PRODUCTION OF HYPERFRAGMENTS FROM THE INTERACTIONS OF 1.3 GeV/c AND 1.5 GeV/c K^- MESONS WITH EMULSION NUCLEI

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It has been shown recently by B. D. Jones et al [1] that most (~ 80%) of the hyperfragments produced in the interactions of 800 MeV/c K^- mesons with emulsion nuclei are of short range (< 5 μm) and possess mass numbers between A = 60 and A = 90. According to the model proposed in [1], a Λ^0 hyperon created in the cascade process initiated by a K^- meson may sometimes become trapped in the heavy highly excited residual nucleus. The Λ^0 hyperon may then be emitted either free or bound to a nuclear fragment during the evaporation stage. Sometimes, however, it will remain trapped until its decay in the heavy spallation product of the reaction, forming a heavy hyperfragment. This letter gives the results of a similar study using K^- mesons of 1.3 and 1.5 GeV/c.

Three stacks of Ilford K5 emulsion were exposed to the separated K^- meson beams of momentum 1.3 GeV/c (two stacks) and 1.5 GeV/c (one stack) which were available at CERN early in 1962. The plates were area scanned for nuclear interactions produced by beam particles; 17871 stars were found at 1.3 GeV/c and 13001 at 1.5 GeV/c. Each star was examined under high magnification to detect the possible presence of two centers. All prongs from each star were followed in the emulsion sheet containing the event and any secondary interaction was noted. Of the double stars found in this search, 746 at 1.3 GeV/c and 532 at 1.5 GeV/c were classified as due to the production and subsequent decay of hyperfragments †.

The yield of observed hyperfragments is respectively (4.2 ± 0.2) % and (4.1 ± 0.2) % of beam stars at 1.3 and 1.5 GeV/c. Due to the uncertainties in the beam compositions it is impossible to obtain the true frequency of hyperfragment production for K^- meson interactions. It is to be noted that at these momenta hyperfragment production for π^- meson interactions can still be neglected ††. The contamination in the present sample of hyperfragments due to the captures of slow negative particles emitted from the primary disintegrations or to the interactions in flight of secondary particles has been estimated at both momenta in the same manner as in [1]. It has been found to be less than 2% and has therefore been neglected in the following analysis.

The range distributions of the hyperfragments produced by 1.3 and 1.5 GeV/c K^- mesons are shown in fig. 1. The cross hatched areas in these histograms represent the contribution from those events in which the prongs of the primary and the decay stars could not be completely resolved from each other (hereafter referred to as "DC" events). These range distributions differ from that for hyperfragments produced in the interactions of 800 MeV/c K^- mesons [1] both in an increase in the number of events in the range interval 5 to 10 μm and in a corresponding decrease in the number with range less than 5 μm. This is illustrated in table 1 (row 1) in which the results of this experiment are

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† In addition, 8 triple centred stars were observed; these will be submitted to a detailed analysis as possible examples of double hyperfragment production [2].

†† The yield of hyperfragments from interactions of 4.5 GeV/c π^- mesons is 0.18 ± 0.03% [3].

Table 1
General results.

		Frequency of HF of ranges R_{HF}	Fraction of mesonic HF	Fraction of stars with $N_t > 7$	$\bar{N}_t$	$\bar{N}_h$ *	Fraction of HF emitted forwards
	$R_{HF} \leq 5$ µm	71.2 ± 3.7	0.8 ± 0.5 (3/379)				76.4 ± 4.6
1.5 GeV/c	$5 < R_{HF} \leq 10$ µm	11.5 ± 1.5	3.3 ± 2.8 (2/61)	82.0 ± 3.9	11.1 ± 0.1	8.7 ± 0.1	73.8 ± 11.0
	$R_{HF} > 10$ µm	17.3 ± 1.8	41.3 ± 6.7 (38/92)				68.5 ± 8.6
	$R_{HF} \leq 5$ µm	74.0 ± 3.1	0.9 ± 0.4 (5/552)				69.9 ± 3.6
1.3 GeV/c	$5 < R_{HF} \leq 10$ µm	7.0 ± 1.0	$1.9^{+2.7}_{-1.9}$ (1/52)	74.8 ± 3.2	10.1 ± 0.1	7.7 ± 0.1	78.4 ± 12.4
	$R_{HF} > 10$ µm	19.0 ± 1.6	27.5 ± 4.4 (39/142)				59.3 ± 6.5
	$R_{HF} \leq 5$ µm	80.9 ± 4.6	$0.3^{+0.4}_{-0.3}$ (1/314)				80.4 ± 5.0
0.8 GeV/c	$5 < R_{HF} \leq 10$ µm	3.6 ± 1.0	$7.1^{+10.0}_{-7.1}$ (1/14)	65 ± 4	8.8 ± 0.2	6.3 ± 0.3	66.0 ±12.0
	$R_{HF} > 10$ µm	15.5 ± 2.0	48.3 ± 9.0 (29/60)				

* "DC" events are excluded

Table 2
Characteristics of the non-mesonic hyperfragment decay stars *

	Hyperfragments of ranges R_{HF}								
	$R_{HF} \leq 5$ µm			$5 < R_{HF} \leq 10$ µm			$R_{HF} > 10$ µm		
	1.5 GeV/c	1.3 GeV/c	0.8 GeV/c	1.5 GeV/c	1.3 GeV/c	0.8 GeV/c	1.5 GeV/c	1.3 GeV/c	0.8 GeV/c
Fraction of stars containing a prong of range between 3 and 30 µm.	8 ± 2% 22/283	9 ± 2% 33/373	5 ± 3%	17 ± 6% 10/59	20 ± 7% 10/50	-	59 ± 11% 31/52	35 ± 6% 35/101	35 ± 10%
Fraction of stars containing a recoil of range shorter than 3 µm.	43 ± 4% 121/283	43 ± 3% 160/273	53 ± 7%	39 ± 8% 23/59	46 ± 10% 23/50	-	27 ± 7% 14/52	19 ± 4% 19/101	17 ± 9%

* "DC" events are excluded

summarized separately for 1.3 and 1.5 GeV/c K^- mesons and are compared with those obtained at 800 MeV/c.

The fraction of hyperfragments decaying mesonically found in this experiment is 6.0 ± 0.9% and 8.1 ± 1.2% at 1.3 and 1.5 GeV/c respectively; this result is very similar to the value of 8.0 ± 1.6% found at 800 MeV/c. It is seen from table 1 (row 2) that at each momentum the non-mesonic decay processes are dominant for hyperfragments of range less than 10 µm, this effect being especially important for hyperfragments of very short range.

The distributions of the sum of the prong numbers of both the primary interaction and the hyperfragment decay stars are shown in fig. 2 *. A large proportion of the hyperfragments are seen to have been produced in the heavy nuclei of the emulsion, i.e. silver and bromine. A comparison of the fraction of interactions in which the total prong number

* In these distributions, tracks of π mesons, recoils and the hyperfragments themselves are not included.

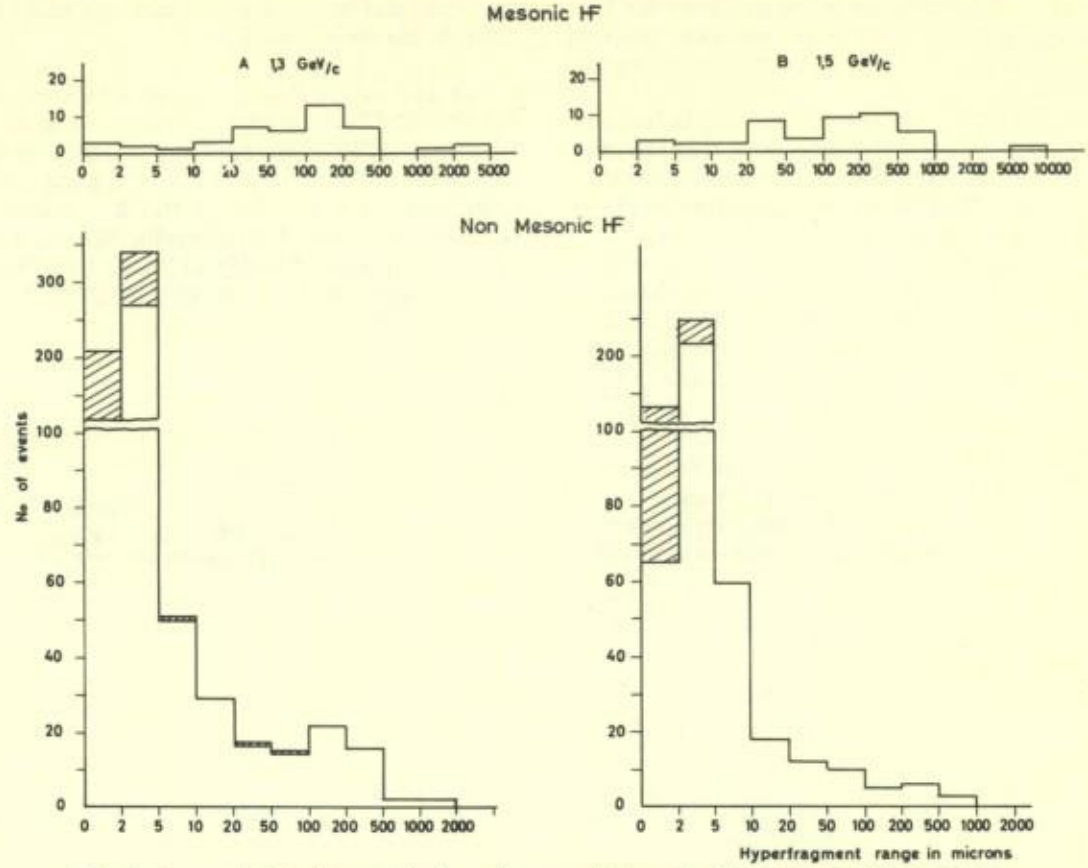

Fig. 1. Range distributions of the hyperfragments from the interactions of K⁻ mesons of 1.3 GeV/*c* (A) and 1.5 GeV/*c* (B) momentum. Hatching indicates "DC" events.

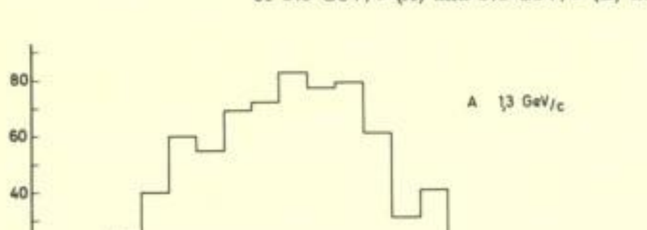

Fig. 2. Total prong number distribution of double stars. Hatching indicates mesonic hyperfragments.

exceeds seven * shows that the proportion of such interactions increases as the incident K^- meson momentum becomes higher (table 1, row 3). This increase is due mainly to the increase in size of the primary star as can be seen from the comparison of rows 4 and 5 of table 1 where the mean total prong number ($\overline{N}_t$) of the interactions and the mean prong number of the primary stars ($\overline{N}_h$) are given.

The hyperfragments are found to have been projected predominantly in the forward direction with respect to the line of flight of the incident K^- meson (see row 6 of table 1).

Table 2 summarizes the characteristics of the non-mesonic hyperfragment decay stars found at 0.8, 1.3 and 1.5 GeV/*c*. Particles of range between 3 and 30 μm ** occur less frequently in the case of short range hyperfragments than of long range ones. On the other hand tracks of length less than 3 μm, which can be attributed to nuclear recoils, are much more frequent in the decay stars of short range hyperfragments.

By applying the arguments used in [1] to the results of this work, it is concluded that the great

* A total prong number greater than 7 implies production in Ag or Br.

** Due to the Coulomb barrier effect in heavy nuclei, the presence of particles of range between 3 and 30 μm implies the disintegration of a light nucleus [1].

majority of hyperfragments of range less than 10 μm are residual spallation products containing trapped Λ^0 hyperons resulting from interactions in heavy emulsion nuclei.

As the incident K^- meson momentum is increased from 0.8 to 1.5 GeV/c, it can be seen that the average size of the primary star likewise increases (row 5 table 1). Thus the heavy spallation products will, on average, be of slightly lower mass and therefore of longer range. The observed increase in the number of hyperfragments of intermediate range (between 5 and 10 μm) supports this conclusion. An increase in the mean range of these hyperfragments might also be due to an increase in the momentum imparted to the struck nucleus. From the results given in tables 1 and 2 it is indeed clear that this class of events has properties which are intermediate between those of short range heavy hyperfragments and those of long range light ones. This is seen, for instance, in the non-mesonic decay ratio and in the fraction of short prongs and recoils in the decay stars.

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