

# Photoproduction of Mesons from Light Nuclei

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Photoproduction of mesons from light nuclei is important for two different aspects of hadron physics. Electromagnetic excitations of the free proton have been (and are still) under intensive investigation, but so far much less attention has been paid to their neutron counter parts. However, due to SU(3) selection rules, some states are predicted to be much stronger excited electromagnetically in the neutron case. Investigation of the iso-spin composition of the electromagnetic excitations always requires measurements off the neutron. Quasi-free photoproduction of mesons off neutrons bound in light nuclei, in particular in the deuteron, is so far the only experimental possibility to investigate this topic. Coherent photoproduction of mesons off light nuclei can be explored as an additional spin/iso-spin filter for the elementary excitations. The other aspect is the interaction of mesons with nucleons and nuclei. For short lived mesons like the  $\pi^0$ ,  $\eta$ ,  $\eta'$ ,... the only access is via final state interaction (FSI), when the meson is produced in some nucleus and subsequently interacts with it. Topics like the search for mesic nuclei may be addressed.

In a series of experiments at the ELSA accelerator in Bonn with the Crystal Barrel/TAPS setup and at the MAMI accelerator in Mainz with the Crystal Ball/TAPS setup, photoproduction of mesons off the deuteron, off  $^3\text{He}$ -, and off  $^7\text{Li}$ -nuclei has been studied in detail.

A completely unexpected finding is the pronounced structure in the excitation function of the  $\gamma n \rightarrow n\eta$  reaction around 1 GeV, which has no counterpart for the proton. The statistical significance of this structure is large and it has been seen not only for neutrons bound in the deuteron but also for  $^3\text{He}$  target nuclei. Recent measurements at ELSA, GRAAL, MAMI, and in Sendai estimate its width below 50 MeV, which would be extremely narrow for a nucleon resonance at this excitation energy. Many different suggestions of its nature have been discussed, ranging from intricate interference structures between the low-lying  $S_{11}$  resonances, threshold effects in coupled channel dynamics, over contributions of the  $D_{15}(1670)$  resonance (suppressed for the proton), to a narrow  $P_{11}$  state.

In a previous experiment[1], photoproduction of  $\eta$ -mesons off  $^3\text{He}$  nuclei showed a peculiar threshold enhancement, which was tentatively interpreted as a signature for the formation of  $\eta$ -mesic  $^3\text{He}$ . In a new experiment, this reaction was measured with much better statistical accuracy. First results will be discussed.

A third topic is the first observation of coherent photoproduction of meson-pairs ( $\pi^0\eta$ ,  $\pi^0\pi^0$ ) off the deuteron and  $^3\text{He}$ , used as spin/iso-spin filters. The production of  $\eta$ -mesons in the  $\pi\eta$  final state with very small momenta relative to the final state nucleus may be furthermore explored as a new tool for the possible formation of  $\eta$ -mesic states.

Finally, first results for the measurement of polarization observables for quasi-free neutrons, which will be explored intensively during the next few years, will be discussed.

[1] M. Pfeiffer et al. Phys. Rev. Lett. 92 (2004) 252001

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