Imaging of quantum vortices in superfluid helium droplets

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Abstract

Here we investigate the rotation of single, isolated, superfluid 4-He droplets (D=200-2000 nm, T = 0.4 K) via single-shot femtosecond X-ray coherent diffractive imaging. As indicated by large centrifugal deformations, the droplets' angular velocities span a range from vanishing to those close to the disintegration limit. The shapes of rotating viscous and superfluid droplets are also compared. The formation of lattices containing hundreds of quantum vortices inside the droplets is confirmed by observing characteristic Bragg patterns from Xe clusters trapped in the vortex cores. Phase retrieval is used to find the instantaneous positions and shapes of the vortices. Excessive doping by Xe changes equilibrium arrangement of vortices in the droplet and leads to stabilization of widely spaced configurations. Evidence for non-stationary vortex dynamics comes from observations of asymmetric formations of vortices in some droplets. This collaborative work was performed at Linac Coherent Light Source, the free electron laser within SLAC National Accelerator Laboratory. The experiments and the full list of collaborators are reported in: L. F. Gomez et. al. Science, 345 (2014) 906.

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