

Liquid quantum self-bound systems

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Water drops falling from a tap are probably the best known form of liquid drops. They are the small objects bounded by a free surface. In the absence of gravity they take a spherical shape. Very small drops, like in spray applications, are referred to as droplets. About two years ago a new form of droplets were discovered in experiments with magnetized Chromium atoms. Similar objects in a mixture of extremely dilute vapors of two different species of Potassium atoms at temperature almost equal to the absolute zero, have been observed recently.

Both mixed clouds are Bose-Einstein condensates, the form of matter organization with all atoms behaving identically, occupying the same quantum state of zero kinetic momentum, forming a 'giant mega-atom'. These droplets have unusual properties: their densities are about hundred million times smaller than density of ordinary liquid, their temperatures almost reach absolute zero. They do not freeze, look like a vapor and behave like liquid - are incompressible and cannot be squeezed.

The aim of this project is to study on the theoretical ground properties of quantum droplets. We will study not only Bose-Bose mixtures or droplets with dipole-dipole interactions, but also Bose-Fermi systems: a mixture of a Bose-Einstein condensate and different ultracold vapor – quantum Fermi gas. Excitation spectrum, droplets collisions, their merging and splitting, superfluid behavior, effects of temperature are planned to be studied. in 3D space but also in lower dimensions. We collaborate with the theory group of prof. M. Lewenstein and experimental group of Letticia Tarruell at ICFO, Barcelona.

Both analytic and numerical skills are required.