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Cluster-Electron Interaction for Poly-Anion Production

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Synopsis By interaction with electrons in ion storage devices (ion-cyclotron-resonance and radio-frequency traps) negatively charged clusters of gold and aluminum have been produced up to the 6th and 10th charge state, respectively. The production of these poly-anions opens exciting new possibilities to measure their lifetimes, to monitor their relaxation schemes after laser radiation, as well as to probe their Coulomb barriers.

The properties of a nano-sized cluster, e.g. its geometrical shape, ionization potential, polarizability or dissociation energy, are determined not only by its size, but also by its charge state. In the present study, poly-anionic metal clusters are produced by electron attachment to cluster mono-anions stored in Penning and Paul traps [1].

In a Penning trap, charged particles are confined up to a trap-specific mass-to-charge limit, allowing simultaneous storage of both, cluster anions and electrons. In the so-called electron bath [2], attachment of electrons occurs if their energy is high enough to overcome the anions' Coulomb potential (Fig. 1). However, as the co-trapped electrons are produced along the axis of the trap potential, they exhibit a corresponding energy distribution and their actual energy during attachment remains somewhat uncertain.

In contrast, a technique for poly-anion production in a Paul trap at well-defined electron energies has been developed. By applying tailored radio-frequency trapping-voltage signals [3], an electron beam of defined energy can be guided through a linear Paul trap for electron attachment to stored cluster ions [1]. At appropriate storage conditions, the resulting poly-anions remain trapped and are available for further experiments.

Recent measurements on the cluster poly-anion abundance as a function of interaction time in the electron-bath of a cylindrical Penning trap confirm a sequential electron-attachment process. The electrons can be released from the trap while the poly-anionic clusters remain stored and are available for further investigation.

Among the topics of interest are lifetime measurements of meta-stable poly-anionic clusters, i.e. systems too small to provide a positive binding energy for another surplus electron. However, the surplus electron is yet meta-stably bound to the cluster by means of the Coulomb potential, through which it tunnels and escapes at some point [4].

In addition, electron detachment may also be triggered by laser excitation of the cluster poly-anions [5]. It competes - as a function of both cluster size and charge state – with neutral atom evaporation.

Furthermore, by scanning the photon energy the electron detachment energy may be determined, thus probing the Coulomb-barrier heights. Respective results may then be compared with those from electron-attachment studies performed in Paul traps with well-defined electron energies.

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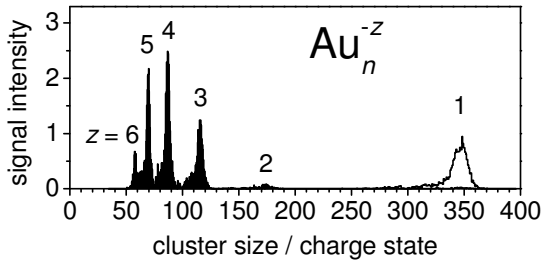

Figure 1. Gold cluster anions Au_n^{-z} before (open curve) and after application of an electron bath in a Penning trap (filled curve).

References

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