

POSSIBILITY OF STUDYING THE INTERACTION OF LONGITUDINALLY POLARIZED V^0 MESONS WITH NUCLEONS IN THE REACTION $\pi^-A \rightarrow V^0A'$

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An analysis of the data on the production of unstable particles on atomic nuclei makes it possible to extract information concerning the zero-angle scattering of unstable particles by nucleons, averaged over the nucleon spins. In the case of forward V^0N scattering (V^0 is a vector meson), such an averaged amplitude is characterized by two complex quantities, $\sigma_T' = \sigma_T(1 - i\alpha_T)$ and $\sigma_L' = \sigma_L(1 - i\alpha_L)$, where $\sigma_{T(L)}$ is the total interaction cross section of transversely (longitudinally) polarized V^0 mesons with nucleons, and $\alpha_{T(L)}$ is the ratio of the real and imaginary parts of the forward scattering amplitude. In coherent photoproduction of V^0 mesons on nuclei, which has recently been diligently studied [1], for well-known reasons, there are produced practically transversely-polarized V^0 mesons, and consequently, only the quantity σ_T' can be obtained from an analysis of the experimental data. To determine σ_L' it is necessary to study such processes of production of V^0 mesons on nuclei, in which longitudinally polarized V^0 mesons are predominantly produced. One of the processes of this type, most accessible for experimental study and simplest for theoretical analysis, is the production of V^0 mesons in pion-nucleus collisions²⁾ ($\pi^-A \rightarrow V^0A'$). Using the standard technique for calculating the cross sections of incoherent processes such as charge exchange on nuclei [3], we can easily obtain the following connection between the observed values of the processes $\pi^-A \rightarrow V^0A'$ and $\pi^-p \rightarrow V^0n$ at not too large momentum transfers ($-t \lesssim 0.2 - 0.3$ (GeV/c)²)

$$\frac{d\sigma^A}{dt} \rho_{\lambda\lambda}'^A = \frac{d\sigma^p}{dt} \rho_{\lambda\lambda}'^p \frac{Z}{A} N \left(\sigma(\pi) \frac{\sigma_{\lambda}'(V^0) + \sigma_{\lambda}'(V^0)}{2} \right). \quad (1)$$

In (1), $d\sigma^A/dt$ and $d\sigma^p/dt$ are the differential cross section of the process under consideration on the nucleus and nucleon, respectively (summed over all the final states of the nucleus in the case of production on a nucleus). $\rho_{\lambda\lambda}'$ are the elements of the density matrix of a spin-1 particle, in terms of which we can express in a known manner [5] the angular distribution of the unstable particle decay products, and $Z(A)$ is the charge (atomic number) of the target nucleus. The "effective nucleon numbers" $N(\sigma_1, \sigma_2)$ (which are in general complex if σ_1 and σ_2 are complex) are expressed in terms of the nucleon density in the nucleus, $\rho(\vec{r}) = \rho(\vec{B}, z)$, normalized to the total number of nucleons A and to the quantities σ_1 and σ_2 in the following manner [4]:

$$N(\sigma_1, \sigma_2) = \int d^2B \frac{[\exp(-\sigma_1 \int \rho(\vec{B}, z) dz) - \exp(-\sigma_2 \int \rho(\vec{B}, z) dz)]}{\sigma_2 - \sigma_1}. \quad (2)$$

Finally, $\sigma(\pi) = (Z/A)\sigma(\pi^-p) + [(A - Z)/A]\sigma(\pi^-n)$, and $\sigma_{\lambda}' = \sigma_T'$ at $\lambda = \pm 1$ and $\sigma_{\lambda}' = \sigma_L'$ at $\lambda = 0$.

From (1) we obtain

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²⁾This process is considered in [2] under the assumption $\sigma_T' = \sigma_L'$.

$$\frac{\frac{d\sigma^A}{dt} \rho_{11}^A}{\frac{d\sigma^P}{dt} \rho_{11}^P} = \frac{\frac{d\sigma^A}{dt} \rho_{1-1}^A}{\frac{d\sigma^P}{dt} \rho_{1-1}^P} = \frac{Z}{A} N(\sigma(\pi), \sigma_T(V^0)), \quad (3)$$

and the effective number of nucleons in the right-hand side of this equation depends on the total cross section of the transversely polarized V^0 mesons with the nucleons $\sigma_T(V^0)$, which is determined independently from data on coherent photoproduction of V^0 mesons on nuclei. A verification of the relation (3) is a check on the self-consistency of this scheme of describing the interaction of the particles with the nuclei, within the framework of which one usually considers such processes (in practice, a check on the optical model). If such a check results in the affirmative, then the next step is to determine σ_L' from an analysis of the production of longitudinally-polarized V^0 mesons, with the aid of the relation

$$\frac{\frac{d\sigma^A}{dt} \rho_{00}^A}{\frac{d\sigma^P}{dt} \rho_{00}^P} = \frac{Z}{A} N(\sigma(\pi), \sigma_L(V^0)). \quad (4)$$

Finally, using the relation

$$\frac{d\sigma^A}{dt} \operatorname{Re} \rho_{10}^A = \frac{Z}{A} \frac{d\sigma^P}{dt} \operatorname{Re} \left\{ \rho_{10}^P N\left(\sigma(\pi), \frac{\sigma_T' + \sigma_L'^*}{2}\right) \right\} \quad (5)$$

(we do not write out the analogous relation for the imaginary part, since it does not enter in the angular distributions of the decay products), we can determine σ_L' either by putting $\operatorname{Im} \rho_{10}^P = 0$ in accordance with the predictions of the Regge-pole model [6], or by assuming $\operatorname{Im} \rho_{10}^P$ to be an independent parameter to be determined. This, in general outline, is the scheme for determining σ_L' from data on the production of V^0 mesons in π^- -nucleus collisions.

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