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Fachbereich Physik, Universität Stuttgart
Max-Planck-Institut für Festkörperforschung
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Dipolar gases: From supersolid atoms to cold molecules

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Festkolloquium zur Verleihung des Rudolf-Kaiser-Preises 2019

Abstract

Over the last two decades ultracold quantum gases have become a versatile tool in many fields of physics ranging from quantum simulation to non-linear optics and precision measurements. Their particular appeal stems from the precise tunability of nearly all relevant parameters, including the strength of interactions between the particles in the gas. However, the character of these interactions is typically limited to be isotropic and short-ranged. If the particles, on the other hand, feature magnetic or electric dipole moments, interactions can become anisotropic and long-ranged. In this talk I will discuss how this subtle change has recently lead to the discovery of a wealth of new phenomena, including novel states of matter, self-bound quantum liquids, or the emergence of quantum chaos.

In the first part of the talk, I will introduce a series of experiments with ultracold dysprosium atoms, which feature the strongest magnetic dipole moment in the periodic table. Such gases can form exotic droplets that are - counterintuitively - stabilized by quantum fluctuations. These droplets are a 100 million times more dilute than liquid helium droplets, but exhibit similar liquid-like properties. Moreover, multiple droplets can self-organize into coherent crystals, providing the first conclusive evidence for the existence of the elusive supersolid state of matter, which is both solid and superfluid at the same time.

In the second part of the talk, I will present our recent progress towards the direct laser cooling of electrically dipolar molecules [5,6]. With typical electric dipole moments of several Debye, such molecules exhibit dipolar interactions that can be orders of magnitude stronger than in magnetically dipolar atoms. Moreover, ultracold molecules will offer unique experimental possibilities for precision measurements and cold chemistry.