EmC 63/3

Proposal of an emulsion experiment requiring a mass-separated K^{+}_{-} beam

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25th January 1963

5823/p

SUMMARY

The following is essentially a restatement, in the light of subsequent developments, of that part of an earlier proposal (E.38) which relates to experiments with K mesons. We propose a preliminary search for examples of the production of pairs of charged pions by energetic K mesons, in interactions in which the nucleons in the target nucleus act coherently. This experiment is analogous to those of Baldassare et al [1,2] on the production of pairs of pions by pions. It requires a mass-separated $K^{\pm}$ beam of the highest momentum available with adequate intensity and purity. It is anticipated that the O_2 beam to be set up in the East Experimental Area will be suitable for the experiment. The eventual properties of this beam will determine the exact form of, and requirements for, the experiment.

INTRODUCTION

Interactions in which the nucleons in the target nucleus act coherently ("coherent interactions") are marked by the absence of any sign of nuclear excitation and by an extremely low value of the momentum q transferred to the nucleus:

$$q \leqq \frac{m_\pi c}{A^{1/3}}$$

i.e. $q \leqq 30$ MeV/c for heavy target nuclei (Ag, Br)

$\leqq 60$ MeV/c for light target nuclei (C,N,O)

One consequence [3] of the latter condition is that the secondaries are emitted at angles small enough to satisfy the condition:

$$\sum_i m_i \sin\theta_i \leqq \frac{m_\pi}{A^{1/3}}$$

m_i = mass of i^{th} secondary

θ_i = space angle "

When the interaction consists of production of pions in the Coulomb field of the nucleus, it is known as Coulomb dissociation. When the same process occurs in the nuclear field it is called diffraction dissociation, since the target nucleus may be considered to receive the momentum q in causing diffraction scattering of one of the particles involved. Coulomb and diffraction dissociation have been discussed by Good and Walker[4,5] and by Matthews and Salam[6]. These authors have shown that detailed study of simple processes of these types may shed considerable light on the interactions between the elementary particles involved. In particular, therefore, valuable information on the $K\bar{K}\pi\pi$ interaction would be obtainable by study of examples of the following coherent interaction:

$$K^{\pm} + {}_{z}N^{A} \rightarrow K^{\pm} + \pi^{+} - \pi^{-} + {}_{z}N^{A}$$

if the mean free path for the process were short enough to permit it to be studied in detail. We therefore propose to perform a preliminary search for examples of the above coherent interaction, with the primary aim of determining roughly the mean free path, or at least obtaining a lower limit for it. We would like to emphasise that photographic emulsion is a particularly suitable detector for use in such an experiment, because its high spatial resolution permits efficient detection of even comparatively inconspicuous signs of nuclear excitation (such as β-decay electrons or Auger electrons). If the proposed search yields a favourable result, a further experiment could then be planned with the object of obtaining detailed information in the most efficient manner.

EXPERIMENTAL DETAIL

The threshold value of the momentum of the $K^{\pm}$ meson is:

$p_{th} \simeq 3$ GeV/c in the case of a light target nucleus

$\simeq 6$ GeV/c in the case of a heavy target nucleus

It is therefore desirable that the experiment should be performed using a K beam of the highest momentum available with sufficient intensity and purity.

Two alternative experimental arrangements are being considered:

(a) A stack of pellicles, hypersensitised to facilitate rapid and efficient scanning, could be exposed so that the beam particles enter parallel to the surfaces of the pellicles. A beam intensity of 10^3 - 10^4 particles per cm^2 would be appropriate. Interactions would be found by following the tracks of beam particles. Multiple scattering measurements on the secondaries would allow a fairly detailed comparison between events showing no sign of nuclear excitation ("clean events") and other similar events in which such signs are observed ("dirty events"). Such an experiment would be completely analogous to those of Baldassare et al [1,2]. A large contamination of pions (up to about 25%) in the beam would be tolerable, although undesirable, since the events having pion primaries could be identified* by comparing the ionisation of the primary track with that of neighbouring beam tracks.

(b) A stack could be exposed so that the beam particles entered normal to the surfaces of the emulsions and had

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* Using the results of the Bristol-Dublin work on the variation of grain density with velocity in the relativistic region. This work is now nearing completion.

an intensity of 10^5-10^6 particles/cm^2 over a small area (a few mm^2 is adequate). The interactions in a field of view would then be found by rapidly following the "pattern" of beam tracks from surface to glass and back several times. Large stars would be immediately obvious, small stars and scatters would be observed by noticing the change in the "pattern" of beam tracks. With such an exposure, efficient scanning may be performed much more rapidly. Preliminary information on the mean free path for coherent interactions could be obtained comparatively quickly by comparing the angular distributions of "clean" and "dirty" events of a given shower multiplicity. The exposure of a stack of water-soaked pellicles together with a normal stack would provide valuable additional information since Coulomb and diffraction dissociation are expected to occur on light and heavy nuclei with different relative frequencies. A beam of small angular divergence ($\lesssim$ 1 milliradian) and comparatively high purity ($\gtrsim$95%) would be required, the former to facilitate efficient scanning and the latter because ionisation measurements on primary tracks would not be possible.

The experimental arrangement adopted would depend on the characteristics of the beam available and might differ significantly from both of these. In certain circumstances, it might be desirable to expose two stacks, using two different arrangements. One arrangement would then permit preliminary information to be obtained rapidly while the other would yield more detailed information. In any stack, a total

length of at least 200 metres of useful beam track would be desirable.

It is realised that, for a complete investigation employing photographic emulsions, an exposure of a stack in a high magnetic field would be desirable. This would permit more rapid and accurate measurements of momenta to be made, and would also allow the sign of each secondary particle to be determined, thus facilitating the identification of the emerging K meson. Such an experiment would require rather more preparation and it seems likely that there will not be sufficient manpower available during the relevant periods. In any case, we feel that a preliminary, simple, investigation would be necessary to justify any proposal to embark upon the larger project.

Finally, we would like to point out that the stacks exposed for the purposes of the proposed experiment would also be useful for other investigations. Among the most important of these we may mention:

(1) A preliminary exploratory investigation of production of hyperfragments by high energy K mesons.

(2) A study of small-angle $K^{\pm}$ -p scattering. (We are thinking here particularly of a water-soaked stack exposed in arrangement (b) above.)

References

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(b) G. Bellini, E. Fiorini, A.J. Herz, P. Negri, and S. Ratti: Proc. of the 1962 Conference on High Energy Physics at CERN, p. 613.