Kaonic Atoms in Chiral Unitary Model

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We study the kaonic atom in the whole mass region using the kaon-nucleon scattering amplitude calculated in the chiral unitary model in the nuclear medium. The SU(3) chiral unitary model is extremely successful in reproducing the scattering amplitudes of the meson-meson and the baryon-meson reactions with the strangeness $S = -1$, in particular the $\Lambda(1405)$ resonance [1].

We calculate the change of the Λ resonance in nuclear medium, which influences the scattering amplitude of kaon-nucleon scattering largely. We include Pauli blocking in the nucleon propagator and the pion self-energy in the $\pi\Sigma$ and $\pi\Lambda$ channels. The difference of the binding between the nucleons, Σ and Λ is also incorporated. Then the kaon self-energy is evaluated selfconsistently [2]. We use the calculated KN scattering amplitude in the nuclear medium to obtain the kaon-nucleus optical potential with the local density approximation.

We calculate the energy level shifts and widths of various kaonic atoms using the optical potential. In Fig. 1, we compare our calculated results with the experimental data. We find that the data were reproduced nicely for whole mass region considered here. Thus, our model is expected to describe the kaonic atom correctly. In Fig. 2, we show the calculated energy spectrum of kaonic calcium. The widths are indicated by the hatches in the figure. It is interesting that the level spacing between 1s and 2p states are larger than the widths and the states are expected to exist as discrete states. This fact motivate us to calculate the formation cross sections of the 'deeply' bound kaonic states, like 1s and 2p states, by the proper reactions. We consider the (K^-, γ) reaction and evaluate the double differential cross section, which is shown in Fig. 3. Here, we assume the plane wave for the incident kaon. Each bound state is expected to be observed as a peak in the emitted gamma spectrum.

We will study systematically various methods for the formation of the deeply bound kaonic states, which have not been observed so far. And we will try to obtain new information on kaon behavior in the nuclear medium.

References

[1] E. Oset and A. Ramos, Nucl. Phys. **A635**, 99 (1998).
[2] A. Ramos and E. Oset, nucl-th/9810014, in preparation.
[3] S. Hirenzaki, Y. Okumura, H. Toki, E. Oset and A. Ramos, in preparation.

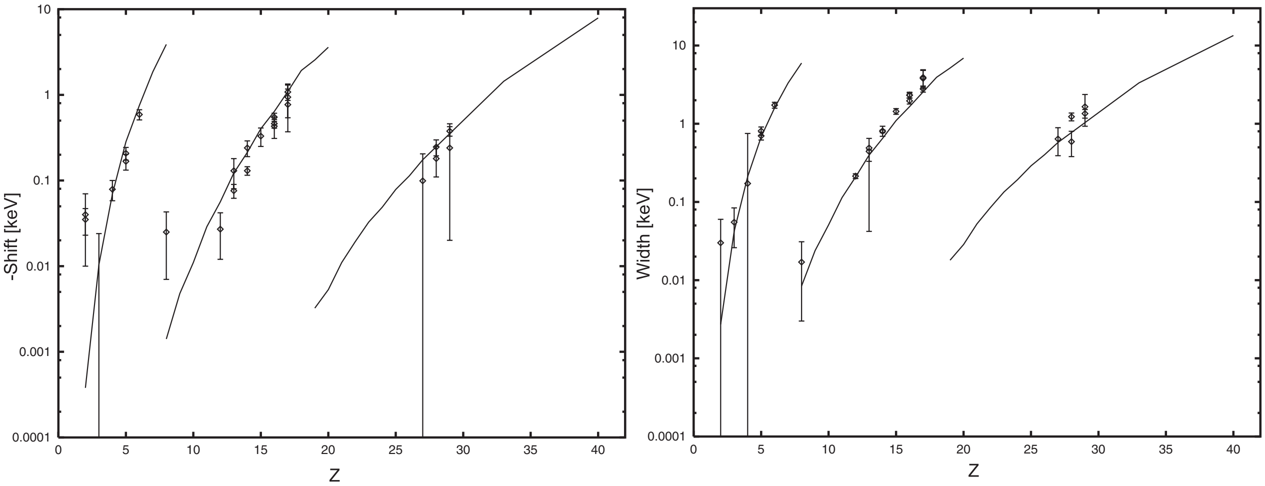

Figure 1: Calculated energy shifts and widths of kaonic atoms as a function of atomic number of nucleus. Experimental data are also shown.

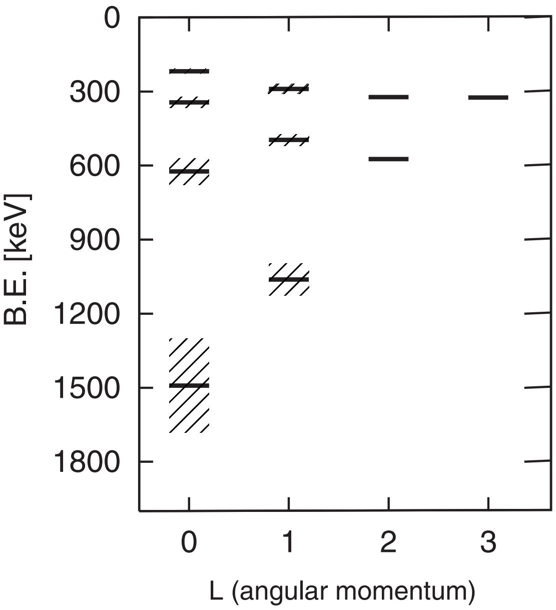

Figure 2: Calculated energy spectra for ^{40}Ca. Widths are indicated by the hatched area.

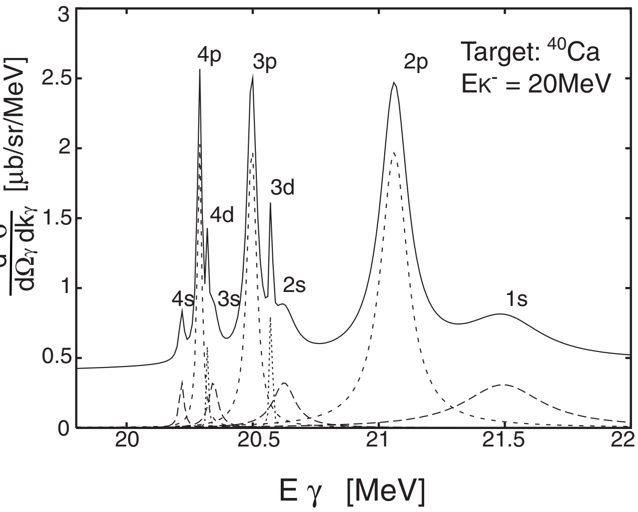

Figure 3: Calculated double differential cross section of (K^-, γ) reaction at E_{K^-}=20MeV and θ_γ=60^o in the laboratory frame.