DYNAMICAL CHAOS IN THE PENETRATION OF RELATIVISTIC HEAVY ION THROUGH MATTER

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Interaction of charged particle beams with matter is one of the important problems of contemporary physics [1-4]. Various processes occurring in the penetration of highly charged ions through solids is still attracting attention of various areas as atomic collision physics and dynamical chaology [2,3]. Chaotic nature of the projectile electron scattering process in the motion of highly charged ions in the solid makes this system an interesting object both classical and quantum chaology. The interaction of the fast charged particles with an electron gas causes a coherent electron displacement. This feature of a strongly anisotrophic distribution of the dynamical screening charge dates back to Bohr [6], who referred to this phenomenon as "wake" behind the charged particle. An explicit expression for the wake was first given by Neufelf and Ritchie [7-9]. The "wake" shows a series of domains with alternately enhanced and depleted electron density relative to the mean density of the medium. Accordingly, the electrostatic potential ("wake potential") exhibits in addition to a monotonic decay as a function of distance an oscillatory feature: domains of enhancement create regions of negative electric potential, whereas density depletion gives rise to a positive potential [4]. In this work we investigate the chaotization problem by solving the relativistic Hamiltonian equation of motion which include two types of relativistic motion: the relativistic motion of heavy ion and relativistic motion of ion's electrons. The phase-space portrait of the considered system is plotted. Thus the system to be considered is electron moving in the field of two potentials: the Coulomb potential V_0 and dynamical screening potential V_1 produced by the displaced electron density. The total potential $V_0 + V_1$ is called wake potential. Dynamical screening potential can be written as [3]

$$V_1 = \tfrac{4\pi}{k^2} F(k,\omega) V_0 ,$$

where $F(k,\omega) = n_s / V_0$.

The total potential can be rep-resented as [3,4]

$$V = \tfrac{1}{\varepsilon(k,\omega)} V_0 ,$$

here

$$\varepsilon(k,\omega) = 1 - \tfrac{4\pi}{k^2} F(k,\omega) + 4\pi F(k,\omega) ,$$

and

$$V_0 = Q \frac{\delta(\omega - k\vartheta_p)}{2\pi k^2} ,$$

being the Coulomb potential in the Fourier transformed representation. Then the Hamiltonian of the system is (the system of units $m_e = \hbar = c = 1$ is used)

$$H = \sqrt{P^2 + 1} + V .$$

The equations of motion describing the electron motion in the wake potential are the Hamiltonian equations:

$$\frac{\partial H}{\partial p} = -\frac{dx}{dt}, \tag{1}$$

$$\frac{\partial H}{\partial x} = \frac{dp}{dt}. \tag{2}$$

Solving these equations numerically we obtain phase-space portrait of the chaotization of the relativistic electron motion in the wake potential. The phase-space portraits (Poincare surface section) are in the Figs. 1 and 2 for relativistic and nonrelativistic cases, respectively. As is seen from this figures, in the relativistic case the electron motion in the wake potential is more chaotic than in the nonrelativistic case. This could be related with the fact that in the relativistic case equations of motion are more nonlinear than in nonrelativistic case.

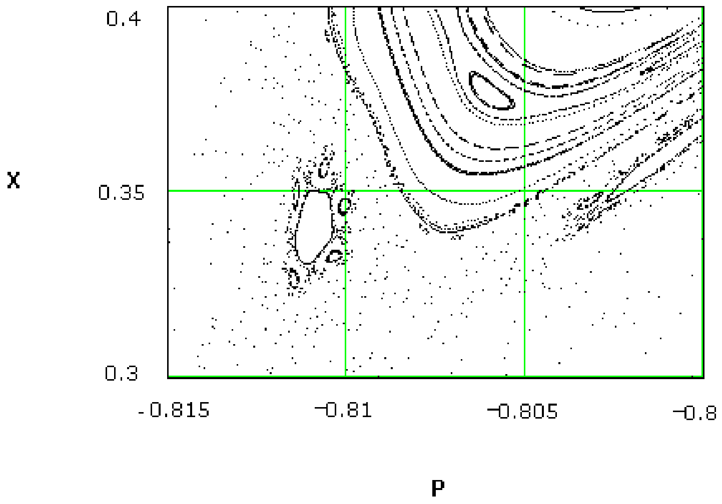

FIG 1. Poincare surface of section (X-P plane) for the motion near the projectile. Initial conditions n=40, l_z=1, 1≤ l_i ≤3.6;

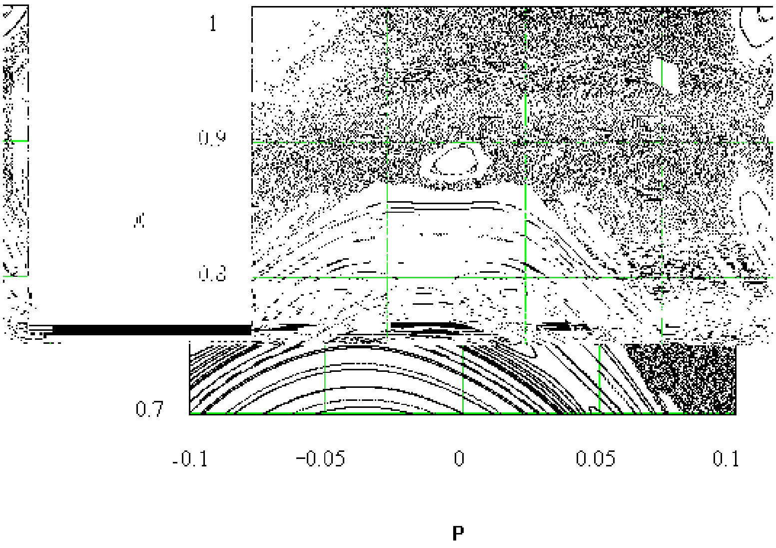

FIG 2. Poincare surface of section (X-P plane) for the motion near the projectile. Initial conditions n=40, l_z=1, 1≤ l_i ≤3.6; (Relativistic case)

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