Lithium atom photoionization by ultrashort photo-pulse

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Synopsis The probabilities of photoionization of the lithium atom by ultrashort laser field were evaluated on base of developed trajectory method.

The process of photoionization of the lithium atom in ultrashort laser field was considered. The trajectory-based method for evaluating transition probabilities developed in [1-6] is in the core of our computations. The method is nonperturbative and take into account all orders of multiphoton and recollision processes.

The photoionization probabilities for several ionization multiplicities were calculated in a wide range of field frequencies and intensities. The frequency range corresponded to photon energies of 8 eV – 8 KeV and wavelengths of 1 – 1500 Å. The range of the field magnitudes corresponded to energy flux densities of 10^6 – 10^{25} W/cm^2. This is unique capabilities compared to the other methods.

We employ a relativistic Hamilton's function. We consider a plane-wave photo-pulse with linear polarization and a Gaussian modulation. Atomic units are used if not stated otherwise.

The results of calculations of the lithium atom photoionization probability dependence on the field magnitude are shown in Fig. 1. Lines 1–4 correspond to the total, single, double and triple ionization respectively. The magnitude of the field is represented by the dimensionless Faisal parameter $\chi = eA/p_0 c$ (where A is vector potential amplitude and $p_0 = \hbar/a_0$). If $\omega\tau >> 1$ then $\chi \sim 1/\gamma$, where γ is the adiabatic Keldysh parameter. The rang of Faisal parameter $\chi << 1$ corresponds to a weak field, $\chi \sim 1$ corresponds to an intermediate field, $1 < \chi < c$ corresponds to a strong superatomic field, but with lower than relativistic intensities, and $c < \chi$ – to a field with relativistic intensity. Note that electron momentum p_0 characterize the valence shell. The inner K shell is characterized by the electron momentum Zp_0, where Z is an atomic number. So a weak an intermediate and a strong superatomic fields in this case are respectively $\chi << Z$, $\chi \sim Z$ and $Z < \chi$. For lithium atom $Z = 3$. The calculations are presented for the frequency of the radiation field of $\omega = 30$ (~0.8 KeV) and the photon-pulse duration of $\tau = 30$ (~0.8 fs).

It should be mentioned that hardly any data on the probability of photoionization of lithium atom in a strong field can be found in the literature. In contrast to hydrogen and helium atoms, calculations for lithium based on direct numerical solution of the nonstationary Schrödinger equation (TDSE) are beyond current computational capabilities. TDSE calculations for the lithium atom were carried out in [7] for the case of simplified one-dimensional model.

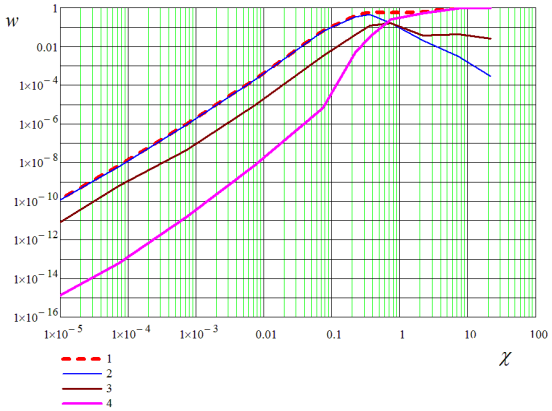

Figure 1. Lithium atom photoionization probability dependence on Faisal parameter

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