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Observation of S_{11} Resonance in Nuclei via (γ , η) Reactions

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The recent nuclear-photoabsorption cross sections have shown clear evidence of nuclear medium effects on nucleon resonances: enhancements in the cross section due to the effects of D_{13} (1520) and F_{15} (1680) resonances, clearly seen in the total photoabsorption measurements on hydrogen and deuteron [1], disappear on nuclei [2]. Large increase of the resonance width in nuclei was proposed as one of the interpretations for the disappearance. However, the resonances are overlapping and superimposed on continuous background, and, thus, it is hard to observe the respective resonance of large width. We have studied the S_{11} (1535) resonance in nuclei. Since it decays to the Nη channel with the branching ratio of about 50% and the elementary H(γ , η) H reaction reaction below 1.0 GeV is explained by the excitation of the S_{11} resonance without any background process, one can expect to excite only the S_{11} resonance in the (γ , η) reactions on nuclei below the photon energy of 1.0 GeV. Thus, we have measured the total(γ , η) cross sections on C, Al and Cu. Part of the present work has been published in ref. [3].

The experiments were performed using a tagged photon beam from the 1.3 GeV electron synchrotron at KEK-Tanashi (former INS). The intensity of the photon beam was 9×10^5/s for $0.68 \leq E_\gamma \leq 1.0$ GeV. Emitted η mesons were identified by the invariant mass analysis of two decay photons, which were detected by two sets of pure CsI calorimetere with plastic scintillators for charged particle veto. Differential cross sections of the C, Al, Cu (γ , η) reactions were measured for the polar angles from 0° to 90° in the laboratory system.

In Fig.1, we show the obtained total η photoproduction cross sections for C, Al, Cu (γ , η) reactions, respectively, with open circles, open squares and open triangles. A broad resonance due to the excitation and decay of the S_{11} resonance is cearly seen in C, Al and Cu nuclei for the first time. In order to deduce the resonance property more quantitatively, we have performed theoretical calculations based on the quantum molecular dynamics model, and have compared the experimental data with the calculations. The medium effects, such as the Fermi motion, the Pauli blocking, and N-η and N-N* collisions are incorporated in the calculation. The resonance energy and width of the S_{11} resonance is not uniquely determined. Thus, we employed two sets of the resonance parameter: The one is deduced by Kursche et al.[4], M_R = 1544 MeV and Γ = 212±20 MeV, and the other reported by Armstrong et

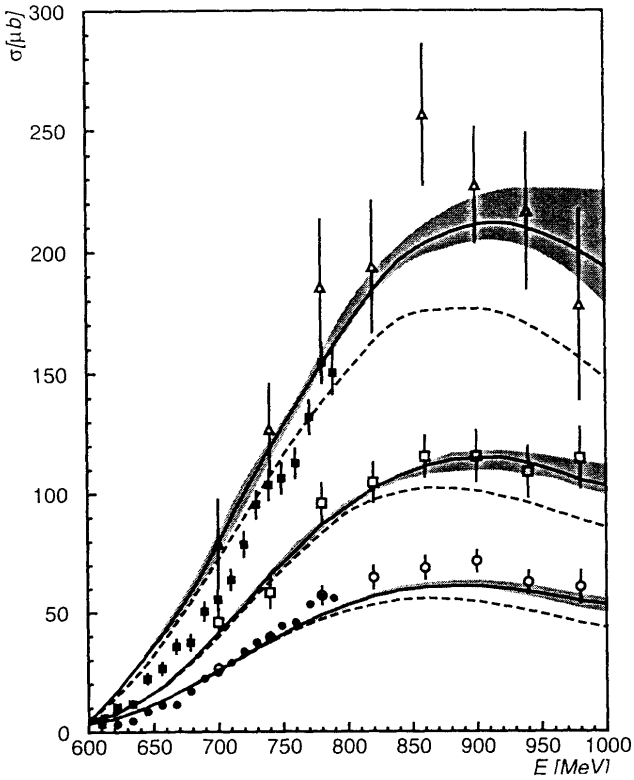

Fig.1. Total photo-η production cross sections on C (open circle), Al (open square) and Cu (open triangle). The results of the QMD calculations are also shown; the solid lines correspond to the resonance width of 212 MeV and the dashed lines to 154 MeV.

al.[5], M_R = 1532 MeV and Γ = 154$\pm$20 MeV. The latter parameter gives much better fit to the cross section of the elementary H(γ , η) reaction up to 1.1 GeV, althogh the former reproduces the data below 800 MeV very well.

The results of the calculations are also shown in Fig.1. Dashed curves are the results with Γ = 154 MeV and solid curves with Γ = 212 MeV. As shown, the solid curves generally reproduce the data very well and the dashed curves always underestimate the yields. It should be noted that the resonance parameter with Γ = 154 MeV can explain the H (γ , η) reaction very well. This indicates that the width of the S_{11} resonance might be changed in the nuclear medium; more than 60 MeV increased. It is difficult to consider such large increase of the width only due to collision broadening.

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