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Number 580 #1, March 13, 2002 by Phil Schewe, James Riordon, and Ben Stein

All-Optical Trapping of a Degenerate Fermi Gas

All-optical trapping of a degenerate Fermi gas has been demonstrated for the first time by Duke University physicists (John Thomas, 919-660-2508, jet@phy.duke.edu), offering a promising route for using an atomic gas to explore the mechanisms of superconductivity.

First created in 1999 (Update 447), a degenerate Fermi gas is a sufficiently dense low-temperature gas of fermion atoms, those atoms with an odd number of total particles (protons, neutrons, and electrons). They are the fermion cousins of Bose-Einstein condensates (BECs) first created in 1995. Last year, a BEC was directly produced in an all-optical trap (Update 545). The Duke group's work builds on their demonstration of the first stable optical trap for neutral atoms, namely fermionic lithium, in early 1999 (Phys. Rev. Focus, 24 May 1999).

Until now, magnetic fields have been required to trap degenerate Fermi gases. Employing a stable, high-power CO_2 laser, the Duke researchers create a kind of "optical bowl" for lithium-6 atoms, in which the hottest atoms evaporate like steam from hot soup. In this way, the researchers trap and cool an equal mixture of lithium atoms in spin-up and spin-down states.

This feat, which isn't possible in magnetic traps, points to perhaps the greatest advantage of the all-optical approach: They can confine essentially any combination of fermion species. By contrast, if a magnetic trap confines the spin-up energy state of a fermion atom, it repels the spin-down version. According to the Duke researchers, such equal mixtures of spin-up and spin-down are potentially ideal for forming neutrally charged analogs of superconducting "Cooper pairs" in Fermi gases.

This achievement of atomic-gas analogs of superconductivity is being intensely pursued in different ways by several groups, including the Duke researchers. While the formation of Cooper pairs requires lower Fermi gas temperatures and stronger interactions between the atoms than have been achieved so far, such an accomplishment would permit tunable studies of superconductivity, and promises to result in a better understanding of the underlying theory. (Granade, Gehm, O'Hara, and Thomas, *Physical Review Letters*, 25 March 2002.)

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