# CRITICISM OF THE SADEH EXPERIMENTAL EVIDENCE FOR THE SECOND POSTULATE OF SPECIAL RELATIVITY

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A critical examination of the Sadeh experiment performed to test the second postulate of Einstein's special relativity is reported. It is shown that this experiment is incorrect and inconclusive.

A review of the experiments that have been performed to test the second postulate of special relativity was undertaken by the author. The Sadeh [1] and Alvager [2] experiments are the two tests which are not invalidated by the extinction theorem [3]. Sadeh used gamma rays produced from annihilation of positrons in flight, while Alvager used gamma rays produced from the decay of $\pi^0$ mesons. The results of the Alvager experiment should be interpreted as a self-consistency test, because the velocity of the $\pi^0$ meson is not directly measured, but is determined by relativistic kinematics.

Sadeh states that the two gamma rays must travel at angles $\theta_1$ and $\theta_2$ compared to the motion of the positron such that

$$0<\theta_1<\pi\,, \quad \pi<\theta_2<\tfrac{3}{2}\pi\,. \tag{1}$$

Sadeh considers two gamma rays. One of these rays travels with a component of motion in the direction of the flight of the positron and the other travels with a component in the opposite direction. If the velocity of the gamma ray sums up to the velocity of the centre of mass (positron–electron), according to classical vector addition, one of the two will have a greater velocity than the velocity of light and the other one will have a velocity smaller than the velocity of light.

In order to verify the conditions (1), Sadeh arranged the gamma ray detectors at angles $\theta_1$ and $\theta_2$ from the direction established by the $^{64}$Cu positron source and the Perspex because he supposes that the direction of the flight of the positron at the moment of annihilation was the same direction $^{64}$Cu–Perspex.

Sadeh also used two single channels which ensured that the only gamma rays gating the multichannel analyser were those between 0.511 and 0.65 MeV. It is shown below that if the two gamma rays have an energy between 0.511 and 0.65 MeV, the positron direction flight does not coincide with the $^{64}$Cu–Perspex direction and the angles $\theta_1$ and $\theta_2$ do not verify the conditions (1).

As we already know [4], the positron enters into the matter and it annihilates with growing probability as the amount of lost energy grows because of interactions inside the matter, this means that the positron changes direction when entering the matter.

A selection of the two gamma rays must be made taking the energies $e_1$ and $e_2$ of the two gamma rays into account, because they depend on the angles $\theta_1$ or $\theta_2$ according to the relations [5]

$$e_1=e_0\frac{1+\gamma}{1+\gamma(1-\beta\cos\theta_1)}\,,$$

$$e_2=e_0\frac{\gamma(1+\gamma)(1-\beta\cos\theta_1)}{1+\gamma(1-\beta\cos\theta_1)}\,,$$

$$\frac{1}{e_1}+\frac{1}{e_2}=\frac{1-\cos(\theta_1+\theta_2)}{e_0}\,, \tag{2}$$

where $e_0=m_0c^2$, $\beta=v/c$, $\gamma=(1-\beta^2)^{-1/2}$, and $m_0$ is the rest mass of the electron, $v$ is the velocity of the positron in the laboratory and $c$ is the velocity of light.

Using the relations (2) it can be shown that the angles $\theta_1$ and $\theta_2$ of the two gamma rays considered by Sadeh, having energy between 0.511 and 0.65 MeV, vary between a minimum value and a maximum value which depend on the energy of the positron ($E_\beta$). The angles $\theta_1$ and $\theta_2$ have the same extreme values because the energies $e_1$ and $e_2$ range between the same values. In fig. 1 the possible values of the angle $\theta_1$ are shown in the hatched area. These values range between about 52°5 and 89°9.

In fig. 2 the angle $\alpha$ is shown in which the flight direction of the positron is limited if $e_1$ and $e_2$ would lie between 0.511 and 0.65 MeV. Therefore, the Sadeh experimental arrangement selects only the pairs of gamma rays that both have a component of motion in the same direction as the flight of the positron at the moment of annihilation. This is the opposite of the set of conditions (1), therefore the Sadeh experiment is incorrect and inconclusive.

In the case of the condition

$$52°5 < \theta_1, \theta_2 < 89°9,$$

the result which Sadeh obtained from his experiment cannot differentiate between the classical and the relativistic vector addition.

If the velocity of gamma rays adds on to the velocity of the source according to classical vector addition, the pairs of gamma rays selected by the Sadeh device can be divided into the following groups (see fig. 2): the pairs of gamma rays produced by annihilation of the positrons whose direction of flight is limited within the angle $\bar{\theta} - (\theta_1)_{\rm m}$, where $\bar{\theta} = (\theta_1 + \theta_2)/2$, and the pairs of gamma rays produced by the positrons whose direction of flight is limited within the angle $(\theta_1)_{\rm M} - \bar{\theta}$. In the former pairs the $\gamma_2$ ray is slowed down compared to the $\gamma_1$ ray for $\Delta t$ such that $0 \leqslant \Delta t \leqslant \Delta t_{\rm M}$, where $\Delta t = 0$ if $\theta_1 = \theta_2 = \bar{\theta}$ and $\Delta t = \Delta t_{\rm M}$ if $\theta_1 = (\theta_1)_{\rm m}$, and in the latter pairs the $\gamma_2$ ray anticipates with respect to the $\gamma_1$ ray for $\Delta t$ such that $0 \leqslant \Delta t \leqslant \Delta t_{\rm M}$, where $\Delta t = 0$ if $\theta_1 = \theta_2 = \bar{\theta}$ and $\Delta t = \Delta t_{\rm M}$ if $\theta_1 = (\theta_1)_{\rm M}$. Therefore, the peak of the time spectrum of annihilation in flight would occur at $\Delta t = 0$.

If the two gamma rays travel with the same ve-

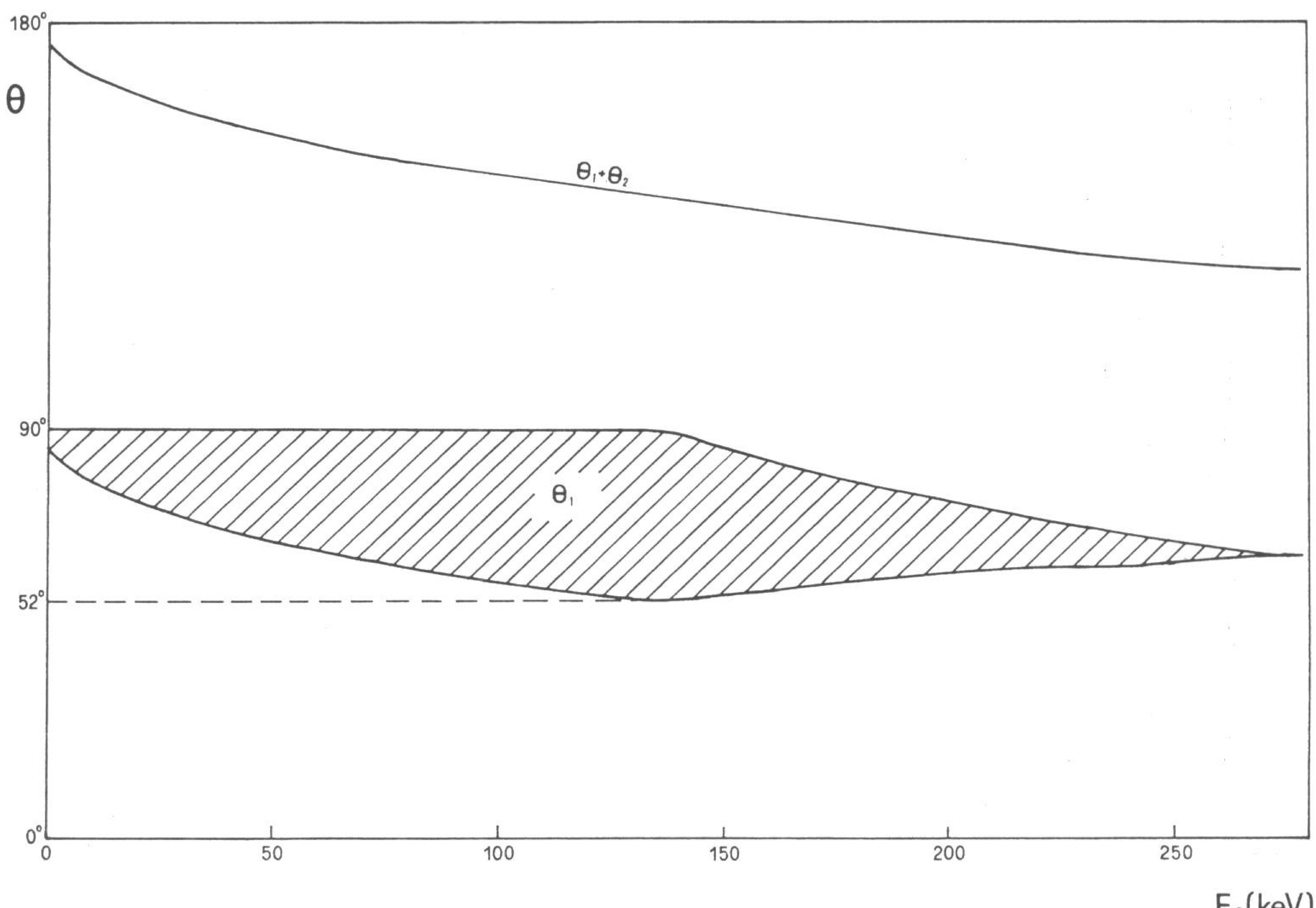


Fig. 1. The angle $\theta_1 + \theta_2$ between the two counters as a function of the energy $E_\beta$ of the positron, if the energies of two gamma rays range between 0.511 and 0.65 MeV. The hatched area represents all the values of the angle $\theta_1$ formed by one gamma ray and by the direction of flight of the positron, as a function of $E_\beta$.

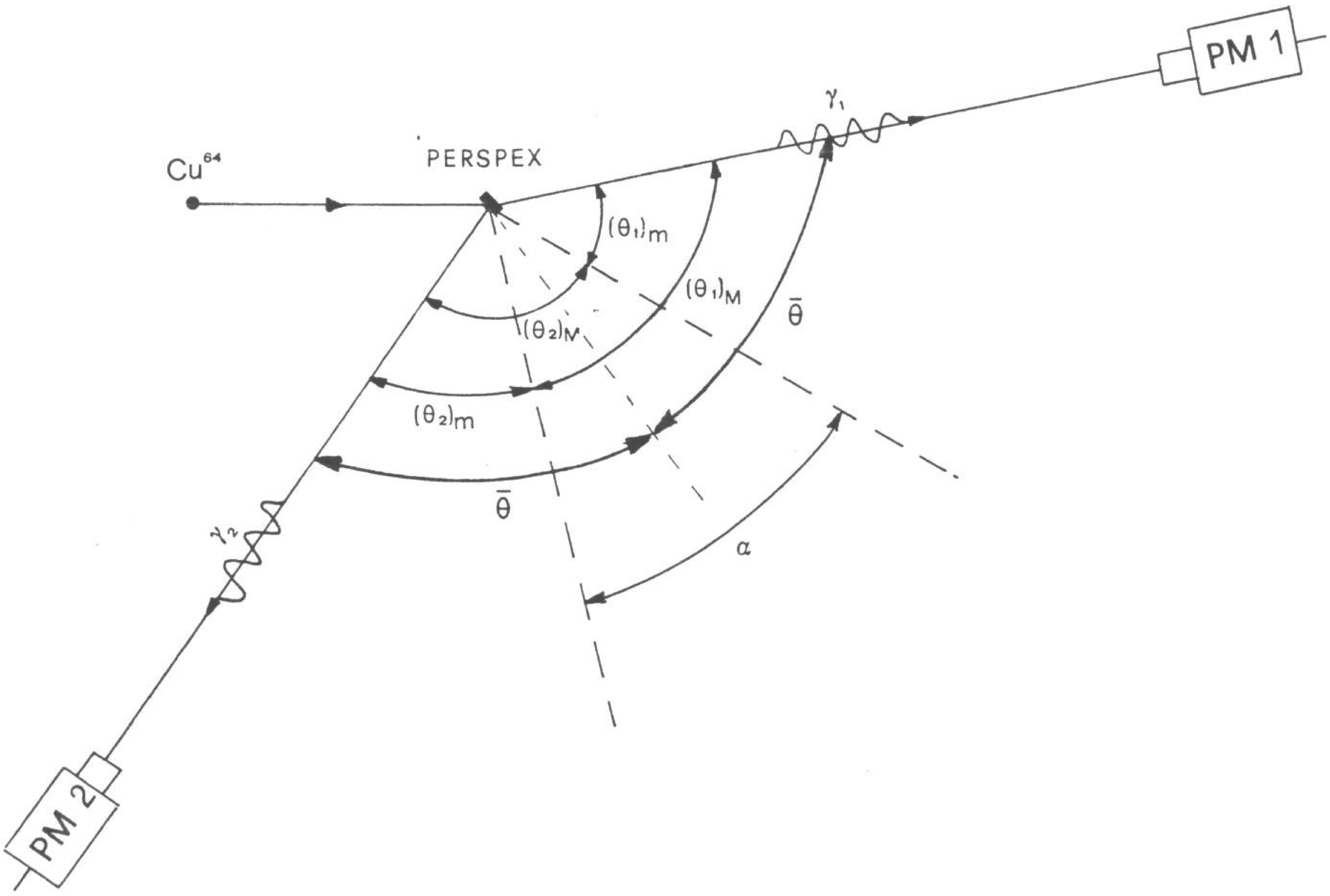


Fig. 2. Arrangement of two gamma ray detectors, $^{64}Cu$ source and layer of perspex in which the annihilation took place as supposed by Sadeh. $\alpha$ is the angle in which the direction of flight of the positron is limited, according to the relations (2), if the energies of two gamma rays are the same as in the experiment of Sadeh; $(\theta_1)_m$, $(\theta_2)_m$, and $(\theta_1)_M$, $(\theta_2)_M$ are resepctively the minimum and the maximum values of the angles $\theta_1$ and $\theta_2$ of the $\gamma_1$ and $\gamma_2$ rays.

locity, according to the second postulate of special relativity, the two gamma rays reach the detectors at the same time after travelling equal distance between the detectors and the point of annihilation. Therefore, the peak of the time spectrum of annihilation in flight occurs at $\Delta t=0$ also in the case of relativistic vector addition. The difference between the two spectra is that the time spectrum of annihilation for the classical vector addition of velocities is wider than that of annihilation for the relativistic case. The width of the time spectrum of annihilation in flight is wider than $2(\Delta t_M)_{Max}$, where $(\Delta t_M)_{Max}$ is the greatest delay between the two gamma rays, and occurs when the $\gamma_1$ ray travels according to an angle $\theta_1=52°5$ or according to an angle $\theta_1=89°9$ and this corresponds to a delay of about $\pm(\Delta t_M)_{Max}=0.08$ ns. The width of the time spectrum of annihilation in flight is wider than about 0.16 ns, and so it is smaller than the resolution time $\tau=0.25$ ns of the Sadeh equipment.

In conclusion, Sadeh did not demonstrate whether the velocity of the gamma rays adds on to the velocity of the source according to the classical vector addition, or according to the Lorentz transformations. The author suggests to repeat this experiment.

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