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PROPOSAL FOR A TEST OF THE SECOND POSTULATE OF SPECIAL RELATIVITY IN THE GeV. REGION

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Introduction

The second Postulate of Special Relativity states that the velocity of electromagnetic radiation is independent of the velocity of the source. If the velocity of the radiation from the moving source is written $c' = c + k \cdot v$, where v is the velocity of the source, the Second Postulate thus implies that $k = 0$, while the so-called emission theories [e.g. Ritz (1)] give $k = 1$. The result of a particular experiment can be stated by giving the k value found.

The empirical evidence in favour of the Second Postulate has until recently been mainly of astronomical origin. The oldest and best known of these astronomical evidences are the considerations of Comstock[2] and de Sitter[3] concerning the orbits of close binary stars. From the data on β Aurigae, de Sitter calculated a k value less than 0.002. A more recent astronomical test has been performed by Bonch-Bruewich[4] who made observations on light from the sun. The velocities of two wave-trains from opposite edges of the sun - one approaching and one receding from the earth - were compared by a phase-modulation method. These measurements indicated that $k = 0.02 \pm 0.07$.

The astronomical evidence has been criticized by several authors who try to invalidate its significance. Moon and Spencer[5] do this by introducing a suitably curved space. In this way the time required for light to reach us from distant double stars is reduced considerably, and the possible effect predicted by the emission theories should be unobservable. However, although their argument might be valid for the double star observations, it is not for the sun observation. Another objection against the astronomical evidence has been given by Fox[6]. He points out that the extinction theorem of dispersion theory implies that an incident light wave is extinguished at the surface of a dielectric and replaced by another wave with a velocity characteristic of the medium in question. This means that information about the velocity of light from a moving source would be lost if the light passed through intervening transparent stationary material before it was measured. Close binary stars are generally surrounded by a common envelope of gas, which might contain enough matter to extinguish the direct light from the stars, and the proof given by de Sitter and others would therefore not be conclusive. A different criticism especially against the double star evidence has also been given by Dingle[7].

The evidence in favour of the Second Postulate obtained from pure terrestrial experiments was until recently much less significant than that obtained from astronomical observations. An early terrestrial test by Majorana[8] was later shown to be inconclusive[9] and no new experiments were reported until 1962. This year a report by Kantor[10] was published with the surprising result that $k = 2/3$. This experiment, which utilized an interferometric method with closed light paths is, however, subjected to the above-mentioned criticism by Fox[6]. Also, another similar experiment meant to be a check on Kantor's result and giving the result $k < 0.025$ [James and Sterberg (11)] is inconclusive if the argumentation of Fox is valid.

One way to avoid this possible extinction effect is, as suggested by Fox, to use γ rays instead of ordinary light. In this way one also gets the advantage that it is possible to make a direct time-of-flight experiment, which is then a terrestrial equivalent to the double star observations. Two such experiments were reported in 1963, one by Alväger, Nilsson and Kjellman[12] and the other by Sadeh[13]. The principle of the first was to measure the velocity difference of γ rays emitted from nuclei in motion (C^{12*}) and nuclei at rest (O^{16*}) as referred to the laboratory system. The excited nuclei were obtained by use of a 14 MeV α beam from a cyclotron, and the velocity difference was measured with a pulsed-beam time-of-flight arrangement. The experiment gave $k = 0.1 \pm 0.1$, which is thus in agreement with the Second Postulate and excludes the emission theories.

Sadeh, who used annihilation in flight of positrons to obtain a moving source of γ rays, obtained a similar result with about the same accuracy.

Principle of the proposed experiment

It is clearly seen from this introduction that there is a need for a much more accurate terrestrial experiment, especially as there does not exist any experiments for very high source velocities ($\approx c$).

In connection with several theoretical attempts to modify the Lorenz transformation for high-energy phenomena, especially those by Heitler et al.[14], an accurate test of the Second Postulate in this energy region is highly desirable.

The test can be performed by a measurement of the velocity of the γ rays from the decay of π^0's. We propose to use the neutral beam in the East Hall, where flight paths from $\approx$ 60-100 m can be utilized. With a thin target ($\approx 5\mu$ foil) in magnet section 60, the bunched structure of the PS beam can be maintained if the RF is kept on during the flat top. A γ detector arrangement similar to the one used by Fidecaro et al.[15] will be used. The RF structure of the beam can be used as a "time-scale" in the following way:

A time spectrum is recorded with the detector at a certain distance, say 60 m. The detector is then moved a distance corresponding to the velocity of light for 105 nsec (i.e. the distance between two RF bursts) and a new time spectrum is recorded. In this way we can hope to reach a time accuracy of $\approx$ 0.2 nsec, making it possible to measure a k value of about 0.002.

According to the Experimental Planning Committee there are no other experiments planned in the neutral beam during the summer. The arrangement can therefore be set up and tested without interference with other experiments. The actual run can be made as a parasiting experiment any time it is possible to get a target bombardment with the RF on.

Estimated running times:

Setting up as parasite on target 60 ~ 1 week.

Collecting data with their target, flat top with r.f. on ~ 2-4 shifts.

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