A Truly 'Super' Fluid

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In the world of quantum mechanics, surprising discoveries are often made. For instance, what happens when you take a fermionic superfluid and convert it into a bosonic superfluid? The answer: a new superfluid that has surprising characteristics that a superfluid isn't expected to have. But it can't be described as anything other than a superfluid.

Aurel Bulgac and Joaquín E. Drut at Seattle's University of Washington and their colleague, Piotr Magierski, at the Warsaw University of Technology in Poland, made just such a discovery. On March 10 their findings were published by *Physical Review Letters* and offer insight into a new world that includes a type of quantum fluid that exists at the crossover state from fermionic to bosonic.

"Simply by changing the temperature," explains Bulgac to PhysOrg.com, "you have something that changes from behaving as a bosonic to behaving as a fermionic system. This is unusual behavior in any system so far."

What makes this superfluid so remarkable is that it exhibits properties of both bosons and fermions at the same time. By definition, something is either bosonic or fermionic. While it is, in fact, fermions (the elementary particles of 'normal' matter — electrons, protons, and neutrons — are fermions) that make up most bosons, once these molecules are created, they act in ways that are baffling. Bulgac and his colleagues describe it thus: "[It is] an unexpected mélange of both bosonic and fermionic properties in an utterly puzzling physical realization."

Another notable oddity is that the thermal properties of this type of superfluid are different from normal superfluid properties. One expects to see interaction between bosons in a bosonic superfluid system, and interactions between fermions in a fermionic superfluid system. Within this crossover system, however, there appears to be very little, if any, interaction between the quantum particles.

Bulgac says, “Superfluid property is one of interaction. The interaction is strong, but it doesn’t show up in the thermal properties. We know that the system is a superfluid, but the thermal properties are those not normal to superfluid.”

The discovery of this new superfluid type will possibly lead to a better understanding of matter, especially as it relates to understanding high temperature superconductors. Bulgac explains that although scientists created such superconductors, they are not very well understood. “This crossover superfluid has many characteristics that are similar to these superconductors,” he explains. “We hope this superfluid system is easier to understand, and that we can then project that understanding into a better understanding of superconductors.”

Bulgac and his colleagues want to try to understand the properties of this unique, and paradoxical, system. They believe that it has the potential to unlock not only the secrets of superconductors, but also the workings of stars and of other condensed matter systems. Understanding this crossover superfluid could also, he asserts, help with the creation of new types of materials and matter that could have further practical uses to humanity in general.

“Like everything else in physics,” he says, “you are able to predict and form new states of matter. And this is a new state of matter.”

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