

THE EFFECT OF NEUTRINO RECOIL IN THE BETA DECAY OF He^6

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Experiments are described on neutrino recoil effects from the β decay of He^6 as observed in a cloud chamber.

THE β decay of He^6 has not previously been studied in a cloud chamber, most likely owing to the difficulties presented by the task of introducing an isotope whose half-life is 0.8 sec into the cloud chamber. A few years ago we became convinced that it would be worthwhile to overcome these technicalities, because this β decay is most convenient from the point of view of the neutrino problem. The process $\text{He}^6 \rightarrow \text{Li}^6 + \beta + \nu + 3.6 \text{ Mev}$ has a wide spectrum of decay energies uncontaminated by γ radiation, and the daughter nucleus (Li^6) has the smallest mass of all radioactive isotopes (with the exception of He^3). It may acquire a large recoil energy (maximum 1.405 ev) and we were hoping that its track could be detected in a cloud chamber filled with hydrogen at low pressure. By the simultaneous determination of the momentum and energy of the β particle and daughter nucleus in the same elementary act we can obtain the missing momentum and energy carried off by the neutrino.

The cloud-chamber method is more convenient than the electronic method utilized by a number of authors^{1,2} because it not only permits the observation of single atomic processes but also the precise measurement of angular correlations.

A cloud chamber with a rubber membrane was built working well when filled with hydrogen at 200 mm Hg and water and alcohol vapor. Figure 1 shows how the problem of introducing He^6 into the chamber was solved. A few seconds before expansion the $4\text{C}(\text{Po} + \text{Be})$ source was introduced pneumatically into the vicinity of the weakly emitting powder [approximately 5 g of $\text{Be}(\text{OH})_2$], placed in a box made out of porous filter paper and located inside the cloud chamber. An elastic rubber bag separated the volume of this vessel from the pneumatic compressor. Immediately (0.3 sec) prior to expansion the neutron source was pneumatically swept past the shielding layer. The same air shock would stretch the rubber bag forcing the He^6

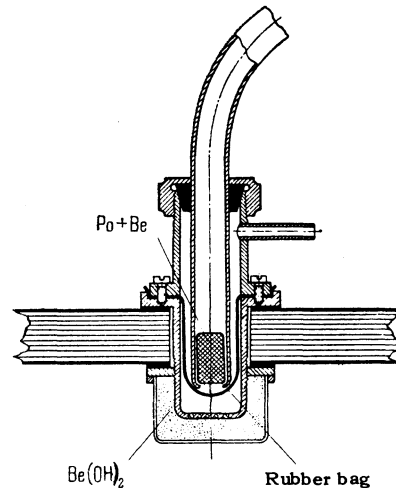


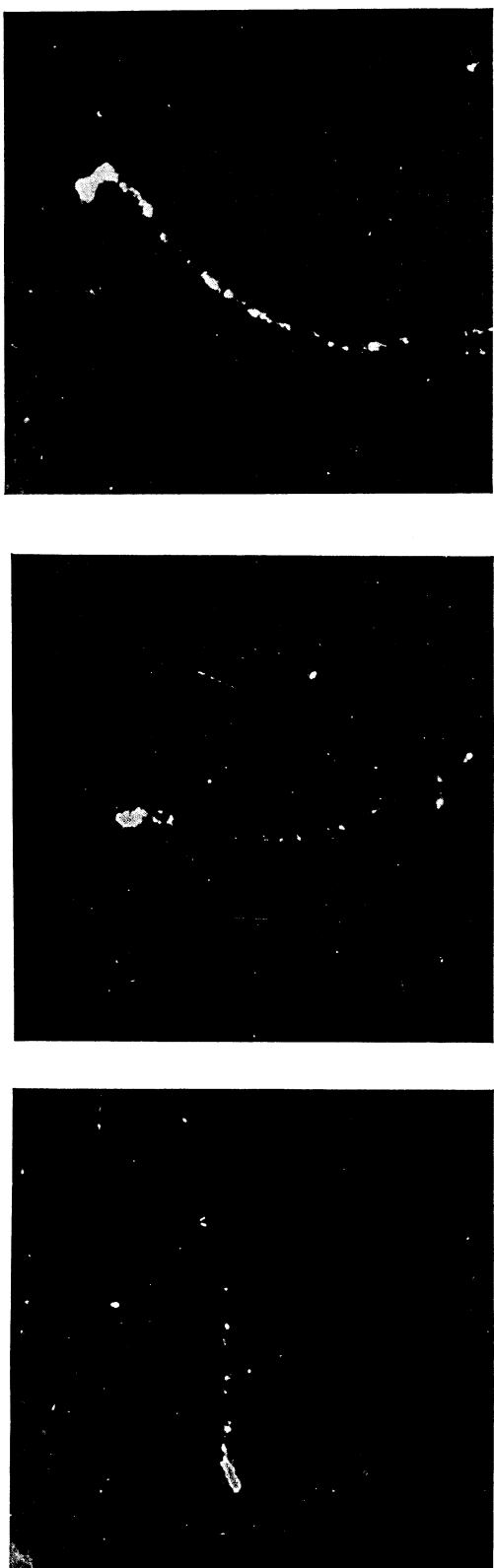
FIG. 1. Setup for the introduction of He^6 into the cloud chamber.

liberated from the $\text{Be}(\text{OH})_2$ powder to enter the chamber through the porous wall.

As can be seen from a few typical examples of our photographs (Figs. 2a, b, c), our expectations were fulfilled. The track of the recoil nucleus is clearly visible. Its direction is usually not directly opposite to that of the β particle: they form an obtuse angle, i.e., it is clearly seen that a certain amount of momentum is missing. In an analogous manner, in the photographs (Figs. 3a, b) in which the ions diffused prior to expansion, the effect of the neutrino manifests itself in the fact that the energy and momentum of the recoil nucleus are smaller or larger than what would have been expected from the energy of the β particle alone.

We obtained a total of more than 2000 stereo photographs, among which there were 120 tracks good enough for a quantitative analysis. The complete energy-momentum balance for the transition can be obtained if the curvature of the β track in a magnetic field and the angle between the β particle and the recoil nucleus are measured.

Figure 4 shows the electron-neutrino angular

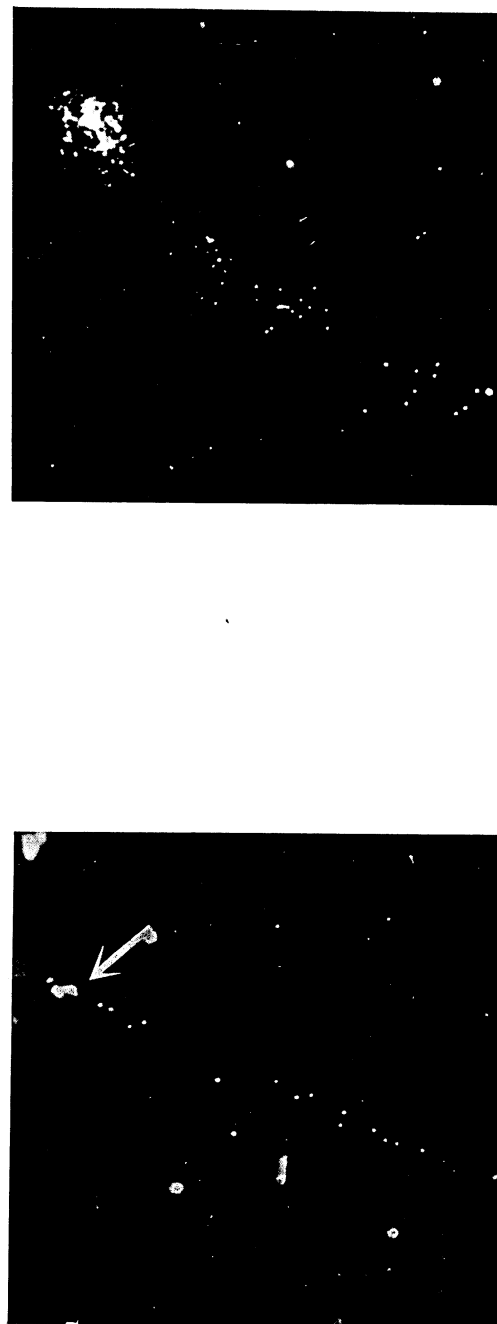


c

b

a

FIG. 2. a, b, c, Cloud chamber photographs of the β decay of He^6 (acute angle between the electron and recoil nucleus tracks).



b

a

FIG. 3. a, b, Cloud chamber photographs of the β decay of He^6 (the energy, i.e., the number of drops in the track of the recoil nucleus, is in contradiction with the energy of the β particle).

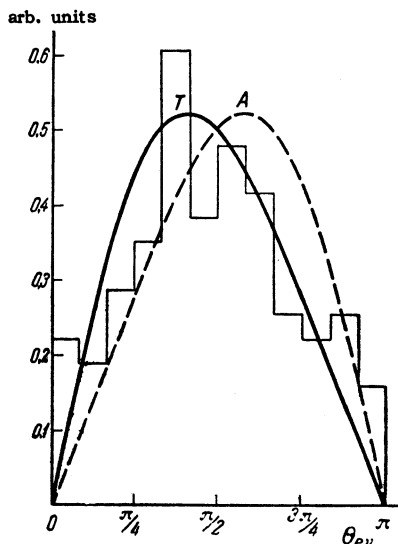


FIG. 4. Electron-neutrino angular correlation from 120 measured tracks in the β decay of He^6 . T and A are the theoretical curves for tensor ($\alpha = 1/3$) and axial-vector ($\alpha = -1/3$) interactions respectively. $v/c = 0.92$.

correlation for the 120 measured tracks; statistical errors are still large, owing to the small number of events. A comparison of the distribution with the theoretical calculations of De Groot and Tolhoek² shows good agreement with the curve calculated on the assumption of tensor interaction for the β decay (the other curve refers to the axial vector interaction).

We hope soon to be able to confirm this result with a larger number of measured tracks.

¹J. S. Allen and W. K. Jentschke, Phys. Rev. 89, 902 (1953). B. M. Rustad and S. L. Ruby, Phys. Rev. 97, 991 (1955).

²S. R. De Groot and H. A. Tolhoek, Physica 16, 456 (1950).

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233