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Isotropy of the Velocity of Light

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Theories claiming existence of the anisotropy in the velocity of light are inconsistent with experimental data obtained by Mössbauer measurements.

Many theories requiring anisotropy in the velocity of light have been devised as competitors to the special theory of relativity (STR) (see Giannoni, 1979). Unfortunately, these theories are in disagreement with experimental data.

It is easy to show, combining equations (9) and (7) in the paper by Feenberg (1979), that the one-way velocity of light c_μ in the frame $\{x_\mu y_\mu z_\mu\}$ moving in "absolute space" with the velocity $u \geqslant 0$ along the z_μ axis is described by the following equation:

$$c_\mu = c/[1 - \mu \cos\theta] \tag{1}$$

where c stands for the two-way velocity of light, θ is a polar angle in the frame $\{x_\mu y_\mu z_\mu\}$ $(0 \leqslant \theta \leqslant \pi)$, and

$$\mu = -nu/c \qquad \text{with } 0 \leqslant |\mu| \leqslant 1 \tag{2}$$

where n has the same meaning as in the paper by Giannoni (1979) $(0 \leqslant n \leqslant 1)$. The spatial coordinates of STR $\{xyz\}$ are claimed to be identical with the coordinates $\{x_\mu y_\mu z_\mu\}$ provided that the two frames are in rest one with respect to another [see equation (3) in the paper by Giannoni (1979)]. Therefore, wavelength λ of monochromatic radiation must remain

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the same in both systems $(\lambda \equiv \lambda_\mu)^2$ as otherwise light generally does not propagate along straight lines in the frame $\{x_\mu y_\mu z_\mu\}$ and this very fact forces us to adopt different geometries (as well as generally different coordinates) for the two frames $\{xyz\}$ and $\{x_\mu y_\mu z_\mu\}$, respectively (the situation is somewhat similar to the transition from STR to the general theory of relativity). Now, using the equation from footnote 3 in Feenberg (1979), we have $c_\mu = \lambda \nu_\mu$ and

$$\nu_\mu = c_\mu/\lambda = (c/\lambda)/[1 - \mu\cos\theta] = \nu/[1 - \mu\cos\theta] \tag{3}$$

where ν and ν_μ describe frequencies in STR and "absolute space" theories (AST), respectively.

It has been shown to a high degree of accuracy that space is isotropic [for all relevant information and references to the experimental data, see Dicke (1968)] and therefore Planck's constant h could not be anisotropic $(h = h_\mu)$ as otherwise "spin-up" (and hence magnetic moment) would be different from "spin-down." Therefore, we may multiply both sides of equation (3) by h, obtaining

$$E_\mu = E/[1 - \mu\cos\theta] \tag{4}$$

where E and E_μ stand for the photon energies in STR and AST, respectively. For small $|\mu|$ $(|\mu| \ll 1)$ and almost monochromatic radiation the line shift $\Delta E = E_\mu - E_0$ is given by the formula

$$\Delta E \simeq E_0 \mu \cos\theta \tag{5}$$

where E_0 stands for the line center in STR. This shift must produce a misalignment in the Mössbauer spectrum provided that $\Delta E \gtrsim 2\Gamma$, where Γ stands for the natural linewidth. The misalignment may be compensated applying a very small Doppler shift

$$\Delta E_D \simeq (v/c) E_0 \tag{6}$$

between source and absorber (note, that to first order the Doppler shift does not depend on the particular choice of the theory), where v stands for the velocity between source and absorber. Accumulating counts against velocity (it usually takes many hours or even days) one could observe wandering of the line center owing to the changing angle θ during the Earth's rotation. The effect would be immediately appreciated if the

[2]The assumption $\partial\lambda_\mu/\partial\theta \not\equiv 0$ is equivalent to the explicit anisotropy of the medium (space). On the contrary, empty physical space is found to be highly isotropic [see an excellent review by Dicke (1968)].

change in the Doppler velocity corresponding to ΔE exceeds the velocity W_0 needed to shift the line about 2Γ (Γ is established independently from the nuclear lifetime). Hence,

$$nu\Delta(\cos\theta)\lesssim W_0 \tag{7}$$

as the effect has not been observed; $\Delta(\cos\theta)$ stands for the change in the polar angle θ during the data accumulation. Owing to the commonly adopted geometries of measurement, the beam divergence alone would produce $\Delta(\cos\theta)\simeq 0.01$. $W_0\simeq 0.3\times 10^{-3}$ (mm sec^{-1}) has been observed (Potzel et al., 1976) for the 93.3 keV line in ^{67}Zn using a combination of a (^{67}Ga)ZnO single-crystal source and a ZnO single-crystal absorber. The velocity $u\simeq 10^2$ (km sec^{-1}) [see addendum to the paper by Feenberg (1979)] seems at least to be a correct order of magnitude. Hence, $n\lesssim 3\times 10^{-10}$ at least. This result is more than six orders of magnitude smaller than the result quoted by Giannoni (1979) and derived from the muon lifetime measurements (Bailey et al., 1977). Therefore, it can be concluded that AST are not experimentally supported. Finally, it should be mentioned that the standard Mössbauer absorption effect belongs to the larger class of transient phenomena where the one-way velocity of light is an indispensable and measurable parameter in contrast to the conventionality thesis as stated by Grünbaum (1973).

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