Stresses and flows in ultra-cold superfluids

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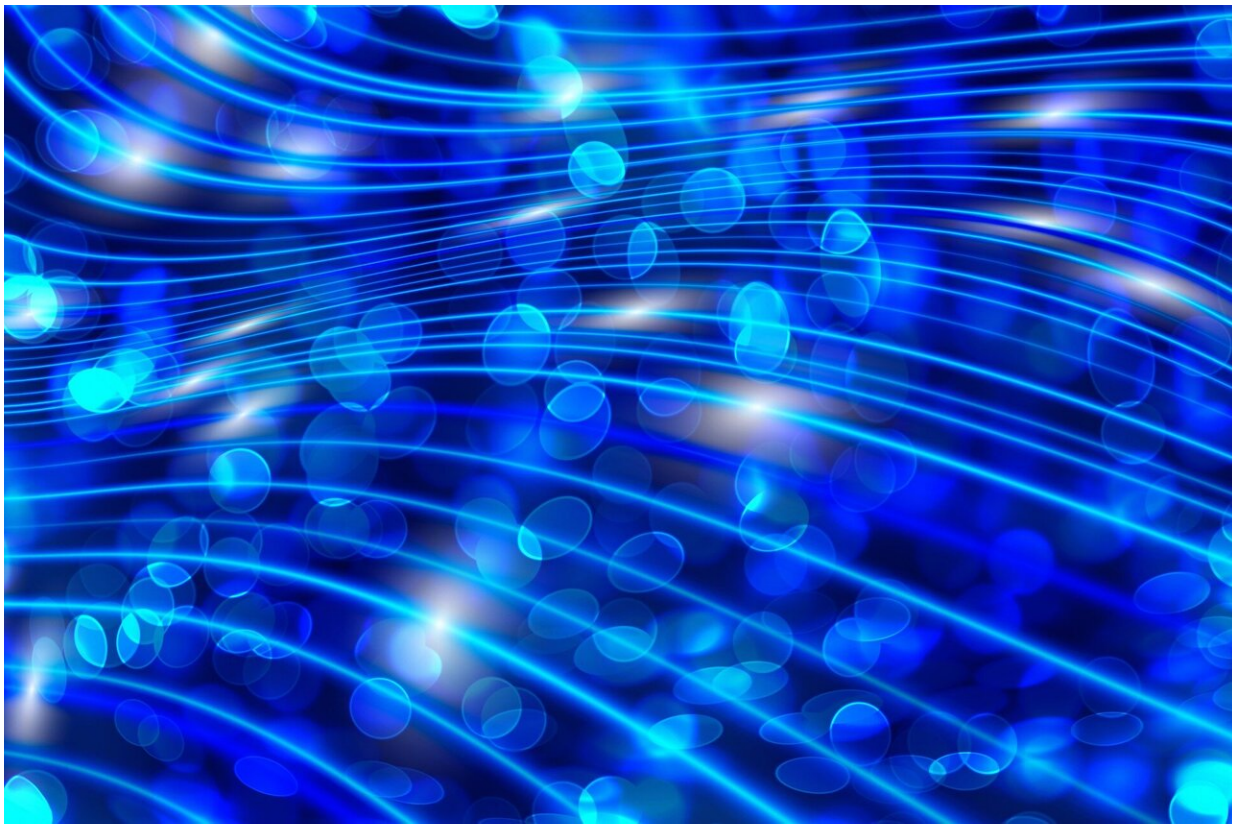

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Superfluids, which form only at temperatures close to absolute zero, have unique and in some ways bizarre mechanical properties. Yvan Buggy of the Institute of Photonics and Quantum Sciences at Heriot-Watt University in Edinburgh, Scotland, and his co-workers have developed a new quantum mechanical model of some of these properties, which illustrates how these fluids will deform as they flow around impurities. This work is published in the journal *EPJ D*.

Imagine that you start stirring a cup of tea, come back to it five minutes later and find that the tea is still circulating. In itself, this is clearly impossible, but if you could stir a cup of an ultra-cold liquid this is exactly what would happen. Below about -270°C—that is, just a few degrees above the coldest possible temperature, absolute zero—the liquid becomes a superfluid: a weird substance that has no viscosity and that therefore will flow without losing kinetic energy, creep along surfaces and along vessel walls, and continue to spin indefinitely around vertices.

Superfluids acquire these properties because so many of their atoms fall into the lowest energy state that quantum mechanical properties dominate over classical ones. They therefore provide a unique opportunity for studying quantum phenomena on a macroscopic level, if in extreme conditions. In this study, Buggy and his colleagues use the essential equations of quantum mechanics to calculate the stresses and flows in such an ultracold superfluid under changes in potential energy. They show that the fluid flow will be steady and homogeneous in the absence of impurities. If an impurity is present, however, the fluid will become deformed in the vicinity of that impurity.

More information: Yvan Buggy et al, On the hydrodynamics of nonlinear gauge-coupled quantum fluids, *The European Physical Journal D* (2020). DOI: 10.1140/epjd/e2020-100524-3

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