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14. ABSTRACT
In this project, we have built the new experiment setup to trap atoms in a CO2 optical dipole trap. The setup consists of a main chamber for the experiment, and a pumping region with the ion and titanium sublimation pumps. In the main chamber, we have installed an electron detector and an ion detector; the later will be able to obtain images of the atoms in the dipole trap. Recently, we have loaded the optical dipole trap from a magneto-optical trap to perform the proposed experiments.
We have also investigated the population transfer collisions involving nS+nS, nP+nP and nD+nD states after a delay of 100 ns following their excitation in a Rb MOT. In the literature, such process has been associated with a many body effect. However, we have proposed a recent theoretical model based on two body interaction and multipole contributions in collaboration with Prof. Shaffer from University of Oklahoma. We have also compared the results obtained in Brazil for Rubidium with the results from University of Oklahoma for Cesium. Several papers were published.

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Report to AFOSR

Cold Rydberg Atoms Trapped in a CO_2 Optical Lattice

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Final Report for FA9550-09-1-0503

Objective:

The main goal in this research is to build an experimental setup which will allow us to image the Rydberg atoms trapped in the CO_2 lattice.

I. Results

In the last three years, we have built a new experimental setup to study cold Rydberg atoms in a CO_2 dipole trap. Nowadays, we are able to load routinely about 10^6 atoms in the dipole trap at a density of 10^{12} cm^{-3} with a temperature of 20 μK. Using a pulsed dye laser at 480 nm, Rydberg states were excited up to n=45 in the dipole trap. Unfortunately, due to the low repetition rate of the dipole trap (one sample is produced every 10 s), it was very hard to synchronize it with the pulsed dye laser (20 Hz repetition rate). Such limitation is intrinsic of the Nd:YAG pumping laser electronics. Therefore, although we were able to excite the atoms in the dipole trap, we were unable to perform any experiment at all. To overcome such limitation, we have built a doubling cavity to obtain 480 nm CW through a grant from Fapesp (São Paulo State Science Foundation, http://www.fapesp.br/en/). In fig. 1a, we show the setup we have built in this project. We also show the fluorescence imaging of atoms into the CO_2 dipole trap.

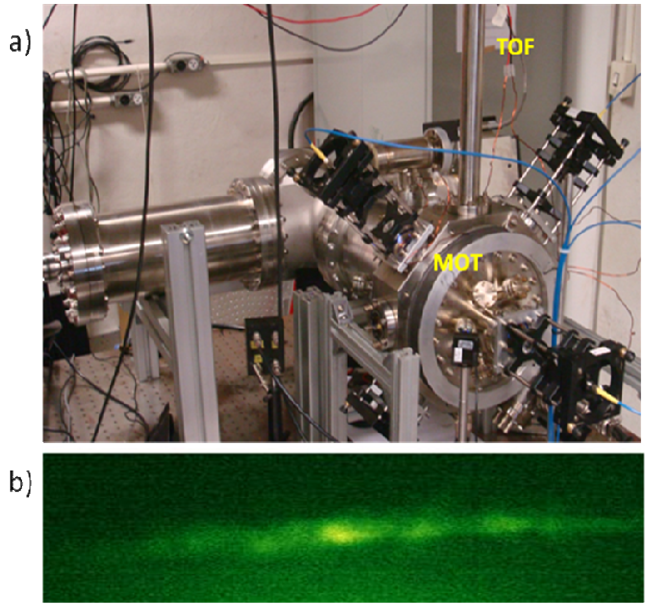

Fig. 1 – a) Dipole trap chamber, showing the MOT region and the ion time of flight region (in front of the MCP detector); b) Fluorescence image of atoms in our CO_2 dipole trap

In this period, we have also built and tested an ion imaging system. Now we are able to excite the Rydberg atoms and to ionize them using the pulsed field ionization technique (PFI). The ions, formed either in a MOT or a dipole trap, are image onto a MCP detector and a phosphorus screen. In fig. 2, we show typical images obtained in our system. Such images show the Rydberg atom spatial distribution, which is due to the overlap of the 780 nm laser beam and the 480 nm laser beam. The 480 nm pulsed laser presents a very bad spatial mode, which produces a very no-uniform ion spatial distribution as well. For this reason, we are still unable to reconstruct the ion distribution from the ion image on the phosphorus screen. In fig. 3, we show spatial ion distribution using the CW 480 nm laser excitation. In the coming months, we shall perform the planned experiments in our dipole trap.

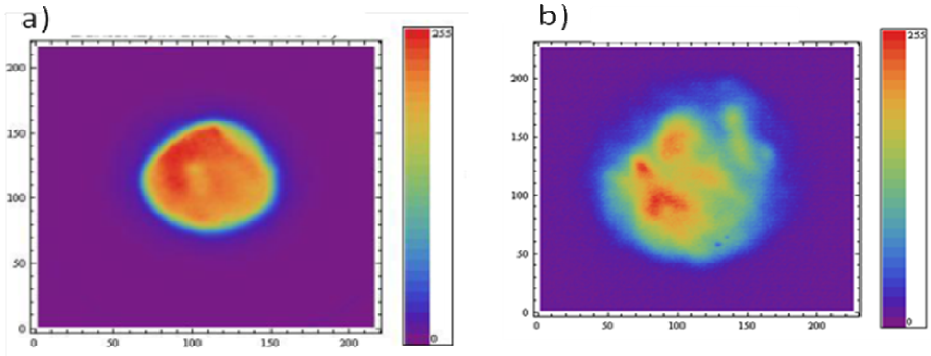

Fig.2 – Ion image from: a)MOT; b) CO_2 dipole trap.

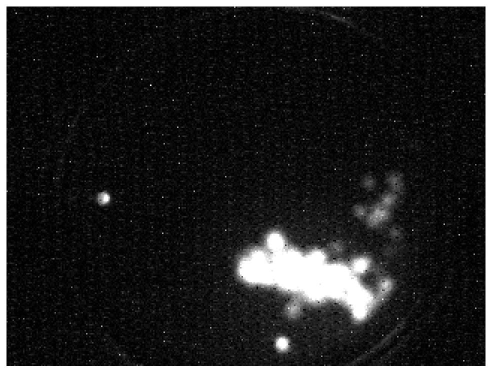

Fig.3 – Ion image from a MOT using a CW 480 nm excitation.

In order to stabilize the 480 nm laser, we have performed an electromagnetic induced transparency experiment in a cell. In fig. 4, we show a spectrum for the transition from $5P_{3/2}$ to $37D_{3/2,5/2}$.

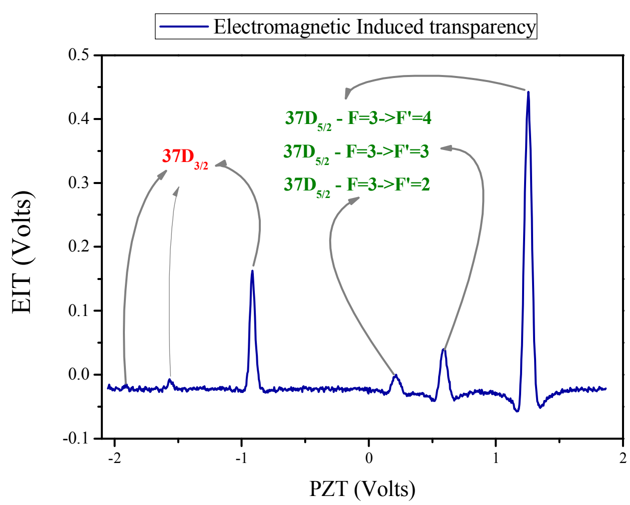

Fig.3 – EIT spectrum from $5P_{3/2}$ to $37D_{3/2,5/2}$.

We should emphasis that during this project, we have also developed a strong collaboration with Prof. Shaffer's group from University of Oklahoma. In collaboration with his group we have: i) Developed the ion imaging system; ii) Developed loading techniques for dipole traps; iii) Built a doubling cavity to produce 480 nm CW laser beam. As we were building our new setup, we have also collaborated with his group to understand cold Rydberg collisions involving nS+nS and nD+nD states in a Rubidium MOT.

Personnel Supported

List of personnel associated with the research:

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São Carlos, 10/September/2012

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