ρ meson decay inside and outside of ^{56}Fe nucleus

Swapan Das
Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA
email: swapand@barc.gov.in

The modification of the hadron parameters of an unstable particle (e.g., rho meson) in a nucleus would occur if it dominantly decays inside the nucleus. The natural decay length of the rho meson (~1 fm) is less than the dimension of a normal nucleus. Due to the interaction of this meson with the nucleus, its decay length as well as its decay probability inside the nucleus can be modified. Therefore, we investigate the decay probability of the rho meson inside and outside of ^{56}Fe nucleus in the ($\gamma,\rho\rightarrow e^+e^-$) reaction.

We describe the rho meson nucleus interaction $V_{O\rho}(\mathbf{r})$ in terms of the ρN scattering parameters:

$$V_{O\rho}(\mathbf{r})=-v_\rho[i+\alpha_{\rho N}]\sigma_t^{\rho N}\varrho(\mathbf{r})/2, \qquad (1)$$

where v_ρ is the velocity of the rho meson. $\alpha_{\rho N}$ is the ratio of the real to imaginary part of the scattering amplitude. $\sigma_t^{\rho N}$ is the total ρN scattering cross section. These quantities, as extracted from the elementary rho meson production data, are used in the calculation. $\varrho(\mathbf{r})$ is the nuclear density distribution, taken from the electron scattering measurements.

The factor (which describes the rho meson decay and appears in the cross section) is given by [1]:

$$D(z',z)=-f\exp[f\int_z^{z'}dz''\{G_{O\rho}^{-1}-2E_\rho V_{O\rho}\}], \qquad (2)$$

with $f=i/(2k_\rho)$. $G_{O\rho}$ is the free space rho meson propagator. z and z' are the production and decay points for the rho meson propagating along the Z-axis. The rho meson decay inside $D(Z)_{in}$ and outside $D(Z)_{out}$ the nucleus can be written as

$$D(z)_{in}=\int_z^{Z_R}dz'D(z',z);$$

$$D(z)_{out}=\int_{Z_R}^{\infty}dz'D(z',z). \qquad (3)$$

Z_R is determined where the nuclear density falls to 1% of its saturation density.

We calculate the rho meson mass distribution spectrum in the photonuclear reaction for the rho meson (produced in ^{56}Fe) momentum range (as measured at Jefferson Laboratory) k_ρ(GeV/c) = 0.8-3 [2]. The calculated results are shown in Fig.1 for the rho meson decaying inside and outside of ^{56}Fe nucleus. The dashed line represents the previous case where as the dot-dot-dashed line describes the latter. It is noticeable in this figure that the decay probability inside the nucleus is larger than that outside the nucleus. The rho meson mass distribution is wider and its peak shifts towards lower value when it decays inside the nucleus. For the rho meson decaying outside the nucleus, the shape of the rho meson mass distribution spectrum does not show the medium effect on this meson, i.e., the peak of the distribution appears at ~750 MeV, and the width of the distribution is ~150 MeV. The solid curve in this figure represents the coherent addition of the amplitudes of the rho meson decaying inside and outside the nucleus.

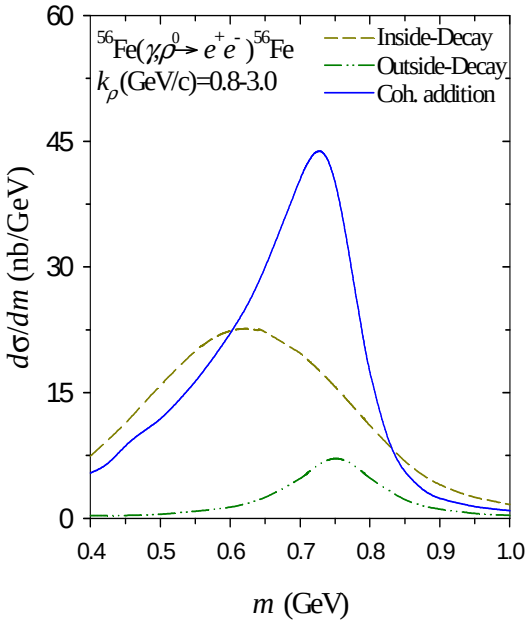

Fig.1 ρ meson decay inside and outside of ^{56}Fe.

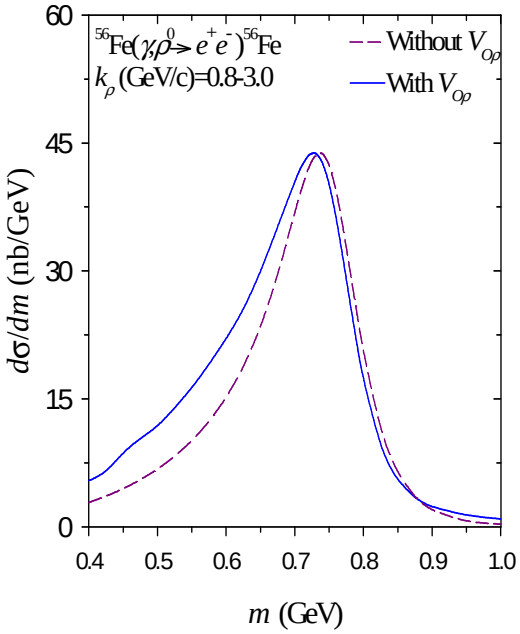

Fig.2 Broadening of the ρ meson.

We present in Fig.2 the calculated rho meson mass distribution spectrum with and without V_{Op}(r), given Eq.(1). This figure shows that the rho meson width is increased by 35 MeV due to this interaction, where as the mass-shift for this meson is found insignificant.

We compare in Fig.3 the calculated rho meson mass distribution spectrum (solid curve) with the data reported from Jefferson Laboratory [2]. The agreement of the calculated spectrum with the data, as shown in this figure, is reasonable.

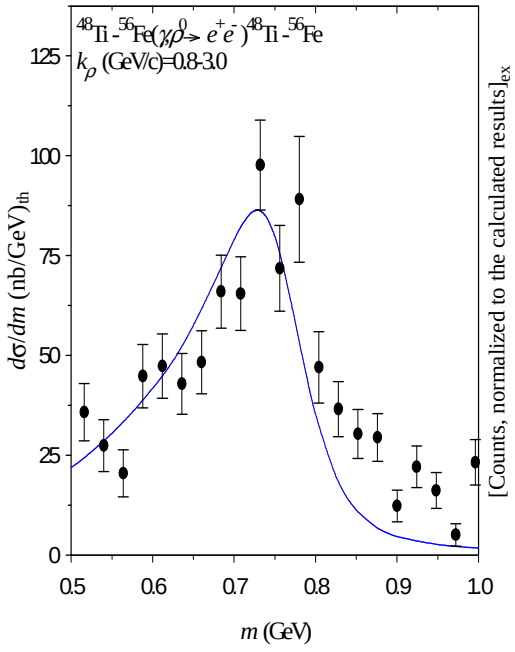

Fig.3 The calculated results and data.

References

[1] Swapan Das, in preparation.

[2] R. Nasseripour et al., (CLAS Collaboration), Phys. Rev. Lett **99,** 262302 (2007); M. H. Wood et al., (CLAS Collaboration), Phys. Rev. C **78,** 015201 (2008).