SYMPATHETIC COOLING IN A MIXTURE OF YB AND RB ATOMS

Axel Gorlitz

Heinrich-Heine-Universitat Dusseldorf,
Institute fur Experimental physik

Studies on mixtures of ultracold atoms are currently attracting significant attention. Among the most prominent results achieved so far are the creation of two-species quantum gases [1], the discovery of interspecies Feshbach resonances [2] and the production of heteronuclear molecules in the vibrational ground state [3].

In our experiment, we investigate a mixture of rubidium (Rb) and ytterbium (Yb) and thus, we combine a paramagnetic alkali atom (Rb) with a diamagnetic rare earth atom (Yb). The different magnetic and electronic properties allowed us to design a combined trap, in which the two species can be manipulated independently. The trap consists of a Ioffe-Pritchard type magnetic trap (MT) for Rb and a bichromatic optical dipole trap (ODT) for Yb employing laser light at 1064 nm and 532 nm. By adjusting the ratio of laser powers, the effect of the trapping light field on Rb can be minimized, so that to lowest order only the magnetic potential affects the Rb atoms. We have successfully trapped a mixture of ^{87}Rb and ^{174}Yb in this novel type of combined trap and very recently, we were able to observe sympathetic cooling of Yb through collisions with evaporatively-cooled Rb. Following the route of sympathetic cooling, we plan to realize a double-species quantum gas and subsequently produce heteronuclear ground state molecules.

In a typical experimental sequence, we first trap more than 10^7 ^{174}Yb atoms at a temperature of around 1 mK in a MOT operating on the strong $^1S_0 \rightarrow {}^1P_1$ transition at 399 nm. Subsequently, we transfer the Yb atoms into a MOT on the $^1S_0 \rightarrow {}^3P_1$ intercombination transition at 556 nm where temperatures below 100 μK are reached. The bichromatic ODT which is superimposed on the MOT is then loaded by switching off the MOT light fields. With this scheme, we can prepare up to $2\text{x}10^5$ ^{174}Yb atoms at a density of several 10^{11} cm^{-3} in the ODT. After several seconds of plain evaporation the Yb cloud has equilibrated to a temperature of 70 μK. After loading of the ODT with Yb atoms, an ensemble of ultracold Rb atoms is prepared by loading an MT from a standard MOT at a distance of 0.7 mm from the ODT in order to suppress loss of optically trapped

Yb atoms through collisions with hot Rb atoms. Only after the Rb cloud has been cooled by rf-evaporation to a temperature below the Yb temperature, we move the MT to the position of the ODT for Yb. In the combined trap, we observe thermalization with Rb on a timescale of 1s. Currently, the reduction of the Yb temperature by sympathetic cooling is limited to roughly a factor of 2. This may be attributed to imperfections in the optical trapping potential which lead to a spatial separation of the Rb and Yb clouds when the temperature is lowered. Nevertheless, we could achieve temperatures below 5 μK in an Yb cloud with $5\text{x}10^4$ atoms, by lowering the optical trapping potential while the Yb atoms are sympathetically cooled. Progress is under way to improve the optical trap to be able to cool the Yb even further and eventually realize a mixed quantum degenerate gas of with ytterbium and rubidium.

[1] G. Modugno et al., *Phys. Rev. Lett.* **89**, 190404 (2002)
[2] C. Stan et al., *Phys. Rev. Lett.* **93**, 143001 (2004); S. Innouye et al., *Phys. Rev. Lett.* **93**, 183201 (2004);
[3] J. Sage et al., *Phys. Rev. Lett.* **94**, 203001 (2005)