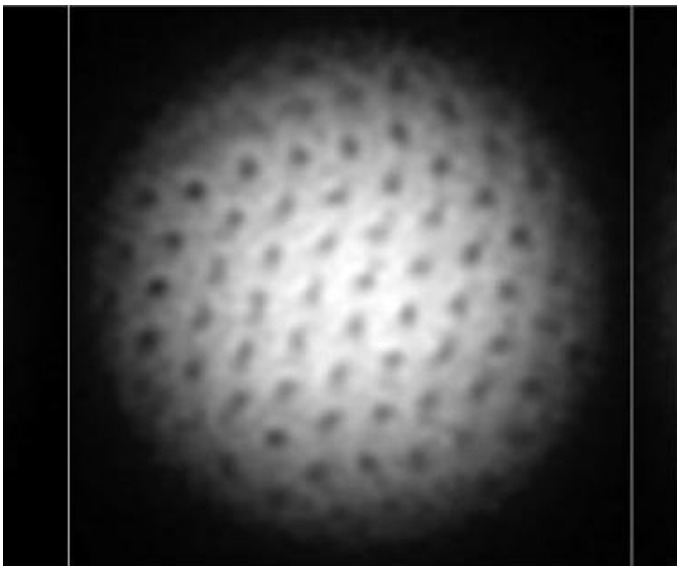
# Image of the Week
## New Matter: Superfluid Fermi Gas



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A team of scientists at the Massachusetts Institute of Technology led by Nobel laureate Prof. Wolfgang Ketterle (MIT-Harvard Center for Ultracold Atoms) recently created a new form of matter: a high-temperature superfluid gas of fermionic atoms. Fermions are protons, neutrons, and electrons—atomic particles with a half-integer spin. Fermionic atoms are those made with an odd number of these particles such as the isotope lithium-6 ($^6$Li), which has 6 fermions in its nucleus (3 protons and 3 neutrons), plus 3 electrons, for a total of 9 fermions. According to the Pauli exclusion principle, two fermions may not occupy the same quantum state; that is, not unless the fermions are paired together to act like a boson with a whole-integer spin. Superfluidity is a frictionless flow of particles moving as one wave.

The gas, consisting of lithium-6 atoms, was cooled to a temperature close to absolute zero (-459°F or -273°C). Then the gas was placed in a round infrared laser beam trap, and two other laser beams were used to stir the gas for 500 milliseconds to set it into rotation. After another 500 milliseconds, the gas developed a lattice of equidistant vortices of uniform size (the dark holes all along the sphere). Theoretically, when a superfluid rotates, it should form vortices throughout the gas, indicating that the particles can be described by a single macroscopic quantum wave function. The appearance of the vortices is a "smoking gun" proving the superfluidity of the gas. It was observed after the laser trap was opened and the gas was allowed to expand.

Experiments with this type of superfluid may lead to applications in superconductivity and transport of electricity, and help to shed light on the physics of neutron stars.

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## For Further Study

**Articles:** » Atomic Fermi gases| Fermi-Dirac statistics |Laser cooling | Neutron star | Particle trap |Superconductivity | Superfluidity
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**Related Web Sites:** » Vortices and superfluidity in a strongly interacting Fermi gas : Nature