Λ-PROTON SCATTERING AT LOW MOMENTA

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This is combined report of two experiments on $\Lambda - p$ scattering by Maryland group and by Rehovoth CERN Heidelberg collaboration.

The Λ's were produced in the Saclay 81 cm Hydrogen Bubble Chamber exposed at CERN to a beam of stopping K^- mesons. The film was scanned twice for Λ scattering with visible recoil proton. The RCH Group used the following criteria:

a) Incident momentum between 120 to 320 MeV/c.

b) Recoil proton and Λ decay proton range is longer than 1.5 mm.

c) Length of flight of the Λ before and after the scatter more than I mm.

The total path length examined in the experiment has been evaluated by measuring a random sample of 362 Λ decay events. The momentum distribution of these events is given in Fig. 1 and is consistent with the distribution of Λ hyperons produced in $K^- - p$ interaction at rest with a small contribution from $K - p$ in flight.

Assuming the reaction to be predominantly in S-wave, we obtained the following cross section values:

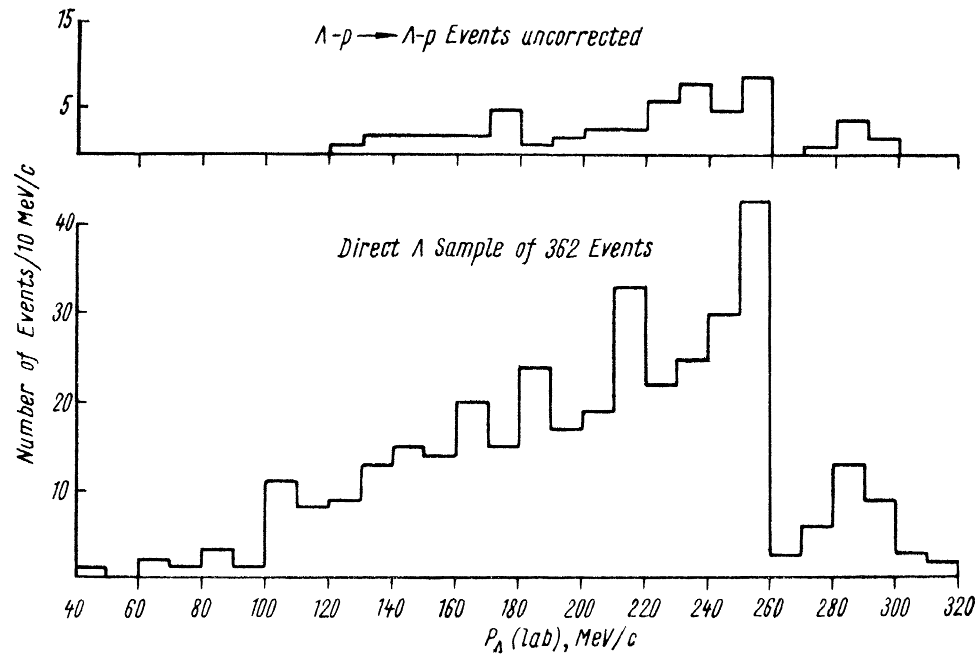

Fig. 1. Momentum distribution of the $\Lambda - p \to \Lambda - p$ events and of the direct Λ decay sample.

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Table 1

σ_T, mb	$\bar{p}$, Mev/c	P, Mev/c	No. of Events Fully Analysed
119,6±29,0	170	120—220	17
77,0±16,8	255	220—320	21

The values of the cross section are plotted together with former results at higher momenta [1, 2] and two theoretical curves for the total cross section, obtained by a potential-scattering calculation following Ram and Downs [3].

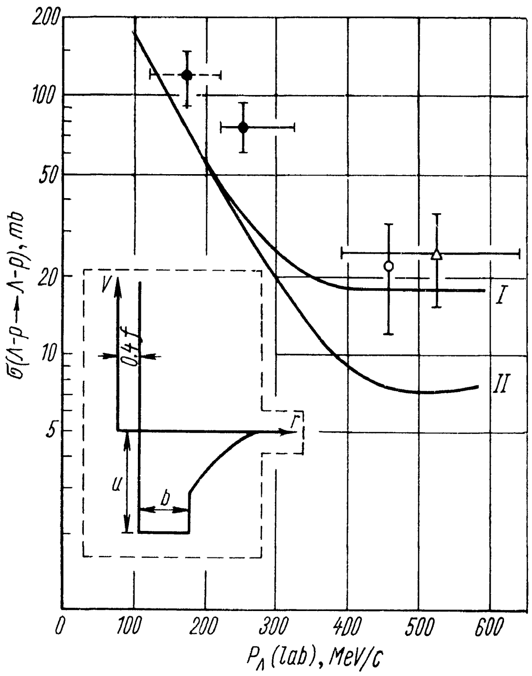

Fig. 2. Total $\Lambda - p$ elastic scattering as function of momentum. The closed circle points are of the present experiment divided into two momentum regions. Triangle point is from [1] and the open circle point from [2].

In this calculation the potential is taken to be consistent with hyperfragment data and is of the type shown in Fig. 2 where

$$V(r) = \begin{cases} \infty, & r \leqslant 0.4f, \\ -U, & 0.4f \leqslant r \leqslant 0.4f + b, \\ -W.\exp(-2(r-0.4f)/R), & r > 0.4f + b, \end{cases}$$

$W = 150$ MeV; $R = 0.847\ f$ (f = fermi units).

In Fig. 2 curve I corresponds to $b = 1.1\ f$ and $V_{1\text{-odd}} = V_{1\text{-even}}$ and curve II for $b = 1.1\ f$ and $V_{1\text{-odd}} = V_{1\text{-even}}$ 0,6. For $V(r)$ to be consistent with hyperfragment data, U has been evaluated as $U_{\text{singlet}} = 51.2$ MeV and $U_{\text{triplet}} = 19.8$ MeV. The experimental σ_T values seem to have the general dependence on momentum, as the theory, however, their value is

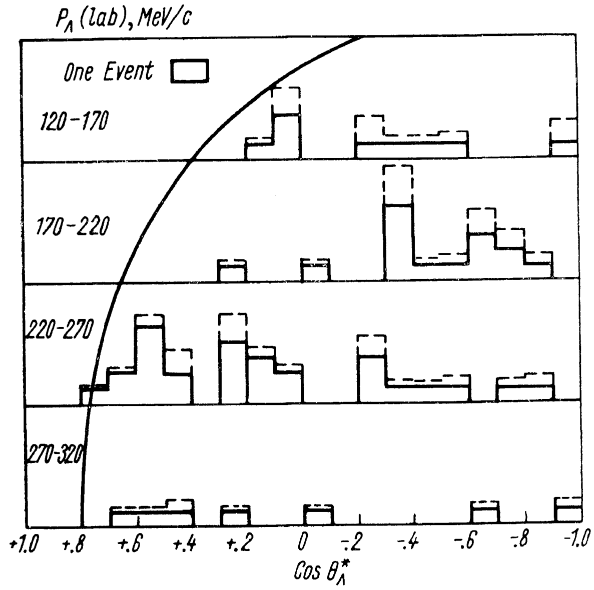

Fig. 3. Angular distribution of the $\Lambda - p \to \Lambda - p$ events in four momentum regions, dashed lines are corrected values. The curved line represents the kinematical limit due to the recoil proton cutoff.

consistently higher than the theoretical one even for a variation in the b parameter changing from $0.7\ f$ to $1.5\ f$.

The distribution in cos ϑ^* for the $\Lambda^0 - p$ events is given in Fig. 3.

The average values of $F/B = 1.29\ {}^{+0.86}_{-0.96}$ and $P/E = 1.41\ {}^{+0.91}_{-0.60}$ are consistent with an isotropic distribution and hence with predominantly S-wave scattering as is expected at this low momentum.

Maryland group found 74 events which are plotted in Fig. 4,a in five momenta intervals as a function of the center of mass system angle. Dots represent events satisfying five criteria. (Method II). The first four required that the projected lengths of the Λ^0 before and after scatter and of the decay proton be greater than 1 mm and that the projected length of the recoil proton be greater than 2 mm. Events satisfying these criteria were assigned appropriate weights. The fifth criterion, that all events have weight less than 2.0, was then imposed. This restricted the scattering angle to the region bounded by the solid curve in Fig. 4, *a*. Events failing any criteria are indicated by crosses. The dashed line represents events with precoil proton 2 mm long. (Method I).

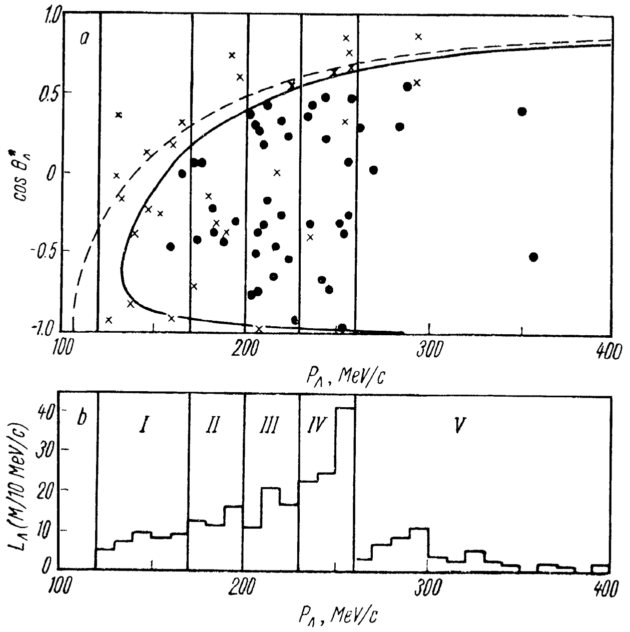

Fig. 4. Scatter plot of incident Λ momentum vs. cosine of Λ scattering angle (a); momentum distribution of Λ path length (b).

The distribution of the Λ^0 path length as a function of incident momentum is also shown in Fig. 4, *b*. It was determined by measuring an unbiased sample of 1000 Λ's and scaling the distribution for those events to reflect the total number of Λ's observed.

Table 2

Interval No.	I	II	III	IV	V
Momentum range, MeV/c	120—170	170—200	200—230	230—260	260—400
a. Path Length meters	39	40	48	87	42
b. No. Accepted events	10	11	18	13	6
c. Cross section	130±50	105±34	195±55	66±22	52±23
d. Effective mean momentum, MeV/c	144	186	216	248	291

The best estimate of the cross sections in momentum intervals I and II were taken to be the results of the recoil proton criteria only. In these intervals the number of events rejected by the all the other four criteria indicates that these criteria were far too conservative.

The number of acceptable events and the cross section for each interval are presented in Table 2 with the effective mean momenta, for each interval, weighted by the path length and $1/k^2$.

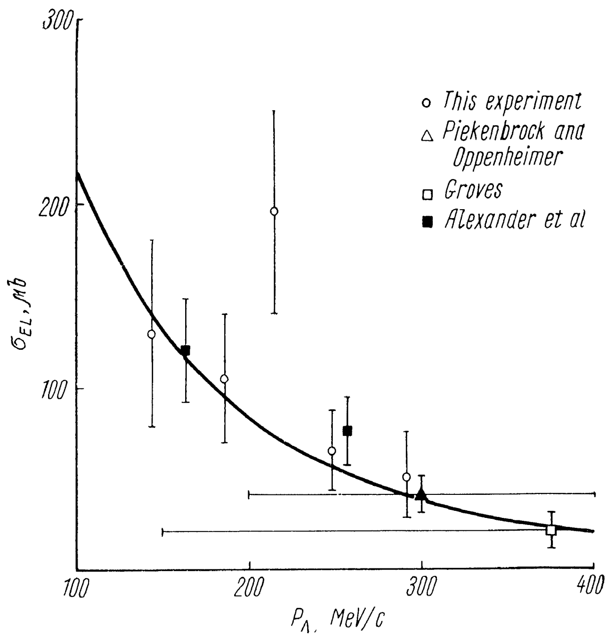

Fig. 5. Λ — *p* elastic scattering cross sections for Λ momentum between 100 and 400 MeV/c. The results of the Rehovoth, CERN, Heidelberg Collaboration (Alexander et al.) are also plotted on this Figure.

Present results, along with those of Groves [2] and Piekenbrock and Oppenheimer [4], are shown on Fig. 5. The theoretical curve shown is the effective range approximation: based on hyperfragment data: and assuming $l = 0$.

$$\sigma = \frac{3\pi}{K^2 + \left[a_t^{-1} - \frac{r_t}{2} K^2\right]^2} + \frac{\pi}{K^2 + \left[\frac{1}{a_s} - \frac{r_s}{2} K^2\right]^2}.$$

The parameters are those given by de Swart and Dullemond [5]: ($a_t = -0.53\,f$, $a_s = -3.6\,f$, $r_t = 5\,f$, and $r_s = 2\,f$). The data generally agree quite well with this curve.

There are two striking features of the data. The first is the forward peaking of the angular distribution of events above 260 MeV/c (See Fig. 4,a). While this effect is not inconsistent with isotropy, such a distribution has been predicted, for this momentum range, by Ram and Downs [3]. The second feature is the large cross section in interval III. No explanation is offered at this time, other than the possibility of a two standard deviation fluctuation of the data.

In general the two experiment agree with each other.

REFERENCES

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DISCUSSION

Phillips.

I wish to comment on the $\Lambda - p$ total cross sections, which agree so nicely with the theory of de Swart et al. Downs and I have a single-meson-exchange model of the Λ-nucleon interaction, which gives the same zero-energy cross section but decreases more rapidly and lies at the bottom of the experimental error bars. Now our potential contains a vide soft core from ω-meson exchange, wihch pushes the potential outwards, increases the effective range, and makes the cross section decrease faster. So these experiments may be some evidence against such a wide soft core. Alternatively, perhaps the zero-energy scattering lengths are bigger than the currently accepted values.

Lagarrigue.

A collaboration between Ecole Polytechnique (Paris) and University of Bergen (Norway) has mesured the elastic cross section Λ^0-nucleon in a momentum range between 500 and 1200 MeV/c. The result based on 86 events is:

$\sigma\,(\Lambda^0 + \text{nucleon} \rightarrow \Lambda^0 + \text{nucleon}) = 25 \pm 4$ mb.