Spectroscopy of the Hydrogen 2S-nS/D Transitions at Colorado State University

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We will report on our ongoing measurements of the 2S-nS/D two-photon transitions in atomic hydrogen. The measurements feature a cryogenic ($\sim$ 5 K) beam of atomic hydrogen and preparation of the 2S state using the 1S-2S two-photon transition.

Previously, we had difficulty measuring transitions with natural linewidths below $\approx$ 500 kHz because the quickly varying light shifts as the atoms traversed the spectroscopy laser beam created distortions of the recovered lineshapes. Therefore, we had only previously measured the 2S-8$D_{5/2}$ transition with a natural linewidth of 572 kHz [1].

We have now introduced an auxiliary radiation field with a wavelength around 650 nm which is enhanced in the same optical cavity as the spectroscopy radiation. This additional field provides a nearly equal and opposite light shift which greatly mitigates the light shift. As shown in Fig. 1, this has allowed us to recover linewidths of $\approx$ 100 kHz for the 2S-nS transitions with $8 \leq n \leq 16$ [2]. The narrow recovered linewidths have provided for a valuable increase in our statistical signal to noise.

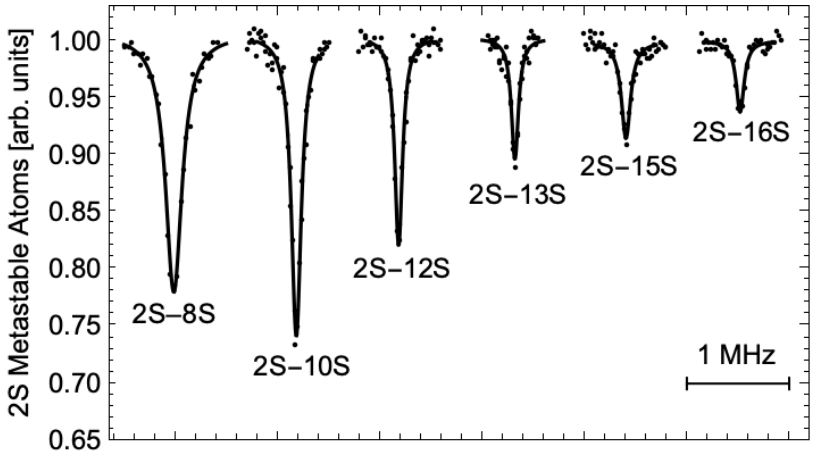

Figure 1: Recovered spectra for a selection of 2$S_{1/2}$-$nS_{1/2}$ two-photon transitions in atomic hydrogen with light shift mitigation. Spectra are obtained at different spectroscopy laser wavelengths but are plotted adjacent to one another for comparison.

We are now focused on characterizing systematic effects. Our new measurements feature active cancellation of stray electric fields, the ability to lower the temperature surrounding the spectroscopy region by around 50 K (to characterize shifts from blackbody radiation), and velocity characterization using a time-of-flight analysis. In addition, our ability to perform measurements on many 2S-nS/D transitions give us additional means to constrain possible systematic effects.

Acknowledgments

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References

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