ACCELERATION OF NEUTRAL ATOMS BY STRONG SHORT-WAVELENGTH SHORT-RANG ELECTROMAGNETIC PULSES

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Non-dipole corrections in the interaction of an atom with laser radiation, which arise when taking into account the spatial inhomogeneity **kr**=ky of the electromagnetic wave and the presence of a magnetic component in it, lead to “entanglement” of the variables of the center of mass (CM) and electrons in a neutral atom and, as a consequence, to its acceleration. We studied this effect, as well as the accompanying processes of excitation and ionization of the hydrogen atom in strong (10^{12} - 2×10^{14}) W/cm^2 linearly polarized short-wave (5 eV ≤ hν ≤ 27 eV) electromagnetic pulses with a duration of about 8 fs. The study was carried out within the framework of a hybrid quantum-quasiclassical approach [1], in which the coupled time-dependent Schrödinger equation for the electron and the classical Hamilton equations for the CM of the atom are simultaneously integrated [2]. A strong correlation was discovered between the velocity (momentum) of the CM of the atom V_y (MV_y) at the end of the laser pulse and the total probability P_{ex}+P_{ion} of excitation and ionization of the atom (see Fig. 1). Two mechanisms of atomic acceleration have been established: through single-photon and two-photon excitation of the atom. It is shown that the one-photon mechanism leads to a linear dependence of the atomic velocity at the end of the laser pulse on the laser intensity, and the two-photon mechanism leads to a quadratic dependence (see Fig. 1). Optimal conditions for the frequency and intensity of the electromagnetic wave were found for the acceleration of atoms without their noticeable ionization in the studied range of changes in laser parameters [2].

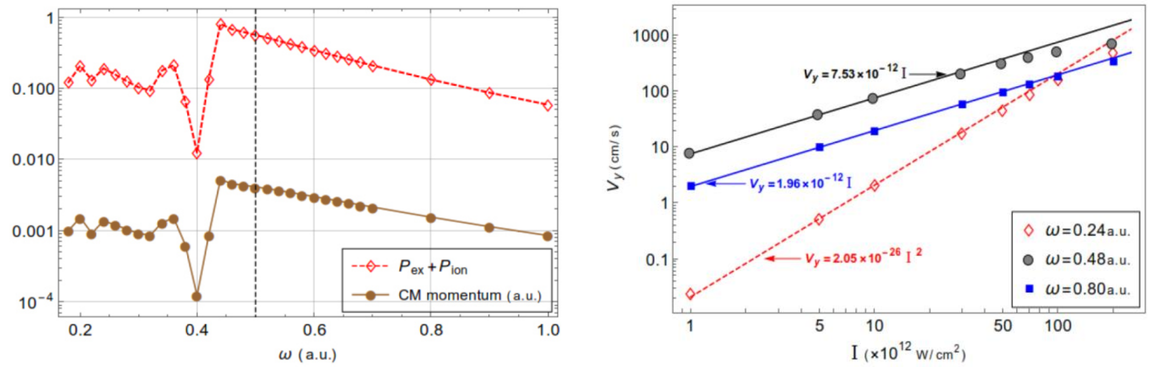

Fig. 1. Calculated dependencies of the total probability $P_{ex} + P_{ion}$ of excitation and ionization and the momentum of the CM of the atom MV_y on the laser frequency ω at I=10^{14} W/cm^2 (left figure) and the velocity of the CM of the atom V_y on the laser intensity I for single-photon (ω=0.48a.u. and 0.8a.u.) and two-photon (ω=0.24a.u.) mechanisms of atomic acceleration (right figure) [2].

References

[1]. Melezhik V. S. J. Phys. A 56 154003-1-15 (2023).

[2]. Melezhik V. S., Shadmehri S. Photonics 10 (12) 1290-1-11 (2023).