CONSIDERATIONS CONCERNING RELATIVISTIC FORCES

by

Albert W. Johnson

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Signature of Author ______________________________
Dept. of Aeronautical Engineering, May 26, 1958

Certified by ______________________________
Thesis Supervisor

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Chairman, Departmental Committee on Graduate Students

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May 26, 1958

Professor Leicester F. Hamilton
Secretary of the Faculty
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

Dear Professor Hamilton:

In accordance with the regulations of the faculty, I hereby submit a thesis entitled Considerations Concerning Relativistic Forces in partial fulfillment of the requirements for the degree of Master of Science in Aeronautical Engineering.

Albert W. Johnson

ACKNOWLEDGEMENT

The graduate work for which this thesis is a partial requirement was performed while the author was assigned by the Air Force Institute of Technology for graduate training at the Massachusetts Institute of Technology: and the author is grateful to the United States Air Force for the opportunity to do this work.

The author is especially grateful to Professor Walter Wrigley for his inspiration and guidance and to John Hovorka for his interest and help with the various theoretical aspects of the problem.

The conversations with Mr. Jim Stockard, Mr. H. Yilmaz, Mr. George Stroke and Mr. L.L. Rulla were also most helpful and were appreciated. It should not be inferred of course, that these gentlemen necessarily agree with the methods used or the conclusions reached in this paper.

Special thanks are due to Janice Johnson for the patience demonstrated and the secretarial services provided.

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Submitted to the Department of Aeronautical Engineering, Massachusetts Institute of Technology on May 26, 1958, in partial fulfillment of the requirements for the degree of Master of Science.

ABSTRACT

The effect of relativistic considerations on space travel will soon be a practical problem and this paper reviews and discusses the observed relativistic phenomena.

Light interference, the possibility of forces varying with relative velocity, and electric phenomena are also discussed.

It is concluded that Newton's second law defines both force and mass, and there is enough doubt about mass being the exact definition of matter that neither force nor mass can be considered as fundamental quantities. However, no navigational error will result if the gravity forces on a space ship are considered to be reduced by the contracting factor $\sqrt{1-\frac{v^2}{\omega_o^2}}$ and the acceleration in Euclidian space caused by the ship's own rockets is considered to be unaffected by the contraction factor.

Thesis Supervisor: Walter Wrigley

Title: Professor of Aeronautical Engineering

ADDENDUM

Page 12. Apparent wave length can be considered as similar to the wave length of a sound wave which would be measured inside of a moving train. Doppler effects from outside sources would still be evident even though the sound waves inside the train would travel in train coordinates at a constant rate. In an interferometer, the transmitting glass or mirror would provide the local coordinate reference and be analogous to the air in the train.

Page 16. Line 17. Fig. 5 should read Fig. 3b.

Page 26 . The quoted minimum observable signals of 336 and 1000 photons/sec are based upon the minimum signal observable to the eye. Assuming a pupil area of approximately one third cm^2 we arrive at the figure of 1000 photons/sec/cm^2 corresponding to the eye sensitivity estimate of 336 photons/sec.

Page 36. A short way to arrive at the formula $E = m\omega_c^2$ would be to argue dimensionally that $E = m\ddot{D}D = m\dot{D}\dot{D} = m\omega_c\omega_c$ if $\dot{D}$ is the velocity of energy transfer ω_c

Page 44. Point A is at the intersection of successive fields in Fig. 12.

Page 50. If repulsion of electrons is due to a resonate effect, it is possible that the peak effect would be reached at relative velocities slightly above the normal electron relative velocities of one tenth to one fifth of the velocity of light. However, it is expected that as relative velocity is further increased, the measured electric field at right angles to the direction of a moving charge would be decreased by the factor $\sqrt{1 - \frac{v^2}{\omega_c^2}}$

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INTRODUCTION

It was hoped that this brief review of the effects of Relativity Theory on space travel could be made with a rather cursory investigation or review of the fundamental physics involved. However, the theory has many relationship cycles which are like the famous question, "Did the chicken or the egg come first?" and the point at which the analysis begins has a tremendous effect upon the development of the theory. It was felt necessary, therefore, to consider some of the fundamental relationships in some detail.

The author was as objective as he was able to be, but it is suspected that it is almost impossible to be 100% objective about a conviction that a man reaches through an inner struggle and it is possible that some of the "reasonable" and "plausible" arguments upon which he was forced to lean may be shaded by opinions of "the way things ought to be." Historically, "plausible" arguments have been almost uniformly in error to some degree; however, even wrong theories have served as stepping stones and this paper will be a success if it does so. The reader must filter these arguments through his own biases and be the judge.

CHAPTER 1

PROPERTIES OF LIGHT

There are several methods of considering the properties of light. There is Huygens' principle that each point on a wave front may be considered as a new center of disturbance. There is the use of rectilinear rays which is essentially Newton's corpuscular theory, and there are the transverse wave and photon theories. These various methods are not strictly compatible, but let us consider a possible rather non-sophisticated and simplified combination of these theories.

First, it is assumed that light is transmitted by the classical discrete photons which act as frequency carriers and unless specified otherwise, when we speak of the velocity of light, we will mean the velocity at which the photons are propagated. Now, in order to retain the Huygens principle, it would appear that we have to assume more or less elastic interactions between the photons to account for the phenomena of diffraction and interference.

Interference

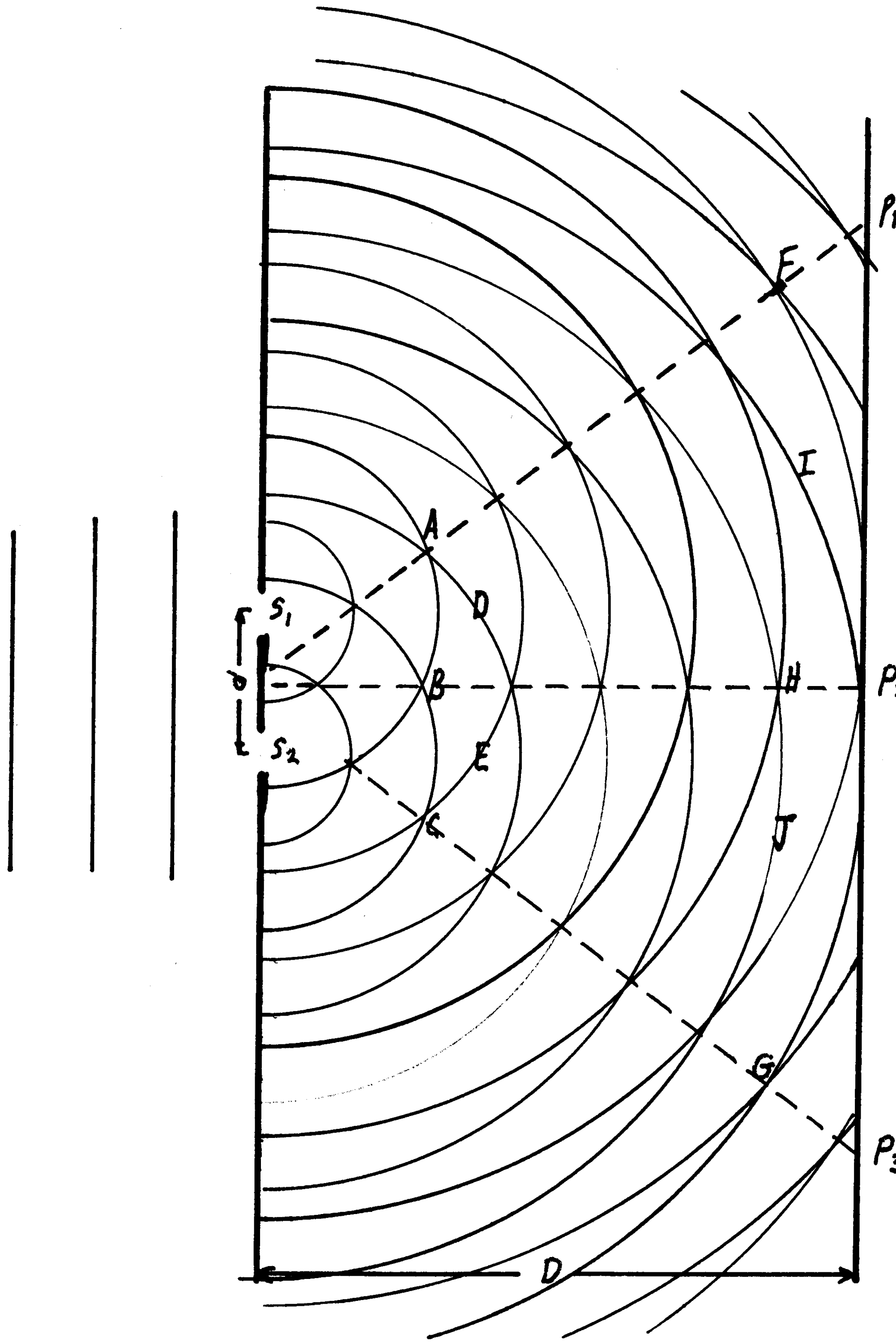
Of course, it is known from the uncertainty principle that the movement of electrons and electrons cannot be measured; however, if we are going to be consistent and call photons particles, the particle, while undergoing interference, must follow a certain path and perhaps we can use a conventional Huygens wave construction diagram as shown in Fig. 1 as an aid in considering the path.

As the photons pass through the slits, they scatter in a diffraction pattern. We can speculate that this scattering is caused by successive photon reactions with each other or even that there are some minor effects due to interactions of the photons with the edges of the slit as Newton thought. However, at this stage it is only important that the photons do disperse. Some of the photons would go through the points where the lines cross in Fig. 1 such as points A,B and C. At these points they would encounter other deflected photons which have gone through the other slit, but since they are in phase, we can assume that there would be no reaction. Other photons, however, would go to points such as E and D where they would also encounter photons which have gone through the other slit; however, in this case, they have traveled such a distance that they are out of phase and they would deflect each other. This process would continue until almost all of the photons are concentrated along the paths such as A-P, B-P , and C-P .

Since photons have cross sections of less than $3 \times 10^{-20}\ cm^2$ have lengths less than 3 cm, and a density (in sunlight at the earth) of approximately $6.6 \times 10^{8}\ \frac{photons}{cm^3}$, photons scattering by collision is not very likely except perhaps under conditions approaching those of the sun's corona. (A.L. Hughes, Phys. Rev. (36)773(1930) and E.O. Lawrence and J.W. Beams, Phys. Rev. (29) 361(A) (1927)). We have to speculate, therefore, that dispersion may be caused by a weak field which would be effective between photons traveling along together.

Even though the mechanism discussed here is different than Huygen postulated, the result is the same and his construction results in a distance between bright fringes of approximately $\frac{n \lambda D}{d}$ which for small angles results in the usual formula: $d \sin\theta = n\lambda$

A little support for this deflection of photons concept might be drawn from analogy with the "interference" which results when electron beams are admitted through two parallel slits. It is observed that the



Huygen's Wave Construction
Fig. 1

electron impacts follow a square distribution law, but note that this distribution envelope is evidently composed of discrete events or electron impacts. The actual or even analytic mechanism by which the electron "knows" that another electron has come through the other slit is one of the basic mysteries of quantum mechanics, but it is not too unreasonable to argue that an analogous mechanism could account for discrete photon deflections.

Other phenomena which are relevant to the photon deflection concept are Newton's Rings and Lloyd's mirror experiment. The dark center of Newton's Rings and the dark center fringe of Lloyd's mirror experiment can be explained in terms of waves by saying that the first reflection from glass to air and the second reflection from air to glass have their phases shifted a total of 1/2 cycle with respect to each other, and the waves therefore cancel each other at this point. (Ref. "Fundamentals of Physical Optics" by F.A. Jenkins and H.E. White, McGraw Hill, 1937). However, if light is considered as being composed of photons, it appears more reasonable to consider that the photons are deflected away from the center instead of assuming that destructive interference occurs. At any event, it is submitted that the theory that interference fringe intensities are due to a redistribution as Jenkins and White, for example, say on page 61, is not quite consistent with the concept that waves cancel and undergo destructive interference as Jenkins and White say on pages 67 and 75 because if a photon does not strike a given place, how can its phase be reversed? It is therefore submitted that photon deflections alone are responsible for the observed optical effects and this paper will be developed using this assumption.

It is interesting to note that Thomas Young obtained a bright center with Newton's Rings by using a reflecting plate of higher refractive index than the sphere and filling the space between the plate and sphere with oil of intermediate index. Light ray refraction calculations will show that the use of oil will cause a light ray to be deflected to ward the center; however, this effect may also be explained in terms of interference with the aid of Fig. 2a and 2b. In order to have interference there must be at least two effective sources and those would be located on the edge of the sphere where the incoming wave and the reflected wave from the plate arrive in phase. If no oil is used, the photons would follow the "no-phase-difference" paths shown in Fig. 2a. The center ring of the pattern would be composed of paths such as R_1 and R_2 (it is assumed that R_3 and R_4 would intersect R_1 and R_2 before the eyepiece is reached; if they do not they would become the center ring). There would be more effective sources, but three is sufficient for illustrative purposes.

If oil were used, the wave velocity would now be less in the oil than it is in the sphere and the "in phase" source points would move in towards the center until: $\frac{2D}{\mu_{oil}} = \frac{n\lambda}{\mu_{sphere}}$ or $D = \frac{n\lambda\mu_o}{2\mu_s}$

From Geometry:

$D = \frac{r^2}{2R-D}$ Where r = distance from center to point
R = Radius of Sphere

$$r^2 = \frac{Rn\lambda\mu_o}{\mu_s} \quad \text{because } R \gg D$$

Since bright fringes appear between the effective sources, We have

$$r^2 = \frac{R(n+\frac{1}{2})\lambda\mu_o}{\mu_s} \quad \text{for bright fringes}$$

It can be seen from Fig. 2b that the paths R and R are now tending to come out of the center and, if the angles are right, the center would now be bright.

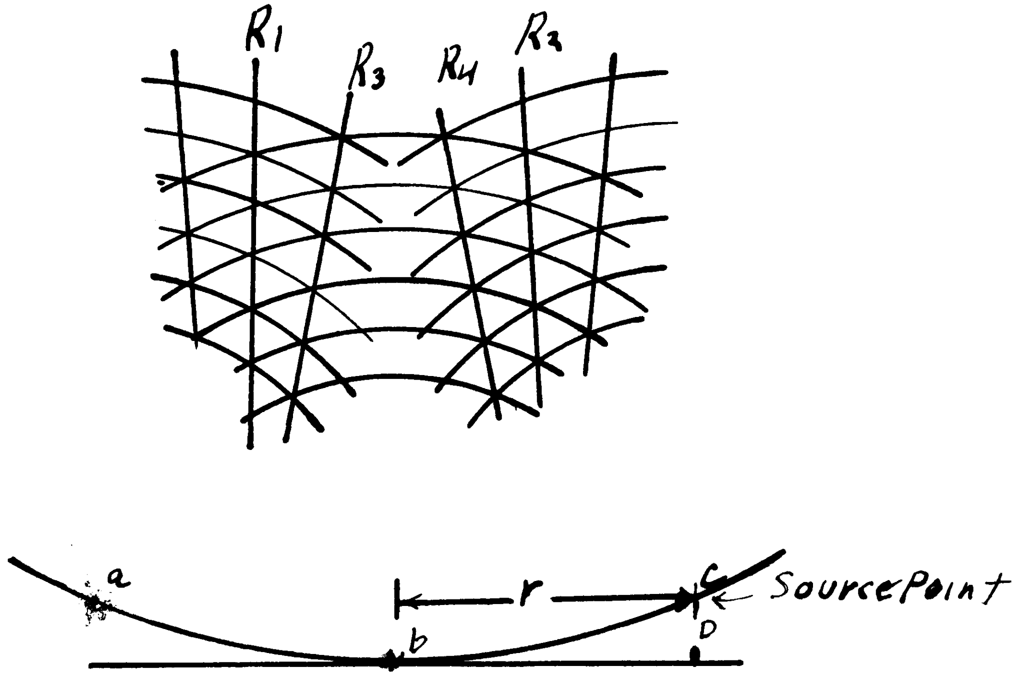


Fig 2a

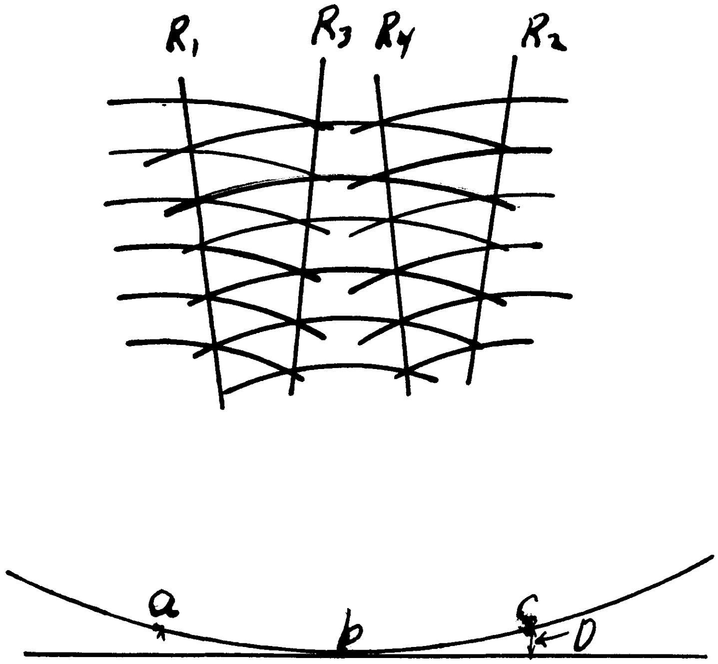


Fig. 2b

Interference With a Combining Glass

The Michelson interferometer must have an "extended" source in order to operate. However, as in all other interference cases, there must be two or more discrete effective sources and determining where these sources are on the combining glass is especially significant.

First, imagine that the mirror arms in Fig. 3 are adjusted so that both mirrors are precisely an even number of wave lengths away from point b and M_1 is about 20 cm farther away than M_2. Since M_1 is farther away than M_2 we can make the simplifying assumption that all of the photons leaving M_1 travel exactly perpendicular to M_1 and the resulting wave front is therefore straight. Dispersion will bend some of the light paths from M and this dispersed light will form an effective source wherever it reaches the glass exactly in phase with the light from M_1 as shown in Fig. 3b. It can be seen from Fig. 3b that the formula for the source separation distance, x, is:

$$x = \sqrt{(m\lambda)^2 - (m\lambda)^2}$$

From this it can be seen that if either the wave length, x, or the mirror arm, mx, get larger then x will have to become larger also, and this will cause the fringe diameters to become smaller.

It should be noted that in these interference cases, if the mechanism is similar to that which was assumed, that the resultant particle path is dependent only on the apparent wave length and the equipment geometry. As long as the velocity of the waves is constant, it does not make any difference whether it is in parsecs per second or microns per century; the paths described would still be the same.

Thus, Q. Mojorana's experiment(Phys. Mag. (35) 163(1918) in which he rotated a series of mirrors as shown in Fig. 4 and examined the output of light with an interferometer, is dependent only on the apparent wave length which would change the effective source separation and thus shift the observed fringe pattern. In addition, there is no reason that the Michelson Morley experiment should be affected by the movement of the source except as the apparent wave length is changed and specifically sun light would not affect it. (D.C. Miller, Observations with sunlight on July 8 - 9, 1924, Proc. Nat. Acad. Sci. (11) 311,(1925)).

For the purpose of this paper wave length is defined as the Euclidian distance from wave to wave and the apparent wave length is defined as the constant, C, divided by the observed frequency. This means that ideally wave length is independent of the wave velocity. This concept does not take advantage of Einstein's profound theory regarding simultaniety; however, let us assume Euclidian concepts are valid, note that simultaniety concepts have not been required so far and be alert to see if and where Euclidian space gets us into trouble in the balance of this discussion.

Michelson's moving mirror experiment described in the April, 1913 Astr. Journal is fairly typical of moving mirror experiments and will be discussed next. Referring to Fig. 5, light is first split at the combining glass then one part of the light impinges on the retreating mirror, then after reflection impinges on the advancing mirror and is reflected back to the combining glass where it combines with the other beam of light which makes the circuit in the opposite direction, first striking the advancing mirror and then the retreating mirror; the interference is then observed at the combining glass.

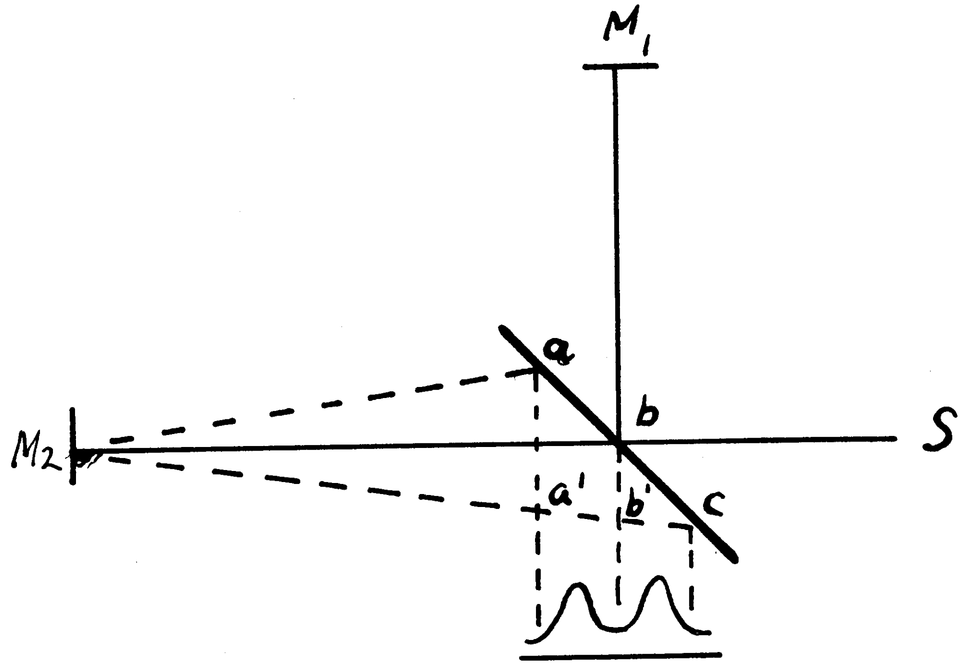


Fig. 3a

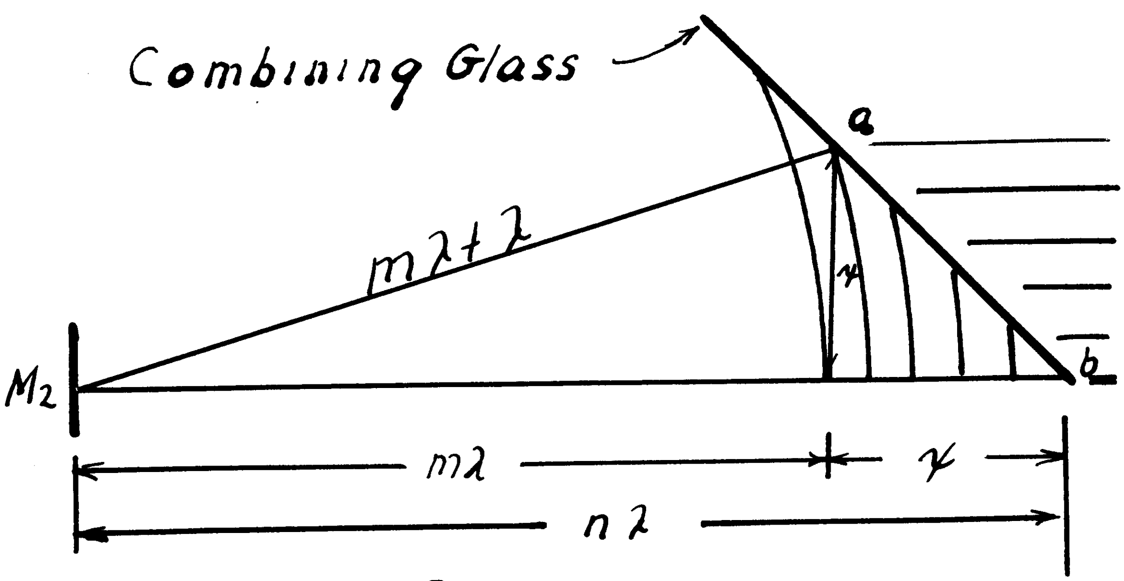


Fig. 3b

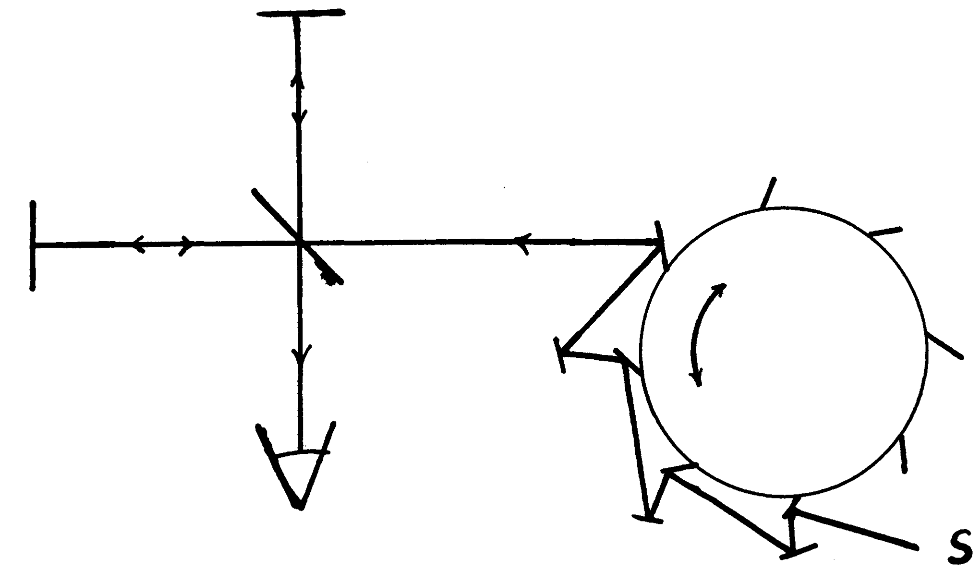


Fig. 4

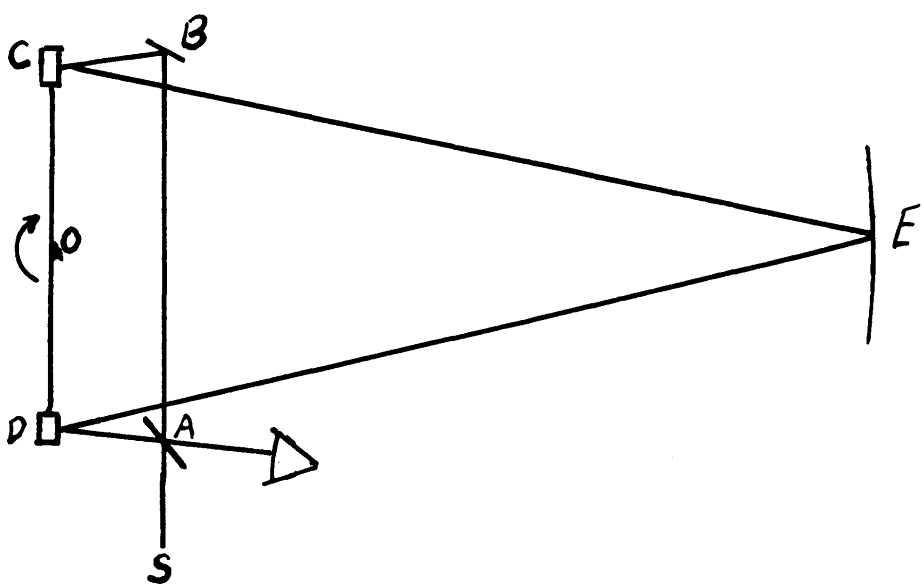


Fig. 5

After correcting for the movement of the mirrors while the light was traveling from one to another, Michelson was not able to find a change in the interference pattern which could be ascribed to a change in the position of the wave fronts due to different velocities between the mirror impacts.

However, if a mechanism similar to what we have previously outlined is responsible for the interference, this effect can be explained by saying that even if there were a shift in wave fronts the interference geometry is not changed and since one wave is pretty much like the next one, the wave fronts could be shifted a thousand even wave lengths and the interference mechanism would not know the difference. In addition, a fractional wave shift, again since the geometry does not change, would probably just shift the entire interference pattern to the right or left a fraction of a wave length and would not change the interference angles. In other words, referring to Fig. 5, any fractional change in wave length will shift the center horizontal reference line (through point b) up or down until the photons from both arms are in phase. However, if this change in wave length is due to a change in the arm length (wave length kept constant) the change in geometry changes the transverse separation of the effective sources; and conversely; if the change is due to the advance of the wave itself, the separation of the effective sources is not affected.

Aberration

Aberration is conceived as exactly analogous to scooping up raindrops with a tube in such a way that the drops do not hit the sides of the tube as shown in Fig. 6. Note that a different set of photons is now observed in comparison to the "rest" position. If this simple concept is correct, however, it would appear that the explanation of Airy's experiment involving the index of refraction and Fresnell's dragging coefficient as found on page 220 of Jenkins and White is superfluous because as long as the optical normal is along the apparent line of sight, the angle of incidence and the angle of refraction will both be zero and it does not matter if the tube is filled with water, ether, or glue.

Rotation

A schematic of the rotation experiment of A.A. Michelson and H.G. Gale as described in the Astrophysical Journal (61) P.142, is shown in Fig. 7.

There are several ways of explaining this experiment. Michelson explains it by assuming that the velocity of light is independent of the source then says that light will make a circuit of the apparatus in $T = \frac{2\pi r}{c}$ seconds. In this time the combining glass will have moved a distance,

$$D = v T = (r\omega)\frac{2\pi r}{c} = \frac{2\pi r^2 \omega}{c} = \frac{2\,\text{Area}\,\omega}{c}$$

This distance is multiplied by 2 and divided by to get the expected number of fringe shifts

$$\Delta = \frac{4\,\text{Area}\,\omega}{\lambda c}$$

In the referenced experiment the results agreed fairly well with the above theory; however, it is desired to point out that an alternate approach might be to say that C does depend upon the source and explain the results in terms of aberration as shown in Fig. 7b. It is critical to

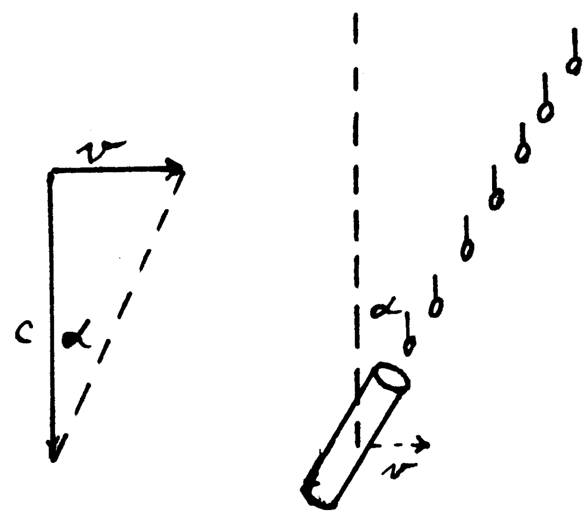


Fig 6

note that the received photons come from a different origin as shown in Fig. 6. In this case, the angle of aberration, $\alpha = \frac{v}{c}$ the phase shift in one arm due to aberration is: $d = \ell \alpha$ where ℓ is the arm length. There are four arms in each path and two paths so the total distance shift, $D = 8\ell\alpha$ and fringe shifts $\Delta = \frac{8\ell\alpha}{\lambda}$ This equation is also compatible with the results of Michelson and Gale's rotation experiment. It should be noted that aberration in this case is equivalent to coriolis and the same result would be obtained if coriolis paths for the photons were drawn. With respect to the rotating base, the photon paths would curve to the right at a constant rate due to coriolis.

However, if an individual mirror, for example, the upper right, is selected to be the reference space, then since $C \gg v$, small angle approximations can be made and, with respect to this mirror, the photon would be traveling in a straight line.

Referring to Fig. 7c, the path bc is the path traveled if there is no rotation. If the equipment is now rotated, the photon which left b would now go to point f and point c would now receive the photon which left point a. The phase shift would be equal to the deflected distance in this case because the mirrors are inclined at a 45 degree angle.

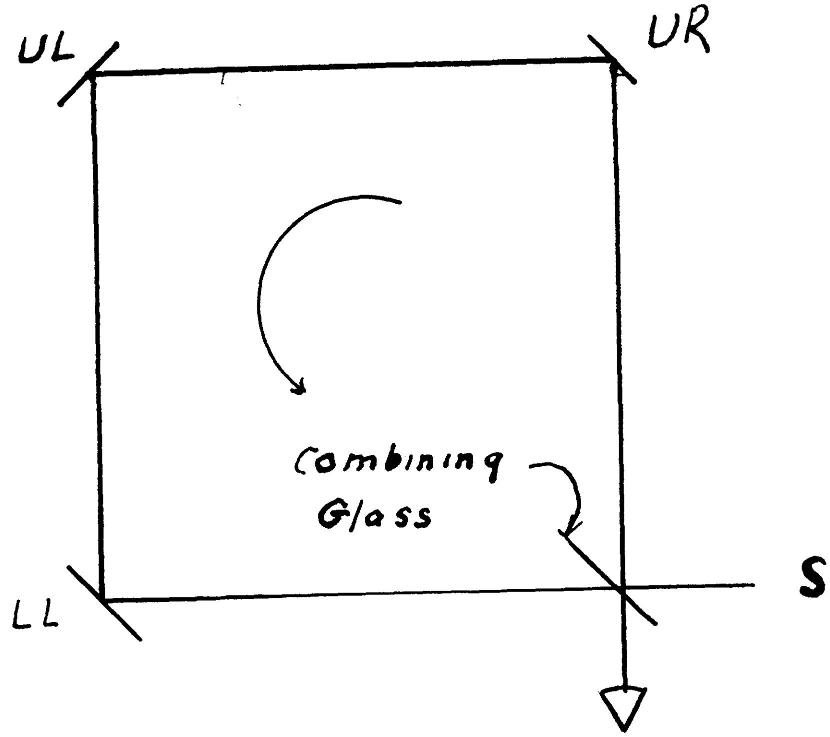


Fig. 7a

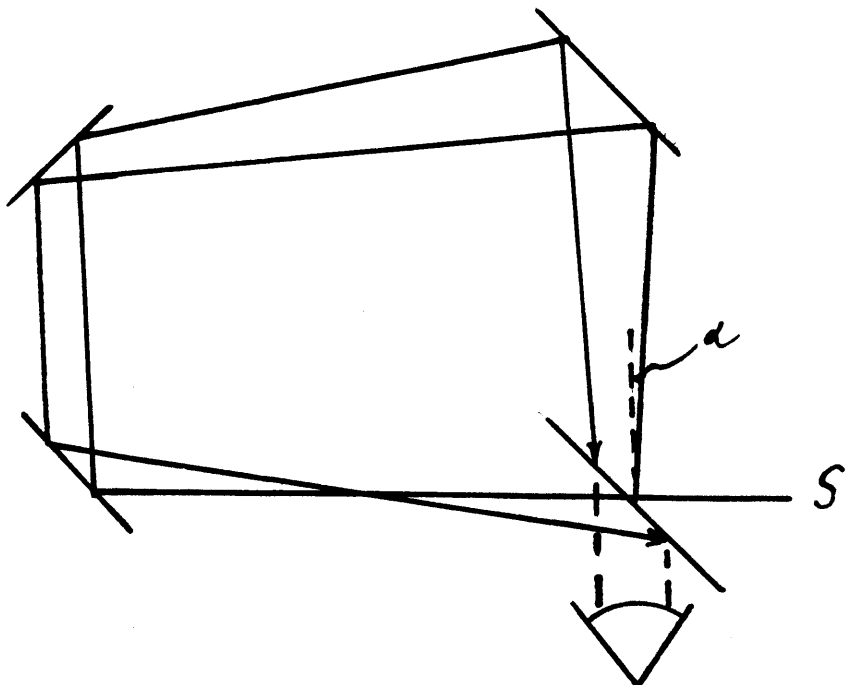


Fig. 7b

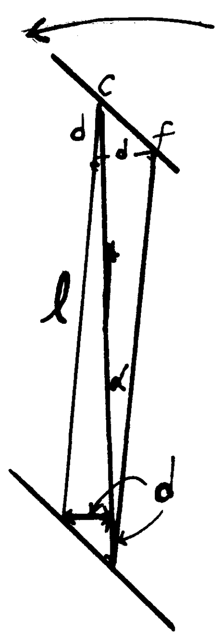


Fig. 7c

Binary Star Orbits

The Dutch astronomer, de Sitter, observed that the light used to find the spectroscopic orbits of eclipsing binary stars appears to have a constant velocity independent of the source. Historically, de Sitter's calculations regarding these orbits were the most important evidence for the constancy of the speed of light and they still are the most convincing. In de Sitter's papers published in Kronik Akademie Wetensch. Amsterdam, Proc. (15)1297 (1913) and (16) 395(1913), the original observational data for the star B Aurigae, which is used as the example, is not given; however, it can be assumed that the data for B Aurigae is similar to the scores of examples of spectroscopic binary orbits found in the Astronautical Journal, the Royal Astronautical Society Notices, the Astro Physics Simposium edited by J.A. Hynek (McGraw Hill 1951), and the publications of the various observatories, etc., etc.

De Sitter pointed out that a theory requiring an additive velocity should make itself apparent in a difference between the observed time of one half rotation of each member around the other, and that this time difference would amount to $\frac{2vl}{c^2}$ where l is the distance from earth, v the velocity of rotation, and c the velocity of light from a fixed source. De Sitter's formula, $\Delta t = \frac{2vl}{c^2}$ can be simply derived as follows:

$$t_1 = \frac{l}{c+v} \quad , \quad t_2 = \frac{l}{c-v}$$

$$\Delta t = t_2 - t_1 = \frac{l}{c-v} - \frac{l}{c+v} = \frac{cl+vl}{c^2-v^2} - \frac{cl-vl}{c^2-v^2} = \frac{2vl}{c^2-v^2} \approx \frac{2vl}{c^2}$$

An examination of the various spectroscopic binary orbits as published in the several professional journals shows that, for observed orbits, de Sitter's conclusions are essentially correct; however, these are several interesting considerations; all of the orbits examined were determined statistically from a large number of observations and in some specific instances, there have been observed rapid changes in amplitude and shape of the velocity curve such as those reported by Mr. R.K. Young in the Pub. of the Dominion Astro Physics Observatory, Victoria (1) #2; and Mr. William Buscombe and Mr. David S. Evans who report individual velocity measurement deviations of approximately 10 km/sec in the Royal Astronautical Society Monthly Notice #3, P. 262 March 1956, and #5, P.557, July 1956 respectively. In addition, Mr. Buscombe also reported that the spectroscopic lines of hydrogen observed in the spectrum of binary HD 170523 were always more diffuse at the maximum velocity of approach, and there are several reports in the AstroPhysical Journal that the bright spectroscopic emission lines from binary stars do <u>not</u> show a doppler shift.

Part of these effects are undoubtedly due to instrument and measurement errors, but even so, there is some question if they are compatible with a "pure" velocity of light.

Now, if the explanation of interference discussed previously is correct, it appears that a photon which passes near another photon traveling in nearly the same direction will be deflected in some way, and two possible explanations of de Sitter's observations come to mind. One possibility is that in stars with slow orbital velocities, the star will emit photons with a range of velocities due to the velocity of the individual molecules within the star. The photons with average velocity with respect to the star over a long period of time, will reach an observer precisely in the sequence in which they left the star and the fast photons would be scattered by the slow photons which left the star during the previous period of time. For example, if we consider the classical Maxwellian distribution law, $\frac{dN}{dv_x} = N\left(\frac{m}{2\pi KT}\right)^{3/2} e^{-\frac{mv^2}{2KT}}$ where N is the number of molecules, M is mass of molecule, K is Boltzman's constant, T is degrees Kelvin, and v is velocity, we find that the mean velocity of the hydrogen molecules at 6000 K is approximately 10 km/sec. Note that 6000 K was determined for the sun using black body assumption and the actual temperature of the photosphere may be considerably higher. The Maxwellian velocity distribution is represented by Fig. 8. Consider a star in an orbit as shown in Fig. 9 (supposing it is rotating around an invisible companion) and associate the orbit positions a, b, c, and d with figures 8a, 8b, 8c, and 8d. Then in each velocity distribution a block of velocities can be found (the hatched area) which will have a constant specified velocity, with respect to a "stationary" observer. If photons were emitted with a constant velocity from each of these molecules in the photosphere they would then be filtered through the reversing layer. Since the reversing layer absorbs photons with constant energy and the energy of the photons is $E = \frac{hc}{\lambda}$, it is reasonable to assume that the slow-high frequency and the fast-low frequency photons would both be absorbed by a specific element and the absorption band would appear sharp to a nearby observer traveling with the star; that is, the observer traveling with the star would not be able, with frequency measurements, to distinguish between the slow and fast photons. The "stationary" observer, meanwhile, will observe a red doppler shift in the light from the hatched area which the star emits at point b and a violet doppler shift in the light from hatched area of Fig. 8d which the star emits when it is at point d.

Now, interference effects will cause the fast photons emitted at point d to deflect the slow photons emitted at point c, the fast photons from point c will deflect the slow photons from point b and so on. It appears that all of the constant velocity blocks except that emitted at point d are fairly well protected from overtaking photons by a slow

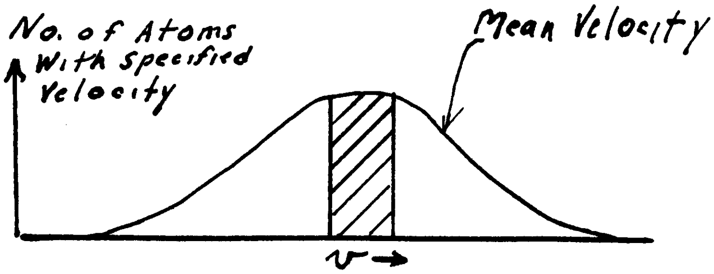


Fig. 8a

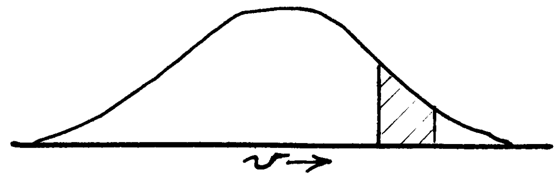


Fig. 8b

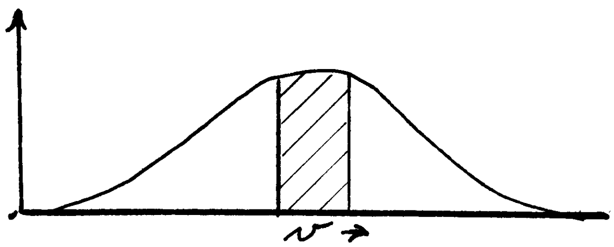


Fig. 8c

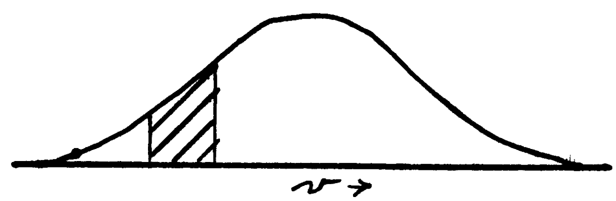


Fig. 8d

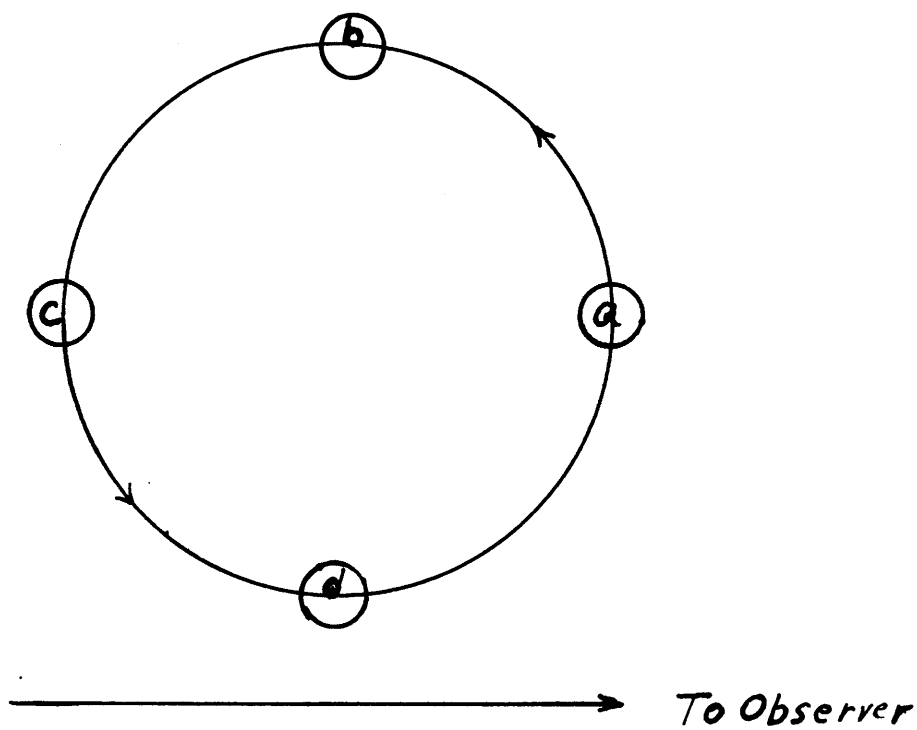


Fig. 9

block of photons. It might be pointed out that the star's rotation would undoubtedly add to the effect just described (for the sun this would be an effect up to approximately 10 km/sec) but shifts in phase something like those mentioned by Comstock, Phys. Rev. (30) 267 (1910) might have to be considered and at any event, effects of the star's rotations need not be considered in the present discussion. One possible objection to this deflected photon theory would be on the basis of an excessive reduction in the transmitted energy. First, it might be argued that almost as many photons which originally started in other directions would be deflected on to the path to the observer as would be deflected away from the path and not as much light from the near stars would be deflected as from distant stars. Be that as it may, in comparison with other stars, it appears that perhaps as much as one half of the total light might be deflected by interference effects in view of the fact that roughly one half of the time it can be considered as a stationary star, one fourth of the time an advancing star, and one fourth of the time a retreating star. The minimum observable signal from a sixth magnitude star is estimated to be between 336 and 1000 photons/sec by A.L. Hughes and D.E.M. Jauncey, Phys. Rev. (36) 773(1930) and H.E. Ives, Astrophysical Journal (44) 124 (1916). Using the sun as an example, the energy output per cm^2 is $6.4 \times 10^{10} \frac{ergs}{second}$ Using a nominal λ of $.47 \times 10^{-4}$ cm we get an energy/photon of $E = \frac{hc}{\lambda} = 4.18 \times 10^{-12}$ and $\frac{6.4 \times 10^{10}}{4.18 \times 10^{-12}} = 1.5 \times 10^{22} \frac{photons/sec}{cm^2}$ Using $1000 \frac{photons/sec}{cm^2}$ as the minimum observable signal and assuming isentropic radiation, we find the distance at which the sun would be a 6th magnitude star to be:

$$1000\left(\frac{D}{radius}\right)^2 = 1.5 \times 10^{22} \text{ or } D = 400 \text{ light Years.}$$

This gives some feeling for the magnitude involved.

It should be noted that it is quite difficult to determine the absolute magnitude of a star to an accuracy of .2 and if a star appeared dim (say for instance because of an unknown intervening dust cloud) then the only way that it could be determined that there were an error would be to calculate the energy of the star on the basis of its star type, then there would be the further question of how far the star is along the evolutionary path. Also, in the transmission of light, there is an absorption factor of one magnitude/5000 light years which is presently attributed to dust particles, and it is possible that some of this observed degradation is due to interference effects. If the degradation factor due to interference were one half as previously estimated, it would mean that the apparent magnitude would be changed by .4 since one magnitude is equal to a difference in intensity of two and a half times and so it appears that this deflection theory is perhaps feasible.

One more possible effect of deflection interference would be with respect to variable stars. Theoretically, variable stars should be brightest when the temperature is highest and the diameter is minimum since radiation is proportional to the fourth power of the temperature and the square of the diameter. However, in the Cepheid Variables, the time of greatest brightness coincides with the maximum velocity of approach and in the long period variables the time of greatest brightness coincides with the maximum velocity of recession. A small lag could be accounted for by saying that it takes time for the hot gases to get to the surface. While this would account for most of the Cepheid Variable lag, it is still rather puzzling.

If the long period variable had a maximum brightness at minimum diameter but with a gradual rise and a steep decline, and if the Cepheid Variable also had its maximum at minimum diameter but with a steep rise and gradual decline, their curves would look like those in Fig. 10a. It is then possible that the fast photons which were emitted from star at b interfere with the slower photons emitted at a. This in effect would remove the wave crest at a and result in the wave shapes shown in Fig. 10b.

As a side issue, it is interesting to assume no interference effects and determine if a range in photon velocities would be observable. Taking Bernard's Runaway, the star with the largest proper motion, for our example we see that it has an angular velocity of 10.3 seconds per year or $5 \times 10^{-5} \frac{\text{radian}}{\text{year}}$. Assuming white light, the resolving power of the 200 inch telescope is $\theta = 1.22 \frac{\lambda}{a} = 1.22 \times \frac{5.6 \times 10^{-5}}{200 \times 2.54} = 1.35 \times 10^{-7}$ rad. The ratio of these two angles is .0027. This means that light emitted at two points .0027 of a year apart could not be detected. Bernard's star is 6.1 light years away and therefore the maximum photon velocity range observable would be $\frac{.0027}{6.1} \times 3 \times 10^{10} = 133$ Km/sec

The pure deflections of photons as described above would be sufficient to account for stars with low velocities but would not be adequate to account for stars with orbital velocities on the order of 100 km/sec even though the effect would still be present and might account for 10 to 20 percent of any observed velocity reduction. We must therefore take another look. At this point, it is natural to consider what the effects of interference would be of a cloud of photons slowly overtaking another cloud. We have seen that from consideration of the photon cross section, photon collision would be negligible but that any observed effects must be due to the photons' field, and being a field, it is natural to assume that it would be proportional to the distance between the photons. If this is so, then as the fast photons approach the slow photons, the fast

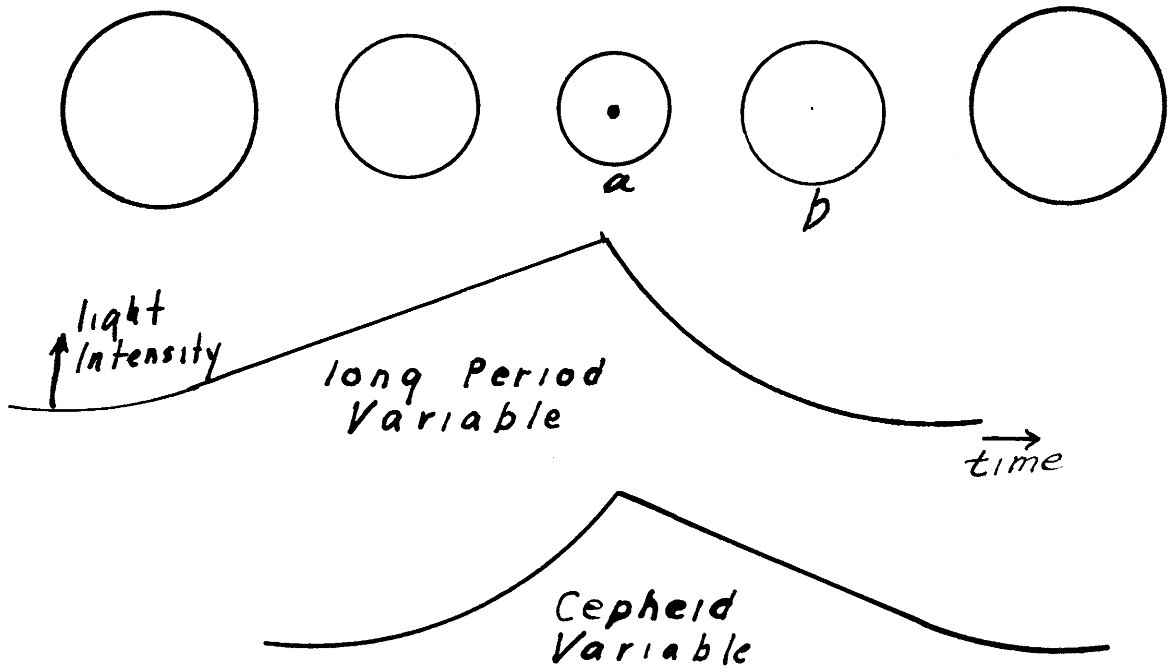


Fig. 10a

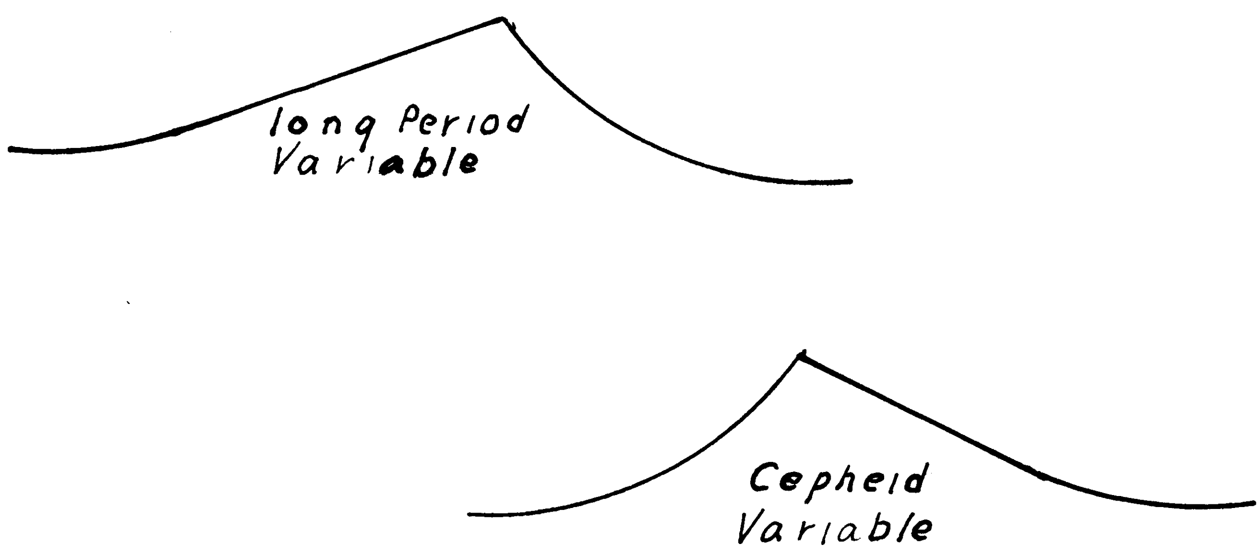


Fig. 10b

photons would be slowed down and the slow photons would be speeded up until both are traveling with the same velocity. Furthermore, it is possible that inertia effects would cause the "wave lengths" of the overtaking photons to be reduced and the "wave lengths" of the overtaken photons to be increased by an amount proportional to the change in velocity so that the observed frequencies would be the same as they would have been for the unaccelerated photons.

It is therefore suggested that interference effects may be the mechanism responsible for the observed invariance of the speed of light. There is considerable independent evidence that interference phenomena would have an effect and it appears that this explanation is logically acceptable.

CHAPTER 2

FORCE CONCEPTS

Even though there is certainly nothing conclusive about the results of the chapter on light, and it may even be that some of the details are in error, it appears that there are some grounds to question the assumption that the velocity of light is completely independent of the velocity of the source. Accordingly, it will be assumed that there is a significant probability that light acts essentially as discussed in the previous chapter, and some space will now be devoted to considering some concepts of force which would be appropriate if space were Euclidian and light were variable.

First, it is interesting to note what Newton said about gravity in his letter to Bentley (The works of Richard Bentley (London 1838) vol. 3, letter III, page 211) :

"It is inconceivable that inanimate brute matter should, without the mediation of something else, which is not material, operate upon and affect other matter without material contact, as it must be, if gravitation in the sense of Epicuus, be essential and inherent in it. And this is one reason why I desired you would not ascribe innate gravity to me. That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance through a vacuum, without the mediation of anything else, by and through which their action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man, who has in philosophical matters a competent faculty of thinking, can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws; but whether this agent be material or immaterial, I have left to the consideration of my readers."

It is a fact that very little if any progress has been made since the time of Maxwell on the understanding of the precise mechanism involved in the transmission of force. The concept of matter is also involved in a discussion of the force mechanism because matter is usually defined as that which can exert forces of inertia.

There are also mass-wave relationships such as De Broglie's Theory which affect the picture. Max Born on page 90 of his book, Atomic Physics (Hafner and Co.) writes of these theories and discusses the attempt to interpret a particle as a wave packet due to the super-position of a number of wave trains; "This tentative interpretation however, comes up against insurmountable difficulties, since a wave packet of this kind is in general very soon dissipated. We need only consider the corresponding case in water waves. If we produce a wave crest at any point of an otherwise smooth surface, it is not long before it spreads out and disappears."

This is approximately the present state of the understanding of matter and in view of the unknown nature of matter the author will, for the present, use the most vague possible definition of matter as "just plain stuff," admit that he does not know what it is, and then go on to talk about it as if he did.

Returning to the discussion of force, it is interesting to note that since the force mechanism is such a mystery, the modern trend is to consider force as a pure relational or mathematical function as Max Jammer in his book "Concepts of Force" (Harvard Press 1957) so ably points out. Indeed, Mach, Kirchhoff and Hertz have logically <u>eliminated</u> the concept of force from mechanics with the aid of Hamiltonian and variational calculus concepts. Whether the influence of a particle on another is called force, potential or a field is really not too important; what is fundamental is that there must be some mechanism between the two. In view of the illustrious brain power which has already been devoted to the problem of "what is the mechanism" with no completely acceptable explanation, it is not to be expected that this paper can contribute much; however, since the mechanism is such a complete mystery, it is interesting and an enjoyable pastime to speculate on the possible characteristics of this mechanism. What is the simplest assumption which can be made regarding a force? It seems to the writer that especially if matter itself is a collection of waves, that there is a very high probability that matter would influence other matter through some sort of a wave mechanism. Let us examine this assumption a little further. For the present, let us ignore all "detail" questions such as, do the waves impinge on the particles or do the waves from both particles interact to cause the force or does the particle "resonate" in response to the wave. The simplest thing which can be said is that if a wave is the force transmitting mechanism, the waves would appear distorted or polarized if the particles are in motion with respect to each other. The observed force would then vary with velocity.

It is therefore submitted then that any scheme which uses the "simple" concept that forces depend only on distance should be carefully considered. In particular, Maxwell's equations will be examined in the next chapter from the point of view of variable forces. It is relevant here to note that on page 527 of "The Scientific Papers of J.C. Maxwell" (Dover Pub. 1890) he says, " the mechanical difficulties in the assumption of particles acting at a distance with forces which depend upon their velocities are such as to prevent me from considering this theory as an ultimate one though it may have been and may yet be useful in leading to the coordination of phenomena.*

Let us now consider two particles in motion with respect to one another as shown in Fig. 11 and also define the velocity of propagation of a wave with respect to the particle which emits it as Webber's Constant, W_c since, according to Maxwell, this was originally Webber's concept which he discussed in Taylor's Scientific Memoirs, Vol V, article XIV.

The wave which is emitted from B has to appear to particle A exactly the same as the wave which is emitted from A appears to particle B. In other words:

In A coordinates:

$$F_A = F_B \, f_1(W_c, v)$$

In B coordinates:

$$F_B = F_A \, f_2(W_c, v)$$

In both coordinates $f_1(W_c, v) = f_1(W_c, v)$

If, in A coordinates, we assume F_B proportional to W_c and F_A proportional to $\sqrt{W_c^2 - v^2}$ we get $\frac{F_A}{\sqrt{W_c^2 - v^2}} = \frac{F_B}{W_c}$ or $F_A = F_B\sqrt{1 - \frac{v^2}{W_c^2}}$

Similarly, if in B coordinates, we assume F_A proportional to W_c and F_B proportional to $\sqrt{W_c^2 - v^2}$ we get:

$$\frac{F_B}{\sqrt{W_c^2 - v^2}} = \frac{F_A}{W_c} \quad \text{or} \quad F_B = F_A\sqrt{1 - \frac{v^2}{W_c^2}}$$

Both of these functions are equal; therefore $f(W_c, v)$ must be $\sqrt{1 - \frac{v^2}{W_c^2}}$ designated $= \beta$ This, of course, is the Lorentz Confraction Factor, but note that it is operating on the connecting link of force between the two particles instead of con-

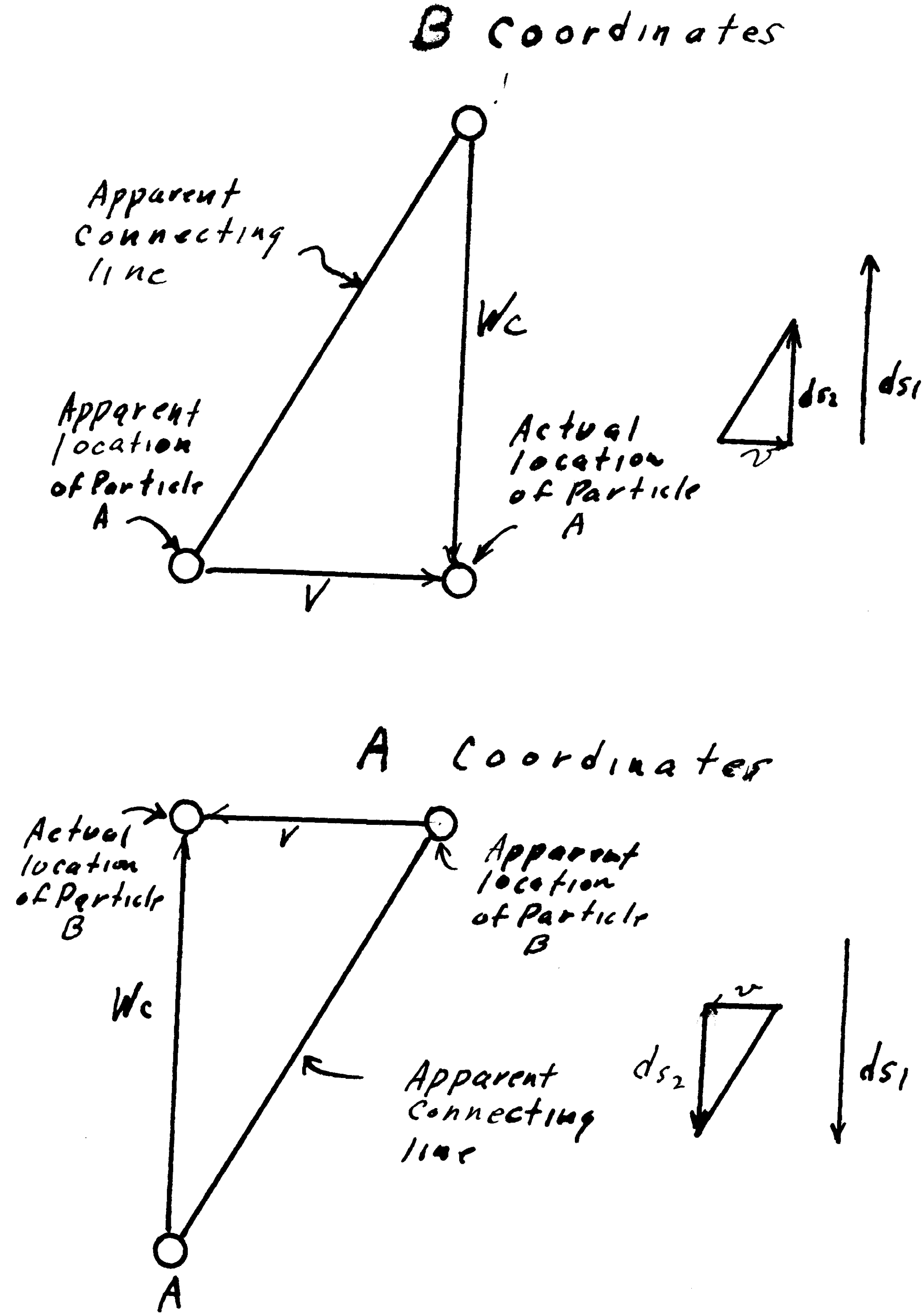

B Coordinates
Apparent connecting line
Wc
Apparent location of Particle A
Actual location of Particle A
V
ds2
ds1
v
A Coordinates
Actual location of Particle B
V
Apparent location of Particle B
Wc
Apparent Connecting line
v
ds2
ds1
A

Fig. 11

tracting the measuring rods. It should be recognized that the author has an emotional preferential bias for a contracted force as opposed to the idea of a contraction of a measuring rod by an ether which does not exist or an inertial memory contained in matter. If there is no ether or an equally magic matter-inertial-memory, then a Euclidian distance in one space is equal to a Euclidian distance in another space, and matter would also have the same dimensions as measured by a Euclidian yardstick.

Of course, everything depends upon which phenomena is taken to be the fundamental mystery. A fundamental phenomena is defined as one which cannot be explained in terms of any other phenomena. If the observer accepts the observed constancy of light as fundamental and describes the other phenomena (for example, interference) in terms of a constant light, he will arrive at a different conclusion than he will if he accepts the phenomena of interference as fundamental.

Returning to Fig. 11, let us consider that the observer is traveling with particle B and that, for simplicity, the energy flow or direction of the acting force is from B to A. We can say that a reduced force will move a particle a reduced distance and we must therefore be careful to associate the appropriate forces and distances when calculating work and energy. If we define ds_1 as the reference incremental distance which would result from a force if there were no relative motion and ds_2 as the incremental distance which would result from the contracted force associated with a relative motion, then $\frac{ds_1}{\omega_c} = \frac{ds_2}{\sqrt{\omega_c^2 - v^2}}$ or $\frac{ds_1}{ds_2} = \frac{1}{\beta}$

ds_2 in A space is equal to $-ds_2$ in B space

A force in A space transferred to B space is: $F_B = F_A \beta$

and force is defined as the rate of change of momentum, $F = \frac{d}{dt}(mv)$

The work in B space is:

$$F_B \, ds_1 = \frac{d}{dt}(mv)\,ds = \frac{ds}{dt}\, d(mv) = mv\,dv \text{ (considering mass to be constant)}$$

in terms of the force in A space this is:

$$F_A \, ds_1 = \frac{mv\,dv}{\beta}$$

The energy is force times the integral of the distance.

$$E = F_A \int ds_1 = m \int \frac{v\,dv}{\sqrt{1-\frac{v^2}{w_c^2}}} = -m w_c^2 \beta$$

In terms of the distance which the force acts through in A space, this is: $F_A \int ds_2 = -m w_c^2$

which is the transferred energy as seen from A space.

Since a force in B space transferred to A space is $F_A = F_B \beta$, $F_B \int ds_2 = + \frac{m w_c^2}{\beta}$ which is the transferred energy as seen from B space. These results can also be derived using vector analysis. Mathematically, of course, the results are identical with Einstein's with the exception that the interpretation involves a variable force instead of a variable mass.

The Equivalence of Mass and Force

It has been mentioned previously that the mass of a particle is defined as the inertial resistance of the particle to a force. Now obviously, if the effective force on a particle is reduced due to a velocity relative to other particles (or the field from other particles) then the apparent mass of the particle as defined above would become greater.

As an aside, it should be noted that the "law" that all particles in the universe attract every other particle is really an assumption and it is conceivable that a particle of matter (matter defined as stuff) might not be responsive to any known field. Thus, the mass of a neutrino, for example, would be zero. We could also associate the energy of a neutrino with the inertial property of the matter of which it is composed; then we would have to say that, for the neutrino, the "inertial matter" is not equal to the "inertial mass." These considerations would lead us to the conclusion that, in general, an inertial mass of a particle is equal to the gravitational mass of the particle because both of these quantities are the measure of the response of the particle to a force. It appears that it might be worth while to separate the concepts of mass and matter; however, it is difficult to arrive at a definition of matter which would be determinable by simple measurements. In the absence of anything better, we will continue therefore, to equate mass with matter and try to make the distinction on an individual basis wherever appropriate.

It is worth while mentioning that in the two particle situation it is not possible to say that the field velocity term, v/c in the force reduction factor is associated with the field emitted from particle A or the field emitted from particle B because it is not at present known whether the particle responds directly to the received force wave or the response depends upon an emitted wave interacting with the received wave. Numerically, of course, the velocity of the field emitted from particle A with respect to A is identical with the velocity of the field emitted from particle B with respect to B. So, for the present, it is not necessary to make a distinction between the two fields and W_C can be considered as simply a characteristic constant of the particle being measured.

The Compton Effect

To show the equivalence of the variable forces and variable mass , we will follow through the derivation of the Compton Effect which is representative of particle collisions.

Electrons are diffracted as if: $\lambda = h/mv$

The energy of a quantum is measured as: $E = hf$

The mass of a quantum is computed as: $M = E/\omega_c^2 = \frac{hf}{\omega_c^2}$

The momentum of the quantum would then be: $P = m\omega_c = \frac{h}{\lambda}$

The change in energy of the electron measured by a stationary observer would be: $E = \frac{m\omega_c^2}{\sqrt{1 - \frac{V_2^2}{\omega_c^2}}} - \frac{m\omega_c^2}{\sqrt{1 - \frac{V_1^2}{\omega_c^2}}}$

The change in momentum of the electron measured by a stationary observer would be: $MV = \frac{mv_2}{\sqrt{1 - \frac{V_2^2}{\omega_c^2}}} - \frac{mv_1}{\sqrt{1 - \frac{V_1^2}{\omega_c^2}}}$

(Note that it is the measurement of the mass which varies with relative velocity due to the fact that the force varies and the mass itself is a constant). V_1 is assumed equal to zero.

From the conservation of energy we have:

$$(1)\quad h f_0 - h f = \frac{m \omega_c^2}{\sqrt{1-\frac{v_2^2}{\omega_c^2}}} - m\omega_c^2$$

From the conservation of momentum we have:

$$(2)\quad \frac{h}{\lambda_0} - \frac{h}{\lambda}\cos\theta = \left(\frac{m v_2}{\sqrt{1-\frac{v_2^2}{\omega_c^2}}} - \frac{m v_1}{\sqrt{1-\frac{v_1^2}{\omega_c^2}}}\right)\cos\theta$$

$$(3)\quad \frac{h\sin\theta}{\lambda} = \frac{m v_2}{\sqrt{1-\frac{v_2^2}{\omega_c^2}}}\sin\theta$$

squaring and adding equations 2 and 3:

$$(4)\quad \left(\frac{h}{\lambda_0}\right)^2 + \left(\frac{h}{\lambda}\right)^2 - \frac{2h^2\cos\theta}{\lambda\lambda_0} = \frac{m^2 v^2}{\beta^2}$$

Dividing equation (1) by ω_c and squaring:

$$(5)\quad \left(\frac{h}{\lambda_0}\right)^2 + \left(\frac{h}{\lambda}\right) - \frac{2h^2}{\lambda\lambda_0} = m^2\omega_c^2\left(\frac{1}{\beta}-1\right)^2$$

Subtracting 5 from 4:

$$\frac{2h^2}{\lambda\lambda_0}(1-\cos\theta) = m^2\left[\frac{v^2}{\beta^2} - \left(\frac{1}{\beta}-1\right)^2\omega_c^2\right]$$

$$= m^2\left[\frac{v^2}{\beta^2} - \left(\frac{\omega_c^2}{\omega_c^2-v^2} - \frac{2}{\beta}+1\right)\omega_c^2\right]$$

$$= m^2\omega_c^2\left[\frac{v^2}{\omega_c^2-v^2} - \frac{\omega_c^2}{\omega_c^2-v^2} + \frac{2}{\beta} - 1\right]$$

$$= m^2\omega_c^2\left[\frac{v^2-\omega_c^2}{\omega_c^2-v^2} + \frac{2}{\beta} - 1\right]$$

$$= m^2\omega_c^2\left[\frac{2}{\beta} - 2\right]$$

$$= 2m\omega_c\left[\frac{h}{\lambda_0} - \frac{h}{\lambda}\right]$$

$$\therefore\ \lambda - \lambda_0 = \frac{h}{m\omega_c}(1-\cos\theta)$$

Summary of Force Concepts

If we let the fundamental concepts be location or distance, time, and matter and measure matter as mass, we would have to use five dimensions to describe an event. These would be the three dimensions of space, plus the dimensions of time and mass.

We can now define the combination concepts in terms of the primary concepts as follows:

Let: D = distance, ds = increment of distance, T = time, $\dot{D} = \frac{d}{dt}(D)$ etc. M = mass = the measurement of matter.

Then:

mass time point	= MTD
mass location	= MD
momentum	= $M\dot{D}$
force XB	= $M\ddot{D}$
work	= $M\ddot{D}D$ or $M\ddot{D}ds$
energy	= $M\ddot{D}\int ds = M\ddot{D}S = M\ddot{D}D = M\dot{D}\dot{D} = M\omega_c^2$ if the velocity of energy transfer $\dot{D} = \omega_c$!!
power	= $M\ddot{D}\dot{D}$
impulse	= $M\ddot{D}T = M\dot{D} - M\dot{D}_0$
weight	= $M\ddot{D}$ where $\ddot{D}$ is due to gravity

The incremental distance, ds, is used to show that under the action of work the energy of a particle is increased by an amount equal to the work.

CHAPTER 3

ELECTRICITY

If we use the mixed system of Gauss, measuring charge in statcoulombs and current in statamperes, magnetic field in electromagnetic units (u for vacuum being 1) and electric field in electrostatic units (ϵ for vacuum being 1), then we can write Maxwell's equations as follows:

$$\text{Curl } H = \frac{1}{c}\frac{\partial D}{\partial t} + \frac{1}{c} 4\pi J$$

$$\text{div } B = 0 \quad , \quad B = \mu H$$

$$\text{Curl } E = -\frac{1}{c}\frac{\partial B}{\partial t}$$

$$\text{div } D = 4\pi\rho, \quad D = \epsilon E$$

The reason that $\text{div } B = 0$ is that there is no such thing as a magnetic charge. The reason that the $\text{Curl } E$ equation is not symmetrical with the $\text{Curl } H$ equation is that there is no such thing as a magnetic current. Now, if we take the equation

$$\text{div } D = \nabla \cdot D = 4\pi\rho$$

and suppress all of the lengths except the general length ψ we get:

$$\frac{\partial D_\psi}{\partial \psi} = 4\pi\rho$$

integrating we get:

$$D_\psi = 4\pi\rho\psi$$

differentiating with respect to time:

$$\frac{\partial D_\psi}{\partial t} = 4\pi\rho\frac{\partial \psi}{\partial t}$$

Considering the current density:

J charge density times velocity $= \rho V = \rho \frac{\partial \psi}{\partial t}$

Substituting these values for $\frac{\partial D}{\partial t}$ and J in the Curl H equation:

$$\text{Curl } H = \frac{1}{c}\left(4\pi\rho \frac{\partial \psi}{\partial t} + 4\pi\rho \frac{\partial \psi}{\partial t}\right)$$

This shows that both the change in the displacement field D and the current density J are equivalent to and can be considered as caused by movements of charge. Furthermore, the vorticity of the magnetic field is caused by these moving charges. In other words, the force produced by the magnetic field depends upon the velocity of the moving charges with respect to each other. The magnetic field should, of course, not be considered as being caused by the movement of the electrical charges but should be considered to be the electrical field emitted by the moving charges.

The simple case of a charge in motion is shown in Fig. 12 where 1, 2, and 3 are successive positions of the charge. It is easily seen that the field at point A is a counterclockwise rotation or vortex. The equation of this vortex is:

$$\text{Curl } H = \frac{4\pi\rho}{c}\frac{\partial \psi}{\partial t} = \frac{v}{c}(4\pi\rho)$$

This equation describes how the magnetic field is produced perpendicular to the electrical field but, of course, mathematics does not pretend to "explain" phenomena and the fact that the magnetic force is perpendicular to the electrical field makes one wonder how the force turns the corner and even wonder if the magnetic and electrical fields are not essentially different even though we have said previously that the magnetic field is the electrical field emitted by a moving charge. It would also be interesting to know why the force makes a left hand turn instead of a right hand turn.

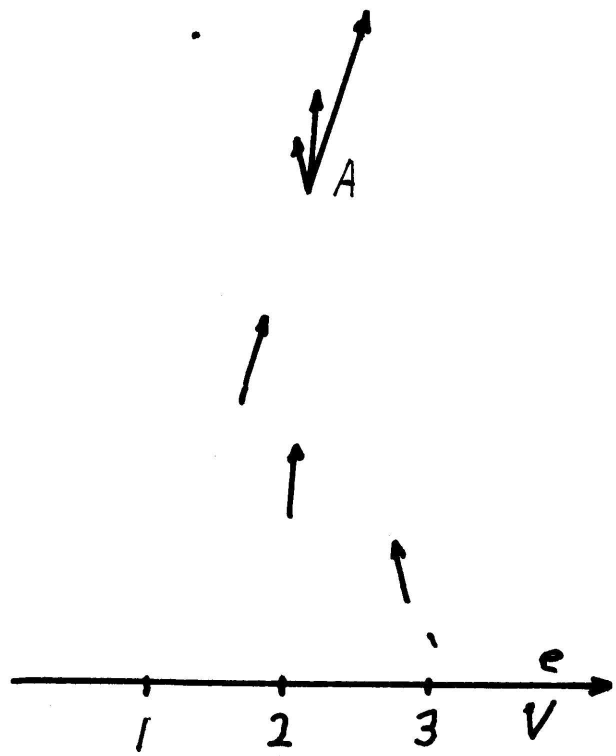


Fig. 12

Let us consider a possible qualitative explanation of magnetism using idealized electron orbits as the model for a thought experiment. Fig. 13 shows electrons in orbit rotating in opposite directions with a stream of electrons moving across the orbits. It would be expected that the electrons in orbit would be affected most when they are traveling with the electron stream. Gyroscopic action, while important, does not determine the final orientation of the orbit because the electron orbits are actually ellipses which precess in a rosette according to Sommerfeld. This in effect, shifts the location of the successive effective impulses to an earlier point on the changed orbital plane which counteracts the gyroscopic effect. Under the influence of a repulsion at the point on the orbit where the electrons are traveling with the electron stream, the orbits would be precessed as shown in Fig. 13b. Note that both of these orbits are rotating in the same direction. Now, if an electron, e , were to move across the face of the bar, it would move through the successive rotating <u>electrical</u> fields; and again, since it is influenced most by the part of the field with the least relative motion, it would be repelled upward. We can in this way explain all of the magnetic effects in terms of the electrical field.

There is one thing seriously wrong with the above explanation and that is that in Fig. 13b, the exciting electron stream is moving in the opposite direction to the electron orbits. This means that if magnetic material is inserted in a solenoid, the magnetic material should reduce the effect of the solenoid or else small circular currents should be explained by a mechanism different from that explaining a large circular current.

It is wondered then if we should not take a completely different

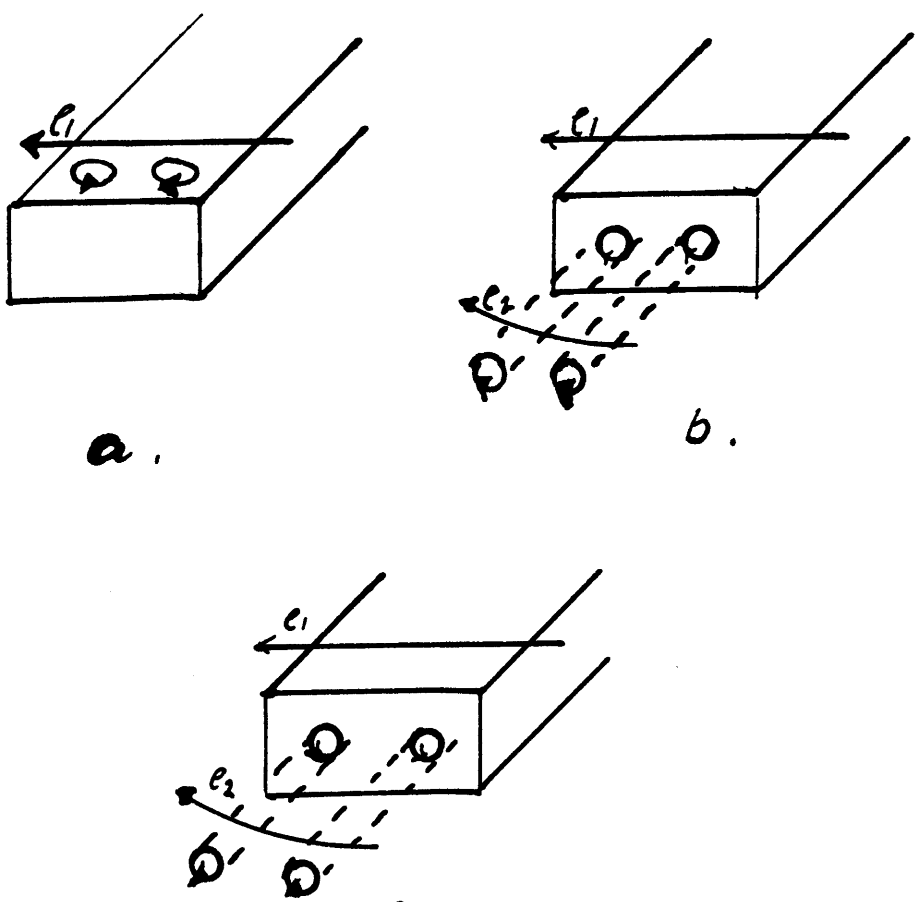


Fig. 13

approach such as ascribing the repulsion of electrons to a harmonic effect due to their relative motion. This would mean that electrons at rest with respect to each other would actually attract one another. Using attraction forces, we would get a picture as shown in 13c with the test electron moving in the same direction as before and in addition, this picture explains the attraction of one magnet for another in the most direct way possible.

The author is encouraged to propose this radical idea by the fact that electron streams have a tendency to contract and get smaller instead of scattering as we would expect if electrons have a fixed repulsion. It is also rather difficult to explain the space charge in a vacuum tube in terms of repulsion because if the space charge is just due to electrons which have been emitted with slow velocities then the space charge should be right next to the cathode and they should be swept along by the greater numbers of faster electrons even if they were not being accelerated by the field.

It should be noted that our measurements of electrical charge are not made with the charges at rest but by observing the effect of adding or subtracting an additional moving orbital electron to an atom.

That which is called the magnetic field is actually a collection of electrical field helixes and the response of a positive particle can be explained by attributing a handedness to the positive particle field which would deflect the helix so that the particle would not travel through a helix but would travel between helixes. Then, the positive particle would be deflected in the opposite way from the electron by the same attractive force phenomena which acts on the electron.

These effects are, of course, still described by Maxwell's equations except that the electron charge would appear different if measured at a small relative velocity. We have shown how the electric field in motion might be the magnetic field if velocity variable forces are acting and of course, if a quantity is equal to another quantity in motion, they are covariant by definition.

CHAPTER 4

CONCLUSIONS AND RECOMMENDATIONS

Newton's second law seems to be primarily a definition of both force and mass; and since there is some doubt that mass and matter are synonomous, neither concept can be regarded as fundamental; however,

1. If we accept light interference phenomena as a fundamental observation, there is a finite probability that the initial velocity of light is a constant with respect to the source.

2. If we consider force as a deformable connection between two particles, we can account for most of the observed phenomena (even the deflection of light by gravity might be accounted for by setting the "mass" of the photon equal to E/c^2 and then using Plank's constant), and consider coordinate transformations to be Euclidian.

3. If the above are true, the dimensions of time and space can be considered as absolutes, and a gravity field affecting a space ship would be reduced by the factor $\sqrt{1 - \frac{v^2}{w_c^2}}$. However, the relativistic reduction factor would not apply to the acceleration of the ship due to its own rockets.

Possible Tests

It is submitted that measurements involving moving charges should be the most feasible test of the variable force concept. Relativity Theory says that the intensity of a moving charge varies as presented on page 537 of Leigh Page's "Introduction to Theoretical Physics." Page gives the relativistic result in terms of components of E parallel and normal to the velocity.

$$E_p = E_{op} \quad , \quad E_n = \frac{E_{on}}{\sqrt{1-\frac{v^2}{c^2}}}$$

This says that the electric field at right angles to the direction of motion is <u>increased</u> by the ratio $\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$

The variable force concept predicts that the measured electric field at right angles to the direction of a moving charge would be <u>decreased</u> by the factor $\sqrt{1-\frac{v^2}{w_c^2}}$

Measurement of the effects of electrons at rest with respect to one another should be attempted.

The rotating interferometer experiments of Sagnac as reported in Journal de Physique (4) ser. 5, P. 177 (1914) and Michelson should be repeated using non right angle reflections.

It is conceivable that the effective distance for congruence for light could be shortened by successive reflections from moving mirrors.

The determination of the velocity of the light from one of the receeding galaxies on a time-distance basis would be a conclusive experiment if positive results were observed. It is especially attractive because it would be a one way measurement and would therefore avoid the "time-at-the-reflecting-mirror" question; it would also be a direct measurement of light velocity and avoid all "magic" mirrors, etc., etc. One can conceive of a refinement of Fizeau's rotating cogwheels using narrow slits on the first cogwheel arranged so that interference (which should not affect the velocity) would produce very narrow lines at the second cogwheel which would have slits placed and be rotating at such a rate that only slow photons would pass through and be recorded on film. Unfortunately, there is a question about the nature of transmission of light through a medium such as the atmosphere. The experiment, therefore, should be performed from a satellite and even then there would be a final question about the effect of the photons from nearby stars (within a thousand light years or so) which are traveling nearly parallel to the light from the distant galaxy. For these reasons it would not be surprising if the experiment produced a negative result; however, in view of the conclusive knowledge which would be gained if the result were positive, it is felt that the experiment should eventually be attempted.

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