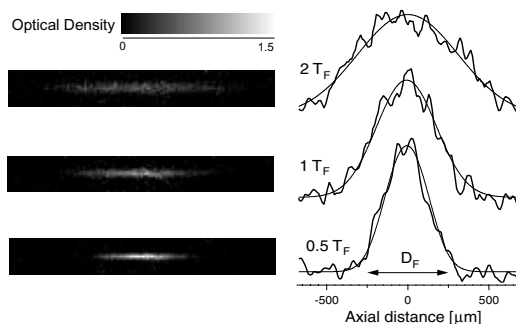


Two species mixture of quantum degenerate Bose and Fermi gases

Experimental methods of laser and evaporative cooling, used in the production of atomic Bose-Einstein condensates have recently been extended to realize quantum degeneracy in trapped Fermi gases [1]. Fermi gases are a new rich system to explore the implications of Pauli exclusion on scattering properties of the system, and ultimately fermionic superfluidity.

We have produced a new macroscopic quantum system, in which a degenerate ${}^6\text{Li}$ Fermi gas coexists with a large and stable ${}^{23}\text{Na}$ BEC [2]. This was accomplished using inter-species sympathetic cooling of fermionic ${}^6\text{Li}$ in a thermal bath of bosonic ${}^{23}\text{Na}$. We have achieved high numbers of both fermions ($>10^5$) and bosons ($>10^6$), and ${}^6\text{Li}$ quantum degeneracy corresponding to one half of the Fermi temperature. This is the first time, that a Fermi sea was produced with a condensate as a “refrigerator”.

Low rates for both intra- and inter-species inelastic collisions result in a lifetime longer than 10 s. Hence, in addition to being the starting point for studies of the degenerate Fermi gas, this system shows great promise for studies of degenerate Bose-Fermi mixtures, including collisions between the two species, and of limitations to the sympathetic cooling process.



Onset of Fermi degeneracy. Three pairs of images (top to bottom) correspond to $T/T_F=2, 1,$ and 0.5 . (a) Column densities of the ${}^6\text{Li}$ cloud were recorded by absorption imaging. (b) Axial line density profiles and the Fermi-Dirac fits to the data are plotted. The arrow indicates the size of the Fermi diameter, D_F , which is the diameter of the cloud at zero Kelvin.

1. B. DeMarco and D.S. Jin, *Onset of Fermi Degeneracy in a Trapped Atomic Gas*, *Science* **285**, 1703 (1999).
2. Z. Hadzibabic, C.A. Stan, K. Dieckmann, S. Gupta, M.W. Zwierlein, A. Görlitz, and W. Ketterle, *Two species mixture of quantum degenerate Bose and Fermi gases*, *Phys. Rev. Lett.* **88**, 160401 (2002).