A New Determination of the Capture Ratio

\[ r_c = \frac{\Sigma^- p \rightarrow \Sigma^0 n}{(\Sigma^- p \rightarrow \Sigma^0 n) + (\Sigma^- p \rightarrow \Lambda^0 n)}, \]

the \( \Lambda^0 \)-Lifetime and the \( \Sigma^- - \Lambda^0 \) Mass Difference

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The two \( \Sigma^- \) reactions at rest \( \Sigma^- p \rightarrow \Sigma^0 n \) and \( \Sigma^- p \rightarrow \Lambda^0 n \) have been studied in order to determine the capture ratio

\[ r_c = \frac{\Sigma^- p \rightarrow \Sigma^0 n}{(\Sigma^- p \rightarrow \Sigma^0 n) + (\Sigma^- p \rightarrow \Lambda^0 n)}, \]

the \( \Lambda^0 \)-lifetime and the \( \Sigma^- - \Lambda^0 \) mass difference. The following results were obtained:

\[ r_c = 0.474 \pm 0.016 \]

\[ \tau_{\Lambda^0} = (2.47 \pm 0.08) \times 10^{-10} \text{ sec} \]

\[ M_{\Sigma^-} - M_{\Lambda^0} = 81.64 \pm 0.09 \text{ MeV/c}^2. \]

The \( \Sigma^- \)-mass was determined from the range of the stopping \( \Sigma^- \)-hyperons, \( M_{\Sigma^-} = 1197.19 \pm 0.32 \text{ MeV/c}^2. \)

The two capture reactions:

\( \Sigma^- + p \rightarrow \Sigma^0 + n \), \hspace{1cm} (1)

\( \Sigma^- + p \rightarrow \Lambda^0 + n \) \hspace{1cm} (2)

were studied in order to measure the following quantities:

(i) the capture ratio

\[ r_c = \frac{\Sigma^- p \rightarrow \Sigma^0 n}{(\Sigma^- p \rightarrow \Sigma^0 n) + (\Sigma^- p \rightarrow \Lambda^0 n)}, \]

(ii) the \( \Lambda^0 \)-lifetime \( \tau_{\Lambda^0} \),

(iii) the \( \Sigma^- - \Lambda^0 \) mass difference.

The \( \Sigma^- \)-hyperons were produced by stopping \( K^- \)-mesons in the 81 cm Saclay Hydrogen Bubble Chamber at the CERN PS\(^1\). The film

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was scanned for $\Sigma^- p$-interactions with a visible $\Lambda^0$-decay. Only events where the $\Sigma^-$-hyperon came to rest were considered. Results on $\Sigma^- p$-interactions in flight have been published in a previous paper $^2$.

1. The Capture Ratio

$$r_c = \frac{\Sigma^- p \to \Sigma^0 n}{(\Sigma^- p \to \Sigma^0 n) + (\Sigma^- p \to \Lambda^0 n)}$$

The kinetic energy of $\Lambda^0$-hyperons produced from reaction (1) $\Sigma^- p|_{\text{lat rest}} \to \Sigma^0 n$, $\Sigma^0 \to \Lambda^0 \gamma$ is limited between 0.16 and 7.8 MeV, whereas in the two body process $\Sigma^- p|_{\text{lat rest}} \to \Lambda^0 n$ the kinetic energy of the $\Lambda^0$-hyperons is fixed at 36.9 MeV. Therefore the two reactions can easily be separated.

In order to exclude background events it was necessary to apply the following selection criteria:

a) the interaction volume inside the bubble chamber was restricted to:

$$-23.0 \leq X \leq 31.5 \text{ cm}$$
$$-11.5 \leq Y \leq 11.5 \text{ cm}$$
$$-30.6 \leq Z \leq -1.0 \text{ cm},$$

b) the confidence level for the hypothesis $K^- p|_{\text{lat rest}} \to \Sigma^- \pi^+$ had to be greater than 1%.

c) the projected angle between $K^-$ and $\Sigma^-$ direction was limited between: $10^\circ \leq \alpha(K^-, \Sigma^-)_{\text{proj}} \leq 170^\circ$,

d) the dip-angle of the $\Sigma^-$-track had to be less than 60$^\circ$,

e) the length of the track was restricted to $0.95 \leq L_{\Sigma^-} \leq 1.15 \text{ cm}$.

In order to avoid systematical losses of $\Lambda^0$-decays the following conditions were imposed:

a) the projected path length of the $\Lambda^0$-hyperons had to be limited to $0.2 \leq (L_{\Lambda^0})_{\text{proj}} \leq 6.0 \text{ cm}$; the spatial path length was required to be also less than 6.0 cm.

b) The projected length of the $\Lambda^0$-decay proton had to exceed 1.5 mm.

c) The projected angle between $\Sigma^-$ and $\Lambda^0$-direction had to be less than $150^\circ$.

d) The projected angle between pion and proton direction of the $\Lambda^0$-decay had to be limited to $10^\circ \leq \alpha(p, \pi^-)_{\text{proj}} \leq 170^\circ$.

e) The $\Lambda^0$-momentum had to be greater than 30 MeV/c.