Many-body phases in ultracold dipolar gases: novel quantum mixtures and supersolidity

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In the past decades, ultracold atomic gases revealed to be an ideal platform for simulating quantum phenomena thanks to the ability to tune the inter-particle interactions, the geometry of the system, and the possibility of adding complexity in a controlled way. Recently, ultracold gases made of magnetic atoms brought to the discovery of exotic states of matter arising from the long-range and anisotropic dipole-dipole interactions, such as liquid-like self-bound droplets and supersolid states [1].

This talk presents the latest results from our dipolar quantum gas experiment, in which we combine the two highly magnetic atomic species, erbium and dysprosium, merging for the first time the field of hetero-nuclear mixtures with the one of ultracold dipolar gases. After the realization of dipolar quantum mixtures of erbium and dysprosium [2] and the investigation of their interspecies interactions [3,4], we proved supersolidity with dysprosium, a state combining the phase coherence of a superfluid with the spatial periodicity of a crystal.

By following the lifecycle of the supersolid state, we investigate the role that thermal fluctuations play in the development of density modulation [5]. Finally, we extend the supersolid properties from one to two dimensions [6], reaching circular supersolid states. This result paves the way to the study of vortices, persistent currents, and phases with exotic geometry.

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