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The first precision measurement of deeply bound pionic states in ^{121}Sn

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We report our recent experiment of the pionic ^{121}Sn atom using missing-mass spectroscopy of the ^{122}Sn(d,^{3}He) reaction near the π^- emission threshold. While a detailed analysis is on-going, preliminary spectra already show distinct structures in bound region. The experiment serves as a pilot experiment for systematic study of deeply bound pionic atoms at the RIKEN RI beam factory (RIBF).

Recent studies revealed that the chiral condensate at the normal nuclear density can be deduced by precision spectroscopy of pions captured in deep states (such as $1s$ or $2p$) of heavy atoms, which are called deeply bound ponic atoms[1, 2]. So far the $1s$ pionic states in ^{205}Pb and ^{115,119,123}Sn have been discovered at GSI [3-5]. The deduced chiral order parameter was compared with that of the vacuum, which was deduced from the pionic hydrogen, and partial chiral restoration was suggested. However, the evaluation still had large systematic and statistical errors. To reduce the systematic errors from ambiguity of the nuclei, we are planning the pionic Atom Factory (piAF) project, in which the deeply bound pionic atoms of isotopes and isotones will be produced.

As a pilot experiment for the project, we performed a precision spectroscopy of the ^{122}Sn(d,^{3}He) reaction. In the experiment, we succeeded in the first observation of the pionic states in $1s$ and some other orbits of ^{121}Sn and the angular dependence of the pionic-atom formation cross section owing to the large angular acceptance of the BigRIPS spectrometer [6]. The resolution was at least as good as in the previous experiment. At the same time, the data-taking time was reduced dramatically, which is essential for the systematic spectroscopy. These results revealed the encouraging potential capability of the RIBF facility for systematic high-precision spectroscopy of deeply-bound pionic atoms.

Now we are working to decompose the spectrum to each state and extract the chiral order parameter. The current status of the analysis, including new results about the angular dependence of the pionic-atom formation cross section for each state, will be reported.

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