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Laser-induced delayed electron emission of Co_4^- anions

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Synopsis The cryogenic trap for fast ion beams (CTF) located at the Max-Planck-Institut für Kernphysik has been used to study laser-induced delayed electron emission of various molecular and metal-cluster anions. We will discuss recent experiments investigating the radiative cooling respectively heating of Co_4^- anions produced in hot and cold ion sources. The experiments will be continued at the cryogenic storage ring (CSR), which is presently being commissioned, to disentangle laser-induced electron emission from atom or cluster dissociation.

In the CTF [1] stored ions with an energy of some keV are reflected back and forth between two electrostatic mirrors. Einzel lenses focus the ion beam towards the trap center ensuring radial confinement. The CTF can be operated at any temperature between 300 K and 4 K. Excellent vacuum conditions allow storage times up to seconds at room temperature and minutes under cryogenic conditions. Confined particles can interact with a laser beam in cross beam configuration within a field free region between the mirrors. Neutralized particles leaving the trap through holes in the electrodes of one of the mirror are detected by a microchannel plate detector. The setup is well suited to investigate dynamical processes of stored ion beams. Vibrational electron autodetachment (also called delayed electron detachment) is observed by measuring the rate of neutral particles escaping from the EIBT as a function of storage time as well as a function of the time after laser excitation.

In a recent measurement campaign the electron emission of cobalt cluster anions consisting of four atoms has been investigated. The ions were produced in two different types of ion sources: (A) a cesium sputter ion source, producing ions ro-vibrational temperatures around 1000 Kelvin, (B) a laser vaporization ion source with helium expansion to produce Co_4^- with ro-vibrational excitation levels corresponding to cryogenic temperatures. The ions were stored in the CTF at room temperature and the cooling respectively heating of the ions was visible in the change of the delayed electron detachment rate. The photo excitation measurements were performed by a pulsed, tunable laser system (OPO) as a function of storage time and wavelength of the laser. In figure 1 the counts of delayed electron emission for Co_4^- produced with source (A) are displayed in dependence of storage time (top) and photon energy (bottom); they clearly reflect the change of the clusters internal energy distribution by radiative cooling. These results together with recent findings using the cold ion source (B) will be discussed.

After successful commissioning of the CSR at cryogenic temperatures these experiments will be extended towards the observation of the competing photofragmentation processes.

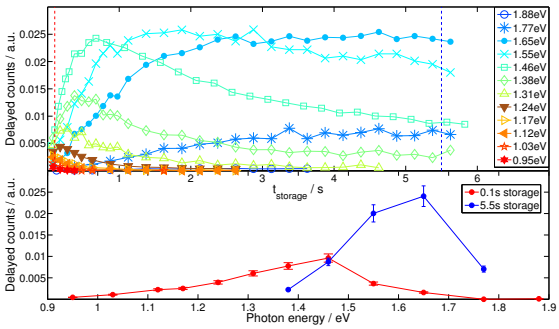

Figure 1. Top panel: The counts of delayed neutralized Co_4^- clusters are plotted for different photon energies for excitation (legend) as a function of storage time. Bottom panel: Delayed electron count-rate in dependence of the laser excitation energy for two storage times indicated by dashed lines in the upper panel. (All data taken at room temperature)

References

[1] M. Lange et al., Rev. Sci. Instrum. **81** (2010) 055105.

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