Breakdown of stabilization of atoms interacting with intense, high frequency laser pulses

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Theoretical studies of atoms interacting with intense, high-frequency laser pulses have predicted a significant decrease in the ionization probability with increasing laser intensities. This phenomena is referred to as atomic stabilization, and has been extensively studied over the past decade [1]. The majority of studies have relied on nonrelativistic quantum mechanical approaches that employ the dipole approximation. However, at extremely high intensities, relativistic and non-dipole effects have the potential to alter the stabilization dynamics. We have investigated the laser-atom dynamics in the stabilization regime beyond the dipole approximation [2]. We demonstrate that stabilization breaks down at relatively modest laser intensities, i.e. at intensities where the laser-atom interaction can be described by the non-relativistic Schrödinger equation. In particular, we show that the dipole approximation leads to survival probabilities which are too large The magnetic field, neglected in the dipole approximation, strongly influences the stabilization dynamics, thereby restricting considerably the intensity regime in which the atom is stable against ionization. Counter propagating pulses do not negate the detrimental effects of the magnetic field. By comparing our results with those obtained from classical Monte Carlo simulations, we confirm the validity of classical approaches in describing atoms interacting with short, intense, high-frequency laser pulses.

[1] For reviews, see C. J. Joachain, M. Dörr and N. J. Kylstra, Adv. At. Mol. Opt. Phys. **42**, 225 (2000); M. Protopapas, C. H. Keitel and P. L. Knight, Rep. Progr. Phys. **60**, 389 (1997).

[2] N. J. Kylstra, R. A. Worthington, A. Patel, P. L. Knight, J. R. Vázquez de Aldana and L. Roso, submitted (2000).