Formation of ω-mesic nuclei by (γ,p) reaction

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The ω mesic nuclei were studied many years by several groups theoretically (e.g. [1]) and also experimentally [2, 3]. In the present work, stimulated by the work of [4], we study the photon induced ω production in nuclei, looking both at the experimental set up of [4], as well as to other set ups which we consider more suited to see bound ω states with this reaction. We make predictions for cross sections for the (γ,p) reaction in nuclei for several photon energies and proton angles. In this report, we show a few calculated spectra of the formation of the ω-mesic nuclei. The detailed and systematic studies including the background discussions are reported in Ref. [5].

In Fig. 1(left), we show the momentum transfer of the (γ,p) reaction as a function of the incident photon energy, at forward and finite angles of the emitted proton. We find that the recoilless condition is satisfied at $E_\gamma \sim 2.0$ GeV at $E_\omega = m_\omega - 50$ MeV with forward proton angle. In such condition, we can see the clear peaks of the bound states in the spectra as in Fig. 1(a) with the attractive potential [1]. Only a limited numbers of subcomponents corresponding to the substitutional states are important in this case as a consequence of the recoilless kinematics. In the spectra, we can clearly identify the ω mesic $2p$ state around $E_\omega - m_\omega = -50$ MeV.

However, the recoilless condition is never satisfied for finite angles. We obtained the spectra with significantly different shapes at $\theta_p^{\rm Lab} = 10.5^\circ$ as shown in Fig. 1(b). Because of the large momentum transfer around 350 MeV/c at this proton angle, many subcomponents have finite contributions to form the total spectrum, as shown in Fig. 1(b), and the ω production spectrum is more similar to a continuum.

We also show the expected spectra with finite experimental energy resolutions $\tilde{\Gamma}$. We implement this experimental resolution in our calculations by convoluting the theoretical curves with a Gaussian distribution of width $\tilde{\Gamma}$, which is the width of the distribution at half its maximum strength. The energy resolution is estimated to be around 35-50 MeV in a realistic case [4]. We find in the figures that the peak structures in the spectra almost disappeared for larger experimental resolutions than $\tilde{\Gamma} = 10$ MeV.

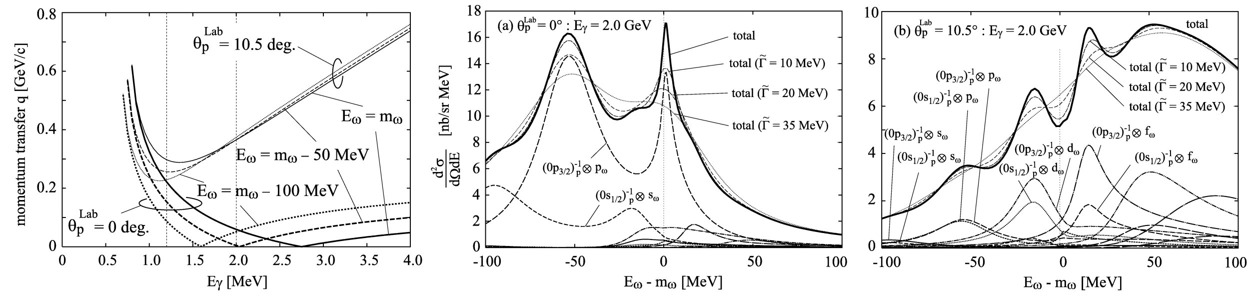

Figure 1: (left) Momentum transfer as a function of the incident photon energy. (middle and right) Formation spectra of the ω-mesic nuclei at emitted proton angle (a) $\theta_p^{\rm Lab} = 0^\circ$ and (b) $\theta_p^{\rm Lab} = 10.5^\circ$ calculated with the potential depth $(V_0, W_0) = -(156, 29)$ MeV, which is obtained by the linear density approximation with the scattering length $a = 1.6 + 0.3i$ fm [1].

We conclude that, in order to obtain the new information on the ω mesic nucleus, we need to have the data measured with sufficiently good energy resolution, otherwise we can not conclude the existence and/or non-existence of the signals due to the mesic-nucleus formation. Furthermore, when planning to perform experiments, it is important to consider the kinematical conditions carefully.

For detailed discussions including the background considerations, please see Ref. [5].

References

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