Numerical modeling of atomic and nuclear systems in an intense laser field and resonance phenomena in heavy ions collisions

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We present new numrical approach for studying interaction of the finite Fermi systems (atoms, nuclei) with an intense external fields (electric and laser fields). It is the combined relativistic operator perturbation theory (OPT) and energy formalism [1]. The OPT formalism includes a new quantization procedures of states for finite Fermi-systems in a strong field. The zeroth order Hamiltonian H of this PT possesses stationary bound and scattering states. To overcome formal difficulties, the zeroth order Hamiltonian was defined by the set of the orthogonal eigen values and eigen functions without specifying the explicit form of the 0th potential. The special computer code is carried out (PC complex "Superatom"). New data on the DC, AC strong field Stark resonances, multi-photon and autoionization resonances, ionization profiles for several few-body atomic (H, He, Li etc) and heavy atomic (Tm, Gd) systems are presented and compared with some other known theories (c.f.[1]). It has been discovered a significant broadening effect of the autoionization resonances in a sufficiently weak electric (laser) field for uranium atom.We present the results on the AC Stark shifts of single proton states in the nuclei ^{16}O, ^{168}Er and compared these data with known results by Keitel et al [3]. New data are also listed for the ^{57}Fe,^{171}Yb nuclei. Shifts of several keV are reached at intensities of roughly 10^{34} W/cm^2 for O and 10^{32} W/cm^2 for heavier nuclei. Lower excitations of even parity are possible in the two- or higher-order photon processes, and their energies are still more than 20 keV above the ground state energy.

Further a new unified quantum approach (OPT formalism, energy approach) [1] is used for numerical modeling the electron-positron pair production (EPPP) in the heavy nuclei collisions and treating a compound nucleus in an extreme electric field. Heavy ions collisions near the Coulomb barrier are surrounded by existence of narrow e+ line in a positron spectra [1,2]. The positron spectrum narrow peaks as a spectrum of the resonance states of compound super heavy nucleus are treated. The nuclear and electron subsystems are considered as two parts of the complicated system, interacting with each other through the model potential. The nuclear system dynamics is treated within the Dirac equation with an effective potential. All the spontaneous decay or the new particle (particles) production processes are excluded in the 0th order. The calculation results for cross-sections at different collision energies for ^{238}U+^{238}U, ^{232}Th+^{250}Cf systems are presented.

References

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