soil of experimental physics, and therein lies their strength. They are radical. Henceforth space itself and time itself, are doomed to fade away into mere shadows, and only a kind of union of the two will preserve an independent reality."

9. As usual, **R. Bruce Lindsay and Henry Margenau** are factual, comprehensive and balanced. In their *Foundatuons of Physical Reality*, Dover 1957 they write:

"Michelson's interferometer method was sensitive enough to detect a chan"ge by the shift in the interference fringes brought about by a rotation of the apparatus. When the experiment was first performed in 1881 the values … obtained were of the order of one-tenth to one-fourth of the expected value.

The strange results were attributed to experimental error, and it was concluded that the experiment was inconsistent with the assumption of a stationary ether with respect to which the earth moves. Alternatively, one could say that even if the earth does move through the ether the experiment might, for some reason, be incompetent to detect this motion. When the experiment was repeated more carefully and with more elaborate apparatus by Michelson and Morley in 1887 the result was that the indicated relative velocity of the earth and ether did not exceed one-fourth of the earth's orbital velocity. , As D.C Miller has pointed out, this was not strictly speaking a null result. Nevertheless, it has been so interpreted for many years.

The experiment has been repeated with various modifications and refinements a great many times/. The work of Miller has been the most extensive and appears to indicate a genuine positive result with a time difference corresponding to a maximum velocity of about 10 km/sec, which however has a slight seasonal variation. (Other observers (mentioned in Miller's paper, to which reference should be made for details) have reported results corresponding to velocities as low as 1 km/sec. and have interpreted them as indicative of a nul effect. It seems

clear that the whole question is still an open one and further work should be carried out. The situation is interesting, for a great deal of theorizing during the last years of the nineteenth century and the first part of the twentieth were based definitely on the existence of a nul result of the experiment."

[Just how pivotal the Michelson-Morley results are can be seen from the following additional comments by Lindsay and Margenau in the same book]:

"It must be confessed that the theory of relativity is by no means complete, its greatest shortcomings being its failure to take account of electromagnetic properties and of the quantum theory in the quantum domain… It may be appropriate to raise again the question discussed in connection with the experimental findings of D.C. Miller and their bearing on the special theory; if the predicted observations of an eventually modified general relativity theory do not agree with the precise experimental results , what attitude should one take towards the theory? Its real realm of usefulness in the future will in all probability be in the field of cosmological speculation."

10 .**D.C. Miller** himself put it this way (*Reviews of Modern Physics*. July 1933):

"Since the Theory of Relativity postulates an exact nul effect from the ether-drift-experiment which had never been obtained in fact, the writer (Miller) felt impelled to repeat the experiment. "

Both Lorentz and Einstein took an intense interest in the D.C. Miller extensive work, meeting with him, discussing his results and encouraging him to continue the tests.

11. **Einstein** himself is characteristically both restrained and straightforward in his assertions:

***(a) Relativity*. Hartsdale House, New York. 1947: "If the principle of relativity were not valid we would therefore expect that the direction of motion of the earth at any moment would enter into the laws of nature. However, the most careful observations have never revealed any such anisotropic properties in terrestrial physical space."**

(b) In his original paper entitled *On the Electrodynamics of Moving Bodies* . Annalen der Physik, 1905 (The Principle of Relativity . Dover , New York, 1952), he wrote: "the unsuccessful attempt to discover any motion of the earth relative to the light medium suggests that the phenomena of electrodynamics as well as mechanics posses no properties corresponding to the idea of absolute rest".

(c) (Scientific American , March 1930 quotes Einstein as saying : *"If Professor Miller's research is confirmed, my theory falls, that's all."*

5. The New Compressible Energy Flow Solution to the Velocity Addition Problem:

In 1979 it was first realized that the theory of compressible energy flow had something fundamental in common with the Einstein theory of relativity. The work began with a study *Shock Waves in a Photon Gas* (4)] on the Fizeau Effect related to the speed of light in moving water. A proposal was requested by NASA and a number of papers followed **Power [4,5,6,7,8,9,10,11].** The connection to relativity arose because the fundamental Fitzgerald/Lorentz/Einstein contraction factor $(1- (V/c)^{2)})^{-1/2}$ has exactly the same (inverted) form as in the compressible energy flow equation for the special case where n, the energy division parameter is unity. We have the steady flow energy equation

$$c^2= c_o^2 - V^2/n,$$

and, dividing through by c_o to get the compressibility ratio of wave speeds c/c_o, we have

$$c/c_o = [\, 1 - 1/n(V/c_o)^2 \,]^{1/2},$$

which is identical to the inverse of the Fitzgerald/Lorentz/Einstein factor $\gamma = [\, 1 - (V/c_o)^2]^{-1/2}$ with n set to unity.

In compressible flow, the Lorentz contraction factor γ becomes a physical speed of light ratio c_o/c.

At first, this remarkable result was simply interpreted as showing that special relativity was basically a physical compressibility effect, since all the transformations for length, time, mass, work, velocity etc. could now be derived by simply computing the wave speed compression ratio c/c_o, for the case where n = 1:

$$c/c_o = 1/\gamma = [\, 1 - 1/n(V/c_o)^2 \,]^{1/2} = l'/l = dt'/dt = W/W_o = E_o/E = m_o/m = \nu/\nu_o \text{ etc.}$$

Later, however, the analysis led to a critical review of the numerous Michelson-Morley type experiments over the past century. It was then realized that the discarded, small, residual, observed fringe shifts effects in that experiment, which Lindsay and Margenau emphasized were real, **could all now be interpreted as a detection of the (local) motion of the earth (and the attached Michelson interferometer) through space at the orbital speed of 30 km/s.**

This is because, when the Michelson-Morley type results were reanalyzed using various values for the energy partition parameter n, it was found that n = 9 gave a very good fit to the experimental data from a dozen or so separate experiments, and that the fit improved as the sophistication of the instruments improved, with the deviation being less than 1% for some highly stable laser interferometers where the experimental errors are minimal.

The Miller interferometer had an optical path length l of 32 m, and the wave length of light λ was 5.7 x 10^{-7} m. The classical fringe shift expected with the orbital speed of the earth V taken as 30 km/s was $\delta = [2(V/c)^2]\, l / \lambda$ which gives shift of 1.12 fringes. The observed value was 0.122. When the compressible formula $[2(V/c)^2]\, l / n\lambda$ with n = 9 is used, the expected fringe shift becomes. 0.124, in good agreement with the observed value.
Further tests by Michelson et.al., Kennedy and Thorndike, Illingworth, Joos, Picard and others followed. These all give results with n = 9 which agree with the compressibility predictions. See **APPENDIX A *Compressible Photon Flow and The Results of Michelson-MorleyType Experiments***

We can see more clearly the changed situation with compressible flow if we restate the fringe shift equation to include the energy partition parameter n. We then have for the fringe shift

$$\delta = [(V/c)^2]\, 2l / \lambda n \qquad (3)$$

and for the 'contraction' factor γ, we have

$$c/c_o = 1/\lambda = [\, 1 - 1/n(V/c_o)^2 \,]^{1/2} \;;\text{ or } \gamma = [\, 1 - (V/c_o)^2 \,]^{-1/2} = c_o/c \qquad (4)$$

Let us now examine three different physical cases.

First we take **isothermal flow where n is equal to infinity** ($n = \infty$**)**. In this case the expected fringe shift becomes zero from Eqn. 3 and the wave speed c becomes always c_o for all observers. These two conditions match the Einstein assumptions of a zero detectible fringe shift in Michelson-Morley-Miller optical experiments, and also yield his constant value for c for all observers on internally consistent physical flow grounds. However, his Lorentz contraction factor then simply becomes unity! Special relativity, when physically based, becomes internally inconsistent. Furthermore, if the system is isothermal, then the speed of light is constant and all the related dynamic and thermodynamic variables (V, p. v. T, ρ, etc.) must also be constant; therefore there can be no forces, and no global cosmic expansion or contraction without violating the first law of thermodynamics. The constant speed of light proposition therefore appears to be inconsistent with the observations of mechanics, of gravitation and of an expanding universe.

Second, if we **take n equal to 1,** we get the Lorentz/Fitzgerald contraction factor from Eqn. 4 in the same form as Einstein did, but now the predicted fringe shift of Eqn. 3 becomes the maximum value predicted by the classical addition of velocity which is never experimentally observed. Moreover, the speed of light must now be a variable and dependant on the flow speed V, thereby contradicting his constant speed of light assumption.

So if we take the Einstein constant speed of light assumption we inevitably we get the wrong fringe shift, and if we take his Lorentz transformation factor we must get a variable speed of light.

However, when we **take n = 9**, we get the predicted fringe shift values for the Michelson-Morley-Miller experiments which are actually observed. Therefore, compressible flow equations yield fringe shift values which agree with the observations, and are physically and internally consistent; in contrast, special relativity is internally contradictory, is not physically based, and its fringe shift predictions do not agree with experiment **APPENDIX A** ***Compressible Photon Flow and The Results of Michelson-MorleyType Experiments***

Thus, while compressibility can physically explain, simply and directly, a positive shift from Equation 3, special relativity cannot. For special relativity, Eqn. 3 is to be discarded, and, instead, a rather involved argument must be advanced for the existence of an (unobserved) length contraction. This hypothetical contraction in a specific direction is designed to exactly cancel a predicted fringe shift and to justify an essentially arbitrary decision to claim that all fringe shifts observed under uniform motion must actually be zero. In compressible flow fringe shifts continually occur as the fractional speed of light $\Delta c/c_o$ changes due to observable relative motion V, or due to the equally observable fractional changes in frequency $\Delta\nu/\nu_o$].

An so we are back to the possibility envisioned by Lindsay and Margenau in the excerpt above, namely that: (a) the Michelson Morley experimental results are real, (b) they fit a self-consistent, experimentally verified physical theory, (c) the earth's orbital, and axial motions through (local) space are detectible by optical or electromagnetic observations. What are the consequences?

6. Unsteady Flow and Acceleration: Effect on Spatial Directionality of Michelson-Morley Fringe Shifts

There were two problems with Miller's results. First, his observed fringe shifts while undoubtedly real, were only about one third (and the corresponding 'ether drift' velocities only about one ninth) of the classically expected values. Second, everyone agreed that his maximum fringe shifts should occur when one of the interferometer arms is aligned with the orbital speed ($V_o = 3 \times 10^8$ m/s) at noon and midnight, and would therefore be periodic at 6 hourly intervals. Instead, they occurred almost randomly at other times during the sidereal day as the earth turned on its axis in space. Both of Miller's problems must be addressed.

We have shown above (and in Appendix A) that the first problem of the magnitude of the fringe shifts is resolved when the compressible flow parameter n = 9 is introduced. The second problem, the directionality of the fringe shift maxima, requires taking into account the hitherto neglected accelerated motions that are associated with the rotation of the interferometer itself on its own axis as the reading are made.

These rotational motions are very small in comparison with the orbital speed of 30,000 meters per second. But, the steady flow of the earth's orbital motion is a second order effect in the ratio of V and c_o i.e. $[(V_o/c_o)^2]$, with the fringe shift given by

$$\delta = (2l / \lambda) [(V^2/c_o^2)] /n \qquad (3)$$

whereas, in the case of unsteady flow, that is for accelerated motions and pulse flow, we have instead a first order equation in (V/c_o) and a first order fringe shift:

$$\delta = (2l/ \lambda) (V/c_o)/n$$

And so, even very small motions, if they are unsteady or involve accelerations, can produce fringe shifts which are comparable to those produced by the much larger uniform orbital speed. We also must not uncritically assume that the value for n is always the same for accelerated motions as for uniform or steady flow motions.

Let us, for example , consider the tangential rotational speed V_T of Miller's interferometer. The instrument was 4 m in diameter and rotated once in 50 seconds. The tangential rotation velocity V_T was therefore about 0.25 m/s.

Inserting Miller's value of 32 m for the optical path length l and 5.7×10^{-7} m for the wave length of light, the fringe shift to be expected is $\delta = (2l / \lambda)(0.25/c_o)/n$. For n = 9 we get 0.094. For n = 2 the shift is 0.047, and for n = 9 it is 0.01. This additional rotational fringe shift is also periodic in a half-turn of the instrument, just as is the case for the orbital fringe shift. Therefore it will interact with the latter effect to obscure the expected dependence of maximum orbital fringe shift on the noon and midnight orientations. This interaction or interference could therefore account for Miller's second problem of lack of an expected six hourly **directionality i**n his orbital fringe shifts.

For the radial component of rotational motion, ($V_r = 0.16$ m/s), the associated fringe shift is 0.06 for n = 1, for n equal to 2 it is 0.03 and for n = 9 it is 0.007, the effect being periodic in a full 360 degree turn of the instrument. This radial acceleration may possibly account for the so-called full turn effect which Miller always observed, and which had about the same magnitude as the orbital half-turn fringe shift. Morley, Miller and Lorentz were all quite concerned with the full turn effect. Miller in his data analysis simply filtered out the large first harmonic shift and retained only the second harmonic or half turn periodic effect as pertinent to the orbital speed or ‘ether drift’ test. Lorentz considered that the full turn effect challenged the validity of special relativity and that the existence such an effect would be forbidden by it [21].

The introduction of accelerations into the fringe shift calculation clearly complicates the matter. However, it also - together with the introduction of a variable energy partition parameter n - allows us to explain the observations of the various classical Michelson-Morley type experiments in a satisfactory manner. The matter of accelerations and the possible variability of n in such cases will be discussed in more detail in the next section.

7. Results of Laser/Maser/Oscillator Tests on the Variability of the Speed of Light in Space

Following the optical Michelson-Morley type experiments described above, there were a number of tests carried out using masers and lasers and crystal oscillators in various configurations and combinations.. These include:

22. Ives, H.E., and Stillwell, G. R. An Experimental Study of the Rate of a Moving Atomic Clock *J. Opt. Soc. Amer*. 28, 7, 215-226, (1938) .

23. J. P. Cedarholm and C.H. Townes, A New Experimental Test of Special Relativity. *Nature*, **184**, 1350-51 (1959).

24. T.S. Jaseja, Javan, J. Murray, and C.H. Townes, Test of Special Relativity or of the Isotropy of Space by the Use of Infrared Masers. *Phys. Rev.* **133**, A1221 (1964).

25. Brillet, A and Hall, J.L. Improved Laser Test of the Isotropy of Space. *Phys. Rev. Letters* 42,9, 49 (1979).

26. Wolf, P., et al. Test of Lorentz Invariance using a Microwave Resonator. *Phys. Rev. Lett*. 90, 6, 060402 (2003).

27. Muller H, et al., Modern Michelson- Morley Experiment using Cryogenic Optical Resonators. *Phys. Rev. Lett*. 91, 2, 020401, (2003).

All of these tests involved measuring a frequency change $\Delta\nu$ against the expected Lorentz frequency relationship for uniform flows. One group of tests involves a $(V/c_o)^2$ or second order term

$$\nu = \nu_o \; [\, 1 - (V/c_o)^2 \,]^{1/2}$$

None of these researchers suspected, however, that the compressibility parameter **n** might be involved and that the proper test, instead, might be

$$\nu = \; = \nu_o \; [\, 1 - (1/n)\,(V/c_o)^2 \,]^{1/2} \quad ; \quad \Delta\nu/\nu_o = 1 - [\, 1 - (1/n)\,(V/c_o)^2]^{1/2}$$

In addition, we have seen above that acceleration terms can be about the same order of magnitude as the steady flow effects usually sought. For this second group, which comprises the unsteady flows, and starting from rest conditions with c_o as the rest wave speed, we have a first order equation in (V/c_o)

$$\nu/\nu_o = 1 \pm (1/n)(V/c_o), \text{ or}$$

$$\Delta\nu/\nu_o = (1/n)(V/c_o)$$

Since all of the published laser/maser/oscillator tests ignore both the energy partition parameter **n** and acceleration effects, their conclusions are now more or less invalid.

A complete analysis of all the recent tests listed is outside the scope of the present study. In some instances not enough information on the precise dimensions of the instrumentation and the operational procedures is given in the original papers to reassess the results arising from unsteady flow effects. More seriously, in most cases, large frequency shifts arising from rotation are simply discarded completely as presumably due to magnetic or other effects, or to systematic frequency drift, and only the residual changes in the shifts at different times of the day are examined.

(1) **Stillwell and Ives** [22] (1938) used the rays from a canal ray tube to test for a Doppler shift caused by the rays moving at about 1/5 x 10^6 m/s or 0.005 of the speed of light. They established that within experimental error the emitted frequency was altered by the factor $[1-(V/c_o)^2]^{1/2}$. Thus was a positive demonstration of the effect of motion of a light source on the speed of the emitted light. [It therefore differs completely from the Michelson Morley experiment where special relativity requires that there be no observable effect whatever from the motion of the source on the optical transmission of light i.e. it requires a zero fringe shift.

Compressibility, on the other hand requires and accepts a positive effect in both experiments: a positive fringe shift in Michelson-Morley and a positive frequency shift in Stilwell and Ives, as observed.

(2) **Cedarholm and Townes** [23] (1959) used an ammonia maser to look for an ether drift effect in the Doppler shift. They compared the frequencies of two such masers with their opposing beams run in parallel, and when the apparatus was rotated through 180°. Their tests were run at intervals over a year. The expected beat shift f, based on an ether drift effect, was $f = [4uV/c_o^2]\nu$ where V = 30 km/s, u the speed of the ammonia molecules is 600 m/s, and ν the frequency of the excited molecules is 2.387 x 10^{10} /s. The expected beat shift was 19.8 cps, so that the actual expected frequency shift was half this or about 10 cps. The observed shift was only 1.08 ± 0.02 cps. Their conclusion was, since the observed shift of 1.08 was far less than the predicted 10 cps, that the speed of light was thereby shown to be unaffected by the orbital motion of the earth in space of 30 km/s.

Cedarholm et al., in effect, simply discarded the small 1.08 cps frequency shift they observed at each revolution, considering it as due mostly to magnetic effects, and instead, considering only the variability of the observations from turn to turn which was about 1/50 cps they concluded that there was no orbital speed effect.

However, if compressible flow with n = 9 is included, then the predicted frequency shift becomes f = 10/9 = 1.11 cps , which agrees well with the observed value of 1.08.

(3) **Jaseja, Javan, Murray and Townes** [24] (1964), using two rotating masers positioned at right

angles to one another, tested for the ether drift second order effect in $(V/c)^2$. They reported on a short six hour test in January. Upon rotation through 90° they got a basic, repeating frequency shift of 275 kc/s plus a variation of not more than 3 kc/s. They discarded the observed repeatable frequency shift on rotation of 275 kc/s as presumably due to magnetostriction, and concluded that there was no evidence of any frequency shift effect arising from the from the earth's orbital motion of 30 km/s

Their expected frequency shift equation was $2\Delta\nu \approx (V/c_o)^2$, which for V = 30 km/s gives 3000 kcs expected frequency shift on rotation. Only about 275kcs shift was observed and was discarded. However, when the compressibility parameter n is included, we get $2\Delta\nu \approx (V/c_o)^2/9$ which gives 3000/9 = 333 kcs predicted versus 275 observed. Put another way 275 kcs (275kHz) gives a velocity of 27.2 km/s which is within 10% of the earth's orbital speed of 30 km/s.

If the unsteady effects of rotation are included, using estimates of the effective radius of rotation of their apparatus of about 1 meter or less, we get about 20 kcs with n = 9, 100 kcs with n = 2, and 200 kcs shift with n = 1. These additional unsteady shifts will add or subtract from the basic rotational shift of 275 kcs depending on their respective periodicities with respect to that of the basic shift.

The conclusion now is that Jaseja et al. did detect the effect of the steady orbital motion of the earth plus unsteady or accelerated motions of rotation, and that the observations generally agree with compressibility predictions.

(4) **Brillet and Hall** [25] in 1979 used a helium- neon stabilized laser beam coupled to a Fabry -Perot resonator and mounted on a rotating table. .They tested for frequency shifts related to the earth's rotation and orbital motion looking for a zero effect as required by the Lorentz contraction formula $1-[(1/n)(V/c_o)^2]^{1/2}$ where n is equal to one. They observed a large frequency shift on rotation of the apparatus on its axis which they labeled spurious and caused by what they termed centrifugal stretching of the Fabry-Perot interferometer due to rotation. They state only that : The centrifugal stretching due to rotation is - 10 kHz at f = (1 turn)/13 sec) and implies a compliance -10 times that of the bulk spacer material. This frequency shift cannot , however, be due to centrifugal stretching since their Fabry-Perot interferometer which is their length etalon is mounted <u>tangentially</u> on the rotating table and not radially where any centrifugal effect would have eto act if it were to alter the length of an instrumental component. It seems most probable that their frequency shift observed upon rotation is the same one as found by Jaseja et al. where it amounted to 275 kHz. Brillet and Hall do not give the observed frequency shift for a full turn of their instrument. If their 10 kHz is a frequency shift rate per second (and their inclusion of the rotation rate seems to support that) then the frequency shift due to rotation would be 10 x 10 kHz = 100 kHz ,since their operational rotation rate is given as a table rotation frequency , f, of 1 per -10 sec.

If their observed and discarded frequency shift is 100 kHz, then with n = 9 we get a motion in space

of $V = [(\Delta\nu/\nu_o)9\,c_o]^{1/2}$ = 30.25 km/sec, using their basic laser frequency of ν_0 equal to 8.85×10^{13} cps.. Thus, Lorentz violations have been observed in this test as well as in the others cited above, and the alternative conclusion from compressibility considerations now is that (a) the variability of light speed $\Delta c/c_o$, (b) frequency shift $\Delta\nu/\nu$ and (c) the motion of the earth through space of $V \approx 30$ km/s may in fact all be verified.

Brillet and Hall, having screened out any rotational effects and drift (including cosmic drift) effects, went on to test the tiny residual frequency fluctuations for correlation with the earth's motions, and quite naturally finding none of statistical significance after their efficient screening of the real effects, concluded instead that Lorentz violation was now ruled out to a new and higher degree of precision.

(5) **Wolf et al. [**26**] and Muller et al.** [27] in 2003 have taken up experimental work again since the last major test by Brillet and Hall. They no longer rotate their instrumentation, operating it in a fixed laboratory orientation in the manner of Kennedy and Thorndike . This procedure relies on the rotation of the earth on its axis and the earth's orbital motion around the sun for the relative motion test. This means that the effects shows up only as an accumulated systematic frequency drift over the lapsed time for the motion (namely 86,400 sec. diurnally , and 1.58×10^7 sec. semiannually). Given that any systematic drift of the instrumentation is once again routinely eliminated from the data as being spurious, these new tests for space motions using only $[\,1 - (1/n)\,(Vc_o)^2\,]^{-1/2}$ where n is always taken as unity and there is no distinction made between steady and accelerated motions , are nearly meaningless, although the instrumental precision is impressive indeed.

The great precision now possible with use of lasers and masers in optical experiments on the effect of motion on the speed of light is potentially a great advance. However, the theoretical or expected outcome of the test must also be correctly formulated if the proper conclusions are to be drawn from the increasingly more precise observations. The addition and subtraction of relative speeds to the speed of light cannot be arbitrary or uncritical, but must be in accord with the physical nature of the interaction of light with the instrumentation. Otherwise, only greater and greater precision in establishing that an inapplicable theory will result. All the above experiments test the observations against Lorentz violation [28], that is to say against $[\,1 - (1/n)(V/c_o)^2]^{-1/2}$ where n is always taken as unity whereas compressibility requires a test for steady motions against $[\,1 - \mathbf{1/9}(V/c_o)^2\,]^{-1/2}$ which in general means that fringe shifts or frequency oscillations as little one ninth of the Lorentz permitted values are the real physical effects to test against. Small effects presently discarded completely are actually the very evidence for detection of relative motion which is the object of the experiments in the first place.

One final note should be added on the choice of the energy partition parameter **n** in the case of unsteady motions. A possible difference from the value n = 9 for steady motions is not really so unexpected in unsteady compressible flow when we consider that when unsteady flows and accelerations occur ***forces and inertia*** also immediately arise. However, at the moment the value for n that is appropriate in each case of accelerated motion appears to be a matter for experimental determination in this relatively unexplored area of optics and photonics.

In the case of material gases, it is well established that the accelerations in boundary layer, for example, bring about many unexpected complications including changes in specific heat which require a change in the value of n.

In conclusion, the data from Stilwell and Ives, Cedarholm and Townes, Jaseja et al., and from Brillet and Hall fit the predictions of compressible flow theory. The oscillator tests of Wolf et al. and Muller et al. apparently discard the essential relative motion data as due to systematic drift or other spurious effects, and so these tests can not yet be fully evaluated.

8. Revision to Lorentz Transformations and Lorentz Form Invariance

The standard Lorentz transformations of special relativity are:

$$x = (x' - vt)/\gamma$$

$$y = y'$$

$$z = z'$$

$$t = (t' + vx'/c^2)/\gamma$$

$$\text{where } \gamma = [1- (V/c)^2]^{-1/2}$$

These highly useful formulae for high-speed (i.e. relativistic) mechanics will obviously be changed somewhat by the proposed new revision of special relativity.

1. The principal change necessary will be to replace $\gamma_{n=1} = [1 - (V/c)^2]^{-1/2}$ by a **generalized correction factor** with other values of the energy partition factor n included namely $\gamma_n = [1 - 1/n(V/c)^2]^{-1/2}$ n being always a positive number whose value is to be determined by experiment for each class of physical applications. [For example, for terrestrial optical interactions of the Michelson-Morley type the proper value for n appears from the experiments to be 9].

a). For n = 1, that is for 1-dimensional flow, and probably also for highly accelerated flows,: the value of γ is the current Lorentz transformation value $\gamma_{n=1} = [1- V/c)^2]^{-1/2}$; $c < c_o$ for any velocity V;

$V_{max} = \sqrt{n}\, c_o = c_o$. Length corrections due to relative motion are a maximum and are given by the Lorentz/Fitzgerald/Einstein contraction factor.

b) For $n = \infty$, that is for isothermal flow, the value for γ_n is unity; $c = c_o$ = constant; $V_{max} = c_o \sqrt{n} = \infty$. Relative motion has no effect on physical parameters such as length at all.

c) For $1 < n < \infty$, that is for n-dimensional flow , the value for γ_n is $[1 - 1/n(V/c)^2]^{-1/2}$; $c < c_o$ for any value of V greater than zero; $V_{max} = \sqrt{n}\, c_o$. Corrections for relative motion to length, etc, are less than the Lorentz maximum and depend on the value of 1/n.

2. In the **Minkowski** space-time representation of special relativity where the variables are x and ct, the angular contraction or *squeezing* of the transformation axes given by $\tan \varphi = v/c$ is to be replaced by $\tan \varphi = (1/ \sqrt{n}\,)V/c_o$. .The magnitude of the angular contraction or squeezing together of the transformation axes then ranges from a maximum for n = 1 to zero for $n = \infty$

3. In the **Minkowski** representation by rotation of rectangular axes in imaginary space-time where the variables are x and ict, the angular rotation given by $\tan \varphi = iv/c$ is to be replaced by $\tan \varphi = (1/ \sqrt{n})\, iV/c_o$.

It is worth pointing out here that the concept of **space-time** introduced by Minkowski as a new discovery in physical reality is a commonplace graphical representation of the effect of motion in compressible flow theory, where x-t diagrams are designated as the ***physical plane*** and the ratios V/c_o and c/c_o are called ***state variables***.

4. In place of the usual **metric interval ds** of special relativity where $ds^2 = dx^2 + dy^2 + dz^2 – c^2t^2 = (V^2 - c^2)dt^2$ and c always stands for the maximum static speed of light in space, we must instead now write

$$\mathbf{ds^2 = [V^2/n - c_o^2] dt^2 = -c^2dt^2}$$

where the distinction now made between c and c_o is crucial if the proper physical relationships of compressible flow are to be respected. [It is worth noting, however, that the special relativity custom of writing $(V^2 - c_o^2)$ for reasons of mathematical symmetry for example, is unphysical and gives rise to negative ds^2 and imaginary values of ds itself. The proper and physically correct expression is

$$c^2t^2 = c_o^2t^2 - (V^2/n)t^2$$

This would make ds = c dt where c is now the **variable speed of light** calculated from Equation 1.

The above changes mean that Lorentz invariance as presently employed is not **in general** correct and applies only if the compressibility and attendant change in c with change in V is neglected, that is if c is arbitrarily held constant. Alternatively we could perhaps say that Lorentz invariance applies only to accelerated motions where n = 1.

It is worth noting here that the metric **ds** in special relativity theory deriving from Minkowski is essentially different from compressible flow theory. In the Minkowski formulation of special relativity, ds can be either positive or negative at will or convenience. That is, it can be arbitrarily ether

$$ds^2 = (dx^2 + dy^2 + dz^2) –c^2 t^2 , \text{ or } ds^2 = c^2t^2 - (dx^2 + dy^2 + dz^2).$$

But in compressible flow theory any arbitrary change in sign is forbidden since it represents two completely different physical fields.

For World A systems with n a positive integer and where only compressive shocks occur, the proper form would be

$ds^2 = c_o^2 t^2 - (dx^2 + dy^2 + dz^2)/n$, corresponding to $c^2 = c_o^2 - V^2/c$. This of course makes ds = c dt, where c is now the variable speed of light from Equation 1.

The Minkowski formulation and its sign discrepancies is especially important since it is the basis for generalized metric tensor in **general relativity** theory. In addition, the value for n never explicitly appears in general relativity, and this therefore restricts any validity to the n = +1 case only. Therefore, whether the general relativity theory properly applies to gravitation is at present in question, since it has been necessary to introduce the compressible Chaplygin gas with n = -1 to try and solve the cosmological dark energy problem.

5. In summary and contrast, in the case where n = 1 . with $[1 - (V/c_o)^2]^{-1/2}$, compressibility predicts the maximum decrease in the speed of light c with relative motion, together with maximum fringe shift and/or maximum frequency shift. Special relativity for the same case requires a zero change in c , and predicts a zero fringe shift and a maximum (unobservable) length contraction.

For n = 9 which predicts fringe shifts and frequency oscillations which are one-ninth of the classical predicted values, the data match the known orbital and axial motions of the earth in space. Special relativity rejects the possibility of detecting such motion and must therefore discard the observations of experiment and treat them as being zero.

Because this matter of Lorentz transformations and Lorentz invariance is so important, it may benefit from a further restatement as follows:

Case: n =1 When n is equal to unity all the increased energy of motion (V^2) acts to reduce the wave speed c (Equation 1). If one still insists on using the classical addition of velocities (c ± V) in the 'rest" coordinate system as special relativity theory does, then all the corresponding physical quantities in any relatively moving system will have to be adjusted by a so called 'contraction factor' because the possibility of a compression of the wave speed c has been ignored in the classical addition assumption. The correction factor in this case is $[1 - V^2/c_o^2]^{-1/2}$.
Case: n greater then 1: In these cases, only a fraction (1/n) of the increased energy of any motion (V) acts to reduce the wave speed The correct addition of velocity would then be $c \pm V/\sqrt{n})$, so that if the classical addition of velocities (c ± V) is still used in the 'rest' system, than all the corresponding physical quantities in any relatively moving system will have to be corrected by a correction factor with the appropriate value of 1/n, which now is $[1 - 1/n\,(V/c_o)^2\,]^{1/2}$. For the application of this to the Michelson-Morley type experiments see (See **APPENDIX A *Compressible Photon Flow and The Results of Michelson-Morley Type Experiments)***

It should also be noted that most oscillator/resonator experiments now test for general Lorentz invariance under a model where both rotations and boosts or linear motions may be present. However, Lorentz invariance tests employ only the second order $[\,1 – (V/c_o)^2]^{-1/2}$ as a criterion, whereas, as we have seen, compressibility not only requires discrimination between first and second order effects in V/c_o but requires the assignment of the proper integral value for n, from 1 to 9. If these basic physical modes and differences are not recognized, then actual observed speed of light variations may unknowingly be discarded or lost in an inappropriate test which misses the real physical effects.

Although special relativity is restricted to uniform motions it still is routinely used in **accelerator** calculations where the accelerations are enormous because it gives close answers to the observed increase of momentum of elementary particles of matter with increasing velocity. In these cases the Fitzgerald/Lorentz /Einstein transformation and correction factor with n equal to 1 gives good results. This now appears to mean that in accelerators the additional energy of motion V^2 is not partitioned and all change in motion directly adds to or subtracts from the wave speed c. When the correction factor with n equal to 1 is plotted, it is seen that for very large values of V (near the maximum speed of light c_o), the change in wave speed c progressively diminishes; and so, to reach zero wave speed would require infinite velocity (i.e. infinite mass or infinite momentum). This would explain the underlying reason why it has always been assumed that there is agreement between special (uniform velocity) relativity and accelerator (non-uniform velocity) experiments. The special relativity corrections in fact do not **exactly** apply even to uniform motion experiments, but they are invoked to explain the observations involving accelerated motions where they are supposed not to apply! Physically based compressible flow corrections, in contrast, apply without contradiction to both motions.

An **experimental test** of the applicability of compressible theory and the correctness of n = 1 for accelerations appears available as follows: When flow speed v equals the wave speed c, (i.e. V = c = c*) we have the ***critical flow*** condition, and the ratio of this critical wave speed c* to the static or maximum wave speed c_o is given by

$$c^*/c_o = [\ n/(n + 1)]^{1/2}$$

For n equal to unity, this ratio becomes equal to 0.707, which means that c* will occur at a wave speed equal to 0.707 of the maximum speed of light 3×10^{8} m/s. Now at the critical speed V* = c* there is always the possibility that a **shock** wave will form, so that instead of a smooth curve between two variables, such as velocity squared (V^2) and mass m, there will instead be an abrupt discontinuity in the curve at the critical speed. Therefore, an inspection of accelerometer data should show such a change in the curves. It is also possible in compressible flow for the transition through the critical speed to occur shock free. This, however, can occur only under certain definite restricted physical conditions which are well established, and therefore these cases are also available for testing. The existence of a value of n other than unity in an acceleration could obviously also be established.

9. Summary of Review of Relativity

A). Special relativity is: (a) based on arbitrary postulates, (b) derives the specialized Lorentz contraction factor $[\ 1- (V/c)]^{-1/2}$ by inserting it as an arbitrary mathematical correction (c) maintains the non-detectiblity of uniform motion (invoking the reality of the unobservable contraction factor) only by rejecting the observed fringe shifts of Michelson-Morley type experiments and insisting that the results must always be equivalent to a zero shift, (d) accepts observed doppler frequency shifts to establish the reality of time dilation caused by uniform motion, but at the same time rejects the large frequency shifts of rotational experiments to maintain its nul Michelson-Morley interpretation, (f) is restricted to uniform motions, while at the same time appeals to the observations of enormously accelerated motions to establish the mass/energy relationship of the theory.

B). Compressible flow theory is (a) physically-based on long established theory, (b) is internally consistent involving no arbitrary corrections (c) derives a universal , physically based compressibility factor $c/c_o = [\ 1 - (1/n)\ (V/c_o{}^2]^{1/2}$, (d) accepts all observed data for both uniform and non-uniform, accelerated motions (including rotations), (e) predicts length contraction effect for uniform motions from the observed fringe shifts of Michelson-Morley experiments, as $\Delta c/c_o = 1 - [\ 1- (1/n)(V/c_o)^2\ ]^{1/2}$, (f) predict time dilation from the observed frequency shifts of oscillator experiments such as Ives and Stilwell where $\Delta\nu/\nu_o\Delta = \Delta\ c/c_o = 1 - [\ 1- (1/n)(V/c_o)^2\ ]^{1/2}$ for uniform motions and then $\Delta\nu/\nu_o = \Delta c/c_o = 1/n(V/c_o)$ for accelerated motions, both linear and rotational verifies the mass-energy relationship involving n = 1, while predicting experimentally testable deviations in mass/energy curves at critical c* = V* speeds.

C). Energy compressibility on the analysis to date establishes **a physically-based, self consistent, universal relativity** for all types of motions, steady and accelerated, which is verified by, and accepts the data of, all the available observations.

D). In the early decade of the 20th century when physicists were struggling with the effects of relative motion on observations of electromagnetic propagation, compressible flow theory was only developing. Lorentz himself at a conference in 1928 [21] speculated that compressibility might possibly help with the problems raised by the Michelson-Morley experiment. He apparently did not pursue the matter.

However, it was only after World War II that compressible flow theory matured in aeronautics, gas dynamics and the physics of compressible atmospheres, so that its explanatory power became widely known. In hindsight it might appear that the possibility of the contraction factors of relativity theory actually being a physical compression effect should have been followed up earlier, but at the beginning of the relativity era the full scope of compressible flow theory was simply not available. Later on, relativity had become so entangled with the mistaken notion that the result of the Michelson-Morley experiment was actually zero, that it was then overlooked. Today, with the problems in cosmology so pressing that variable speed of light (VSL) theories are abounding, the applicability of compressible flow theory to the problem seems much more obvious.

WAVE SPEED RATIO c/c_o AND THE ISENTROPIC RATIOS

$$c/c_o = [1 - 1/n(V/c_o)^2]^{1/2} = (p/p_o)^{1/(n+2)} = (\rho/\rho_o)^{1/n} = (T/T_o)^{1/2} \qquad (5)$$

All the basic state parameter ratios of a compressible isentropic flow are therefore specified by the wave speed ratio c/c_o.

We point out that in engineering and thermodynamic practice the ratio of the specific heats k is often used instead of n. The relationships between n and k are: n = 2/(k-1) and k = (n + 2) /n

The isentropic ratios then become

$$c/c_o = [1 - ((k-1)/2)(V/c_o)^2]^{1/2} = (p/p_o)^{(k-1)/2k} = (\rho/\rho_o)^{(k-1)/2} = (T/T_o)^{1/2} \qquad (5a)$$

In the present report only n is used, as it is appears more transparent to the underlying physics by representing the number of ways the energy of the system is divided, and in particular for relativity applications because it represents the portion of the flow velocity energy V^2 that affects the wave speed energy c^2 in Equation 1.

THE ENERGY EQUATION HAS TWO FORMS: WORLD A →WORLD B

In the basic energy equation $c^2 = c_o^2 - V^2/n$, the parameter **n** can be either positive or negative. In all ordinary material gases it is positive. It is negative, to take one example , in a theoretical state called a Chaplygin gas or ‘tangent gas’ , where n = -1. This duality in the sign of **n** gives us the possibility of transformations of matter as follows:

A). If n is positive, energy Equation 1 plots as an ellipse in velocity variables c and V, and the isentrope then is a concave downward curve. The plot in variables c^2 and V^2 is a series left-sloping straight lines in the energy variables c^2 and V^2. (Fig. 1). The maximum wave speed is then c_o and the maximum flow speed is V_{max}.

B). If n is negative , energy equation becomes an hyperbola in the velocity variables c and V, and a series of right-sloping straight lines in the energy variables.

$$\underline{c^2 = c_o^2 - V^2/n \quad (\pm n)}$$

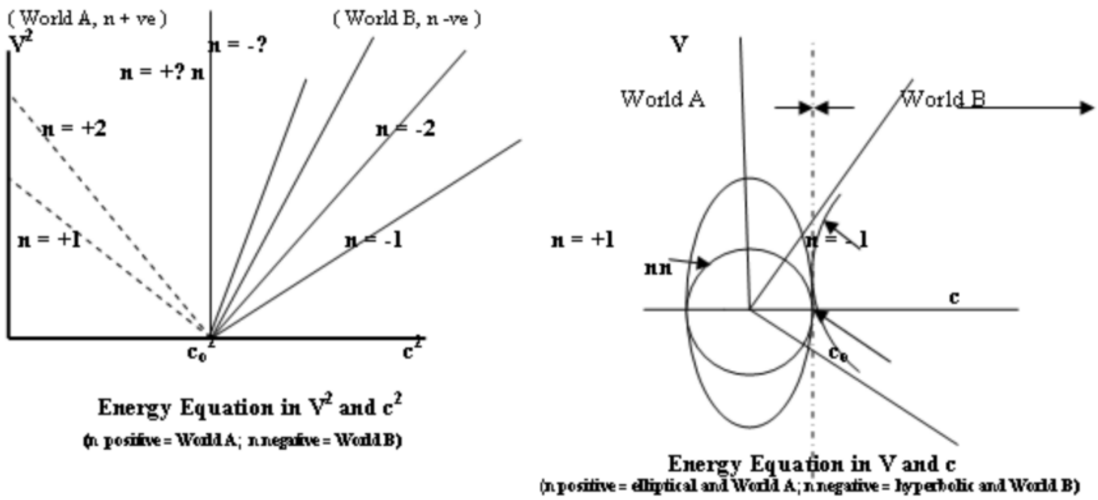


Fig. 1. The Compressible Flow Energy Equation

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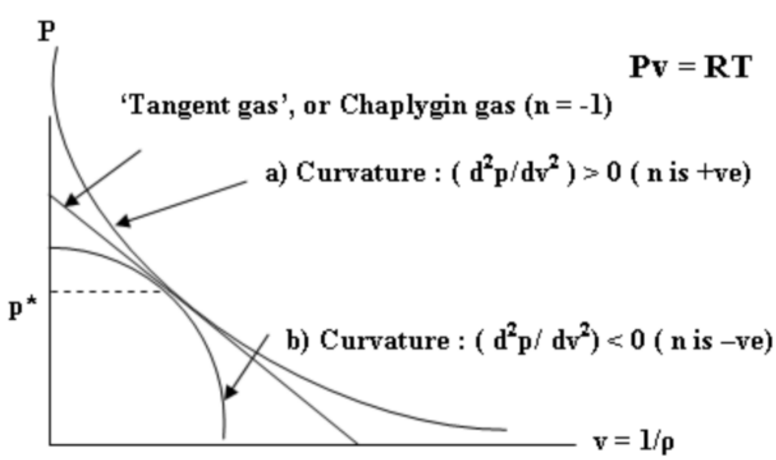
EQUATION OF STATE FOR COMPRESSIBLE SYSTEMS

$$\mathbf{pv = RT\ ;\quad p/\rho = RT\ ;\ c^2 = k\,p/\rho = kpv}\ (\text{ n being +ve}) \qquad \mathbf{(4)}$$

where $k = c_p/c_v = (n+2)/n$; p = pressure; v = volume; $1/v = \rho$ the density; R = gas constant; T = temperature.

Since **n** in the energy equation can theoretically be either positive or negative, **the equation of state also** has not just one, but two possible forms:



World A (positive n) and World B (negative n) Compressible Fluid

Equations of State

In World A: $(d^2p/dv^2)_s > 0$. Compression waves (condensed energy waves) steepen with time to form compression shocks, and these in turn produce the condensed energy elementary particles of matter (protons, neutrons, electrons, etc.) Rarefaction waves, on the other hand, die out.

In World B: $(d^2p/dv^2)_s < 0$). Rarefaction waves (rarefied energy waves) steepen to form rarefaction shocks. Compression waves and compression shocks would die out.

In the tangent gas case, plane waves of finite amplitude can propagate without change of form, that is without steepening or flattening.

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THE HIDDEN MASS, OR 'DARK MATTER' OF THE UNIVERSE: A NEW SOLUTION

Currently, the observed astronomical motions of certain structures of the universe, such as spiral galaxies, can be explained by Newton's laws of motion only with the assumption that there is present in and around the structures additional hidden or optically and electromagnetically unobservable dark matter which greatly exceeds the quantity of optically and electromagnetically observed mass The existence and nature of this dark matter is a central problem of cosmology today.

$$c^2 = c_o^2 - V^2/n - 2cV/n.$$

In all known material gases n is a positive integer, but the possibility of it being alternatively a negative number, either integral or fractional, raises the possibility of a binary, evolving universe encompassing both our ordinary, condensed energy matter and the astronomical 'dark matter'.

The adiabatic equation of state in compressible flow is

$$\mathbf{pv^k = const.}$$

Where **n** = 2/(k-1) ; k = (n+2)/n = $\gamma = c_p/c_v$,the ratio of specific heats of the fluid. As in the energy equation, n and k can be either positive or negative. Positive n values correspond to all know material gases where compression waves are the rule and wave speeds are equal to or less than the static wave speed c_o **(World A).** Negative values of n (**World B**) yield hypothetical exotic fluids where k can be variously positive or negative. Rarefaction waves are the rule. Here, wave speeds are always superluminal , that is c is greater than the static wave speed c_o.

THE DARK ENERGY OF THE UNIVERSE

Within the last five years, observations on the Hubble red shift have indicated that the expansion of the universe, instead of slowing down, may actually be accelerating. To explain this, a hypothetical dark energy has been postulated in the amount of around two-thirds of the total mass/energy of the universe. (The combined dark matter and dark energy make up around 96% of the total matter of the universe). This postulated strange energy is also supposed to have negative pressure and to exert gravitational repulsion so as to account for an accelerating expansion. The application of the theoretical Chaplygin gas (World B, n = -1) to this problem is now under intensive study.

In 1999 the discovery of anomalous red shifts in the cosmic microwave background CMB by **Bachall, Ostriker, Perlmutter and Steinhardt** [17] was interpreted to mean an accelerating expansion of the universe under the influence of an anomalous 'negative pressure energy', which was called dark energy.

The proposals of **Kamenshchick, Moschella and Pasquier** [18,19,20] that the dark matter and dark energy can both be related to the so-called Chaplygin gas - also called the tangent gas in aerodynamic theory [1,2] - has now opened the door to widespread active investigation of the suggested involvement of **negative-n states** with dark matter and dark energy.

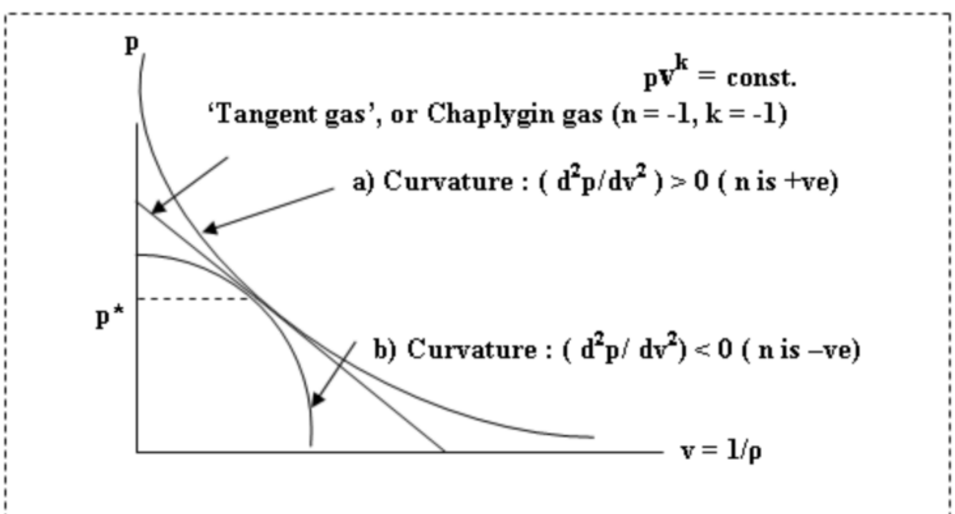
In the Chaplygin gas n and k are both negative and equal to -1; its wave speed c, interpreted as the speed of light, is always superluminal, since in (Eqn 1), with n negative, V^2 always adds to the static wave energy $c_o{}^2$.

The Chaplygin gas has the following form:

$\mathbf{pv^{-k} = const.}$ where k = -1 and n = -1, that is

$\mathbf{pv^{-1} = p(1/v) = const.}$ and since $1/v = \rho$, the density, then we have

$$\mathbf{p = A/\rho}$$



World A (positive n) and World B (negative n) Compressible Fluid

Equations of State

Since the Chaplygin gas curve has negative n (unlike the asymptotic World A isentropes (a) where n is positive) it intersects the v axis. Therefore, **negative pressures** can be experienced, and it is this property that is used to explain the observed anomalous red-shift currently interpreted as being an accelerated expansion of the universe. At the present time extensive investigation is continuing into this new possibility.

This problem of the dark energy of the universe will be explored in future Updates of the Website.

The following are relevant excerpts from [11] (*Summary of a Universal Physics,* Power 1992), where the possibility was advanced that our physical universe has a binary nature.

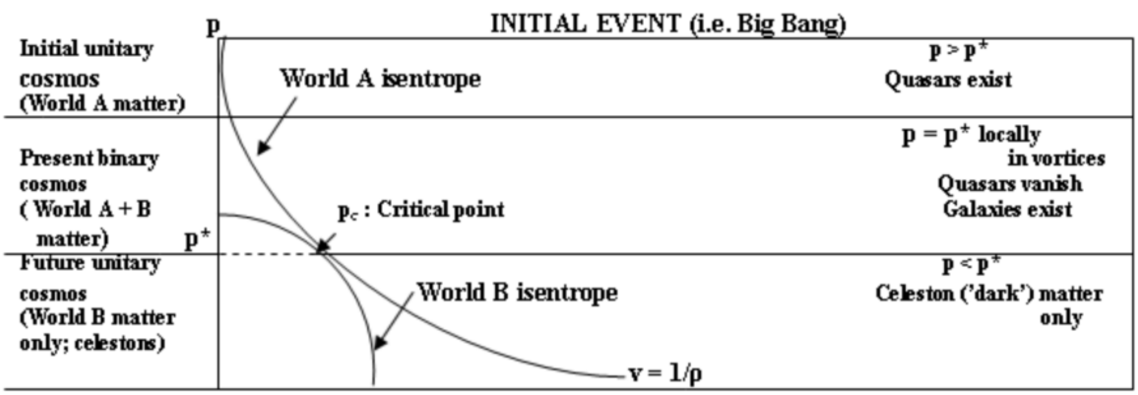
RAREFIED OR 'CELESTON' MATTER IN (WORLD B)

Rarefaction shocks in World B would form rarefied, elementary particles (which we shall designate *celestons*). These are the counterparts to the baryons, mesons and leptons of out World A of condensed energy forms . (The electron-neutrino ν_e, muon-neutrino ν_μ and tau-neutrino ν_τ may possibly be already known examples of World B particles).

TRANSFORMATIONS FROM WORLD-A MATTER TO WORLD-B MATTER

We now propose a transformation from World A matter to World B matter. This transformation A $\rightarrow$ B takes place at a critical pressure p* . Because of an entropy relationship

$$\Delta S_A = \Delta n/(+n);\text{(entropy increases)} \qquad \text{and} \quad \Delta S_B = \Delta n/(-n) \quad \text{(entropy decreases)}$$



Equation of State Transformations : World A(initial) ? World (A + B) (present) ? World B (future)

the transformation A $\rightarrow$ B once begun, would be irreversible.

At an Initial or Creation Event (e.g. a Big Bang) in a compressible expanding universe we would have p >>>p*, and so only condensed elementary particles of World A matter could emerge.

World B (rarefied or celeston matter) could only form when the critical pressure p* was reached. This point, however, might be reached *locally* **(for example, in the centre of a spiral galaxy vortex where the pressure is lower**) before the expansion of the universe had reduced the overall cosmic pressure to the critical value p*.

The Initial Event would usher in a Unitary World A of condensed matter only ($p > p^*$) . Our present era ($p \geq p^*$) is that of a **Binary Universe** (A + B) where both compressed and rarefied energy forms of matter can exist.

A final cosmic state ($p < p^*$), which will begin when the overall cosmic pressure falls to the critical value, will again usher in a Unitary universe, but this time it will consist of World B, rarefied, or celeston matter only.

The gravitino ν_g would be the simplest possible rarefaction wave form, or celeston. How the graviton relates to the electron-neutrino, or to the muon-neutrino is a matter for study by quantum specialists, as is also the further theoretical investigation of the various possible other types of celeston particles which might be generated by a rarefaction shock process using negative values for the entropy parameter n. The scientific grounding of such a theory would necessarily rest on astronomical data.

The energy change ΔE in the transformation A $\rightarrow$ B is given from the energy equations

$$\Delta E = c_B^2 - c_A^2 = V^2[\ 1/n_A - 1/n_B]$$

Since n_A is positive and n_B is negative, energy must be evolved in the A $\rightarrow$ B transformations.

It might, therefore, be possible to calculate the energy evolved in galactic transformations of the type A $\rightarrow$ B from the above equation, that is to calculate the energy released by the production of the proposed celeston matter from our ordinary condensed World A matter in the vortex core of a galaxy. Thus might be another experimental test of the A $\rightarrow$ B transformation.

CONCLUSIONS

Compressible energy flow provides a physically-based, variable speed of light (VSL) theory.

Compressibility will require a revision to the theory of special relativity. The experimental evidence requiring this lies (1) in the results of the Michelson- Morley type experiments whose small interference fringe shifts, previously discarded as zero, can now be related by the modified fringe shift equation $\delta = [2\, l\, (V/c_o)^2\ ]/n\,\gamma$,with n = 9, to the orbital and rotational motions of the earth through local space, and (2) in the more recent maser/ maser/ resonators and oscillator experiments where for steady flow $\Delta\nu/\nu_o = 1 - [\ 1 - (1/n)\ (V/c_o)^2]^{1/2}$ and for accelerated flows $\Delta\nu/\nu_o = (1/n)\ (V/c_o)$.

Compressible energy flow theory predicts a possible binary universe and A $\rightarrow$ B energy transformations.

The prediction of a binary material cosmos by compressible energy flow theory may provide the first plausible scientific explanation for the existence and nature of the all- pervasive ‘dark matter’ and ‘dark energy’ of the universe, which taken together are today thought to comprise 96% of the cosmos.

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FUTURE UPDATES: Part 2: Compressibility and Quantum Physics

Part 3: Compressibility and Cosmology

APPENDIX A

Compressible Photon Flow and The Results of Michelson-Morley Type Experiments

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August 2002

The interference fringe shifts that are always observed with experiments of the Michelson-Morley type have never been completely explained. Special relativity and isothermal compressible flow theory both predict that no fringe shift should occur at all. However, with nine degrees of energy partition, compressible theory applied to photon flows predicts the fringe shifts that are observed and which appear to reflect the earth's basic motion in space.

PACS number(s): 03.30.+p., 01.55.+b., 47.40.Dc.

The failure of a long series of classical experimental tests to detect any motion between the earth moving in its solar orbit and some sort of theoretical substratum or ether, using the Michelson interferometer to detect any anisotropy in the speed of light in space, eventually led to the abandonment of ether models and the universal adoption of the special theory of relativity.

With encouragement from Lorentz and Einstein among others, however, a continuing test of the Michelson-Morley [1] experiment by D. C. Miller [2] at Cleveland and at Mt. Wilson was carried on until the mid -nineteen twenties. All of these observations refuted the ether drift hypothesis. But, equally, all of them yielded a definite small fringe shift upon rotation of the interferometer. The tests of D.C. Miller were the most extensive, spanning several years of time and covering most of the epochs or seasons of the earth's orbital year. Instead of the full expected shift of $\delta = 1.12$ fringe, he found a smaller average shift ($\delta = 0.122$) which corresponded to a computed ether drift velocity of about 10 km/s rather than the expected earth's orbital speed of 30 km/s. The observations did show a very small seasonal and azimuth oscillation which, however, could never be put into any convincing relationship to physical effects.

Later versions of this type of interferometer experiment [3-7] generally reported considerably smaller average shifts, and, as these gradually came to be viewed as being simply statistical or environmental effects, inquiry was eventually dropped [10].

For the classical Michelson-Morley experiments, the expected fringe shift, calculated on the basis of Galilean addition of orbital velocity to the speed of light, is given by

$$\delta = 2\, l\, (V_o / c_o)^2 / \lambda \qquad (1)$$

Here l is the optical path length (32 meters in the Miller apparatus), c_o is the speed of light in space, V_o is the mean orbital speed of the earth taken as 30 km/s, and λ the wavelength of light used by Michelson-Morley and by Miller is 5.7×10^{-7} m. The expected fringe shift from Eq.1 was 1.12. A zero fringe shift was to be expected from special relativity, and eventually the smaller fringe shifts (0.122 average) which were always observed were also taken as being effectively zero. However, there is a third possibility, which is that of compressibility in the energy flow. Lorentz [3] speculated that compressibility might somehow be a factor in reconciling Miller's results with the apparently necessary properties of the hypothetical ether then under discussion: He said …*in the case of Planck's modification of Stokes theory. A further possibility would be a compressible ether. This would remove even the necessity of having an irrotational ether*.

If, however, we apply compressibility, not to an ether, but instead to an energetic field - for example a compressible fluid flow, a compressible gravitational field, a compressible 'vacuum' field, or a compressible photon flow - we have the basic steady state energy equation [11-12]

$$c^2 = c_o^2 - V^2 / n \qquad (2)$$

Here the mass m is taken as being unity, as is usual in hydrodynamics; c_o for a photon flow is the static compression wave speed equal to 3×10^8 m/s (when V the uniform relative motion is zero); c is the reduced wave speed under any uniform relative flow V; n is the number of degrees of freedom of the field, that is the number of ways the energy of the system is equally divided. For one-dimensional motions (n = 1) the right hand side of Eq. 2 becomes $(c_0 + V)(c_0 - V)$ which is also the going-and-coming addition of velocities used in deriving the classical fringe shift Eq. (1). Since these predicted shifts are nine or ten times too large, attention historically then turned to finding a theory that predicts zero fringe shifts instead. In the present theory we can rearrange Eq. (2) with n = 1 to get

$$c/c_0 = [1 - (V/c_o)^2]^{1/2} \qquad (3)$$

and the right hand side now becomes, when inverted, identical to the Lorentz/Fitzgerald contraction factor, which, if it is arbitrarily applied to shorten the length of the interferometer arm in the direction of V, will then exactly cancel the reduction in the speed of light caused by V and give a zero fringe shift. A second way to employ compressibility to get a zero shift would be to take n = ∞ so that in Eq.

(2) V^2/n becomes zero, and c is always equal to c_0; thermodynamically this would require isothermal flow.

There is also, however, the possibility of having a compressible photon flow with multiple degrees of energy partition. When this option is explored there is at once an improvement in explaining the observed residual fringe shifts. However, there is still no really good fit obtained until we take n = 9. For steady flow the fringe shift Eq. (1) becomes

$$\delta = 2\,l\,(V_o / c_o)^2 / 9\lambda \qquad (4)$$

Relationship (4) greatly changes the prediction of fringe shifts since these now become only one ninth of the classical expectations from Eq.(1), while classical ether drift velocities associated with any observed shift become three times larger. For example, Miller in his day expected a fringe shift of 1.12 from Eq. (1), whereas now, with compressible flow and n = 9 assumed, we find that the expected fringe shift becomes 0.125 which is close to what Miller observed (2), his average for the four seasons being 0.122. The flow velocity now becomes three times larger, so that δ = 0.122 corresponds not to Miller's computed 10 km/s but to $\sqrt{9}$ x 10 km/s or 30 km/s which is the expected orbital speed.

The small velocity changes associated with the earth's cosmic motions are: (a) the change in the earth's orbital velocity ΔV_o from perihelion on January 3 to aphelion on July 3 of approximately 498 m/s over the half solar year; (b) changes in the expansion and contraction velocity ΔV_r of the earth's orbital radius between perihelion and aphelion, which amount to about 322 m/s over the 180 days, and (c) the tangential velocity ΔV_{rev} associated with the diurnal revolution of the earth on its axis, which is about 385 m/s at 34° N, the latitude of Pasadena and Mount Wilson. These are not considered here.

In any assessment of the results of the various interferometer tests, it should noted that the observed data are fringe shifts, except where masers were used, in which case the basic observations are a beat frequency or frequency shift. In the classical literature the test results are commonly expressed as ether drift velocity which is just the basic fringe shift observation converted to an equivalent drift velocity using Eq. (1). Early experiments concentrated on attempts to detect the orbital speed of the earth namely 30 km/s. Later, when only about one third of this velocity was found, the approach changed fundamentally; the fairly large fringe shifts observed at each rotation through 90° were discarded, since they were too small to be explained by classical ether drift theory, and efforts were directed instead at trying to find very small changes in the fringe shifts at different times of the day so as to sample any effect of the changing orientation of the instrument in space as the earth turned on its axis. However, as we shall see, with compressible flow and n = 9, the large discarded basic fringe shifts observed at each 90 degree turn substantially match the orbital speed of 30 km/s that was earlier thought to be lacking.

Turning now to other tests than those of Miller, there is first the original Michelson-Morley test in 1887 at Cleveland [1,2] that used an optical path length of 1100 cm and light with wavelength of 5.7 x 10^{-7} m. They reported an equivalent ether drift velocity of not more than 5 km/s to 7.5 km/s in 6 hours of testing over four days in July. Based on compressibility considerations with n = 9 this would corresponds to cosmic motions of about 15 to 22.5 km/s. Miller later recalculated the results using a harmonic analyzer to retrieve the ether drift periodicity (i.e. the effect which is periodic in each 180 degree turn of the interferometer) and got 8 to 8.8 km/s, the corresponding compressibility calculation then giving 24 to 26.4 km/s (n = 9).

Morley & Miller [2] in 1904, also at Cleveland, used an optical length of 3220 cm, and in October observed a drift of 8.7 km/s (fringe shift 0.12) corresponding to about 26.1 km/s in compressibility theory with n = 9.

Michelson, Pease and Pearson [4] used an instrument similar to that of Miller, with an optical length of 25.9 m, which was installed at Mount Wilson in a basement room having small temperature or pressure variations. They reported their results to be an ether drift velocity not greater than 6 km/s, which corresponds in compressibility theory to 18 km/s.

Kennedy and Thorndike [5] (1929-30) at Pasadena used an ingenious interferometer with one arm longer than the other by only 0.16 m. They used light of wavelength 5.461×10^{-7} m. Their small instrument was completely enclosed in an inert gas and could be maintained at a near constant temperature over long periods of time. **The instrument was not rotated** but, instead, observations were taken at a fixed azimuth orientation daily over a full year, the fringe shifts being photographically recorded. For the case of the diurnal observations their average fringe shift was 0.000212, which, from Eq. (4) with n = 9, gives an orbital velocity of 17.1 km/s. They also reported an annual orbital effect of 10 ± 10 km/s, corresponding to 30 ± 30 km/s with n = 9, a result in which they did not express much confidence

Illingworth [6] at Pasadena used an improved instrument, originally designed and used by Kennedy, which had a much shorter optical path length (2 meters) It was kept in an isothermal room. It was not rotated continuously but was turned intermittently through 90 degrees, going from either north to west or northwest to southwest. Observations were carried out for a period of 10 days in early July. Illingworth observed a basic fairly large shift at each 90° rotation, which in his calculations he discarded, presumably because on classical fringe theory it would not have given the orbital speed of 30 km/s but only about a third as much. He does not explicitly give the magnitude of this discarded rotational fringe shifts except for a one hour period at 11 A.M on July 9, where he tabulated a weight difference of 4.7 units at each turn, and at 1/500 fringe shift per weight, this gives a fringe shift of 0.0094 with each 90° turn of the instrument. From Eq. (4) with n = 9 this corresponds to 32.6 km/s which is about 10% higher than the aphelion value of 29.557 km/s on July 3, but of course this estimate rests on only the one 11 A.M. observation. The small variations in the basic large background shift which was observed at intervals over the day ranged from a maximum of 0.00036 at 5 A.M to 0.000008 at 11 A.M., 0.000082 at 5 P.M. and 0.00034 at 11 P.M.

Joos [7] (1930) at Jena used an elegant instrument with an optical length of 21 meters. His instrument was sealed and kept at a near constant temperature. His observations were made during twenty one days in May. Like Illingworth he observed a large fringe shift at each rotation but searched only for variations on this basic larger background during the day. He does not give the magnitude of the larger rotational shift, but from inspection of the fringe photographs reproduced in his paper it would appear to be about 0.1 to 0.08 fringe per rotation. From Eq. (6a) shift of 0.083 would correspond to 29.557 km/s, which is the orbital speed at aphelion on July 3. He reported an average fringe shift of 0.001 for the small diurnal variations with changing orientation.

There were two tests of space anisotropy and special relativity carried out using masers shortly after they became available. The basic observations in these experiments were beat frequency shifts upon rotation of the instrument, this quantity being proportional either to uV/c_0^2 or $(V/c_0)^2$. In reassessing these tests with compressible flow theory and n = 9, these two velocity ratios are to be divided by 9.

1) Cedarholm and Townes [8] (1959) used an ammonia maser to look for an ether drift effect in the Doppler shift. They compared the frequencies of two such masers with their opposing beams run in parallel, and when the apparatus was rotated through 180°. Their tests were run at intervals over a year. The expected beat shift f, based on an ether drift effect, was $f = [4uV/c_o^2]\ \nu$ where V = 30 km/s, u the speed of the ammonia molecules is 600 m/s, and ν the frequency of the excited molecules is 2.387×10^{10} /s. The expected beat shift was 19.8 cps, so that the actual expected frequency shift was about 10cps. The observed shift was only 1.08 ± 0.02 cps. Their conclusion was, since the observed shift of 1.08 was far less than the predicted 10 cps, that the speed of light was thereby shown to be unaffected by the orbital motion of the earth in space of 30 km/s.

However, if compressible flow with n = 9 is included, then the predicted frequency shift becomes instead f = 10/9 = 1.11 cps , which agrees well with the observed value of 1.08.

(2) Jaseja, Javan, Murray and Townes [9] (1964), using two rotating masers positioned at right angles to one another, tested for the ether drift second order effect in $(V/c)^2$. They reported on a short six hour test in January. Upon rotation through 90° they got a basic, repeating frequency shift of 275 kc/s plus a variation of not more than 3 kc/s. They discarded the observed repeatable frequency shift on rotation of 275 kc/s as presumably due to magnetostriction, and concluded that there was no evidence of any frequency shift effect arising from the from the earth’s orbital motion of 30 km/s

Their expected frequency shift equation was $2\Delta\nu \approx (V/c_0)^2$, which for V = 30 km/s gives 3000 kcs expected frequency shift on rotation. Only about 275kcs shift was observed and was discarded. However, when the compressibility parameter n is included, we get $2\Delta\nu \approx (V/c_0)^2/9$ which gives 3000/9 = 333 kcs predicted versus 275 observed or only about 20% high. Expressed in relative motion terms this corresponds to about 27.2 km/sec.

Compressible photon flow theory is self-consistent and moreover it matches the experimental data, thereby fulfilling the two essential requirements for viability. We can then, from this new standpoint, evaluate classical Galilean addition of velocities, the Lorentz/Fitzgerald contraction factor and the special relativity theory of Lorentz transformations.

Classical or Galilean addition of velocities uncritically extended the addition of mass particle velocities to the case of addition of particle velocity to the wave speed of light c in the formulation of the classical fringe shift equation for the Michelson-Morley experiment. Fortuitously, the two-way going-and-coming design of the experiment involves forming the quantity $(c^2 - V^2) = (c + V)(c - V)$ which, if c is identified with the static speed wave speed c_o, agrees correctly with the compressible flow Eq. (2) for n =1. It is important to realize that with n = 1 all of the velocity adds to or subtracts from the wave speed c, whereas with n larger than unity only a fraction of V adds to or subtracts from c which gives $(c + V/\sqrt{n})(c - V/\sqrt{n}) = (c_o^2 - V^2/n)$.

The classical formulation with n =1 predicted the impossibly large fringe shifts which posed a major problem to the science of the day. The Lorentz/Fitzgerald solution was not just to reduce the fringe shift but to eliminate it entirely. This was accomplished by inserting into the velocity transformations an ad hoc reduction factor $[1- (V/c_o)^2]^{-1/2}$ which simply cancelled the large shift completely.

The special theory of relativity succeeded in putting the ad hoc formulation on a theoretical basis by assuming, first, the classical Galilean addition of particle and wave velocities as before, and second by postulating the constancy of the speed of light in all relatively moving inertial coordinate systems. When this is done the Lorentz/Fitzgerald contraction factor emerges automatically. The price of an apparent inconsistency was eventually felt to be justified since the unacceptably large fringe shift predictions were now eliminated. On compressible flow theory, such an addition of the entire relative velocity V to the wave speed c would be interpreted as being an adiabatic photon flow with n = 1, while the postulated constancy of $c = c_0$ would necessarily be seen as an isothermal flow ($n = \infty$); the two assumptions taken together now become physically inconsistent.

The development of compressible theory in the last half-century permits the alternative solution outlined here, which not only explains the partial success of previous attempts, but which, instead of incorrectly eliminating the fringe shift entirely, reduces it to the experimentally observed values by postulating a relative photon flow with n = 9.

The transformations between relatively moving inertial coordinate systems in the new theory are made by replacing the static speed of light c_o with the reduced local speed of light c required from Eq. (2), by computing $c = c_o [1- 1/9(V/c_o)^2]^{1/2} = c_o \varepsilon$. Alternatively, if desired or more familiar, the compressibility could be ignored, with the wave speed arbitrarily taken at the static speed of light c_o (3×10^8 m/s) in all coordinate systems as before, but then the factor γ of special relativity theory ($\gamma = [1- (V/c_o)^2]^{-1/2}$) must be replaced by the factor ε where $1/\varepsilon = c/c_o = [1- (1/9)(V/c_o)^2]^{1/2}$ in the transformation equations. If this computation method is chosen, the space and time coordinates and the various physical quantities must then be altered to: $\varepsilon = l'/l_o = dt_o/dt' = m'/m_o$, etc.

In the case of a material gas, the energy partition is among random kinetic motion of molecules in three space dimensions plus perhaps rotation and vibration, and these random motions give rise to pressure and compressibility. For photons, however, there are no obvious equivalents to thermodynamic pressure, random kinetic motion, and so on, and therefore the precise physical nature of a photon flow that could give rise to the observed agreement with compressible flow theory remains to be established. However, it does appear possible that three space dimensions, each with associated states, plus vibration states might provide the nine-dimensional energy partition required to explain the results summarized in Table 1.

Table 1. Observed interference fringe shifts and corresponding computed flow velocities.

Observer	Observed fringe shift (δ)	"Ether drift" velocity V [a] (km/s)	Compressible flow (n = 9) Orbital velocity V [b] (km/s)
Michelson-Morley	0.01	5 - 7.5	15 - 22.5
(1887) Cleveland	(Miller revision)	8- 8.5	24 - 25.5
Morley & Miller	0.09	8.7	26.1
(1905) Cleveland			
Miller	0.122 (avg)	10.05	30.1
(1925-6) Mt. Wilson			
Michelson *et al.*	0.01 (max)	≤6	≤18
(1929) Mt. Wilson			
Kennedy-Thorndike	0.000212 (daily)		17.0 [c]
(1929-30)	(annual)	10 ± 10	30 ± 30
Pasadena			
Illingworth	0.0094 (rotational)		32.6 [c]
(1927) Pasadena	0.000195 (orientational)		
Joos	0.083 (est.) (rotational)		29.56 [c]
(1930) Jena	0.001 (orientational)		
Cedarholm & Townes	Maser	1.08 ± 0.02 cps	(30 km/s ± 556 m/s)
(1959) New York			
Jaseja *et al.*	Maser	275 ± 3 kc/s	27.2 km/s
(1964) Round Hill, Mass.			

[a] Computed from Eq. 1; [b] V = ('ether drift')x√9; V computed from Eq. 4;

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