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PRODUCTION RATIO OF PHOTOMESONS FROM BERYLLIUM

Heinrich A. Medicus

June 8, 1951

Berkeley, California
PRODUCTION RATIO OF PHOTOMESONS FROM BERYLLIUM

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By the irradiation of targets with a high energy x-ray beam, both negative and positive \( \pi \)-mesons are produced. An investigation was made to determine the ratio of the numbers of mesons of either sign produced in beryllium because its single isotope \(^{4}\text{Be}^9\) has one neutron with only 1.6 Mev binding energy which might affect this ratio.

For this study, the same arrangement was used with which Peterson, Gilbert, and White\(^1\) had determined the corresponding ratio for carbon. The x-ray beam of the 320 Mev synchrotron was collimated and hit the target, a beryllium sphere of about 1/2 inch diameter. The target was surrounded by a copper absorber in which were imbedded the nuclear emulsion plates, Ilford C2, of 200\(\mu\) thickness. They were oriented in such a way that the planes of the emulsions were approximately radial. Thus the mesons give relatively long tracks in the emulsion. The plates were scanned for mesons stopping in the emulsion. From the thickness of the traversed material (beryllium, copper, glass, and emulsion) and the energy-range relation one can determine the initial energy of the mesons. The discrimination between negative and positive mesons was made by observing their type of

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\(^1\) J. M. Peterson, W. S. Gilbert, and R. S. White, Phys. Rev. 81, 1003, (1951).
endings. As in the work of Peterson et al., the fact was used that in emulsions negative $\pi$-mesons are captured by nuclei and form stars with visible prongs 73 percent of the time; the remaining 27 percent stop without showing a visible track at their end.\(^2\) Positive mesons are not captured and decay to $\mu$-mesons. By counting the meson-produced stars and the $\pi^-\mu$ decays, one therefore can calculate for each energy interval the $\pi^-/\pi^+$ ratio. Only mesons emitted at an angle of $90^\circ \pm 7^\circ$ to the x-ray beam and in the energy range of 30 to 70 Mev were investigated in this experiment. Because stars are much more conspicuous events in emulsions than $\pi^-\mu$ decays, the probability of missing stars in the scanning process is slightly lower than that of overlooking $\pi^-\mu$ decays. For this reason, a correction in the ratio of 5 percent, derived from scanning certain areas of the emulsions twice, was applied. Only mesons ending more than 5 microns away from the surface of the emulsion after processing were counted. The ratios were determined from a total of 661 $\pi^-\mu$ decays and star forming mesons. The errors given include standard deviations and estimated systematic errors.

The results are given in Table I.

<table>
<thead>
<tr>
<th>Meson Energy (Mev)</th>
<th>$\pi^-/\pi^+$ Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-40</td>
<td>2.5 ± 0.6</td>
</tr>
<tr>
<td>40-55</td>
<td>2.0 ± 0.3</td>
</tr>
<tr>
<td>55-70</td>
<td>2.2 ± 0.3</td>
</tr>
<tr>
<td>30-70</td>
<td>2.2 ± 0.25</td>
</tr>
</tbody>
</table>

It is seen that the ratio of negative to positive mesons depends little, if any, on the energy in the investigated range. The over-all ratio for mesons of 30 to 70 Mev is 2.2. This value is, within the limits of accuracy, the same which Littauer and Walker\(^3\) got for mesons of about 50 Mev at an angle of 135° to the x-ray beam direction. In their measurements the discrimination between the mesons of both signs was made by means of a magnetic field.

This high minus-plus ratio cannot be explained only by the fact that the beryllium nucleus has one more neutron than protons. Rather it seems as if this one neutron of the low binding energy would act as a free particle, and therefore, would have a higher production cross section. This is analogous to the case of the production of positive mesons, where free protons have a higher production cross section for \(\pi^+\)-mesons than bound ones, because of the action of the exclusion principle.\(^4\),\(^5\) In light elements in which no particle has such a preferred position, as in deuterium, helium, and carbon, the respective minus-plus ratios are 1.0,\(^6\) 1.06\(^{,3}\) for an angle of 45°, and 1.06\(^{,3}\) (angle 135°).

I want to express my gratitude to Professor E. M. McMillan for his continued interest and to Dr. J. M. Peterson for his valuable help during the first stages of this work. It is a pleasure to thank the members of the film program group under Dr. W. Barkas, in particular Mrs. W. R. Gaffey who did a part of the scanning. I am particularly grateful to Professor E. O. Lawrence for the privilege of visiting and working at the Radiation Laboratory. This work was performed under the auspices of the AEC.

\(^3\) R. M. Littauer and D. Walker, Phys. Rev. 82, 746 (1951).
\(^4\) J. Steinberger and A. S. Bishop, Phys. Rev. 73, 494 (1950).
\(^6\) M. J. Jakobson, A. G. Schulz, and R. S. White, private communication.