News Releases

Whirling Atoms Dance Into Physics Textbooks
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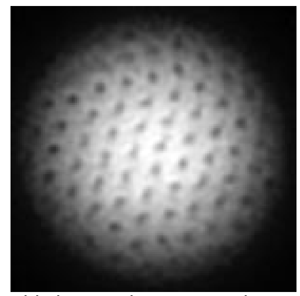
NASA-funded researchers at the Massachusetts Institute of Technology, Cambridge, Mass., have created a new form of superfluid matter. This research may lead to improved superconducting materials, useful for energy-efficient electricity transport and better medical diagnostic tools.

The research marks the first time scientists have positively created a friction-free superfluid using a gas of fermionic atoms, atoms with an odd number of electrons, protons and neutrons. The breakthrough happened on the night of April 13.

"It's a night I won't forget. It was overwhelming to watch on our computers as the lithium atoms behaved in a way that no one had ever seen before," said Dr. Wolfgang Ketterle, a Nobel prize- winning physics professor at MIT who led the team of researchers.



This image shows a rotating superfluid made up of fermionic atoms. Image credit: Andre Schirotzek, MIT
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To accomplish this experiment, Ketterle's team cooled a gas cloud of lithium atoms to nearly absolute zero (about minus 459 degrees Fahrenheit). They used an infrared laser beam to trap the gas, then a green laser to spin it.

A normal gas simply spins, but a superfluid can rotate only by forming quantum whirlpools. A rotating superfluid looks like Swiss cheese; the holes are the cores of the whirlpools. This is exactly what the MIT physicists observed that night.

In 1995, Ketterle and his team were among the first to create a Bose-Einstein condensate, composed of bosonic atoms that have an even number of electrons, neutrons and protons. In Bose-Einstein condensates, particles act as one big wave, a phenomenon predicted by Albert Einstein in 1925. That discovery earned Ketterle a shared Nobel Prize in Physics in 2001. Bose-Einstein condensates were later shown to be superfluids.

The new frontier became fermions. Fermions must pair up to have an even number of electrons, neutrons and protons, which allows them to form a Bose-Einstein condensate. Breakthroughs at MIT and several other institutions, including Duke University, Durham, North Carolina, produced Bose- Einstein condensation of fermion pairs loosely bound as molecules, but found no concrete evidence of superfluidity.

Over the past two years researchers have been looking for the "smoking gun" for fermionic superfluidity. Despite some hints and indirect evidence, it was not found until this research team's discovery.

Superconductivity is superfluidity for charged particles instead of atoms. High-temperature superconductivity is not fully understood, but the MIT observations open up opportunities to study the microscopic mechanisms behind this phenomenon.

"Pairing electrons in the same way as our fermionic atoms would result in room-temperature superconductors," Ketterle explained. "It is a long way to go, but room-temperature superconductors would find many real-world applications, from medical diagnostics to energy transport." Superfluid Fermi gas might also help scientists test ideas about other Fermi systems, like spinning neutron stars and the primordial soup of the early universe.

The MIT research was supported by the National Science Foundation, the Office of Naval Research, the Army Research Office, and NASA's Fundamental Physics in Exploration Systems Mission Directorate, in support of the Vision for Space Exploration. NASA's Jet Propulsion Laboratory, Pasadena, Calif., Pasadena, manages the Fundamental Physics program.

The research was published in the June 23 issue of Nature. Ketterle's co-authors include MIT grad students Andre Schirotzek, Christian Schunck, and Martin Zwierlein, and former grad student Jamil Abo-Shaeer. They are all members of the NSF-funded MIT-Harvard Center for Ultracold Atoms.

For more information about NASA's Fundamental Physics Program on the Internet, visit http://funphysics.jpl.nasa.gov or http://spaceresearch.nasa.gov

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