Investigation of Multiply Charged Metal Cluster Anions

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An important aspect of atomic cluster research is the comparison of the clusters' properties as a function of the clusters' size. The variation of their charge state adds another dimension. In recent years dianionic systems have attracted much interest [1]. Doubly negative charged metal clusters have been discovered at Mainz only very recently [2]. Now their properties are studied at the *Mainz Cluster Trap* [3] and in the following the first results are presented.

For the dianion production singly charged metal cluster anions are created by laser vaporization in a helium gas pulse and transferred into a Penning trap. After a size selection by radial excitation of all unwanted ions an electron beam is guided through the trap. During the period of electron bombardment argon gas pulses are directed into the trap region, which leads to ionization of the argon atoms. The secondary electrons stay trapped and eventually some of them attach to the stored cluster anions. Finally the resulting ion ensemble is analyzed by time-of-flight (TOF) mass spectrometry. As an example, fig. 1 shows the TOF-spectrum of Ti_{55}^- after size selection (a) and dianion production (b).

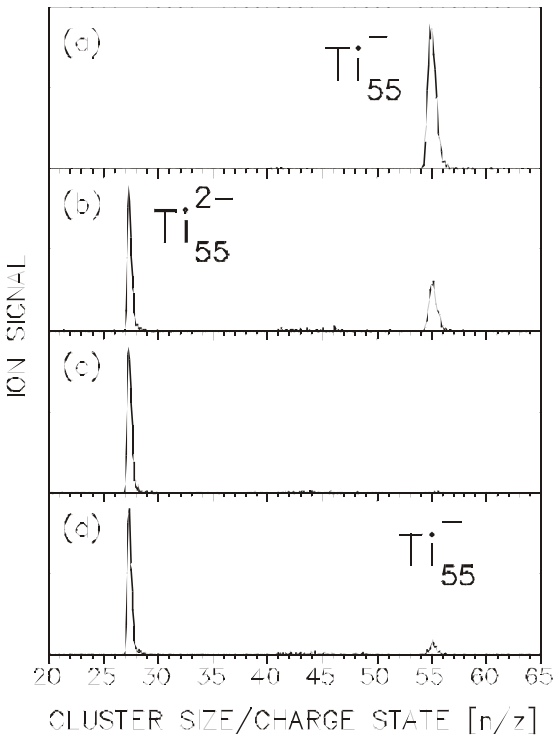

Fig. 1: TOF spectra demonstrating the experimental sequence (from [4]; for details see text).

For the case of gold, the relative dianion abundance has been measured for sizes $12 \le n \le 28$ [5] (see fig. 2). In the size region $n \le 20$ dianions with an even number of atoms (and atomic valence electrons) show an increased production efficiency compared to their direct neighbors, which can be explained with the pairing of electrons, while the large step between $n = 18$ and $n = 19$ seems to come from a shell closing for the valence electrons. For $n > 20$ the relative abundance of dianions is rising steeply, which is in agreement to a simple charged sphere model, where above a threshold size of $n = 19$ the electron affinity of gold cluster anions becomes positive and an additional surplus electron may attach.

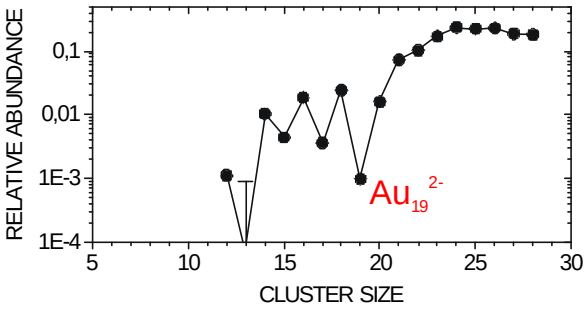

Fig. 2: Relative abundance of gold cluster dianions after the producion as a function of cluster size (from [5]).

As illustrated in fig. 1 future studies will include photodetachment of this surplus electron. The dianions are selected after the production (see fig. 1(c)) and then excited with a single photon. Photodetachment leads to the loss of one electron and the anion signal reappears in the TOF-spectrum [4] (see fig. 1(d)).

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