

- no citation, to June 2004



An Implication of Ether Drift

Hong-Yi Zhou
China Center of Advanced Science and Technology (World Laboratory),
P.O.Box 8730, Beijing 100080, China,
and Institute of Modern Physics and Department of Physics,
Tsinghua University, Beijing 100084, China ¹

ABSTRACT

The experimental results of the two-photon absorption(TPA) and Mössbauer-rotor(MR) for testing the isotropy of the speed of light are explained in an ether drift model with a drift velocity of $\sim 10^{-3}c$. Further tests of the ether drift assumption are suggested.

arXiv:gr-qc/9805086 v2 25 May 1998

In Einstein's theory of special relativity (SR), the speed of light c is a universal constant which is isotropic and independent of the source velocity in any inertial frame. The advances of modern technology have made the precise experimental tests of this fundamental postulate possible. The experiment of Riis et al.^[1] measured the frequency shift of a two-photon transition in a fast atomic beam while the direction of the fast beam is rotated to the fixed stars. This experiment tests the isotropy of the first-order Doppler shift. The Mössbauer-rotor experiments of Turner and Hill^[2] and of Chanpeney et al.^{[3][4]}, measured the isotropy of the second-order Doppler shift of an emitter mounted on the rim of a rotating disk, as received by an absorber at the center. These two kinds of experiments are sensitive to the one-way speed of light in contrast to the round-trip experiments as the Michelson-Morley one. The experimental results show that the deviations from the special relativity seem to be quite small^[5]. We note that the TPA experiment gave a 12-h period frequency variation which was explained by the authors to be a systematic effect. The 12-h period variation also appeared in other experiments^{[6][7]}. Whether this variation is a systematic effect or new physics should be studied carefully. In this paper, we show that the TPA 12-h period variation can be explained in an ether drift model while the model give a consistant result of the MR experiment.

The basic assumption of our ether drift model is that the speed of light c measured in the rest frame of the ether is isotropic and constant. When an atom moves with velocity \vec{u} in the ether, it will contract with a factor $1/\gamma$ ($\gamma = \frac{1}{\sqrt{1-u^2}}$ with $c \equiv 1$) along the direction of \vec{u} and its energy level E will become E/γ due to the retarded potential^[8]. The atomic transition frequencies will all be lowed down by a factor $1/\gamma$ which results in the time dilation, nonetheless, this change as well as the length contraction is not measurable by a comoving observer. That means our model is an ether drift model with Lorentz length contraction and Larmor time dilation. The round-trip velocity of light measured by a comoving observer is precisely isotropic and constant. Therefore, the round-trip experiments can not distinguish this ether model from the SR. We may expect that some effects different from the SR exist in the one-way experiments as can be seen below.

We consider now the TPA experiment. Assuming the laboratory moves with \vec{u} through the ether, the beam velocity relative to the laboratory is \vec{v} , then we have the following laser frequency ν_L :

$$\nu_L = \frac{1 - u \cos(\phi + \theta)}{1 - u \cos(\phi + \theta) - v \cos \theta} \sqrt{\frac{1 - u^2 - v^2 - 2uv \cos \phi}{1 - u^2}} \nu_1, \quad (1)$$

$$\nu_L = \frac{1 + u \cos(\phi - \theta)}{1 + u \cos(\phi - \theta) + v \cos \theta} \sqrt{\frac{1 - u^2 - v^2 - 2uv \cos \phi}{1 - u^2}} \nu_2, \quad (2)$$

where ϕ is the angle between \vec{u} and \vec{v} , θ is the angle between the light ray and the beam axis, $\sin \theta = u \sin \phi$.

It is easy to obtain v and ν_L from eqs.(1) and (2):

$$v = \frac{(1 - \lambda_\nu)}{\cos \theta} \frac{(1 + u \cos(\phi - \theta))(1 - u \cos(\phi + \theta))}{1 + u \cos(\phi - \theta) + \lambda_\nu(1 - u \cos(\phi + \theta))}, \quad (3)$$

$$\nu_L = \left\{ \frac{(1 + u \cos(\phi - \theta))(1 - u \cos(\phi + \theta))}{(1 + u \cos(\phi - \theta) + v \cos \theta)(1 - u \cos(\phi + \theta) - v \cos \theta)} \right. \\ \left. \times \frac{1 - u^2 - v^2 - 2uv \cos \phi}{1 - u^2} \nu_1 \nu_2 \right\}^{\frac{1}{2}}, \quad (4)$$

where $\lambda_\nu \equiv \frac{\nu_1}{\nu_2} (< 1)$. If $u = 0$, then we get the SR result

$$v_0 = \frac{1 - \lambda_\nu}{1 + \lambda_\nu} = \frac{\nu_2 - \nu_1}{\nu_1 + \nu_2}, \quad (5) \\ \nu_{L,0} = \sqrt{\nu_1 \nu_2}.$$

We also get the SR result $\nu_L = \sqrt{\nu_1 \nu_2}$ for $\phi = 0, \pi$ with $v = \frac{v_0(1 - u^2)}{1 \pm uv_0}$. Note that this v is not directly measured.

Assuming the beam direction is pointed to the north pole, \vec{u} has a declination δ , time $t = 0$ when \vec{u} and the beam direction have the same right ascensions, we can express ϕ as

$$\phi = \cos^{-1}(\sin 56^\circ \cos \delta \cos(\omega t) + \cos 56^\circ \sin \delta), \quad (6)$$

where 56° is the lab's latitude, ω is the Earth's rotation angular velocity. We calculated $\delta \nu_L = \nu_L - \nu_{L,0}$ as a function of t with the parameters u and δ , and found that when $u \sim 1.2 \times 10^{-3}$, $\delta \sim 10^\circ$, $\nu_1 = 5.045 \times 10^{11}$ kHz and $\nu_2 = 5.081 \times 10^{11}$ kHz, there exists a 12-h period variation with an amplitude of about 7.7 kHz (see Fig. 1). They are close to the TPA experiment results of 11.8-h period and 7.1 kHz amplitude.

Since the Mössbauer-rotor experiment gave a more stringent constraint on the frequency variation, one may worry about that the other model will be excluded by this experiment. We do not assume here the rigidity of the rotor because there exist absolute length contractions. The received frequency ν_r is found to be

$$\frac{\nu_r}{\nu_e} = \sqrt{\frac{1 - u^2 - v^2 + 2uv \sin(\phi - \delta_2)}{1 - u^2}} \frac{1 + u \cos(\phi + \delta_1)}{1 + u \cos(\phi + \delta_1) + v \sin(\delta_1 + \delta_2)}, \quad (7) \\ \sin \delta_1 = u \sin \phi, \quad \sin \delta_2 = u^2 \sin \phi \cos \phi,$$

where ϕ is the angle between the radial direction of the emitter and \vec{u} , δ_1 is the angle between the radial direction and the light ray, δ_2 is the deviation of the angle between the radial direction and \vec{v} from 90° ($\delta_2 \neq 0$ due to the contraction along the \vec{u} direction).

For $u = 1.2 \times 10^{-3}$, $v = 1.2 \times 10^{-6}$, we found

$$\frac{\nu_r}{\nu_e} = 1 - \frac{1}{2}v^2 + O(10^{-18}). \quad (8)$$

The variation of $\frac{\nu_r}{\nu_e}$ is quite below the MR experiment constraint (2×10^{-16}).

We plotted $(\frac{\nu_r}{\nu_e} - 1 + \frac{1}{2}v^2) \times 10^{18}$ against ϕ in Fig. 2.

It is easy to understand our results if one knows that the differences between the model used here and the SR are of order $(\vec{u} \cdot \vec{v})^2$. For the confirmation of the ether drift model, further experiments must be done. For example, one can do the TPA experiment at different time of the year to see if there exists a direction correlation between the beam and the maxima of the 12-h period. One can also do the same experiment by changing the beam direction with 180° which is equivalent to the case of $\delta = -10^\circ$. In this case, the 24-h amplitude will be observable. Finally, it should be noted that the direction of \vec{u} may not be coincide with the symmetry axis of the 3 K microwave background radiation, because local gravitation forces may influence the ether drift.

ACKNOWLEDGMENT

I am grateful to the CCAST for use of their computation facilities.

References

- [1] E.Riis, L.-U.A.Anderson, N.Bjerre, O.Poulson, S.A.Lee, and J.L. Hall, Phys. Rev. Lett. 60 (1988) 81; 62 (1989) 842. ✓
- [2] K.C.Turner and H.A.Hill, Phys. Rev. 134 (1964) B252 .
- [3] D.C.Champeney, G.R.Isaak, and A.M.Khan, Phys. Lett 7 (1963) 241.
- [4] G.R.Isaak, Phys. Bull. 21 (1970) 255.
- [5] C.M.Will, Phys. Rev. D45 (1992) 403.
- ✓ • [6] J.D.Prestage, J.J.Bollinger, W.M.Itano, and D.J.Wineland, Phys. Rev. Lett. 54 (1985) 2387.
- [7] S.K.Lamoreaux, J.P.Jacobs, B.R.Heckel, F.J.Raab, and E.N.Fortson, Phys. Rev. Lett. 57 (1986) 3125.
- [8] S.J.Prokhorovnik, <<Light in Einstein's Universe >> (Reidel, Dordrecht, 1985).

FIGURE CAPTIONS:

Figure 1: Predicted frequency variations of the TPA experiment with $u = 1.2 \times 10^{-3}$, $\delta = 10^\circ$ (solid line) and $\delta = -10^\circ$ (dashed line).

Figure 2: Predicted frequency variation of the MR experiment with $u = 1.2 \times 10^{-3}$, $v = 1.2 \times 10^{-6}$.

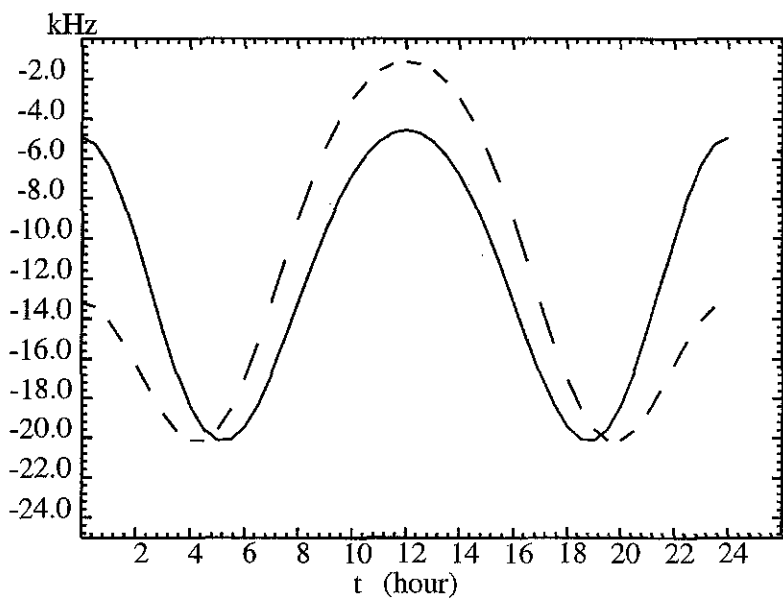


Fig. 1

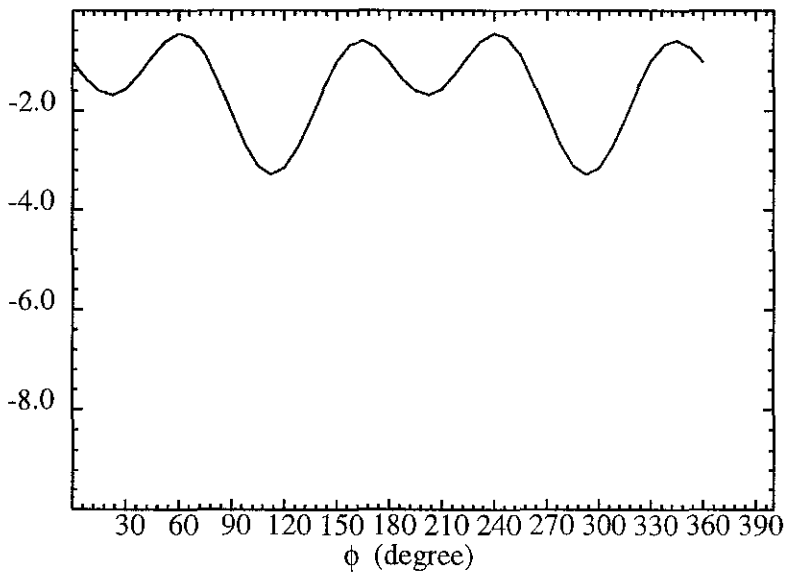


Fig. 2