Quantum droplets in ultracold spinor gases

Quantum droplets of ultracold atoms represent a new state of matter that was discovered recently. They can arise in ultracold quantum gases if the interaction between the atoms of the gas possesses both attractive and repulsive aspects. This is in particular the case for two-component atomic gases, consisting of atoms that belong to two different species (or that are prepared in two different internal spin states), namely if the intra-species interaction is repulsive while the inter-species interaction is attractive [1–3].

The aim of this master thesis is to perform a numerical simulation of the formation of quantum droplets in such two-component systems. This simulation can be done on the basis of an extended Gross-Pitaevskii equation, which is obtained via a density functional theory for the interacting Bose gas. The objective would be to investigate, within a dimensionally reduced configuration, how droplets form in this particular system and what are the characteristic properties of such droplets.

References

[1] D. S. Petrov, *Quantum Mechanical Stabilization of a Collapsing Bose-Bose Mixture*, Phys. Rev. Lett. 115, 155302 (2015).

[2] R. Cabrera, L. Tanzi, J. Sanz, B. Naylor, P. Thomas, P. Cheiney, and L. Tarruell, *Quantum liquid droplets in a mixture of Bose-Einstein condensates*, Science 359, 301 (2018).

[3] G. Semeghini, G. Ferioli, L. Masi, C. Mazzinghi, L. Wolswijk, F. Minardi, M. Modugno, G. Modugno, M. Inguscio, and M. Fattori, *Self-Bound Quantum Droplets of Atomic Mixtures in Free Space*, Phys. Rev. Lett. 120 235301 (2018).