Quantum liquid droplets in a mixture of Bose-Einstein condensates

C. R. Cabrera†, L. Tanzi†,
J. Sanz*, B. Naylor, P. Thomas, P. Cheiney, L. Tarruell*

ICFO-Institut de Ciències Fotòniques,
The Barcelona Institute of Science and Technology
08860 Castelldefels (Barcelona), Spain

Quantum droplets are small clusters of atoms self-bound by the balance of attractive and repulsive forces. I will present the observation of a novel type of droplets, solely stabilized by contact interactions in a mixture of two Bose-Einstein condensates [1]. We demonstrate that they are several orders of magnitude more dilute than liquid helium by directly measuring their size and density via *in situ* imaging. Moreover, by comparison to a single-component condensate, we show that quantum many-body effects stabilize them against collapse. We observe that droplets require a minimum atom number to be stable. Below, quantum pressure drives a liquid-to-gas transition that we map out as a function of interaction strength. These ultra-dilute isotropic liquids remain weakly interacting and constitute an ideal platform to benchmark quantum many-body theories.

[1] D. S. Petrov, Phys. Rev. Lett. **115**, 155302 (2015).

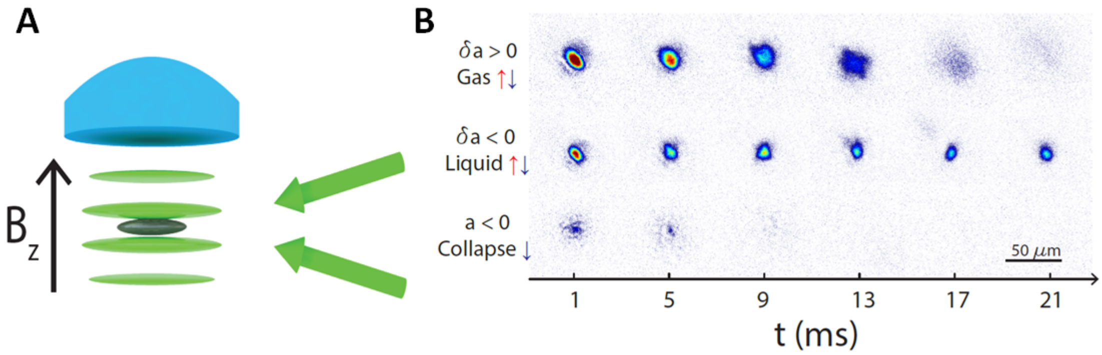

Figure 1: A) Schematic view of the experiment. Atoms are prepared in a plane of a blue-detuned optical lattice created by two beams intersecting at a small angle, and imaged *in situ* with a high numerical aperture objective ($\leq 0.97(4)$ μm measured resolution, $1/e$ Gaussian width). B) *In situ* images of the free expansion of Bose-Einstein Condensates in a lattice plane . Top panel: A spin mixture ↑↓ with effective repulsive mean field interactions ($\delta a > 0$) expands like a gas. Middle panel: A spin mixture ↑↓ with effective attractive mean field interactions ($\delta a < 0$) remains self-bound like a liquid without collapsing. Bottom panel: A single component BEC ↓ with attractive mean field interactions ($a < 0$) collapses. This reveals that the stabilization mechanism observed in the middle panel cannot be explained at the mean field level. In this case the effect of quantum fluctuations, which is irrelevant in the weakly interacting regime for a single component BEC, stabilizes the mixture into a quantum droplet.

*Contact: julio.sanz@icfo.eu, leticia.tarruell@icfo.eu, www.qge.icfo.es