# Light-Shift Tomography of an Optical Dipole Trap

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Here we describe a technique for directly characterising an optical dipole trap called *light-shift tomography* [1]. The intense trapping light induces a significant AC Stark shift on the atoms, and if the trap wavelength is appropriately close to an excited state transition this shift is much stronger for the excited state than the ground state. In our experiment we use $^{87}$Rb and light at 1560 nm, which is close to the $5P_{3/2}$–$4D_{5/2}$ transition at 1529 nm. This proximity to an excited state transition strongly affects the polarisability of the excited state, and so the Stark shift is about 42 times stronger on the $5P_{3/2}$ excited state than the $5S_{1/2}$ ground state (Fig. 1). The differential light-shift means the resonance frequency of the atom is dependent on its position in the laser beam. By probing at different frequencies, one can 'see' atoms at different positions in the trap, and the probe detuning can be used to infer the local trapping light intensity. A measurement of the position of resonant atoms versus frequency effectively maps the isopotentials of the trap in-situ, from which one can reconstruct the trap shape, width, and depth (Fig. 2). This method also has the advantage of being able to measure non-harmonic potentials, unlike e.g. measuring trap frequencies. Here we present an explanation of this effect, our results in using this technique to make a 3D reconstruction of our trap, and point out some limitations and sources of systematic error. Specifically we found two major problems: 1) it is difficult to measure at the bottom of the trap due to the weak signal, and 2) as a result of the probe beam being off-resonant for most of the atomic cloud, a spatially-dependent phase shift leads to a lensing effect on the imaging beam which can distort measurements.

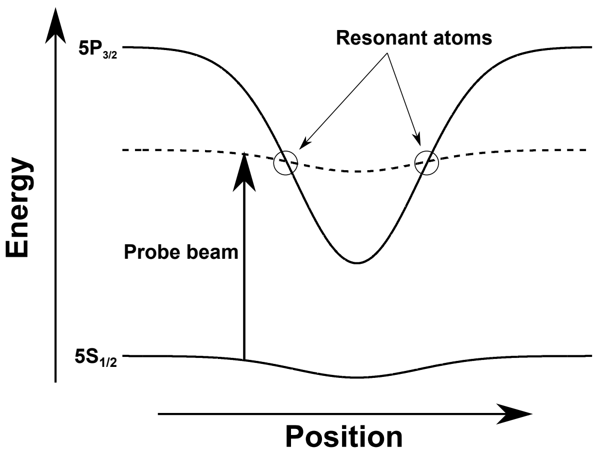


**Figure 1:** *Light-shift of a $^{87}$Rb atom in a 1560 nm Gaussian laser beam.*

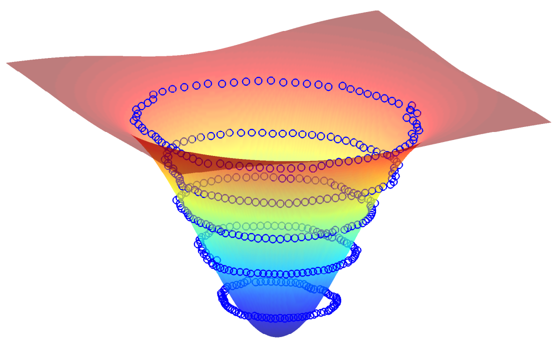

**Figure 2:** *Reconstructed crossed-dipole trap from measured isopotentials.*

**References**

[1] J. P. Brantut *et al.* PRA 031401 **78** (2008)