Direct laser cooling of the BH molecule

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Ultracold polar molecules are of interest for a variety of applications [1], including tests of fundamental physics, ultracold chemistry, and simulation of many-body quantum systems. The laser cooling techniques that have been so successful in producing ultracold atoms are difficult to apply to molecules. The extra vibrational and rotational degrees of freedom make it difficult to find a closed system for optical cycling. Recently however, laser cooling has been applied successfully to a few molecular species [2–5], and a magneto-optical trap of SrF molecules has now been demonstrated [6]. We have investigated the BH molecule as a candidate for laser cooling [7]. We have produced a molecular beam of BH and have measured the branching ratios for the excited electronic state, $A^1\Pi(v'=0)$, to decay to the various vibrational states of the ground electronic state, $X^1\Sigma$. Our measured branching ratios are shown in figure 1. We verify that the branching ratio for the spin-forbidden transition to an intermediate triplet state is inconsequentially small. We measure the frequency of the lowest rotational transition of the X state, and the hyperfine structure in the relevant levels of both the X and A states, and determine the nuclear electric quadrupole and magnetic dipole coupling constants. Our results show that, with a relatively simple laser cooling scheme, a Zeeman slower and magneto-optical trap can be used to cool, slow and trap BH molecules.

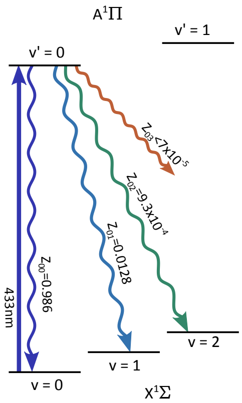

Figure 1: *Vibrational branching ratios, Z_{0n}, for the $A^1\Pi \rightarrow X^1\Sigma$ transition in BH.*

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