A 39

Search for a Permanent EDM in Diamagnetic Atoms

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At present the best limit on the EDM of a diamagnetic atom comes from an experiment in ^{199}Hg [1]

$$d_{^{199}Hg} < 8.7 \times 10^{-28}\,\mathrm{e\,cm} \quad (1)$$

This limit can be translated into limits on various extensions to the Standard Model, many of which are better than or comparable to the limits obtained from measurements in the neutron and paramagnetic atoms, like Tl.

We are working on the next generation ^{199}Hg EDM experiment. The sensitivity of the last measurement was limited by shot noise. We implemented several improvements which reduce the shot noise limit by at least a factor of 10. We constructed a UV laser for optical pumping at 254 nm. The light is produced by quadrupling the output of a high power single frequency diode laser at 1016 nm. We obtained $300\mu W$ of UV light, about 100 times more power than was used in the last experiment. Furthermore, using a collimated laser beam we can improve the collection efficiency of the light and use high QE photodiodes for detection. Larger pumping rate also allows us to increase the density of Hg atoms.

Construction of the cells containing ^{199}Hg represents a significant challenge. The cells have SnO electrodes and paraffin wall coating to reduce the spin relaxation of ^{199}Hg on the surface. We have succeeded in producing EDM cells with lifetimes up to 180 s, which represents a factor of 3 improvement. The dependence of the longitudinal spin relaxation rate on the magnetic field and temperature will be reported. These data are used to characterize the spin relaxation processes on the walls, which dominate the spin relaxation. We expect to begin taking EDM data in the near future.

We also began investigating the use of laser cooling and trapping techniques for EDM searches in diamagnetic atoms. A suitable trap for such experiments is a far-off-resonance dipole trap, which does not perturb the Zeeman transition frequency to first order [2]. Diamagnetic atoms offer an advantage in that the collision and light induced shifts of the Zeeman frequency are much smaller than in atoms with electron spin [3]. We calculated the shift due to the residual circular polarization of the dipole trapping light, second order AC and DC Stark shifts, and the shift due to the interference between E1 and M1/E2 transitions [4], which is linear in the applied static electric field. The calculations were performed for Cs and Hg, as examples of atoms with and without electron spin. The shifts are typically 5 orders of magnitude smaller for Hg than for Cs. In addition, for diamagnetic atoms with $I = 1/2$ (^{199}Hg, ^{171}Yb, for example) the second order Stark shift is absent.

We are pursuing laser cooling and trapping of ^{171}Yb, which has relatively easily accessible absorption lines (at 556 and 398 nm) and yet is sensitive to EDM effects. We have constructed an Yb beam apparatus and a doubling cavity to produce the light at 398 nm from a Ti-Sapphire laser. We are planning to slow Yb atoms and trap them in a MOT. Then the atoms will be loaded into a far-detuned dipole trap. The calculations of the light scattering rate indicate that the lifetime of atoms in the dipole trap should only be limited by the background pressure.

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