Dipolar quantum gases and liquids

Tilman Pfau[*1]

1. 5. Physikalisches Institut and Center for Integrated Quantum Science and Technology (IQST), Universität Stuttgart, Germany

Dipolar interactions are fundamentally different from the usual van der Waals forces in real gases. Besides the anisotropy the dipolar interaction is nonlocal and as such allows for self organized structure formation. Candidates for dipolar species are polar molecules, Rydberg atoms and magnetic atoms. More than ten years ago the first dipolar effects in a quantum gas were observed in an ultracold Chromium gas. By the use of a Feshbach resonance a purely dipolar quantum gas was observed three years after [1]. By now dipolar interaction effects have been observed in lattices and also for polar molecules. Recently it became possible to study degenerate gases of lanthanide atoms among which one finds the most magnetic atoms. The recent observation of their collisional properties includes the emergence of quantum chaos and very broad resonances [2][3]. Similar to the Rosensweig instability in classical magnetic ferrofluids self-organized structure formation was expected. In our experiments with quantum gases of Dysprosium atoms we could recently observe the formation of a droplet crystal [4]. In contrast to theoretical mean field based predictions the super-fluid droplets did not collapse. We find that this unexpected stability is due to beyond meanfield quantum corrections of the Lee-Huang-Yang type [5][6]. We observe and study self-bound droplets [7] which can interfere with each other. These droplets are 100 million times less dense than liquid helium droplets and open new perspectives as a truly isolated quantum system.

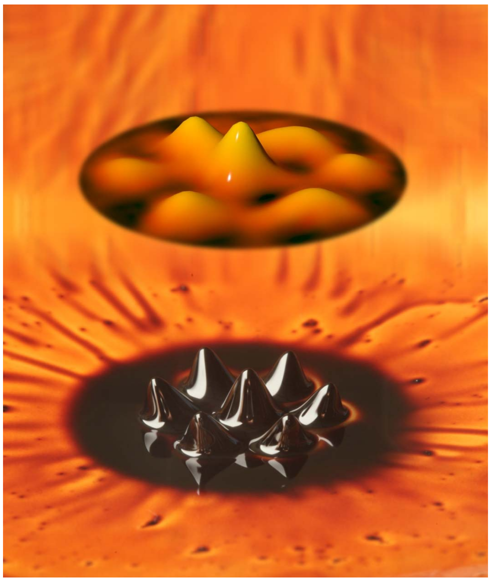

Fig. 1: Insitu image of a quantum droplet arrangement (shown above where the distance between droplets is about 3 microns) in comparison to a ferrofluid showing a Rosensweig Instability (shown below).

References

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*Corresponding author: t.pfau@physik.uni-stuttgart.de