Fermionic lithium atoms in a resonator dipole trap

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In a neutral Fermi gas the interplay between interatomic interactions and quantum statistics is fascinating. Interactions between particles in identical internal states become forbidden at low temperatures, while interactions between particles in non-identical spin states may be the driving mechanism for an expected phase transition to superfluidity. It is therefore interesting to study the interactions between fermionic atoms in different spin states.

An optical dipole trap can confine atoms in any mixture of spin states, and is therefore ideally suited for collisional studies. We have built a resonator dipole trap (RDT) relying on resonant enhancement of the optical field inside a cavity (see figure). Since the trap depth is enhanced by a factor 150, we expect to trap $\approx 3 \times 10^4$ atoms from a magneto-optical trap with only modest laser power (a 400 mW Nd:Yag laser at 1064 nm).

Once transferred into the RDT, the atoms only scatter one photon per four seconds, which leaves us enough storage time to study the internal thermalization of the gas. We are especially

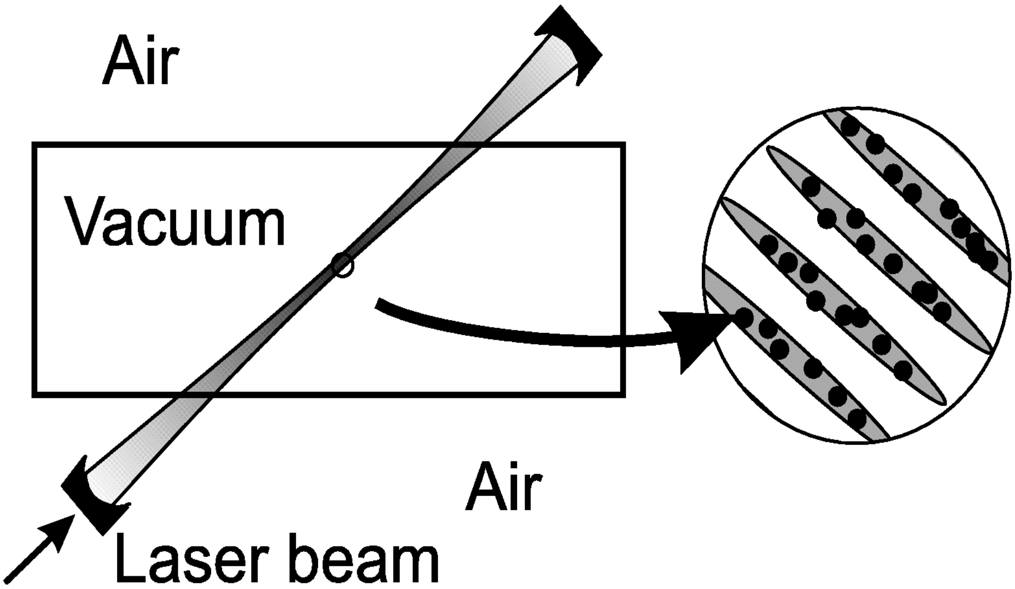

Figure 1: Schematic of the resonator dipole trap. The mirrors are in air to facilitate alignment. The 1064 nm standing wave intersects the glass surfaces of our vacuum apparatus at Brewster's angle, thus minimizing optical loss. The inset shows the configuration of the microtrap array. The actual size of the microtraps is 150 × 0.5 μm.

interested in observing Feshbach resonances through the exceptionally high collision rates they induce. Strong Feshbach resonances have been predicted for the high-field seeking states of ^{6}Li [1]. These Feshbach resonances can be used to increase the temperature of the phase transition to superfluidity, making the phase transition easier to attain. More importantly, using Feshbach resonances one can also move the sample through the phase transition in an adiabatic way. This makes a direct comparison between a normal Fermi gas and a superfluid gas at the *same* temperature possible!

An important feature of the RDT is the fact that the optical potential is spatially modulated, thus creating an array of quasi-two-dimensional microtraps. The width of each microtrap is of the order of the beam waist (150 μm), while the height is only half the wavelength of the trapping light, i.e., 532 nm.

The two-dimensional character of the sample will also influence the scattering properties, possibly giving rise to new types of scattering resonances [2].

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