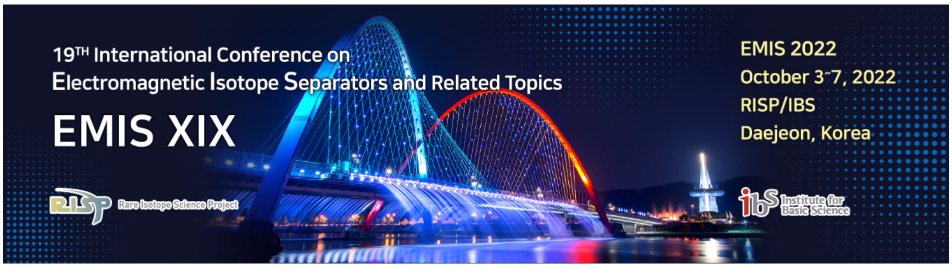

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Studying negative ions at the CRIS experiment

Monday, 3 October 2022 22:38 (8 minutes)

The valence electron of a negative ion is not bound by a long-range Coulomb potential but instead a shallow induced dipole potential which mainly arises from electron-electron correlation. As a result, negative ions have binding energies of about an order of magnitude smaller than neutral atoms. These correlation effects can be probed by measuring the electron affinity (EA) which is the amount of energy released when an electron binds to a neutral system to form a negative ion.

Little is known about the structure of radioactive negative ions. Such studies are of interest for benchmarking atomic theory as well as medical and environmental applications e.g., targeted alpha therapy and uranium mine management. The first EA investigations for radioisotopes were of iodine-128 (128I) [1] and astatine (At) [2] made at CERN-ISOLDE. However, the production of radioactive negative ion beams can be challenging [3]. With the collinear resonance ionization spectroscopy (CRIS) experiment at ISOLDE, negative ions can be produced via the double charge exchange process. Therefore, we plan to add a permanent spectrometer to the beamline where radioactive negative ions can be studied, specifically in the actinide region.

The EA can be experimentally determined with laser photodetachment. At CRIS, we plan to observe the cross section of photodetachment in two ways. The residual neutral atoms can be detected or, depending on the electron configuration, a two-step excitation scheme of laser photodetachment followed by resonance ionization can be used.

Negative ion yield tests at CRIS will be carried out for polonium (Po) followed by francium (Fr) and uranium (U). After commissioning the spectrometer, EAs can be measured. Fr, the heaviest alkali metal, will require a two-step excitation scheme as mentioned above. This method has been successful for stable cesium (Cs) [4] and is currently being tested on stable rubidium (Rb).

In this contribution, results from the Po- yield test, methods for alkali metal EA measurements, and the future spectrometer for negative ion studies at CRIS will be presented.

[1] S. Rothe et al., "Laser photodetachment of radioactive 128I-,"J. Phys. G, vol. 44, no. 10, 2017.
[2] D. Leimbach et al., "The electron affinity of astatine,"Nat. Commun., vol. 11, no. 1, pp. 1–9, 2020.
[3] M. Menna et al., "R&D for the development of negative ion beams of halogens,"Nucl. Instr. and Meth. B, vol. 266, no. 19–20, pp. 4391–4393, 2008.
[4] J. E. Navarro-Navarrete et al., "A high-resolution measurement of the electron affinity of Cs,"To be published, 2022.

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