Contribution ID: **75** Type: **not specified**

Electron affinity and lifetime measurements of negative ions

In neutral atoms and positive ions, the binding of the electron cloud is due to the Coulomb attraction of the positively charged nucleus, allowing the description of electronic states via the independent particle approximation. In negative ions, however, the Coulomb potential of the nucleus is almost entirely screened, and the binding of the additional electron is resulting from polarization effects caused by the many body interactions between electrons.
Therefore, negative ions are sensitive probes for electron correlation theories that go beyond the independent particle approximation, which is of crucial importance for the precise understanding of atomic and molecular structure. As a consequence of the the weak binding potential, the energy gained by attaching an electron to a neutral atom, referred to as electron affinity (EA), is typically only in the order of one eV. For the same reason, negative ions typically lack bound excited states with opposite parity, noticeable exceptions being lanthanum, cerium, osmium and thorium [1-4]. Consequently, the EA is the only parameter which can be probed with high precision, typically via laser photodetachment threshold spectroscopy.
At the Gothenburg University Negative Ion Laser Laboratory (GUNILLA) [10], the structure of negative ions is characterized by laser photodetachment threshold experiments where individual detachment channels can be investigated using a resonance laser ionisation scheme for detection [5] and measurements of the angular distributions of the outgoing electron give insight into the electronic states [6], including recent developments utilising velocity map imaging to recreate the three dimensional distribution of photoelectrons [7]. Second, lifetimes of metastable and doubly excited states of negative ions are studied at the Double ElectroStatic Ion Ring ExpEriment (DESIREE) in Stockholm, Sweden [8]. Finally, we perform measurements of the EA of short-lived radioactive elements at CERN-ISOLDE [9], where additionally a proof-of principle experiment utilizing a multi reflection time of flight device is conducted.
Here, we will present the results of lifetime and EA measurements of arsenic and rubidium at GUNILLA and DESIREE as well as EA measurements of radioisotopes at ISOLDE and will give an outlook on future activities, including the commissioning of a velocity map imaging spectrometer.

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Session Classification: Plenary session

Track Classification: Posters