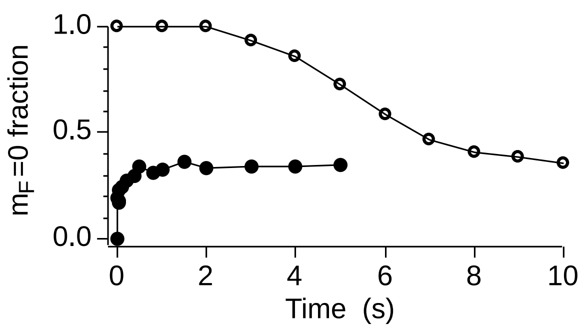
Metastable Bose-Einstein condensates

During the studies of the spinor ground states we encountered two different types of metastability which we investigated in more detail [1]. In one case, a two-component condensate in the m_F=+1, 0 hyperfine states was stable in spin composition, but spontaneously formed a metastable spatial arrangement of spin domains. In the other, a single component m_F=0 condensate was metastable in spin composition with respect to the development of m_F=+1, -1 ground-state spin domains. In both cases, the energy barriers which caused the metastability were much smaller than the temperature of the gas (as low as 0.1 nK compared to 100 nK) which would suggest a rapid thermal relaxation. However, since the thermal energy is only available to non-condensed atoms, this thermal relaxation was slowed considerably due to the high condensate fraction and the extreme diluteness of the non-condensed cloud.

When a condensate was initially prepared in a pure m_F=0 state metastability of up to 5 sec was observed for the formation of the equilibrium spin domain structure (see figure). In contrast when the system was prepared in an equal mixture of m_F=+1 and m_F=-1 atoms the fraction of atoms in the m_F=0 state grew without delay, arriving at equilibrium within just 200 ms.

Metastability of the spatial distribution was observed in a system of m_F=+1 and m_F=0 atoms. After the m_F=0 state was populated with an rf pulse, the system rapidly developed into alternating layers of m_F=0 and m_F=1 spin domains of about 40 μm in thickness which were metastable for 20 seconds in the absence of magnetic field gradients.



Metastability of the pure m_F = 0 state in the presence of a magnetic bias field (250 mG) and gradient (44 mG/cm). The evolution toward equilibrium of an initially pure m_F = 0 condensate (open symbols), and a mixture of m_F = 1 and m_F = -1 (closed symbols) is shown by plotting the fraction of atoms in the m_F = 0 state vs. dwell time in the optical trap.

1. H.-J. Miesner, D.M. Stamper-Kurn, J. Stenger, S. Inouye, A.P. Chikkatur, and W. Ketterle, Phys. Rev. Lett. **82**, 2228 (1999).