The 5s→6s Stark shift measured via two-photon spectroscopy in laser-trapped rubidium

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Introduction
We have measured the Stark shift of the 5s→6s transition in ⁸⁷Rb using two-photon spectroscopy. Atoms are held in a magneto-optical trap (MOT) at the center of two optically-transparent electric field plates providing unhindered optical access for the MOT beams. The Stark shift was determined for electric fields from 0.350 kV/cm to 5.249 kV/cm. The 993 nm spectroscopy laser was referenced with a Pound-Drever-Hall frequency offset lock to a ULE cavity with a frequency stability better than 200 kHz/day. Although we are still evaluating systematic error, we so far find that our results are consistent with predictions from literature of the differential polarizability of this transition[1].

Experimental Procedure
1. ⁸⁷Rb is dispensed into magneto optical trap
   • Trap is maintained between electric field plates (Fig. 2)
2. 993 nm laser drives transition (Fig. 1) as wavelength is scanned
   • Frequency first scans upward, than downward
   • Laser intensity: ~3 W/mm²
   • Photons counted using PMT, correlated with wavelength (Fig. 3)
3. Measurement is repeated for several different electric fields

Example: 1.05 kV/cm Downward Scan

Data Analysis
• For each frequency sweep, a Lorentzian is fit to a counts/frequency plot (Fig. 3)
• The centroids of these fits are plotted against the square of the electric field applied to the atoms (Fig. 4)
• Separate plots are made for scans that moved the laser frequency from low to high (upward scans), and those in which the frequency went from high to low (downward scans)
• Reduced χ² of the linear fit of frequency shifts with respect to square of E-field is constrained to 1 by multiplying errors by constant amount, with error bars shown in Fig. 5 as solid lines.

The slope of these lines gives us the Stark shift, which is within one sigma of the theoretical determination of the this transition’s differential polarizability by Safronova et. al. We modelled the electric fields inside our science chamber and found significant dependence on the MOT’s position along the axis normal to the field plates. We assume an uncertainty in the MOT’s position of 3 mm and show the resulting uncertainty in the Stark shift as dashed lines in Fig. 5. Future work shall include further evaluation of possible systematic errors.

References

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