Production of Θ^+ hypernuclei with the (K^+, π^+) reaction

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The discovery of the Θ^+ at SPring-8/Osaka [1], followed by its confirmation in different other experiments, has made a substantial impact in hadronic physics. The possibility that there would be Θ^+ bound states in nuclei has not passed unnoticed and in [2] the Θ^+ selfenergy in the nucleus was evaluated, however with only the part tied to the KN decay, which is known experimentally to be very small. As a consequence, the Θ^+ potential obtained was too weak to bind Θ^+ in nuclei.

In a recent paper [3] the possibility of having Θ^+ bound states in nuclei, tied to the $K\pi N$ content of the Θ^+, was investigated and it was concluded that there is an attractive Θ^+ potential, which, within uncertainties, is strong enough to bind the Θ^+ in nuclei. Restrictions from Pauli blocking and binding reduce the Θ^+ width in nuclei to about one third or less of the free width, and with attractive Θ^+ nucleus potentials ranging from 60 to 120 MeV at normal nuclear matter density, the separation between the deeper Θ^+ levels in light and medium nuclei is larger than the width, even in the case that the free Θ^+ width were as big as 15 MeV. This is a desirable experimental situation in which clear peaks could be observed provided an appropriate reaction is used.

In [3] the Θ^+ selfenergy tied to the KN decay was also studied and found to be very small like in [2]. The large attraction found in [3] is tied to the coupling of the Θ^+ to two mesons and a baryon which was related to the strong decay of the $N^*(1710)$ resonance to a nucleon and two pions.

In this study, we investigate the reaction (K^+, π^+) in nuclei and present results on the production of bound states of Θ^+ in nuclei. By taking into account the states obtained within a wide range of strength of the Θ^+ nucleus optical potential, plus the possibility to replace different nucleons of the nucleus, we obtain an excitation spectra with clearly differentiated peaks [4]. The magnitude of the calculated cross sections is well within reachable range (Fig. 1).

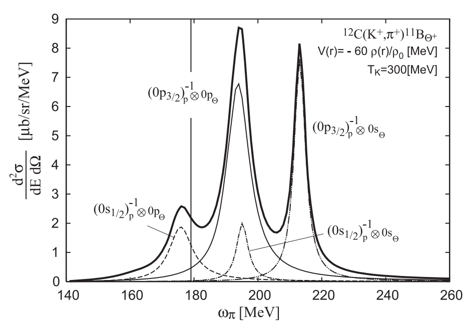

Figure 1: Calculated Θ bound states formation cross section shown as a function of the emitted pion energy ω_π at forward angles for a ^{12}C target. Detail discussions are given in Ref. [4].

Measurements of binding energies and partial decay widths in nuclei would provide precise information on the coupling of the Θ^+ to two meson channels and about the $K\pi N$ component in the Θ^+ wave function. The results obtained here should strongly encourage to do this experiment which could open the doors to the new field of Θ^+ hypernuclei.

References

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