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STUDIES ON THE PROCESS OF SLOWING ATOMS WITH THE ZEEMAN TUNED TECHNIQUE

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In using radition forces to decelerate an atomic beam we face two problem: the undesired optical pumping and the changing Doppler effect as the atoms slow down. Both can interrupt the slowing process after just a few photons absorption. One of the alternatives to avoid them is to use a spatially varying magnetic field to compensate the Doppler shift, which also helps avoiding optical pumping when circularly polarized light is used. This technique, conveniently called Zeeman tuned has beem proposed a few years ago[1] and successfuly used[2,3,4] to demonstrated deceleration of atoms.

We present a work where we study the influence of optical pumping and adiabatic following effects one the deceleration process in the Zeeman tuned technique.

Observing the atomic fluorescence along the deceleration path we observe that depending on the slowing laser detuning the atoms ceases to fluoresce much before expected. Figure 1 shows the results of this observation for deceleration of Na atoms. For blue detuning the dramatic drop on the fluorescence profile is associated with the fact that the atoms are actually stopping inside the solenoid. For red detuning the drop of fluoresecency ocours because atoms can not follow the field adiabatically ($kv(z) \sim -\Delta + \mu B(z)$) due to the fact that for those laser frequencies the local deceleration required for the atoms to follow the magnetic field is above the maximum possible value ($a_{max} = \frac{\hbar k \Gamma}{2} \frac{S}{S+1}$) with $k = 2\pi/\lambda$, Γ the natural line width of the transition and S the saturation parameter). This fact shows the impossibility of produzing slow atoms outside the solenoid. One way of avoiding this is to work with a convenient magnetic field profile such that the atoms can follow all way along the field profile.

By controlling the field gradient is possible to decelerate the atoms using the $S_{1/2}(F = 2) \rightarrow P_{3/2}(F = 3)$ transition till they get close to the end od the selenoid where they are pumped out of the $S_{1/2}(F = 2)$ state to $S_{1/2}(F = 1)$ which do not interact with the slowing laser, alowing the atoms to move freely out of the magnet.

In Fig. 2 we observe the atomic distribuition of sodium atoms along the two hyperfine states emerging from the slowing solenoid. It is clear that atoms in $S_{1/2}(F = 2)$ do not follow the magnetic field down to very low valves. However atoms that emerges in $S_{1/2}(F = 1)$ are consistent with been decelerated of following $B(z)$ down to very low values and after that been optically pumped to this state. In this paper we explore those facts in a systematic way.

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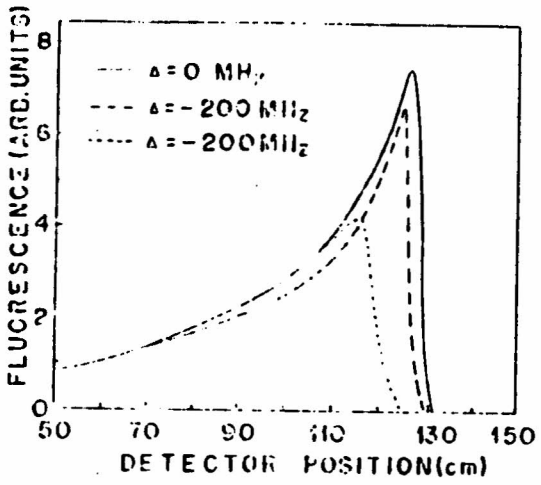

Fig.1. Fluorescence profile along the slowing magnet for different laser detunings

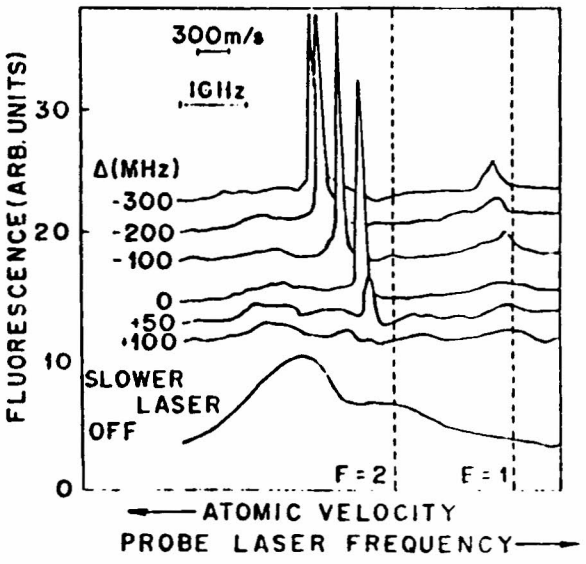

Fig. 2. Atomic velocity distribuition emerging from the slowing magnet.

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