A METHOD TO VERIFY EXPERIMENTALLY THAT THE SPEED OF LIGHT IS INDEPENDENT OF THE VELOCITY OF THE SOURCE

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Submitted to JETP editor September 15, 1960

J. Exptl. Theoret. Phys. (U.S.S.R.) **40**, 860-862 (March, 1961)

A laboratory experiment is suggested which can be employed to verify directly whether the speed of light is independent of the velocity of the source. The effect is of the first order in v/c.

A direct experimental confirmation of the law that the speed of light does not depend on the velocity of the source would be a significant matter of principle.

The work published by A. M. Bonch-Bruevich[1,2] in 1956 is based on astronomical observations, namely comparison of the speed of light from different regions of the solar disc. We do not consider this work entirely convincing.

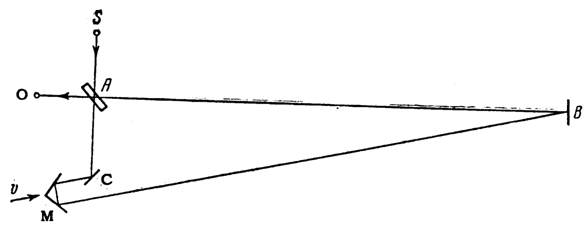
On the one hand, the author begins with some a priori assumptions concerning the speed of light after reflection from a mirror; on the other hand, owing to the low accuracy inherent in the method, the observed results have a large scatter, several times larger than the effect expected from classical theory. To obtain the final result the author had to treat statistically a very large number (1727) of observations, in which very large deviations were excluded outright.

In view of what has been said this work should not be regarded as a direct experimental verification of the independence of the speed of light of the source velocity.

Below we propose a scheme by which to verify directly in the laboratory the postulate of the constancy of the speed of light. In this method the difference between the effects predicted by the postulate and by classical theory is of the order v/c (not v^2/c^2), so that the postulate can be verified with an accuracy far greater than by any other method.

The basic idea of the method is to use an interferometer with a moving mirror. Calculation shows that the speed of the mirror in this experiment can be of the order of one meter per second and even less.

One variant of the experiment is shown in the figure. Here S is a monochromatic light source, A is a half-silvered mirror, B and C are plane mirrors, O is the observer of the interference



pattern, and M is a system of two mutually perpendicular plane mirrors which can be moved in the direction of the arrow with a controlled speed v.

The system M will serve to keep the incident and reflected light parallel when the mirrors are moved, and to reduce greatly the influence of deviations from exact parallel motion. This system also eliminates the aberration of light, since here the aberration of one mirror is compensated by that of the other.

The beam traveling from S to A is split into two beams. The left beam follows the path ACMBA, and the right beam the path ABMCA. The two beams are recombined at A and both travel towards the observer O. If M remains fixed, both path lengths are the same, and the observer sees some definite interference pattern.

If the system of mirrors M is given a speed v, the two path lengths become unequal, and if the speed of light is constant, a shift of the interference fringes results. We shall show that the shift will be stable for any constant speed v.

We note first that the frequency ν is changed after reflection from M by the same amount for both beams; they return to A and arrive at O with the same frequency ν'.

Denote the length ACM by l_1, and the length MBA by l_2. Although l_1 and l_2 change, the difference $L = l_2 - l_1$ is constant. The left beam takes a time $t_1 = (l_1 - vt_1)/c$ to travel through ACM, so that $t_1 = l_1/(c+v)$. The same beam takes a time $t_2 = (l_2 - vt_1)/c = [l_2 - vl_1/(c+v)]/c$ to cover the distance MBA. The total time spent by the left beam is

$$T_L = t_1 + t_2 = \frac{l_1}{c+v} + \frac{1}{c}\left(l_2 - \frac{vl_1}{c+v}\right).$$

Similarly the total time for the right beam is

$$T_R = \frac{l_2}{c+v} + \frac{1}{c}\left(l_1 - \frac{vl_2}{c+v}\right).$$

The difference in time is

$$\Delta T = T_L - T_R = \frac{2v\,(l_2 - l_1)}{c\,(c+v)} = \text{const}$$

Therefore the interference pattern is stable.

The fringe shift is

$$\delta = c\Delta T/\lambda' = 2vL/\lambda'(c+v) \approx 2vL/\lambda c. \qquad (1)$$

For example, for $L = 30$ m, $v = 1$ m/sec and $\lambda \sim 5000$ A, the pattern is shifted by 0.4 fringes.

If the speed of light depended on the velocity of the source, it would have the value $c + 2v$ after reflection from M. This would be exactly compensated by the difference in path lengths and there would be no fringe shift:

$$T_L = \frac{l_1}{c+v} + \frac{1}{c+2v}\left(l_2 - \frac{vl_1}{c+v}\right) = \frac{l_1 + l_2}{c+2v} = T_R$$

Therefore the experiment suggested by us can show with high accuracy that the speed of light is independent of the velocity of the source.

Small deviations from parallelism and uniformity in the motion of the mirror, small errors in the length L and the speed v, performance of the experiment in air instead of vacuum, etc., deviations which in our estimate will not exceed a few percent, cannot spoil the outcome of the experiment. If it should turn out for some unforeseen reason that the actual errors exceed our estimate considerably, or if the experimenter has only an interferometer of low sensitivity available, the fringe shift could be increased by increasing L or v.

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[1] A. M. Bonch-Bruevich, Doklady Akad. Nauk SSSR **109**, 481 (1956), Soviet Phys.-Doklady **1**, 430 (1956).

[2] A. M. Bonch-Bruevich and V. A. Molchanov, Оптика и спектроскопия (Optics and Spectroscopy) **1**, 113 (1956).

Translated by D. R. Brill
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