Formation of mesic nuclei by (γ,p) reactions

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In this study we make a theoretical evaluation of the formation rates of the η and ω mesons in nuclei induced by the (γ,p) reactions in ideal recoilless kinematics [1]. We show the expected spectra in order to investigate the meson-nucleus interactions. We find that the (γ,p) reactions are good practical tool to investigate the properties of the mesons created deeply inside the nucleus due to the small distortion effects. This good advantage provides the distinct difference in the formation spectra of the η-nucleus system obtained by the two chiral models which are based on the different physical pictures of the $N(1535)$ resonance (Fig.1). For the ω-nucleus system, we have compared three types of the ω optical potentials in the (γ,p) spectra, showing the definitely different shapes of the spectra.
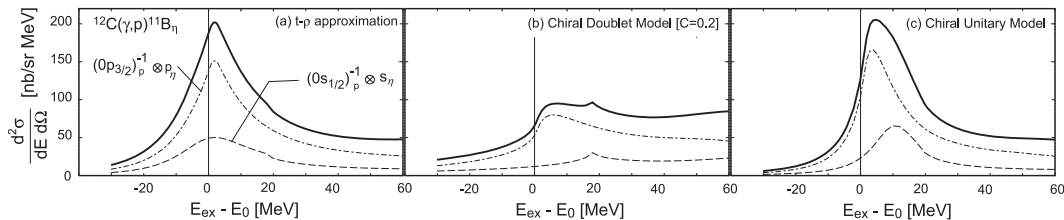

Figure 1: Calculated spectra of ^{12}C$(\gamma, p)^{11}$B$\otimes\eta$ reactions at $E_\gamma = 950$ MeV. The η-nucleus interactions are evaluated by (a) the t-ρ approximation, (b) the chiral doublet model with $C = 0.2$ and (c) the chiral unitary model. Detailed discussions are given in Ref. [1].

We also investigate the (γ,p) spectra at the recoilless condition for the two pion production in isoscalar channel in order to study an impact of the creation of the deeply bound states of the sigma meson associated with the partial restoration of chiral symmetry in heavy nuclei. We find that a prominent enhancement around the two pion threshold in the missing mass spectra in case of a sufficient strength of the partial restoration in medium, owing to the transparency of the (γ,p) reaction to create deeply bound states (Fig.2). Thus we expect that the (γ,p) reaction is a good tool to create the sigma meson in nucleus.
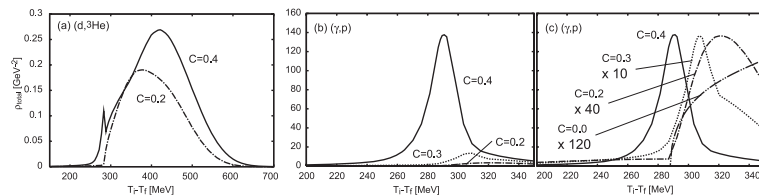

Figure 2: Total spectral functions ρ_{tot} defined in Ref. [1] for (a) (d,^{3}He) reactions and (b) (γ,p) reactions on ^{208}Pb target. The incident particle energies T_i are (a) 1.5 GeV and (b) 400 MeV, respectively.

The study of the bound states is one of the most promising method to investigate the meson properties at finite density. Nevertheless the large natural widths of the meson bound states in nucleus disable to distinguish contributions from each bound state. In such a case, global conformation of the missing mass spectra is necessary to extract valuable information of the meson nucleus interaction. It is also beneficial to compare the spectra of the (γ,p) and (d,^{3}He) reactions at corresponding recoilless conditions, since each configuration differently contributes to the total spectra due to the different distortion effects. We expect that the present results stimulate the experimental activities and help the developments of this research field.

References

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