[3]The technique as such was described at the Hawaii American Physical Society meeting, prior to present findings [J. R. Pellam, Bull. Am. Phys. Soc. 4, 370 (1959)].

[4]R. P. Feynman (private communication).

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FIRST-ORDER TERRESTRIAL ETHER DRIFT EXPERIMENT USING THE MÖSSBAUER RADIATION

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Despite the general acceptance of the special theory of relativity, the Fitzgerald-Lorentz contraction theory and its ability to account for previous experiments have persisted. In particular, the extension of the Fitzgerald-Lorentz contraction theory by Ives[1] appears to bring the contraction theory on a par with both the special and general theories of relativity. It has been pointed out[2] that this impasse may be resolved by astronomical observations and satellite experiments designed to detect a variation in the one-way velocity of light with direction in space. The existence of such an observed variation, which may be considered to be synonymous with the existence of an ether, is allowed by the Fitzgerald-Lorentz contraction theory but not by the special theory. This note proposes a terrestrial experiment which has considerable sensitivity when the Mössbauer radiation is used and which permits a first-order test for a variation in the velocity of light with direction in space.

An electromagnetic radiator having a highly stable frequency, a frequency-selective absorber or filter, and a counter or other suitable detector are placed on a turntable, as shown in Fig. 1. Electrical connections to the counter or detector may be made through slip rings. If there is an ether and the velocity of the plane of the turntable through the ether is v, then the time taken for the radiation to travel the distance s between radiator and absorber is

$$\tau = \frac{s}{c - v\cos\theta}, \tag{1}$$

where c is the velocity of the radiation in the medium between radiator and absorber. When the table is rotated there is a variation in this time if $v \neq 0$. As the time varies there is a change, $-f\,d\tau$, in the phase of the radiation as received at the absorber, where f is the frequency of the radiation. The time rate of change of the phase corresponds to a change in frequency.

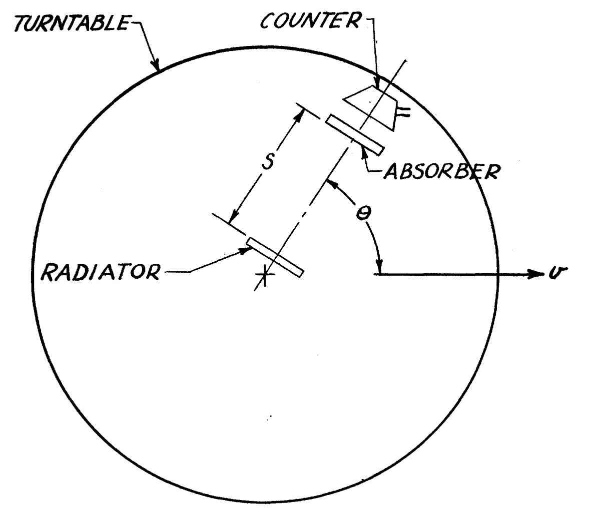

FIG. 1. Arrangement for the detection of a one-way variation in the observed velocity of light.

The relative change in frequency at the absorber, when $v \ll c$, is then, to first order,

$$\frac{\Delta f}{f} = -\frac{d\tau}{dt} = \frac{\omega s v \sin\theta}{c^2} - \frac{v}{c^2}\frac{ds}{dt}\cos\theta - \frac{1}{c}\frac{ds}{dt}, \tag{2}$$

where ω is $d\theta/dt$, the angular velocity of the turntable. The last term is the Doppler shift. It and the second term may be minimized by using a rigid construction to insure that ds/dt is substantially zero.

If the linewidth of 1 part in 10^{12} achievable with the Mössbauer radiation[3] is used for detecting a minimum change in frequency, s is made $1/10^4$ km and is constant, and ω is 60π rad/sec, corresponding to 1800 rpm, then an ether drift of about 5 km/sec is measurable. With a "least count" sensitivity of 3 parts in 10^{16} estimated for the Mössbauer radiation[4] and the above values for s and ω, an ether drift of about 0.0015 km/sec is measurable.

The axis of the table may be located anywhere along the measurement axis to permit a rotationally balanced structure. The table may be placed on gimbals to allow adjustment of the angle between the plane of the table and v. To remove an ambiguity in the direction of v, which results when the absorber and radiator are nominally resonant at the same frequency, their resonant frequencies should be separated. It is expedient to make the separation such that maximum sensitivity is obtained, i.e., when the resonant frequency of radiator or absorber is along the linear portion of the resonance curve of the other. The separation may be accomplished, for example, with a Doppler shift, by mounting the radiator or absorber on a loudspeaker movement or similar transducer and providing a sawtooth motion of proper amplitude and phase and of the same period as that of the table rotation. A difference in temperature between radiator and absorber[5] may also be used to separate the resonant frequencies.

Since this experiment is a first-order test, second-order effects are neglected. These include the transverse Doppler shift, Lorentzian variations in mass, length, and time, the bending and frequency shift of light in a gravitational field, and any anisotropy of space of gravitational origin. Only if a negative first-order effect is obtained will it be reasonable to use the proposed experimental arrangement to search for second-order effects.

Parenthetically, the resemblance between the proposed experiment and the terrestrial measurement[6] of the red shift in an accelerated system is superficial. In the latter, the counter is fixed near the periphery of the table and measures the difference in frequency between radiator and absorber for only one orientation of the table in space. If there is an ether, a frequency shift would result from the daily rotation of this particular orientation, but it would be very small, and probably immeasurable, due to the low angular velocity of the earth. If the radiation between radiator and absorber were not perfectly parallel, it would, in the presence of an ether, increase the error in the red shift measurement, but the effect would be small and difficult to interpret. To detect sensibly a variation in the frequency difference between radiator and absorber resulting from an anisotropy in the observed velocity of light it is expedient to monitor the difference frequency as the orientation of the radiator-absorber axis changes. To accomplish this in lieu of rotating the counter it is feasible to add stationary counters around the periphery of the table and to compare their outputs simultaneously.

This experiment, because it is a one-way test, is uniquely capable of differentiating between the special and contraction theories. In the contraction theory, the observed velocity of light, to the first order, is the denominator of Eq. (1), i.e., $c - v \cos\theta$. The special theory is correct and there is no Lorentz (optical) ether only if $v = 0$. If $v \neq 0$, the observed velocity of light varies with angle θ in contradiction with the second postulate of the special theory, only the contraction theory can be correct, and a Lorentz ether (which should not be confused with a modern ether attributable to a gravitational anisotropy) then physically exists. All previous experiments have been measurements of a two-way light signal or the equivalent. The measured two-way velocity in the contraction theory, to first order, is the average of $c \pm v|\cos\theta|$, or just c, as predicted by the special theory. The cancellation of the first-order terms has always produced an identical result (to the second order) for the contraction and special theories. Thus, the two-way experiments, as has been intermittently noted in the past, are not capable of measuring v or of detecting a Lorentz ether. A one-way test, which has never been knowingly performed on earth heretofore, may thus be termed a crucial experiment for it provides a final resolution of the issue between the relativity and contraction theories.

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