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By Martin Zwierlein

ESI Special Topics, February 2005
Citing URL - http://www.esi-topics.com/fbp/2005/february05-MartinZwierlein.html

Martin Zwierlein answers a few questions about this month's fast breaking paper in field of Physics.

From • > > February 2005

Field: Physics

Article Title: Condensation of pairs of fermionic atoms near a Feshbach resonance - art. no. 120403
Authors: **Zwierlein, MW**;Stan, CA;Schunck, CH;Raupach, SMF;Kerman, AJ;Ketterle, W
Journal: PHYS REV LETT
Volume: 9212
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Year: MAR 26 2004
* MIT, Dept Phys, MIT Harvard Ctr Ultracold Atoms, Cambridge, MA 02139 USA.
* MIT, Dept Phys, MIT Harvard Ctr Ultracold Atoms, Cambridge, MA 02139 USA.
* MIT, Elect Res Lab, Cambridge, MA 02139 USA.

ST: Why do you think your paper is highly cited?

Superfluidity in strongly interacting atomic Fermi gases is currently a rapidly advancing field of research in atomic physics, with many theoretical and a growing number of experimental groups joining in for the excitement. The breakthrough came with the Bose-Einstein condensation of molecules, tightly bound pairs of fermionic atoms, in November 2003 in Boulder, Innsbruck, and in our group at MIT. Using these molecular condensates as the starting point, we can now access a new regime in which the molecules loosen up their bonds and become large, comparable to, or even larger than the average distance between particles. This strongly interacting "soup" of fermions finds its analogies in such exotic systems as nuclear matter or neutron stars.

"Through the study of this novel system, physicists might be led to a better understanding of superfluidity and superconductivity in general, which could pave the way to the invention of new materials with "designed" properties, the ultimate dream being a room-temperature superconductor."

ST: Does it describe a new discovery or a new methodology that's useful to others?

Together with work from other groups, it does present a new discovery. We observe fermion pair condensates in lithium-6 and find them to be very pure, in contrast to the case of potassium-40. It is foreseeable that ultracold atomic Fermi gases will become an experimental test-bed for many-body theories, just like bosonic atom gases represent the paradigm of Bose-Einstein condensation. The future goal is to create an artificial crystal of atoms trapped in interfering laser beams, in which all parameters can be set by the experimenter, like the lattice spacing and depth as well as the interaction strength between particles. From these idealized systems people hope to gain insight into the workings of strongly correlated systems, most prominently superconductors with high critical temperature.

ST:

Bose-Einstein Condensates (BEC) is the mechanism responsible for superfluidity in helium and superconductivity in metals. It occurs at very low temperatures, when bosons, particles with integer spin, tend to all gather in the state of lowest energy and form a condensate. Fermions (particles with half-integer spin), like electrons in a metal or the lithium-6 atoms we use in our experiment, cannot form such a condensate by themselves. They have to first find a partner to form a bosonic pair. These pairs of fermions can then condense just like bosonic atoms. The nature of the pairs depends on how strong the particles attract each other. They can be either tightly bound into small molecules, which are stable even in free space, or they can form very loose pairs, which can only exist because of the stabilizing presence of all the other particles in the gas. For very small attraction, this latter form of pairing is known from electrons in superconducting metals. In our experiment, we can smoothly tune the attraction between the fermions and observe condensates of either tiny molecules or of large pairs of fermions. It is the latter case which creates a lot of excitement, since this finding provides strong evidence for superfluidity in this interesting regime, where pairing would not occur in free space but is induced by the presence of the surrounding cloud of atoms.

Through the study of this novel system, physicists might be led to a better understanding of superfluidity and superconductivity in general, which could pave the way to the invention of new materials with "designed" properties, the ultimate dream being a room-temperature superconductor.

ST: How did you become involved in this research?

The machine on which the experiments have been conducted is the same which produced the first Bose-Einstein condensates of sodium atoms in 1995. I joined Wolfgang Ketterle's group as an intern from the Ecole Normale Superieure in Paris in 2001. That year, the machine was upgraded to a double-species experiment which could cool fermionic lithium-6 sympathetically with sodium. After receiving a diploma in theoretical physics in Paris, I started my Ph.D. studies in 2002 on the same experiment.

Martin Zwierlein
Research Assistant
Research Laboratory for Electronics
MIT-Harvard Center for Ultracold Atoms
and Department of Physics
Massachusetts Institute of Technology
Cambridge, MA, USA

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- Fast Breaking Comments - **from Wolfgang Ketterle**
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