ACCELERATION/DECELERATION OF ATOMS BY CIRCULARLY POLARIZED LASER PULSES

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We discuss the m-photon resonance mechanism proposed in our recent work [1]

$$H_{n=1} + m(\hbar\omega) \rightarrow H_{n'}\ , \quad m(\hbar\omega)=1/(2n) - 1/(2n')$$

for twisting atoms by a circularly polarized laser pulse with the transfer of photon helicity to them. It is shown that when interacting with a circularly right-polarized electromagnetic pulse, the atom accelerates/ decelerates and twists - it acquires an orbital momentum with a projection $L_z=m\hbar$ on the direction of its motion (see Fig. 1). The proposed method of twisting atoms opens up new possibilities here compared to traditional methods using fork-shaped diffraction gratings developed for elementary particles (photons and electrons), but requiring significant modifications for twisting composite particles (protons, neutrons and atoms). In this regard, it should be noted that, despite the almost thirty-year history of experimental studies of twisted photons and electrons, obtaining twisted atoms represents a difficult experimental task. So far, only one experiment has been carried out in which twisted helium atoms were obtained using a specially designed diffraction grating [2].

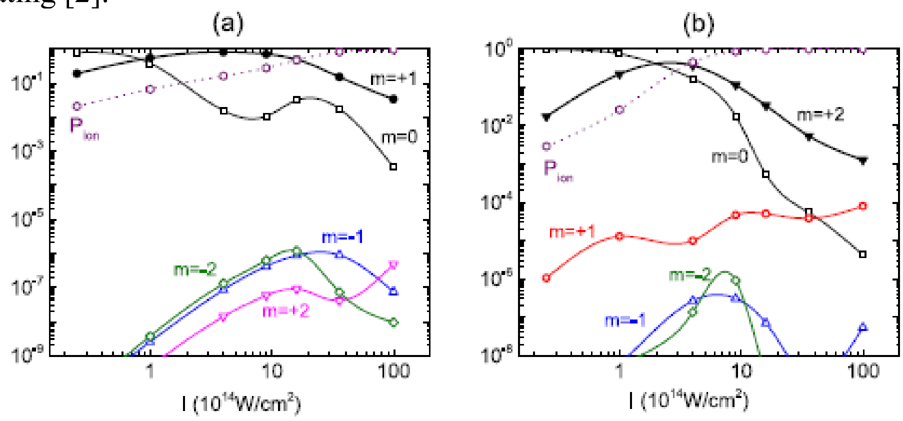

Fig. 1. Calculated dependences on the intensity (I) and laser frequency (ω) of the populations $P_m(I,\omega)$ of states with a fixed value $m\hbar$ of the projection of the orbital momentum of the hydrogen atom onto the direction of propagation of the laser pulse after the interaction of the atom with circularly right-handed polarized laser radiation of duration 8 fs. The calculation was performed for two resonant frequencies ω=0.48 a.u. (a) and 0.24 a.u. (b) [1]. The calculated probabilities of the competing ionization process of the atom $P_{ion}(I,\omega)$ are also given.

References

[1]. Melezhik V.S., Shadmehri S. *J. Chem. Phys.* **162**, 174304 (2025).

[2]. Luski A. et.al. *Science* **373**, 1105 (2021).