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Non-perturbative relativistic calculations of electronic quantum dynamics in low-energy ion-atom collisions

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Heavy-ion collisions play a very important role in studying of relativistic quantum dynamics of electrons in the presence of strong electromagnetic fields [J. Eichler and W. E. Meyerhof, Relativistic Atomic Collisions, (Academic Press, New York, 1995)]. What is more, if the total charge of the colliding nuclei is larger than the critical one, Z1 + Z2 > 173, such collisions can provide a unique tool for tests of quantum electrodynamic effects at the supercritical fields [W. Greiner, B. Mueller, J. Rafelski, Quantum Electrodynamics of Strong Fields, (Springer-Verlag, Berlin, 1985); Proceedings of the Memorial Symposium for Gerhard Soff, Ed.: W. Greiner and J. Reinhardt, (EP Systema, Budapest, 2005)]. In oder to investigate of these effects one have to be able to describe in details the relativistic quantum dynamics of electrons in low-energy ion-atom collisions. Realization of FAIR project and particular CRYRING at the present GSI SIS18/ESR facility will open novel and unique physics opportunities with large discovery potential for studying low-energy heavy ion-atom collisions.

In the work we present results of non-perturbative relativistic calculations of electronic quantum dynamics in low-energy ion-atom collisions. Method of calculations is based on the independent particle model, where the effective many-particle Hamiltonian is approximated by a sum of single-particle Hamiltonians reducing the electronic many-particle problem to a set of single-particle equations for all electrons in the collision system. Dirac-Kohn-Sham operator is taken as effective sigle-electron Hamiltonian. Solving of the effective single-particle equations is based on coupled-channel approach with atomic-like Dirac-Sturm-Fock orbitals, localized at the ions (atoms) [I.I. Tupitsyn et al., Phys. Rev. A 82 (2010) 042701; 85 (2012) 032712; Y.S. Kozhedub et al., Phys. Scr. T156 (2013) 014053.] Many-particle probabilities are calculated in terms of single-particle amplitudes employing the formalism of inclusive probabilities [H.J. Luedde and R.M. Dreizler, J. Phys. B 18 (1985) 107; P.Kuerpick, H.J.Luedde, Comput. Phys. Commun. 75 (1993) 127]. Calculations are performed for systems already studied experimentally and theoretically Ne–Ne^{9+}, Ar–S^{15+}, as well as for systems Xe–Xe$^{52+-54+}$, Xe—Bi^{83+}, which experimental research is planed at GSI in the nearest future. The role of relativistic and many-particles effects is analyzed.

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