Notas de Física Nº 13, 1953

THE ANOMALOUS LARGE ANGLE SCATTERING OF MU MESONS*

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December 14, 1953

Several recent experiments[1-5] indicate an anomalous large angle scattering of μ-mesons with a cross section of the order of 10^{-28} cm^2/nucleon. Calculations of the cross section for inelastic collisions of the μ-mesons with individual protons of the nucleus made by Amaldi and Fidecaro[1] (in iron) and by George, Reeding and Trent[3] (in lead), account only for a very small percentage of the observed anomalous scattering. This would seem to indicate that the mechanism responsible for this scattering involves the entire nucleus rather than the individual nucleons.

A mechanism for the production of stars by μ-mesons has been given[6] in which the coulomb field of the rapidly moving meson is replaced by its equivalent photon spectrum (the Weizsäcker-Williams method). In the present case the virtual photon beam does not give rise to appreciable star production since the energy is only of the order of a few hundred Mev; however, it is well known that all nuclei possess a "giant" photon resonance in the neighborhood of 15-20 Mev which could be excited by the virtual

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(*) To be published in Nuovo Cimento.

photons.

One may consider a rapidly moving charged particle of energy E to be equivalent to a beam of photons whose number with energy between $\hbar\omega$ and $\hbar\omega + d(\hbar\omega)$ is given by

$$N(\hbar\omega)\, d(\hbar\omega) = \frac{2\alpha}{\pi} \ln\left(\frac{E}{\hbar\omega}\right) \frac{d(\hbar\omega)}{\hbar\omega} \qquad (1)$$

α the fine structure constant.

For $\hbar\omega_o$, the energy at which the photon absorption is a maximum, recent experiments on the photonuclear effect give[7]

$$\hbar\omega_o = 37\, A^{-0.186} \text{ Mev} \qquad (2)$$

and for the cross section integrated from 0 to 27.5 Mev[8]

$$\int_o^{27.5} \sigma_n(\hbar\omega) d(\hbar\omega) = 5.2 \times 10^{-4} A^{1.8} \text{ Mev barns} \qquad (3)$$

If one considers the "giant" resonance to have the character of a delta function centered at $\hbar\omega_o$ then one may write

$$\sigma_n(\hbar\omega) = 10.4 \times 10^{+4} A^{1.8}\, \delta(\hbar\omega - \hbar\omega_o) \text{ barns} \qquad (4)$$

Assuming the photon absorption results only from this "giant" resonance then no harm is done in writing $\hbar\omega_{max} \approx \infty$ even for incident μ-mesons with E = 300 Mev. Thus

$$\sigma_\mu = \frac{1}{A} \int_o^\infty \sigma(\hbar\omega) N(\hbar\omega) d(\hbar\omega) \qquad (5)$$
$$= 6.54\, A^{0.986} \ln(E\, A^{0.186}/37) \times 10^{-32} \text{cm}^2/\text{nucleon.}$$

When evaluated for lead, equation (5) gives $\sigma_\mu = 3.34 \times 10^{-29}$ cm^2/nucleon. While this is somewhat lower than the observed values it must be remembered that no account has been taken of the not insignificant high energy "tail" to the photon absorption cross section. Finally, it is of interest to note that σ_μ is essentially proportional to A which seems to be in agreement with the experimental evidence (cf. Table 4, reference 5).

Of course all charged particles of sufficient energy should produce such scattering; however, for sufficiently energetic electrons the effect will be masked by bremstrahlumg while for protons and π-mesons it will be masked by the strong nuclear scattering.

It would seem that the anomalous scattering of μ -mesons can be explained by the interaction of the meson's coulomb field with the entire target nucleus, and thus it is not necessary to postulate an interaction between the μ-meson field and the nucleon field in addition to the Fermi interaction. A more complete discussion of this scattering process will be published elsewhere.

The author wishes to express his appreciation to Professors U. Camerini and J. Leite Lopes for stimulating conversations.

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