LETTERS TO THE EDITOR

PHYSICS

A Direct Terrestrial Test of the Second Postulate of Special Relativity

The following is a preliminary report of an investigation performed to test directly, in a terrestrial experiment, the second postulate of special relativity, which states that the velocity of light is independent of the motion of the light source. A direct test means here that the velocity of the light from a moving source is measured by a time-of-flight technique and not by use of interference effects in a closed light path or a frequency measurement. Investigations of the last-mentioned type may lead to difficulties in the interpretation of the result and are therefore not very satisfactory, as pointed out by, for example, H. Dingle[1].

In testing the second postulate it may be of advantage to use γ-radiation instead of ordinary light. One should thereby avoid possible effects caused by interaction between the light and stationary material situated between the source and the detector, as discussed, for example, most recently by J. G. Fox[2]. According to this author it may be that older evidence for the second postulate obtained from ordinary light experiments as, for example, the well-known double star evidence, are impaired with systematical errors which would weaken their reliability.

The principle of the investigation here undertaken was to measure the velocity difference between γ-rays from recoiling nuclei and nuclei at rest.

The moving γ-ray source was ^{12*}C excited in the reaction ^{12}C$(\alpha,\alpha')^{12*}$C and the γ-ray source at rest was ^{16*}O from the reaction ^{16}O$(\alpha,\alpha')^{16*}$O. The 14-MeV α-beam and the time-of-flight equipment of the 80-cm cyclotron of the Nobel Institute of Physics were used for the measurement[3]. The targets were placed at 30 cm from each other in the beam direction and could be interchanged in a few seconds. Half the beam intensity was used for the ^{12}C target and half for the ^{16}O target. The time delay between the irradiation of the two targets was about 12 ns.

As the half-life of the 4·43-MeV level in ^{12}C is $6{\cdot}5 \times 10^{-14}$ sec (ref. 4), the γ-ray is emitted before the nucleus has been stopped. The half-life of the 6·13-MeV level in ^{16}O, on the other hand, is $1{\cdot}2 \times 10^{-11}$ sec (ref. 4), so that the nucleus is at rest when this γ-ray is emitted. Doppler shift measurements with a sodium iodide crystal showed that the mean forward velocity of the recoiling ^{12}C nucleus was $(1{\cdot}8 \pm 0{\cdot}2)10^{-2}\ c$, where c is the velocity of light in vacuum. In the case of ^{16}O the Doppler shift measurements confirmed that the nucleus was stopped before emission of the 6·13-MeV γ-ray. A small amount (< 15 per cent) of 7-MeV γ-rays from ^{16}O was also present. The influence of these on the measurements could be corrected for, however.

In the time-of-flight experiment the γ-rays were detected by a liquid scintillator (5 in. × 2 in.) located at a mean distance of 5 m from the target arrangement and at an angle of 10° with respect to the α-beam. A small plastic scintillator, placed at 1 m from the target arrangement, was used in parallel with the large detector to give reference peaks in the time spectra.

In Fig. 1*A* is shown an example of a time-of-flight spectrum when target ^{12}C is first reached by the beam. Fig. 1*B* shows the case when the targets have been interchanged. The small detector gives rise to the two peaks in the middle of the spectra while the large detector is responsible for the two other groups. The distance between these corresponds to one cyclotron period. If the distance between the centre of gravity of the two peaks in each group is τ_1 in Fig. 1*A* and τ_2 in Fig. 1*B* then

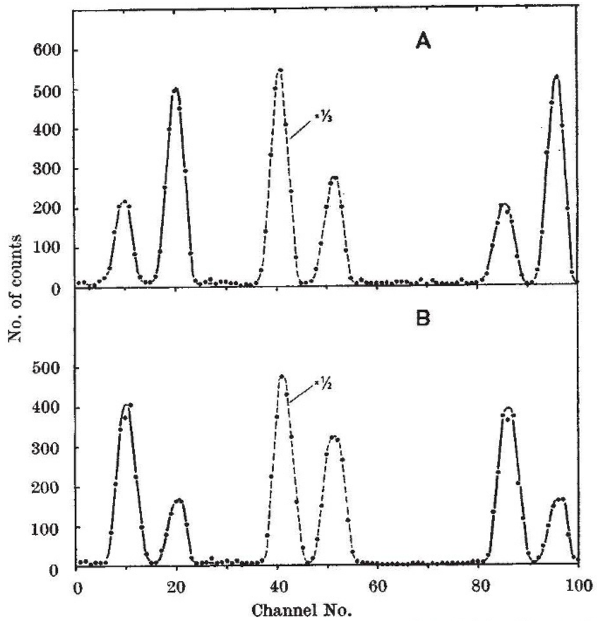

Fig. 1. Time-of-flight spectrum of the γ-rays detected in the small counter (dashed curve) and large counter. Channel width, 1·1 ns. *A* shows the case when target ^{12}C is first reached by the beam; *B* when the two targets have been interchanged

$\tau_1 = \tau_2$ if the velocity of the γ-radiation is independent of the motion of the source. On the other hand, if the velocity of the γ-rays is $V = c + kV_s$, for example, then $\Delta\tau = \tau_1 - \tau_2 = 2S \times V_s \times k \times c^{-2}$, where k is a constant and V_s the source velocity. With $k = 1$ and $S = 4$ m (the distance between the two detectors), $\Delta\tau$ would be 0·5 ns.

From several different runs the following mean value has been found:

$$\Delta\tau = -0{\cdot}2 \pm 0{\cdot}2 \text{ ns}$$

A systematical deviation (in both detectors) of $\Delta\tau$ from zero, independent of the source to detector distance, was present. This systematical error causes the uncertainty of the measurements to be somewhat larger than that predicted from time resolution of the equipment and statistics alone. It is hoped that this systematical error will be eliminated in the continuation of these measurements of which a more detailed report will be given in *Arkiv Fysik*.

The result of this investigation is in agreement with the second postulate but does not agree with the result of a recent work by W. Kantor[5]. It would certainly be of interest to perform a test where the source velocity is larger than that used in the present measurement, as, for example, with a π^0-source as suggested by, among others, W. G. V. Rosser[6].

We thank Prof. O. Klein and Dr. K. G. Malmfors for valuable discussions.

T. Alväger
A. Nilsson
J. Kjellman

University of Stockholm,
Nobel Institute of Physics, and
Research Institute of National Defence,
Stockholm.

[1] Dingle, H., *Proc. Roy. Soc.*, **270**, 312 (1962).
[2] Fox, J. G., *Amer. J. Phys.*, **30**, 297 (1962).
[3] Nilsson, A., and Kjellman, J., *Nucl. Phys.*, **32**, 177 (1962).
[4] Ajzenberg-Selove, F., and Lauritsen, T., *Nucl. Phys.*, **11**, 1 (1959).
[5] Kantor, W., *J. Optic. Soc. Amer.*, **52**, 978 (1962).
[6] Rosser, W. G. V., *Nature*, **190**, 249 (1961).