黎奇凡 [Lí qífán (Qifan Li)], 李新洲 [Lí xīnzhōu (Xinzhou Li)]: *Scharnhorst* 超光速效应的测量问题 *[Scharnhorst chāo guāngsù xiàoyìng cèliáng wèntí]*.
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English translation:

Measurement problems of the superluminal effect of Scharnhorst

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Recently, Scharnhorst[1] has pointed out that between two closely-spaced conducting plates (Casimir plates) light signals would travel faster than c in a normal vacuum. The same result was rederived by Barton[2] in a more economic way using the Euler-Heisenberg effective action. The size of this effect is miniscule, the corresponding value is

$$\frac{\Delta c}{c} \;=\; \eta^{-1}\,(m_e L)^{-4}\;, \tag{1}$$

where m_e is the electron mass, L is the distance between the plates, $\eta \sim 10^6$, and $\hbar = c = 1$. This article will show that this effect is actually a mathematical result, whereby it is impossible to measure it by experiment.

1. Dual-beam interferometry

Split a monochromatic beam into two, one propagates between the plates and experiences multiple reflections between them, the geometric distance is S; the other beam propagates in vacuum and travels the same geometric distance S. Let these two beams meet and interfere with each other, then make a comparison. If the superluminal effect exists, the refractive index difference to the vacuum will result in an optical path difference $\Delta\delta$ producing an interference effect. From the formula for the optical path difference

$$\Delta\delta \;=\; \Delta n \cdot S \sim \frac{\lambda}{2} \tag{2}$$

we can easily deduce $S \sim 10^{21}$m, and there will be 10^{27} reflections. These multiple reflections dissipate the beam energy, at the same time, the plates must be huge. At an incidence angle of $\alpha \geq 10^{-7}$(rad), the estimated size of the plates is $\sim 10^{13}$m, which is 100 times the distance Sun-Earth . Consequently, dual-beam interferometry cannot be applied here.

2. Birefringence method

If the angle of incident linearly polarized light is $45°$ relative to the incidence plane, birefringence will occur to the beam when entering the space between the Casimir plates. For light whose vibration vector is parallel to the incidence plane, its velocity remains the same, and it becomes o light; if the vibration vector is parallel to the plates, it turns into faster-than-light e. Since o and e have different velocities, there will be an optical path difference between their outgoing beams. When this difference reaches a $1/4$ of a wavelength, the outgoing light turns from linearly polarized light into circularly polarized light. Following a reasoning similar to that in Section 1, the geometric distance for light must be $S \sim 10^{23}$m, then the size of the Casimir plates needs to be 10^{13}m.

3. Fabry-Perot interferometer

This approach requires the incident light to have a high degree of monochromaticity. The wavelength variation must be in the range of $\Delta\lambda/\lambda < 10^{-28}$, this is far less than the minimum wavelength variation which is given by Doppler broadening, collisional broadening, and other broadening effects of atomic spectral lines. Therefore, this approach is not feasible.

4. Direct measurement

We can see from formula (1) that the spread in the traversal time of an optical transmission between Casimir plates is

$$\Delta t \ < \ \eta^{-1} \, (m_e L)^3 \, m_e \ . \tag{3}$$

From the uncertainty principle, $\Delta\omega \gg 10^6 m_e$, can be deduced that this is in contradiction to the condition $\omega \ll m_e$ relied on in the quantum electrodynamical calculation. Therefore, this method is not feasible.

In conclusion, it can theoretically be predicted that a superluminal effect may occur between Casimir plates. But it cannot be measured in reality.

[1] Scharnhorst, K., *Phys. Lett.*, **B236** (1990) 354
[2] Barton, G., *Phys. Lett.*, **B237** (1990) 559

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