Two-photon absorption by quantum interference

Min Yan, Edward Rickery, Yifu Zhu

Department of Physics, Florida International University
University Park, Miami, FL 33199, USA
Tel 305-348-4075, Fax 305-348-6700
E-mail: yifuzhu@fiu.edu, Website: http://www.fiu.edu/ yifuzhu

It has been shown that two-photon absorption can be controlled by quantum interference in the multiple excitation paths created by a coherent coupling field [1]. Recently, Harris and Yamamoto described a four-level system that utilizes electromagnetically induced transparency (EIT) to switch on and off the two-photon transition [2]. Because the cancellation of the one-photon absorption, the enhanced two-photon excitation may be observable under low light intensities.

We report an experimental demonstration of two-photon absorption enhanced by quantum interference via EIT in 87rubidium atoms cooled and trapped in a magneto-optical trap (MOT). The four-level system consists of the Rb D1 and D2 transitions in which a coupling laser drives the D1 F=2-F'=1 transition, a weak probe laser drives the D1 F=1-F'=1 transition, and a pump laser drives the D2 F=2-F'=3 transition. The coupling laser creates EIT, and the probe laser and the pump laser induce the two-photon absorption via constructive interference in the dressed state transitions. The experiment is carried out sequentially in time with a repetition rate of 5 Hz. For one period of 200 ms, the cooling and trapping of the Rb atoms lasts 199.6 ms in which a dark repump laser beam and six circularly polarized trap beams are used; the time duration of the two-photon absorption experiment lasts merely 0.4 ms in which a coupling laser is turned on, a probe laser is scanned across the D1 F=1-F'=1 transition, and the trap laser is used as the pump laser with its frequency shifted to the resonance of the D2 F=2-F'=3 transition. This experimental sequence assures that the trapped rubidium cloud is sufficiently stable during the two-photon experiment.

The experimental data show that the two-photon absorption is dramatically enhanced by the quantum interference and becomes even greater than the single-photon absorption of the Autler-Townes' doublet transitions with the coupling laser of moderate intensities. We have carried out theoretical calculations based on the density matrix equations of the four-level model system and obtained quantitative agreement between the theory and the experiment.

Acknowledgment. This work is supported by the National Science Foundation and the U. S. Army Research Office.

[1] G. S. Agarwal and W. Harshawardhan, *Phys. Rev. Lett.* **77** 1039 (1996).
[2] S. E. Harris and Y. Yamamoto, *Phys. Rev. Lett.* **81** 3611 (1998).