Stony Brook University
The Graduate School

Doctoral Defense Announcement

Abstract

Stimulated Raman Adiabatic Passage between Metastable and Rydberg States of Helium

By

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We investigate the coherent population transfer and associated effects for a three level atomic system, with the third level being a Rydberg state. The scheme adopted here is the stimulated Raman adiabatic passage (STIRAP). An atomic beam of metastable helium is orthogonally crossing two laser beams in a tunable dc electric field. The ir laser of 790 - 830 nm connects the triplet 3P state to the Rydberg states (n = 12 - 50) and the uv laser of 389 nm connects the metastable triplet 2S state to the triplet 3P state. A third laser of 1083 nm driving 2S-2P transition is applied downstream, providing a strong bichromatic force on the atoms remaining in the 2S state to deflect them, establishing the absolute count of Rydberg atoms. Rydberg atoms can be ionized by background thermal radiations at room temperature and it is observed in this experiment. This fact actually enables precise measurement, especially spectroscopy, of Rydberg atoms by simply looking at the ions, which are easy to detect. It is also confirmed that background thermal radiation could significantly redistribute the population between neighboring Rydberg states. The 2S, 3P and the final Rydberg states all have magnetic sub-levels, hence the linkage pattern of the excitation has non-trivial crossings, if the polarizations of the two lasers are not parallel to each other. Those phase differences in different excitation paths induced by the laser polarizations can lead to interference which would determine the excitation probability and the polarization of the excited atom. Theoretical calculations predict interesting interference patterns as a function of laser polarizations and Rabi frequencies. Those interference structures have been experimentally observed. Transverse velocity distribution in the atomic beam turns out to be a limiting factor in the efficiency of production of Rydberg atoms. The transverse velocity of an atom can not only induce one-photon detuning but also two-photon detuning, which could effectively reduce the STIRAP process efficiency. By adding a laser to make Doppler molasses in the transverse direction, we can heat or cool the atomic beam transversely and verify this effect.

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