Acceleration and twisting of neutral atoms
by strong elliptically polarized short-wavelength laser pulses

Vladimir S. Melezhik, Sara Shadmehri
Joint Institute for Nuclear Research, Dubna, Russia
melezhik@theor.jinr.ru

We have investigated non-dipole effects in the interaction of a hydrogen atom with elliptically polarized laser pulses of 10^{14} W/cm^2 about 8 fs duration. The study was performed within the framework of a hybrid quantum-quasiclassical approach in which the time-dependent Schroedinger equation for an electron and the classical Hamilton equations for the center-of-mass (CM) of an atom are simultaneously integrated [1]. It is shown that the spatial inhomogeneity **kr** of the laser field and the presence of a magnetic component in it lead to the non-separability of the CM and electron variables in a neutral atom and, as a consequence, to its acceleration [1,2]. We have established a strict correlation between the total probability of excitation and ionization of an atom and the velocity of its CM acquired as a result of interaction with a laser pulse. The acceleration of the atom weakly depends on the polarization of the laser in the considered region (5 eV $\lesssim \hbar\omega \lesssim$ 27 eV) of its frequencies. However, the transition from linear to elliptical laser polarization leads to the twisting of the atom relative to the axis directed along the propagation of the pulse (coinciding with the direction of the momentum of the accelerated atom). It is shown that with increasing ellipticity the twisting effect increases and reaches its maximum value with circular polarization, at this point the projection of the orbital angular momentum acquired by the electron onto the pulse propagation reaches its maximum value. Further exploration of the possibilities for producing accelerated and twisted atoms with electromagnetic pulses is of interest for a number of prospective applications.

[1] V.S. Melezhik, Quantum-quasiclassical analysis of center-of-mass nonseparability in hydrogen atom stimulated by strong laser fields. J. of Phys. A56 (2023) 154003.
[2] V.S. Melezhik and S. Shadmehri, Acceleration of neutral atoms by strong short-wavelength short-range electromagnetic pulses. Photonics 10 (2023) 1290.