OBSERVATION OF TRACKS OF FAST PARTICLES IN A TWO-ELECTRODE SPARK CHAMBER IN A MAGNETIC FIELD

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WE have already reported the first results on the observation of particle tracks when a two-electrode spark chamber with a large gap was placed in a magnetic field.[1]

In the present communication, we report on a study of tracks in a two-electrode spark chamber when the direction of motion of the particles was parallel or almost parallel to the electrodes which were separated by a large distance (15—20 cm). Such chambers are of special interest; they can be used efficiently in a number of studies, in particular, to record tracks in a magnetic field and to measure the momentum of high energy particles.

The first experiments with a chamber of this type were carried out by T. Asatiani, P. Sharkhatunyan et al. with cosmic rays and were described in a report delivered by A. Alikhanyan in the spring school in Nor-Amberd in April, 1963.[2]

One such chamber 60 cm long and 40 cm wide with a discharge gap of 15 cm was placed in the gap of an electromagnet in which a magnetic field of 13,500 Oe was produced. A beam of 4.1 GeV/c π^- mesons from the proton synchrotron of the Joint Institute for Nuclear Research passed parallel to the electrodes.

A double coincidence of discharges in two sets of Geiger-Müller counters located directly in the π^- beam in front of the spark chamber served as a control pulse.

In one series of observations, the control pulse selected showers consisting of two or more particles arising in a layer of polyethylene placed in front of the chamber. In this case, one of the sets of G-M counters was placed behind the spark chamber and the system was triggered when at least two counters discharged.

The π^- beam used by us in these experiments had a spill of from 5 to 100 msec and contained several hundred to several thousand particles in a pulse.

The photographs of the tracks were taken through the upper electrode which consisted of a simple metallic grid. The camera was placed at a distance of 950 mm and was used with a 1:8 diaphragm. After first being evacuated, the chamber was filled with spectrally pure neon at a pressure of 1.15 atm. A 60-kV high-voltage pulse produced by a circuit similar to that described by us earlier [1] was applied to the spark-chamber electrode for 0.5 μsec after the traversal of the particles.

When this pulse was applied across the path of the particles, a large number of streamers were initiated by free electrons produced in the chamber gas by the particles passing through the chamber.

The pictures taken in the manner indicated above showed a chain of light points distributed along the path of the primary particles.

In Figs. 1 and 2, we see the photographs of a shower produced in polyethylene by π^- mesons. As is seen, the tracks are comparatively clear, and from them the curvature of the particle trajectory in the magnetic field can be determined.

A preliminary study of such tracks without a magnetic field indicates that despite their lack of sharpness, the mean square deviation from an approximate straight line drawn through the central point was 0.2—0.3 mm. This gives rise to the hope that such a spark chamber can be successfully used for momentum measurements of high-energy particles.

FIG. 1

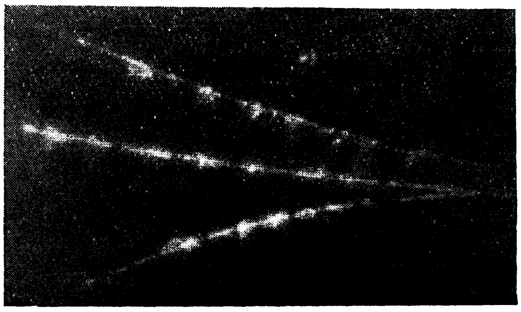

FIG. 2

In comparison with the two-electrode chambers with a large gap described by us earlier,[1] these chambers have a number of important advantages. With the comparatively small high-voltage pulse ~ 60—70 kV necessary for a discharge gap of 20—25 cm and neon pressure of ~ 1.2 atm, the chambers can be quite long (1 m and longer) and they can be placed in a gap of an electromagnet of reasonable size. Moreover, since the accuracy of the measurements of the track curvature is proportional to the square of the length of the track, the possibility of making large chambers is of considerable practical interest. It should be kept in mind that the placing of a chamber with a large discharge gap in the gap of an electromagnet involves a number of difficulties connected with parasitic capacitances with respect to the magnet yoke. The size of the gap between poles imposes a limitation on the size of the maximum amplitude of the applied pulse. In this respect, the chamber of the described type has an advantage over the chamber in which the particles travel from one electrode to the other. Finally, in the chamber described in the present communication, we can record tracks of particles arising directly in the space between electrodes. This makes it possible to use such a chamber to record the decay products of neutral particles or particles arising in the chamber gas. As an example, Fig. 3 shows the circular trajectory of an electron of energy ~ 34 MeV arising in the chamber gas, apparently as a result of a γ ray.

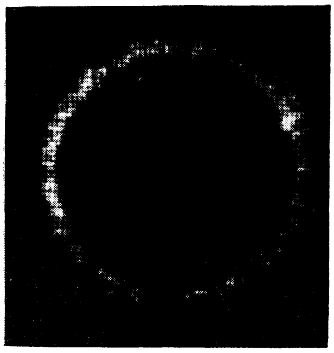

FIG. 3

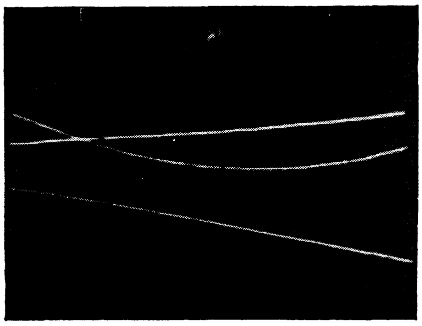

FIG. 4

Despite the many advantages offered by the chamber, the quality of the tracks produced in it cannot be considered entirely satisfactory. For comparison, we show in Fig. 4 a photograph of tracks made by particles arising in a polyethylene slab and recorded in our "ordinary" chamber in which the streamer develops along the trajectory. This picture was obtained with a chamber having an interelectrode distance of 25 cm and was oriented so that the particles crossed both electrodes.

As is seen in Fig. 4, the quality of the tracks in this chamber is better than of those shown in Figs. 1—3. However, we have reason to hope that the quality of the tracks obtained in chambers with streamers developing perpendicularly to the particle trajectories can be considerably improved. We note that in such chambers no significant displacement of the track due to the simultaneous action of the electric and magnetic fields and the proportional quantity $(\mathbf{E} \times \mathbf{B})t$ should occur, since $\mathbf{E} \parallel \mathbf{B}$.

We are now conducting a separate study to establish the limits on the accuracy of momentum measurements for particles in similar chambers of various size and design.

In conclusion, we express our gratitude to Academician V. I. Veksler and I. V. Chuvilo for making it possible to perform our experiment at the proton synchrotron of the Joint Institute for Nuclear Research, to A. A. Kuznetsov for aid in the experiment, and to S. V. Kardonskiĭ, V. A. Ivanov, and K. A. Gazaryan for the measurements.

[1] Alikhanyan, Asatiani, and Matevosyan, JETP **44**, 773 (1963), Soviet Phys. JETP **17**, 522 (1963).

[2] A. I. Alikhanyan, Sb. Voprosy fiziki elementarnykh chastits (Collection: Problems in Elementary Particle Physics), Acad. Sci. Arm.S.S.R., 1963, p. 553.

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