Evaporative cooling in a magnetostatic trap of triplet helium

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Helium in the metastable triplet state $2\,^3S_1$ (He*, lifetime 8000 s) is a promising candidate for studies of ultracold atomic clouds in the quantum degeneracy regime [1]. For ^{4}He* Bose-Einstein Condensation (BEC) is expected, whereas the ^{3}He isotope allows the study of a fermionic system, if the technique of sympathetic cooling is feasible. We plan to reach the BEC transition using forced evaporative cooling in our magnetostatic trap of cloverleaf geometry.

The He* atoms, produced in a liquid nitrogen cooled discharge source, are collimated and deflected, forming a parallel and pure beam of metastable atoms. After deceleration in a two-part Zeeman slower the atoms are captured in a magneto-optical trap (MOT). The MOT contains about 10^9 triplet helium atoms with a central density of 4×10^9 cm^{-3} and a temperature of 1 mK. At the optimal parameters for our MOT, a detuning of -22Γ and a total intensity of

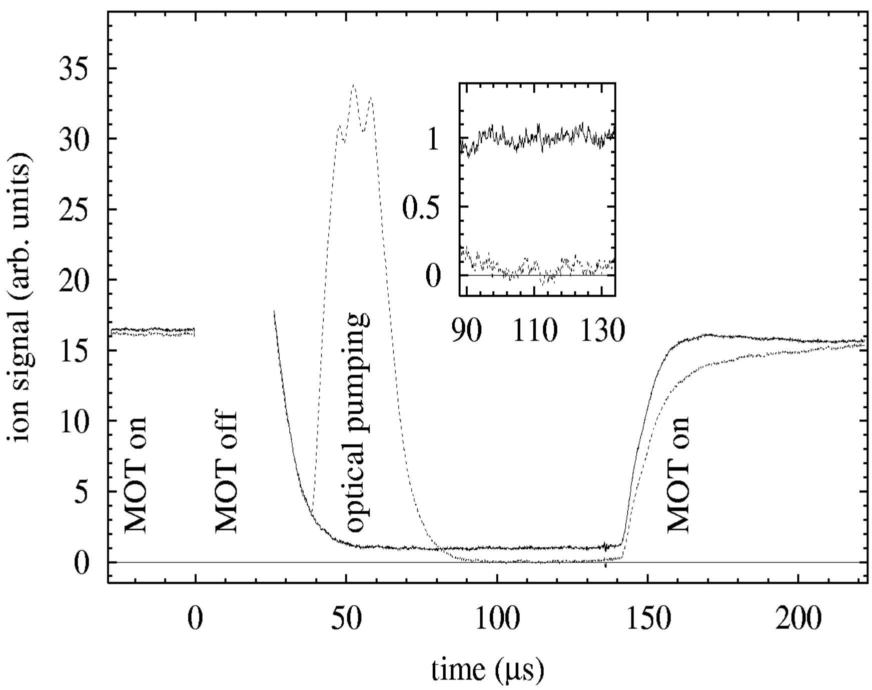

Figure 1: Ion signal with optical pumping (dashed line) and without optical pumping (solid line). The inset shows a magnification of that part of the curves where suppression of Penning ionization occurs.

$150 I_{sat}$, the loss rate constant is 5.3×10^{-9} cm^3/s [2]. These losses are determined completely by Penning ionization: $He^* + He^* \Rightarrow He + He^+ + e^-$. This process is strongly enhanced in the presence of light.

We investigated the production of ions by photo-association spectroscopy [3]. For this purpose a probe laser was sent through the cold cloud after switching off the MOT and ions were counted on a microchannel plate. In a 1 GHz frequency range around the 2 $^3S_1$ - 2 $^3P_2$ atomic transition we observed several photo-association resonances. Surprisingly we did not observe optical shielding of collisions. In the absence of light we measured the ionization loss rate constant for S - S collisions of unpolarized atoms to be $1.8(4) \times 10^{-10}$ cm^3/s [2, 4]. For spin-polarized atoms, in the $M = +1$ state, this rate constant is predicted to decrease by at least four orders of magnitude [5, 6], which is essential to reach BEC in triplet helium. By optical pumping in a small magnetic field we have already measured an upper limit of 6×10^{-12} cm^3/s, as shown in Figure 1 [4]. By compressing the atomic cloud in the cloverleaf trap we hope to observe a larger reduction.

After compression, evaporative cooling is the last stage before BEC. For this purpose we reduced the temperature in Doppler molasses to ~0.2 mK. We trap close to 1/3 of the atoms in the magnetostatic trap without using optical pumping and recently observed first manifestations of evaporative cooling in the cloverleaf trap. We hope to present more results at the conference.

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