Electrostatic Orientation of Cold Molecules and Deflection of Neutral Doped Helium Nanodroplets

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Synopsis We demonstrate large deflections of doped neutral helium nanodroplets enabled by the high degree of orientation of polar dopants in the cold superfluid matrix

We show that, by applying a static electric field to polar molecules embedded in helium nanodroplets, we obtain nearly full orientation of the dipoles to the external field. Moreover, this large orientability was exploited to deflect the host helium droplets, having masses as high as ~40,000 Da, by up to a few millimeters. This method has been demonstrated using helium droplets containing single molecules of cesium iodide, dimethyl sulfoxide, formamide and histidine [1].

The orienting and deflecting field is established by a pair of electrodes in the "two-wire" configuration, which produces a strong inhomogeneous static electric field perpendicular to the droplets' direction of travel. The droplets and their contents are detected with a cross-beam quadrupole mass spectrometer. Deflection of the droplets is detected by placing a narrow slit in front of the mass spectrometer entrance and scanning the entire mass spectrometer chamber across the droplet beam.

This technique and its extensions have many potential applications. The broad size distribution of droplets produced by nozzle sources has long been a complication in experiments that employ helium droplet isolation. The very large deflections exhibited provide a means to disperse droplets by size, by selecting a subset of the deflected beam about a particular position. It also offers a new way to measure electric and magnetic dipole moments of a wide variety of molecules that are difficult to assess by other means. As an example, we have measured the average electric dipole moment of isolated cold histidine molecules.

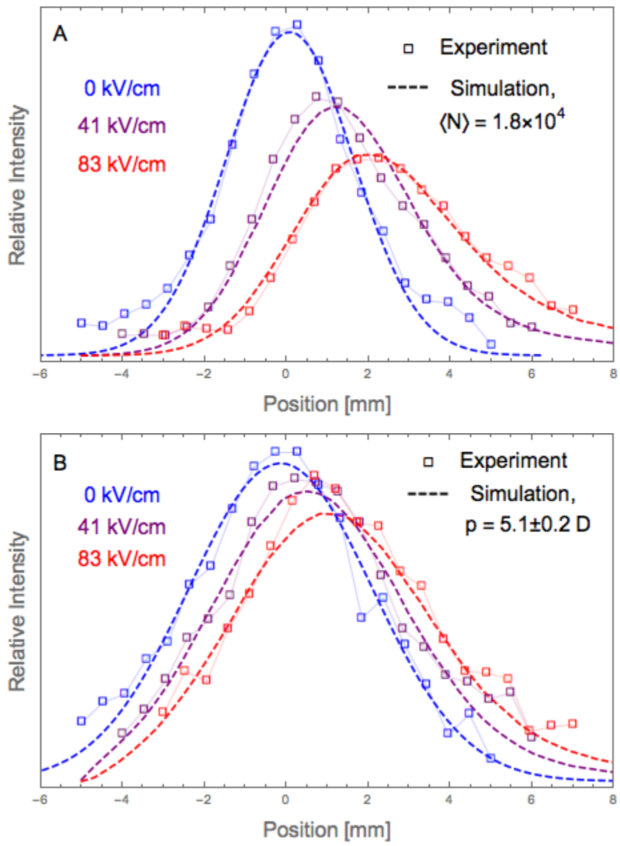

Figure 1. Beam profiles of helium droplets containing single (A) cesium iodide and (B) histidine molecules at three electric field strengths. Using the well-known permanent electric dipole moment of CsI (12 D) as a reference, we determined that the permanent electric dipole of histidine is 5.1±0.2 D.

References

[1] D. J. Merthe, V. V. Kresin 2016 *J. Phys. Chem. Lett.* 7 4879

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