Highly charged helium droplets: a cool tool to grow size well-defined clusters and nanoparticles

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Helium nanodroplets provide an inert matrix, free of walls with outstanding properties to grow complexes and clusters at sub-Kelvin temperatures [1]. However, like for almost every existing method of cluster and nanoparticle formation pickup into neutral helium droplets leads to a wide distribution of dopant cluster sizes. Thus, the limiting factor in all cluster studies is creating a sufficiently high concentration of the desired species and separating them from the overall distribution [2]. Recently, we discovered that large helium droplets can become highly-charged [3]. The charge centers self-organize as two-dimensional Wigner crystals at the surface of the droplets and act as seeds for the growth of dopant clusters [4]. Cluster ions of a specific size and composition can be formed by this technique with unprecedented efficiency. Soft-landing of metal nanoparticles formed in highly-charged helium droplets can be achieved by deposition onto a target surface. Due to the fact that several hundred nanoparticles are formed simultaneously in one helium droplet, the deposition time compared to neutral helium droplets can be reduced by more than two orders of magnitude.
The conditions inside helium nanodroplets are perfect to simulate cold and dense regions of the interstellar medium and to perform spectroscopy of molecules and ions solvated by helium. Efficient formation of helium tagged ions was recently developed based on the pickup of dopants into multiply-charged helium droplets. The present contribution summarizes developments of experimental techniques and methods and recent results they enabled.

References

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