Towards magnetic trapping of NH by buffer-gas cooling

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Loading of a magnetic trap by buffer-gas cooling has been established as a versatile method to trap paramagnetic atoms and molecules. It relies solely on elastic collisions (thermalization) of the species-to-be-trapped with a cryogenically cooled helium gas, independent of any particular energy level pattern [1]. In earlier work we trapped about $10^8$ cold ($\approx 400$ mK) CaH molecules (produced by laser ablation) [2]. Recently, we demonstrated loading of the cryogenic buffer-gas cell by a thermal beam, indicating that the number of cold molecules available for trapping could, in principle, be increased by several more orders of magnitude [3]. We estimate that as many as $10^{11}$ NH radicals can be trapped using an intense pulsed molecular beam.

The NH radical in the $(X^3\Sigma^-, v = 0, J = 1)$ ground-state is especially suited for magnetic trapping [4], because its $2\mu_B$ magnetic moment gives rise to a trap depth of $4$ K in a $3$ T quadrupole field. In addition, the transition to the $A^3\Pi_2, v = 0, J = 2$ state (lifetime $\tau \approx 450$ nsec, at $336$ nm, indicated in Fig. 1) allows for sensitive spectroscopic detection due to its large ($> 0.999$) Franck-Condon factor.

Trapping of cold NH molecules could allow for further promising experiments including evaporative cooling to the ultracold regime, determination of cold and ultracold elastic and inelastic scattering cross sections, the quest for a molecular BEC in $^{15}$NH and $^{13}$ND and for Fermi degeneracy in $^{14}$NH and $^{15}$ND, and the search for a BCS superfluid transition [5]. The efficacy of evaporative cooling remains to be seen as the relevant collision cross sections remain unknown.

An overview on the principle ideas and goals of the experiment, the experimental techniques involved, and the current status of the project will be given.

FIG. 1: Zeeman energies of the ground $(X^3\Sigma^-, v = 0, J = 1)$ and excited $(A^3\Pi_2, v = 0, J = 2)$ states of NH. The vertical dashed lines indicate transitions at $336$ nm which can be used for efficient spectroscopic detection.