Frictionless supersolid a step closer

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Superfluid mixtures of atoms can boil and freeze at ultra-low temperatures. This freezing can result in the formation of supersolids of atoms that can flow alongside each other without friction, but are still set in a fixed structure, says Dutch researcher Koos Gubbels. His research results are contributing to the understanding of superconductors - materials that might help to resolve the energy problem.

Superfluidity and superconductivity cause particles to move without friction. Koos Gubbels investigated under what conditions such particles keep moving endlessly without losing energy, like a swimmer who takes one mighty stroke and then keeps gliding forever along the swimming pool. Superfluidity and superconductivity are of major fundamental and practical significance. The former, for instance, is used for high-precision measurements. Superconductivity allows for the generation of strong magnetic fields for MRI research, the LHC particle accelerator or the Japanese bullet trains. Superconductivity might even be able to help us with our energy problem at some point in the future.

Gubbels investigated atomic gases. These substances are much simpler than the metals that make up superconductors, yet still display the basic process of superfluidity. The major advantage of atomic gases is that they are easy to manipulate. Researchers can readily control the temperature and the strength of interaction among the particles. Along with his supervisor, Henk Stoof, Koos Gubbels developed a theory for predicting the behaviour of these superfluid materials, and discovered that the atomic gasses can have very unique properties.

During his research, Gubbels demonstrated that the atomic gases he was investigating start to 'boil' just above the temperature of absolute zero. The mixture then gives rise to phase separation. Everyone comes across phase separation on a day-to-day basis: a pan of boiling water on the stove consists of a liquid, but at the same time also of gas bubbles. It is, therefore, partly liquid and partly gas. Although phase separation is quite rare in superfluid materials, Gubbels discovered that the phenomenon is still possible at ultra-low temperatures and for specific polarisations. In this case, the polarisation determines how many particles interact with each other and become superfluid. Gubbels predicted that specific superfluid mixtures of atoms could also freeze, so that, paradoxically enough, the atoms could flow without friction and at the same time be trapped in a fixed structure.

The frictionless state of the atomic gases appeared to be surprisingly stable. In a metal, this state would remain superconducting to a temperature of about 1000 degrees Kelvin, which is far hotter than room temperature. The present superconductors have to be kept very cold, though, which is a major problem for large-scale application.

The research done by Koos Gubbels is part of the Vici project led by physicist Henk Stoof, who was awarded a Vici under the NWO Innovational Research Incentives Scheme in 2003.

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