First precision spectroscopy of pionic atoms at RI Beam Factory

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We report preliminary results of our recent experiment for spectroscopy of the pionic ^{121}Sn atom at the RI beam factory, RIKEN. We have measured a spectrum of the ^{122}Sn(d,^{3}He) reaction near the pion-emission threshold. Presently, a detailed analysis is ongoing and the preliminary spectrum shows a distinct structure of peaks in the bound-state region, which is a signature of the first observation of pionic ^{121}Sn atoms. We observed not only the $1s$ state but also the $2s$ and $2p$ states.

Precision spectroscopy of pionic atoms provides information on the strong interaction between pion and nucleus [1,2], leading to the evaluation of the magnitude of the in-medium quark condensate [2-4]. For a better determination of the isovector π-nucleus scattering lengths, spectroscopy of deeply-bound pionic states like $1s$ or $2p$ states in relatively heavy atoms is important. Systematic studies of such states will provide unique opportunities to understand the chiral symmetry and the vacuum structures.

Our work has the goal to allow systematic spectroscopy of pionic atoms with unprecedented resolution using the world-highest intensity of heavy-ion beams. The initial experimental spectra of pionic ^{121}Sn atom already show very interesting features. We have succeeded in the first observation of the angular dependence of the pionic-atom formation cross section owing to the large angular acceptance of the spectrometer BigRIPS.

Details of the experimental procedures and preliminary results will be reported.

[1] K. Itahashi *et al.*, Phys. Rev. **C62**, 025202 (2000).

[2] K. Suzuki *et al.*, Phys. Rev. Lett. **92**, 072302 (2004).

[3] E.E. Kolomeitsev, N. Kaiser and W. Weise, Phys. Rev. Lett. **90**, 092501 (2003).

[4] D. Jido, T. Hatsuda and T. Kunihiro, Phys. Lett. B **670** (2008) 109.

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