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Spontaneous decay of small copper cluster anions Cu_N^-, $N = 3 - 6$

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Synopsis We have measured the spontaneous neutral particle emission from beams of copper cluster anions (Cu_N^-, $N = 3 - 6$) stored in an electrostatic storage ring. These experiments have show that multiple structural isomers may be present in the beam.

We have measured spontaneous neutral particle emission rates for small copper cluster anions (Cu_N^-, $N = 3 - 6$) stored in one of the DESIREE (Double ElectroStatic Ion Ring ExpEriments) storage rings in Stockholm, Sweden [1]. The Cu_N^- clusters are produced in a cesium sputter ion source with a copper cathode. The ions are accelerated to 10 keV/q and a bending magnet is used to select the desired mass per charge before injection into the ring. Neutral particles - produced by electron detachment, unimolecular dissociation or background gas collisions - leave the ring and are collected by two detectors at different locations as shown schematically in the inset of Figure 1.

In this type of experiment, the ensemble of ions stored in the ring is produced with a broad distribution of internal excitation energies. The spontaneous neutral particle emission is then usually observed to follow a power law t^{-P} with $P \approx 1$ [2]. Radiative cooling depletes the population of hot ions without producing neutral particles, effectively quenching the power-law decay rate [3].

Like other cryogenic electrostatic storage devices [4], the excellent vacuum conditions in the DESIREE storage rings permit spontaneous decay to be observed over much longer timescales than in other experiments. We have taken advantage of this new capability to study surprising new phenomena in the decay of small metal clusters where multiple structural isomers may be present in the beam. This is most clearly seen in Cu_4^- (shown in Figure 1) and Cu_5^-, where two components are measured to decay with different characteristic lifetimes. We attribute the more slowly decaying components to linear isomers which lack a dipole-allowed radiative cooling transition. Cu_6^-, for which no stable linear isomer exists, shows a fast one-component decay.

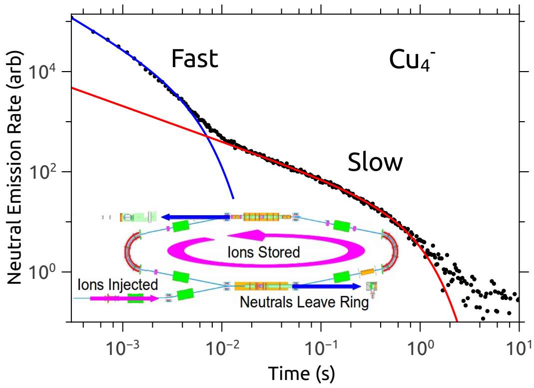

Figure 1. Neutral particle emission from stored Cu_4^- beam. In the inset we show a schematic representation of the experimental procedure.

A single-component decay is also observed for C_3^-, perhaps because only in this case does the *ground state* of the anion have a linear structure. Further, the power law exponent P for C_3^- is much less than unity, which may be due to the shape of the energy distribution. Planned experiments in which the stored ions will be excited by a laser will elucidate the details of this process.

References

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