Electron-positron pair creation in collisions of heavy bare nuclei: One-center approach

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Synopsis The probabilities and cross sections of electron-positron pair creation in low-energy collisions of heavy bare nuclei are calculated. The calculations are performed in the framework of the one-center approach.

Low-energy heavy-ion collisions provide a unique tool for investigation of quantum electrodynamics in presence of the supercritical electromagnetic field [1]. To date nonperturbative calculations of the electron-positron pair creation are mainly confined within the monopole approximation [2, 3], in which the spherically symmetric part of the two-center potential is considered in the center-of-mass frame. In the present work we perform nonperturbative calculations of the electron-positron pair creation in the frame centered at one of the nuclei. The calculation method is based on numerical solution of time-dependent Dirac equation in the basis of eigenfunctions of the static one-center Hamiltonian. These eigenfunctions are obtained by using the dual kinetic balance method [4] with B-splines as the basis functions.

As the first step, we calculated the probabilities of the electron-positron pair creation in the monopole approximation, with an electron being captured into the $1s$ state of the target nucleus. In order to take into account electron capture by the projectile nucleus, the obtained values were multiplied by two. In Table 1, the obtained results for the U^{92+}–U^{92+} collision at 6.2 MeV/u collision energy are compared with the data of Ref. [3]. Despite the fact that Ref. [3] presents the probabilities of the pair creation with an electron captured into all bound states, this comparison is well justified because the ground state gives the dominant contribution to the pair creation probability. As one can see from Table 1, our results are in a reasonable agreement with the data in Ref. [3].

Within the approximation under consideration, we have also calculated the cross section of the electron-positron pair creation in the U^{92+}–U^{92+} collision for the relative ion velocity $v = 0.1c$, where c is the speed of light. The obtained value is several times smaller than the one given by a rough estimate in Ref. [5]. Now we are working on the calculations of the pair-creation probabilities and the cross sections beyond the monopole approximation. The results of these calculations will be presented at the conference.

Table 1. Probability of the electron-positron pair creation in the collision of bare uranium nuclei as a function of the impact parameter b. The projectile energy is 6.2 MeV/u and the nuclear trajectory is of the Rutherford type.

b (fm)	This work	Maltsev *et al.* [3]
0	1.14×10^{-2}	1.25×10^{-2}
5	9.60×10^{-3}	1.05×10^{-2}
10	6.48×10^{-3}	7.03×10^{-3}
15	4.08×10^{-3}	4.39×10^{-3}
20	2.54×10^{-3}	2.70×10^{-3}
25	1.57×10^{-3}	1.66×10^{-3}
30	9.86×10^{-4}	1.03×10^{-3}
40	3.94×10^{-4}	4.09×10^{-4}

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References

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