DAMOP09-2009-000010

Abstract for an Invited Paper
for the DAMOP09 Meeting of
the American Physical Society

Towards entanglement of two individual atoms using the Rydberg blockade

TATJANA WILK, Institut d'Optique in Palaiseau (France)

The Rydberg blockade is of great interest for many quantum information processing schemes, since it provides a way to deterministically entangle two or more atoms and to drive fast quantum gates [1]. Recently, experimental efforts into this direction succeeded in the first observation of the Rydberg blockade between two ^{87}Rb atoms individually trapped in two neighboring dipole traps [2,3]. Furthermore, in the two atom system the Rabi frequency for oscillations between the ground state $|gg\rangle$ and *one* atom in the Rydberg state is enhanced by $\sqrt{2}$ with respect to the Rabi frequency for a single atom [3]. This indicates the production of an entangled state $(|gr\rangle + e^{i\mathbf{k}\Delta\mathbf{r}}|rg\rangle)/\sqrt{2}$, where $\mathbf{k}$ is related to the wave vector of the exciting lasers and $\Delta\mathbf{r}$ is the distance between the atoms. The variation of the interatomic distance from shot-to-shot leads to a random phase in the produced entangled state. However, when the Rydberg state is mapped onto another ground state $|g'\rangle$ before the atoms move, this random phase cancels. The resulting entangled state $(|gg'\rangle + |g'g\rangle)/\sqrt{2}$ could then be tested in a Bell measurement or a state tomography. Rotations of the measurement basis are done with a pair of Raman lasers coupling $|g\rangle$ and $|g'\rangle$. The atomic state is read out observing the fluorescence of the remaining atoms after ejecting atoms in state $|g\rangle$ from the trap. The current status of the experiment will be reported.

[1] D. Jaksch et al., *Phys. Rev. Lett.* **85**, 2208 (2000). M.D. Lukin et al., *Phys. Rev. Lett.* **87**, 037901 (2001).
[2] E. Urban et al., *Nature Phys.* (2009)(accepted, see also *arxiv:0805.0758*).
[3] A. Gaëtan et al., *Nature Phys.* (2009) (accepted, see also *arxiv:0810.2960*).