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Three teams independently show dipolar quantum gasses support state of supersolid properties

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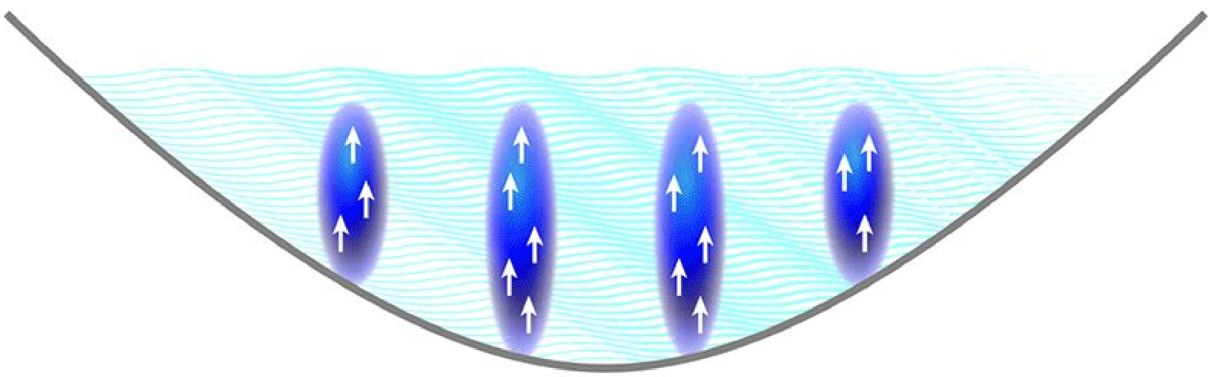

In a Bose-Einstein condensate of dipolar atoms (white arrows), dense “droplets” (dark blue) will form because of the intricate interplay among the trapping potential (gray line), the atoms’ dipolar and contact interactions, and quantum fluctuations. The Modugno, Pfau, and Ferlaino teams created the conditions to achieve coherence between the individual droplets, which is mediated by the background of Bose-condensed atoms (light blue) in the trap. This coherence provides an indirect signature of supersolidity. Credit: APS/Alan Stonebraker/ Physics

Three teams of researchers working independently of one another have shown that certain dipolar quantum gases are able to support a state of supersolid properties. A team led by Giovanni Modugno of the University of Florence has published their findings in *Physical Review Letters*. The second team, led by Tilman Pfau of the University of Stuttgart, has published their findings in *Physical Review X*, and the third, led by Francesca Ferlaino of the University of Innsbruck has uploaded their findings to the *arXiv* preprint server.

Supersolids are theorized materials with atoms that are arranged in the spatial periodicity of crystals, but are able to flow like a liquid when exposed to extremely cold conditions. In essence, they are solids that can flow like a liquid. Because of their unique characteristics, researchers have tried to create them in the lab, but until now, have met with little success. In these three new efforts, all three teams claim to have used theory and experimentation to show dipolar quantum gasses can support a state of supersolid properties—all three teams accomplished this using Bose-Einstein condensates (BECs), which are notably superfluids.

Most efforts to create supersolids have started with attempts to force a superfluid into a crystal-like structure while maintaining its ability to flow—but such efforts have not panned out. Back in 2003, two teams of researchers proposed the idea of engineering atomic interactions by way of long-range dipolar coupling—an idea that showed promise but still did not lead to the creation of a supersolid. All three teams in these new efforts have based their efforts on this idea by using BECs because they have naturally strong magnetic dipole moments, believed to be a necessary part of creating a supersolid.

All three teams worked with the idea that dense "droplets" will form in a BEC under the right conditions, in which just the right interactions would result in coherence between the droplets, allowing for the creation of a crystalline structure—all while maintaining the flow properties of the original BEC.

Two of the teams, those led by Modugno and Pfau, used the isotope dysprosium-162 in their work because of the repulsive forces that dominate dipolar interactions. The third team used two other isotopes, dysprosium-164 and erbium-166 because of their dominant dipolar interactions. In the end, all three demonstrated that dipolar gases can be used to show properties of a supersolid in a material.

More information: L. Tanzi et al. Observation of a Dipolar Quantum Gas with Metastable Supersolid Properties, *Physical Review Letters* (2019). DOI: 10.1103/PhysRevLett.122.130405

Fabian Böttcher et al. Transient Supersolid Properties in an Array of Dipolar Quantum Droplets, *Physical Review X* (2019). DOI: 10.1103/PhysRevX.9.011051

Long-lived and transient supersolid behaviors in dipolar quantum gases, arXiv:1903.04375 [cond-mat.quant-gas] arxiv.org/abs/1903.04375