## Lawrence Berkeley National Laboratory

**Recent Work** 

### Title

INTERACTIONS OF K\* MESONS IN HYDROGEN IK THE 300- TO 850- MeV/c REGION

## Permalink

https://escholarship.org/uc/item/05s0p496

## Authors

Bastien, Pierre L. Berge, J. Peter Dahl, Orin I. et al.

Publication Date 1962-06-19

١

# University of California

## Ernest O. Lawrence Radiation Laboratory

#### TWO-WEEK LOAN COPY

This is a Library Circulating Copy which may be borrowed for two weeks. For a personal retention copy, call Tech. Info. Division, Ext. 5545

Berkeley, California

#### DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.

## For CERN-International Conference on High Energy Physics July 1962

#### UNIVERSITY OF CALIFORNIA

#### Lawrence Radiation Laboratory Berkeley, California

#### Contract No. W-7405-eng-48

INTERACTIONS OF K<sup>-</sup> MESONS IN HYDROGEN IN THE 300- TO 850- MeV/c REGION

Pierre L. Bastien, J. Peter Berge, Orin I. Dahl, Massimiliano Ferro-Luzzi, Janos Kirz, Donald H. Miller, Joseph J. Murray, Arthur H. Rosenfeld, Robert D. Tripp, and Mason B. Watson

June 19, 1962

1962 International Conference on High Energy Physics at CERN.

#### INTERACTIONS OF K<sup>-</sup> MESONS IN HYDROGEN IN THE 300- TO 850- MeV/c REGION<sup>\*</sup>

Pierre L. Bastien, J. Peter Berge, Orin I. Dahl, Massimiliano Ferro-Luzzi,<sup>†</sup> Janos Kirz, Donald H. Miller, Joseph J. Murray, Arthur H. Rosenfeld, Robert D. Tripp, and Mason B. Watson

-1-

#### Lawrence Radiation Laboratory and Department of Physics University of California, Berkeley, California

June 19, 1962

(To be presented by Dr. Arthur H. Rosenfeld)

Results are presented on the total and partial cross sections for K<sup>-</sup> mesons incident on protons at laboratory momenta of 293, 350, 390, 434, 513, 620, 762, and 850 MeV/c. We have studied the interactions in the Lawrence Radiation Laboratory's 15-in. hydrogen bubble chamber, using a purified K<sup>-</sup> beam. For each momentum setting, a total of several thousand interactions has been recorded and analyzed.

The value of the path length was obtained at each momentum from the number of decays; the scanning efficiency for these events (on the order of 95%) is much higher than that for the more frequent one-prong decays. This compensates for the reduction in statistics.

As they appear in the bubble chamber, the interactions fall naturally into one of the following categories (only those reactions kinematically allowed at our momenta are listed):

(a) Zero prongs. These are due to the reactions

 $K^{-} + p \rightarrow \overline{K^{0}} + neutrals$  $\rightarrow \Lambda + neutrals,$ 

Work done under the auspices of the U.S. Atomic Energy Commission.

<sup>†</sup> National Academy of Sciences Fellow.

where the  $K^0$  and the  $\Lambda$  decay via the neutral mode or escape from the chamber. However, the pion contamination in the beam (on the order of 10 to 30%) adds  $\pi^-$  charge-exchange reactions to this class; hence no measurements are practical. Instead the contribution of these reactions to the cross section are accounted for by using the known neutral-to-charged-decay branching ratios of the  $\overline{K^0}$  and  $\Lambda$ , and the "zero-prong + V" data [see (e) below].

(b) Two-prongs. These are due to

 $K^{-} + p \rightarrow K^{-} + p$  $\rightarrow K^{-} + p + \pi^{0}$  $\rightarrow \Lambda (\text{or } \Sigma^{0}) + \pi^{+} + \pi^{-},$ 

where the  $\Lambda$  decays via its neutral mode or escapes observation [see (d) for the  $\Lambda$ -charged-mode counterpart of this case]. Reactions producing a very short  $\Sigma$  may also appear as a two-prong event. Analysis of the events by the PANG and KICK computer programs allows separation of the above reactions.

(c) <u>Sigma-one-prong</u>. These are due to  $K^{-} + p \rightarrow \Sigma^{+} + \pi^{-}$   $\rightarrow \Sigma^{+} + \pi^{-} + \pi^{0}$   $\rightarrow \Sigma^{-} + \pi^{+}$  $\rightarrow \Sigma^{-} + \pi^{+} + \pi^{0}$ .

The computer programs easily separate the elastic from the inelastic processes.

(d) Two-prong + V. These are due to charged-mode decays of  $\Lambda$  and

K<sup>0</sup> from  
K<sup>-</sup> + p 
$$\rightarrow \Lambda + \pi^{+} + \pi^{-}$$
  
 $\rightarrow \Sigma^{0} + \pi^{+} + \pi^{-}, \Sigma^{0} \rightarrow \Lambda + \gamma$   
 $\rightarrow \Lambda (\text{or } \Sigma^{0}) + \pi^{+} + \pi^{-} + \pi^{0}$   
 $\rightarrow \overline{K^{0}} + p + \pi^{-}.$ 

Separation of the reactions is accomplished by the kinematical programs plus ionization estimates in case of ambiguities. To compute cross sections for the above reactions, one multiplies the number of events with a  $\Lambda$  by 3/2 and those with a  $\overline{K^0}$  by 3.

(e) <u>Zero-prong + V</u>. These are due to charged-mode decays of  $\Lambda$  and  $\overline{K^0}$  from

$$K^{-} + p \rightarrow \Lambda + \pi^{0} ,$$
  

$$\rightarrow \Lambda + \pi^{0} + \pi^{0} ,$$
  

$$\rightarrow \Lambda + \pi^{0} + \pi^{0} + \pi^{0} ,$$
  

$$\rightarrow \Sigma^{0} + \pi^{0} , \Sigma^{0} \rightarrow \Lambda + \gamma .$$
  

$$\rightarrow \Sigma^{0} + \pi^{0} + \pi^{0} ,$$
  

$$\rightarrow \overline{K^{0}} + n ,$$
  

$$\rightarrow \overline{K^{0}} + n + \pi^{0} .$$

In this case the separation is based on the decay fit for the V. Lambda and  $\overline{K^0}$  decays are distinguished (ambiguities being resolved by ionization); then we compute the total mass recoiling against the  $\Lambda$  or the  $\overline{K^0}$  in the K<sup>-</sup>p center of mass. From the shape of the mass spectrum, a subdivision is further possible into the various channels. In order to account for the loss of those events without a visible decay, here as in (d) one multiplies by 3/2 for the  $\overline{\Lambda}$ 's and by 3 for the  $\overline{K^0}$ 's before computing cross sections.

The values obtained for the cross sections are collected in Table I and are also shown in Figs. 1 through 3. All values at  $P_K = 1.15$  GeV/c come from reference I. Also shown are the total cross sections obtained in counters experiments.<sup>2</sup>

Inspection of the graphs leads to the following observations:

1. In the low-momentum region, the presence of the excited hyperon  $Y_0^*$  (1520) is manifest from the enhancements occurring for the various channels around  $P_K = 400 \text{ MeV/c.}^3$ 

2. A sudden increase in  $\Lambda \pi^+ \pi^-$  production occurs at about 760 MeV/c, corresponding to copious production of the excited hyperon  $Y_1^*$  (1385) via the reaction  $K^- + p \rightarrow Y_1^{*\pm} \pi^+$ .

3. Some enhancement in the  $\Sigma \pi$  channels--mainly  $\Sigma^{-}\pi^{+}$ --is apparent at about 760 MeV/c, corresponding to a total c.m. energy of about 1680 MeV. This observation, together with strong indications of a sudden change in the differential cross sections for the  $\Sigma \pi$  reactions at this momentum, suggests the possible existence of a new excited hyperon with total mass ~ 1680 MeV.<sup>5</sup>

Further details on the analysis and a study of the differential cross sections will be presented in later publications.

Thanks are due to Prof. Luis W. Alvarez for his support and interest. We are also grateful to the scanning team of the 15-in. bubble chamber, in particular to Miss Nancy Milton and Mr. Ronald Tye who had major responsibilities in this work.

#### FOOTNOTES

- W. Graziano and S. G. Wojcicki, K<sup>-</sup>p Interactions at 1.15 BeV/c., Lawrence Radiation Laboratory Report UCRL-10177, April 17, 1962 (unpublished).
- V. Cook, B. B. Cork, T. F. Hoang, D. Keefe, L. T. Kerth, W. A. Wenzel, and T. F. Zipf, Phys. Rev. <u>123</u>, 320 (1961); O. Chamberlain, K. M. Crowe, D. Keefe, L. T. Kerth, A. Lemonick, Tin Maung, and T. F. Zipf, Phys. Rev. 125, 1696 (1962).
- M. Ferro-Luzzi, R. D. Tripp and M. B. Watson, Phys. Rev. Letters
   <u>8</u>, 28 (1962); R. D. Tripp, M. B. Watson, and M. Ferro-Luzzi, Phys. Rev. Letters 8, 175 (1962).
- 4. M. H. Alston and M. Ferro-Luzzi, Revs. Modern Phys. 33, 416 (1961).
- 5. Indications for the existence of such a 1680-MeV Σπ resonance have also been observed in π<sup>-</sup>p data by G. Alexander, L. Jacobs, G. R. Kalbfleisch, D. H. Miller, G. A. Smith, and J. A. Schwartz, Study of Strange-Particle Resonant States Produced in 1.89-2.24 BeV/c π<sup>-</sup> + p Interactions, Lawrence Radiation Laboratory Report UCRL-10286, June 12, 1962.

$P_{K}(MeV/c) =$	293 ± 42	350 ± 31	390 ± 30	434 ± 26	513 ± 20	$620 \pm 15$	762 ± 8	850 ± 10
Kp	48.2±4.2	34.0±3.2	32.7±1.8	30.6±3.4	26.5±3.3	13.8±3.0	17 ± 3	17.5±4
K <sup>0</sup> n	8.0±1.2	5.1±1.1	8.8±0,7	6.0±1.2	3.6±0.6	2,8±0,7	4.2±0.7	4.8±0.6
$\Sigma^{\dagger}\pi^{-1}$	13.6±1.4	10.6±1.4	12.5±0.08	8.2±0.9	7.5±1.1	4.6±0.7	2.9±0.4	2.0±0.3
$\Sigma^{-}\pi^{+}$	10.0±1.1	6.9±1.0	6.9±0.5	6.1±0.7	4.9±0.8	$2.1 \pm 0.4$	3.3±0.3	1.6±0.2
$\Sigma^{\mathfrak{d}}\pi^{\mathfrak{d}}$	5.2±0.9	6.3±1.4	6.7±0.6	4.9±1.3	1,7±0.3	2.3±0.5	1.8±0.4	0.9±0.3
$\Lambda \pi^{\mathfrak{D}}$	5.2±0.9	4.5±1.0	3.1±0.3	3.2±0.7	1.6±0.4	2.6±0.5	2.2±0.4	2.8±0.5
$\Lambda(\Sigma^0)$ π <sup>0</sup> π <sup>0</sup>	0.3 <b>+0</b> .2	1.9±0.6	1.5±0.2	0.8±0.4	1.1±0.3	0.8±0.2	2.0±0.4	1.4±0.3
$\Lambda \pi^{\dagger} \pi^{-}$	0.15±0.1	0.9±0.3	1.6±0.2	1.5±0.4	2.0±0.4	1.8±0.3	3.3±0.3	3.2±0.3
$\Lambda(\Sigma^0)\pi^{\dagger}\pi^{-}\pi^0$	(a) (a) (a)		Can Can Can	Cana dan dan .	0±0.01	0±0.03	0.25±0.05	0,15±0,05
∑ <sup>+</sup> π <sup>-</sup> π <sup>0</sup>	0±0.05	0.06±0.06	0.11±0.04	0.18±0.11	0,2±0,12	0.2±0.13	0,7±0.1	0.6±0.1
$\Sigma^{-}\pi^{\dagger}\pi^{0}$	0.05±0.05	0±0.06	0.12±0.05	0±0.06	0.14±0.10	0.4±0.15	0.8±0.1	0.7±0.1
$\Sigma^{\mathfrak{d}}\pi^{\dagger}\pi^{-}$	0±0,02	0±0.09	0.07±0.06	0±0.08	0.3±0.15	0.3±0.1	0,7±0,1	0.8±0.1
K <sup>0</sup> pπ <sup>-</sup>	a <b>a a</b>	(a) (a) (a)				0±0.03	0,04±0,03	0.10±0.06
Κ¯pπ <sup>0</sup>	<b>65 69 6</b> 4	ca ca ca		CHP CHP (CHP	ar ar tr	0.06±0.06	0.13±0.1	1.0±0.4
K <sup>-</sup> π <sup>t</sup> n	← 100 000	Ca Ca Ca	c	Cau das Cas		0.06±0.06	0±0.1	0,2±0,1
Total	90.7±4.9	70.2±4.2	73.8±2.3	61.5±4.1	49.5±3.7	31.8±5.0	39.3±4.0	37.8±4.0

Table I.Values of the cross sections in mb for K<sup>+</sup> + p reactions as a<br/>function of the K<sup>-</sup> laboratory momentum.

-6-

#### FIGURE LEGENDS

- Fig. 1. (a) Total K<sup>-</sup>p cross section. The triangles represent the results of the counter experiments of reference 2. The point at 1.15 GeV/c comes from reference 1. (b) K<sup>-</sup>+p → K<sup>-</sup>+p cross section. (c) K<sup>-</sup>+p → K<sup>0</sup> + n cross section.
- Fig. 2. Cross sections for the reactions (a)  $K^{-} + p \rightarrow \Lambda + \pi^{0}$ , (b)  $K^{-} + p \rightarrow \Lambda$  (or  $\Sigma^{0}$ )  $\pi^{0} + \pi^{0}$ , and (c)  $K^{-} + p \rightarrow + \pi^{+} + \pi^{-}$ . Cross section (b) includes production of  $\eta_{neutral}$  (only the neutral decay mode of  $\eta$  falls into this category). At 760 MeV/c,  $\sigma(\Lambda + \eta_{neutral})$  is estimated to be  $0.48 \pm 0.10$  mb; at 850 MeV/c,  $\sigma$  is less than  $0.02 \pm 0.02$  mb. The open circles represent upper limits from charge independence ( $\sigma_{\Lambda \pi^{0} \pi^{0} \pi^{0}} \ll \sigma_{\pi^{+} \pi^{-} / 2}$ ). Cross section (c) includes  $\Upsilon_{1}^{*}$  (1385) +  $\pi$  production; at 760 MeV/c,  $\sigma(\Upsilon_{1}^{*\pm} + \pi) = 2.4 \pm 0.3$  mb, at 850 MeV/c,  $\sigma(\Upsilon_{1}^{*\pm} + \pi) = 1.9 \pm 0.5$  mb. Fig. 3. Cross sections for the reactions (a)  $K^{-} + p \rightarrow \Sigma^{-} + \pi^{+}$ , (b)  $K^{-} + p \rightarrow \Sigma^{0} + \pi^{0}$ , (c)  $K^{-} + p \rightarrow \Sigma^{+} + \pi^{-}$ , (d)  $K^{-} + p \rightarrow \Sigma^{-} + \pi^{+} + \pi^{0}$ (e)  $K^{-} + p \rightarrow \Sigma^{0} + \pi^{+} + \pi^{-}$ , and (f)  $K^{-} + p \rightarrow \Sigma^{+} + \pi^{-} + \pi^{0}$ .



MUB-1157

### Fig. 1

-8-



MUB-1158

Fig. 2



Fig. 3

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

- A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or
- B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.



· · · ·

₹ •

÷

,

r

Ì

۹ ۲

`

r. •

,