Size Distributions of Helium Nanodroplets: An Ongoing Mystery

Michael Renzler*[1], Lorenz Kranabetter*, Andrea Huber*, Paul Scheier*[2]

* Institute for Ion Physics and Applied Physics, University of Innsbruck, Austria

Mass spectra of pure helium nanodroplets (HND) generally show small cluster ions with a maximum size of about 1000 helium atoms [1]. By deflecting the charged clusters in the electric field of a plate condensator in contrast, log normal distributions of these clusters have been reported [2], with huge droplets containing up to a few million helium atoms, depending on the temperature in the expansion region and the stagnation pressure of the helium gas.

Huge cluster ions can not be detected by mass spectrometric means because their high kinetic energy prevents them from reaching the detector region. At the same time it is still a mystery how the above mentioned low-mass cluster ions are ejected from large droplets as vaporization of a HND containing two-million He atoms requires more than 1 keV. The same problem goes for doped HNDs, where mass spectra reveal mostly "bare" ions [3] with the exception of helium attachment in a few cases [4].

For pure HNDs ejection mechanisms for He_2^+ have been proposed [5], but the exact nature of this process still lies in the dark. Furthermore most ions are strongly heliophilic and thus prefer positions inside the HNDs which is in conflict to the preferred formation of low-mass and bare dopant ions.

In our experiments HNDs were ionized in a Nier-type ion source and were size selected using an electrostatic sector-field. We were able to detect log-normal-distributed charged HNDs containing up to 10^7 helium atoms and thus confirming the findings of [2]. By increasing the electron energy and/or the electron current the log-normal distribution was changed dramatically. When the ionizing voltage exceeds the double ionization threshold (49.2 eV = 2x24.6 eV)), another peak in the distribution appears at a smaller droplet size, indicating Coulomb breakup of the clusters due to multiple ionization. By further increasing the voltage/current this peak continues to grow and completely dominates the distribution in the end, leading to very narrow size distributions compared to those obtained at lower energies/currents (see fig.1).

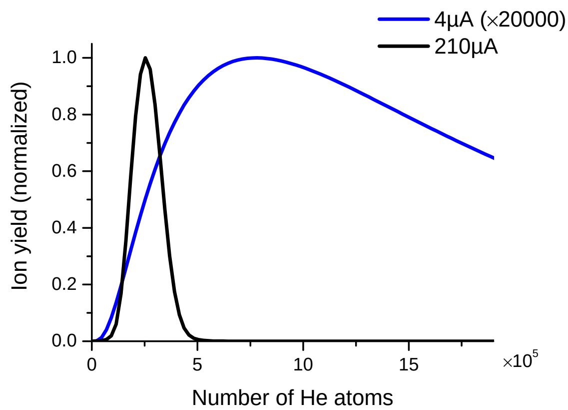

Figure 1. Electron Energy =200 eV, T= 8.5 K

Currently we perform experiments to unravel the nature of the Coulomb explosion of multiply charged HNDs.

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[1]E-mail: michael.renzler@uibk.ac.at
[2]E-mail: paul.scheier@uibk.ac.at