

Ultracold hydrogen and deuterium production via Doppler-cooled molecules

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Synopsis A scheme to produce ultracold hydrogen or deuterium atoms via photo-fragmentation, even allowing direct formation of a quantum gas

A counterintuitive scheme [1] to produce ultracold hydrogen via fragmentation of laser cooled diatomic hydrides is presented (figure 1) where the final atomic H temperature is inversely proportional to the mass of the molecular parent. In addition, the critical density for formation of a Bose-Einstein Condensate (BEC) at a fixed temperature is reduced by a factor $\left(\frac{m_H}{m_{MH}}\right)^{3/2}$ over directly cooled hydrogen atoms.

cooled to a Doppler temperature of $\sim 26 \mu\text{K}$ with just two rovibronic transitions (figure 2), the simplest molecular cooling scheme identified to date. Preparation of a hydrogen atom gas below the critical BEC temperature T_c is feasible with present cooling technology, with optical pulse initiation of the entire condensation process. As isotopic substitution does not alter the feasibility of laser cooling the parent molecule, this method can be used to produce ultracold deuterium atoms as well, a species yet to be brought to quantum degeneracy.

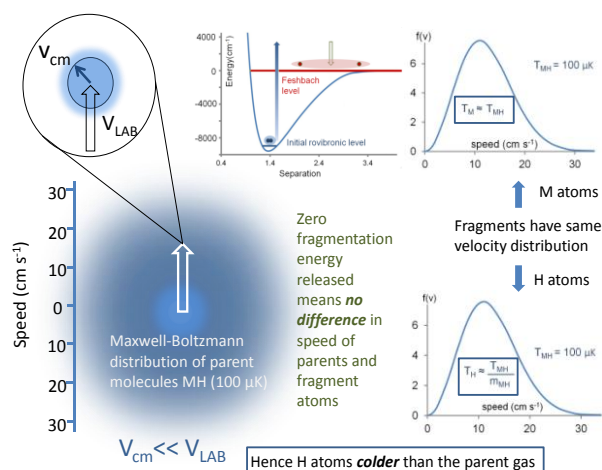


Figure 1. Outline of the production scheme.

The narrow Feshbach resonances between a $^1\text{S}_0$ atom and hydrogen are well suited to a tiny center of mass energy release necessary during fragmentation. With the support of *ab initio* quantum chemistry, it is demonstrated that BaH is an ideal diatomic precursor that can be laser

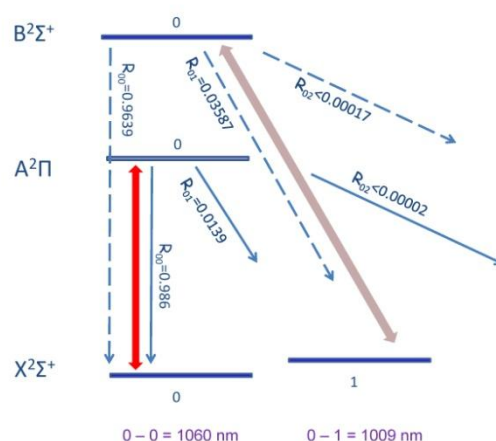


Figure 2. Two color laser scheme for BaH.

References

- [1] I. C. Lane, arXiv:1311.7081.

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