Pair Production of Mesotrons at 29,000 Feet

In a second airplane flight[1] made on April 30, carrying a cloud chamber in a magnetic field of 700 gauss up to 29,000 feet altitude, we found one particularly interesting photograph which shows the occurrence of a mesotron pair. A reproduction is given in Fig. 1.

The radii of curvature of the two partner tracks are 45 and 75 cm. Both particles are stopped in a copper plate of 0.32 cm which was placed in the middle of the chamber. They enter this plate at an angle of 45°, which gives a maximum path length inside the copper of 0.45 cm. If the particles were electrons and were stopped in this amount of copper their maximum energy is 6 Mev. This corresponds to a radius of curvature in the magnetic field smaller than 28 cm. The measured radii are larger by an amount far beyond the errors of measurement. Thus the tracks cannot be produced by electrons. For mesotrons of a mass 200, similar considerations give 25 Mev as the maximum kinetic energy of the particles and a radius of curvature smaller than 350 cm. This curvature limit covers well the measured values. The same holds true, of course, if one considers the particles to be protons.

One can further estimate the masses from the ionization produced in the gas of the chamber. Fortunately the picture shows two slower particles and a fast one. Their ionization is markedly smaller and corresponds to the kind of tracks we get from β-particles and penetrating cosmic rays in the laboratory. There is no doubt that the particles of small radii of curvature are electrons. The ionization of the two particles in the pair is distinctly higher although the radii of curvature are greater. This proves again that the pair must consist of heavier particles.

For the observed curvature of the pair, mesotrons should ionize from 6 to 15 times as strongly as electrons, and protons 10 times as strongly as mesotrons. Such an enormous ionization excludes positively the possibility of assuming that the pair is protons. The theoretical ionization of mesotrons, on the contrary, lies well within the limits one estimates from the pictures.

We therefore must conclude that this pair consists of a slow positive and a slow negative mesotron.

The two stereoscopic pictures taken show that the slow electron emerging upward from the copper plate is possibly associated with this pair and may be a decay electron of one of the mesotrons. It is difficult to state from which mesotron this electron might come. Assuming that it moves upward from the plate its charge is negative. It has a kinetic energy of 0.2 Mev.

Other pictures taken on this flight likewise show mesotrons stopping in the copper plate. In several cases electrons appear which may originate from mesotron decay. A full report on this material will shortly be published.

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[1] G. Herzog, Phys. Rev. **57**, 337 (1940).

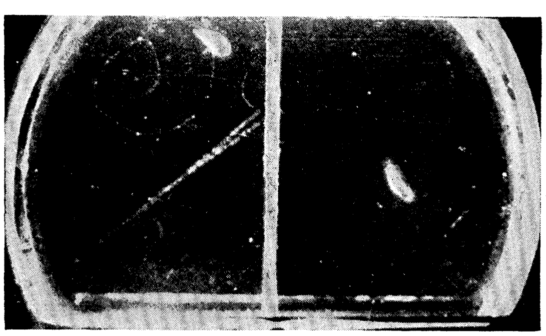

Fig. 1.

Transport Cross Section of Helium

Endeavors to fit the low temperature viscosity measurements of helium[1] have in the past not yielded very satisfactory results. Use of the Slater-Kirkwood field,[2] the Lennard-Jones potential,[3] the elastic sphere[4] and the modified elastic sphere models[5] have all failed in predicting correctly the quantum effect at low energies. It has been pointed out by the author that the general behavior of the transport cross section which is required for a correct temperature dependence is: the existence of minima at low energies, a broad maximum at higher energies, and at energies corresponding to room temperatures an asymptotic approach to a value approximating 4.46×10^{-16} cm^2.

The physical characteristics of the interaction underlying this behavior are that two elements of differing order of magnitude must exist: a strong repulsive potential with a rather sharply defined boundary, and a weak interaction composed of attractive and repulsive terms. It is essential for the existence of minima in the low energy range that the interaction contain attractive terms, as, although the elastic sphere and modified elastic sphere models show minima in the kinetic cross section, these disappear in the viscosity cross sections due to the presence of two compensating series.

It has seemed of interest therefore to determine as exactly as possible the form of the cross section necessary to fit the experimental data. That is, one might attempt to solve the integral equation for $\theta(\gamma)$ the cross section, using the relation given by Enskog[6]

$$\int_0^\infty \gamma^7\theta(\gamma)e^{-\gamma^2}d\gamma=\frac{15}{32\pi^{\frac{1}{2}}}\frac{(mkT)^{\frac{1}{2}}}{\eta(T)}, \tag{1}$$

where

$$\gamma=\frac{h}{2\pi}\frac{k^*}{(mkT)^{\frac{1}{2}}};\quad (k^*)^2=\frac{8\pi^2mE}{h^2}. \tag{2}$$

The exact solution of the above equation presupposes the knowledge of $\eta(T)$ for all values of T. One has, however, only its values for a limited set of values of the temperature. The solution of $\theta(\gamma)$ is then subject to a certain degree of indefiniteness. It has, therefore, seemed most advantageous to assume for θ the expansion

$$\theta(k^*)\equiv\Sigma\, A_j \exp\left[-j(k^*)^2\phi\right] \tag{3}$$

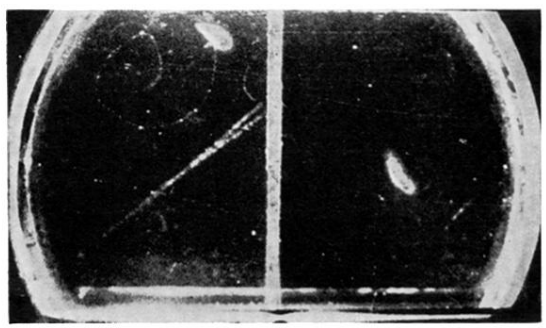

FIG. 1.