Verification of the computer model for the simulation of ION-optical systems

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Calculation of the charged particle trajectories in the given electrostatic fields is a complex task. The axisymmetrical problems are considered. The first step is to find the solution of the Poisson equation with the boundary conditions defined on the boundaries of complex shape (the right hand side of the Poisson equation is equal to zero). The electric potential and electric fields are calculated. In the work this equation is solved numerically using the steady-state method and finite volume method. The mesh is unstructured with triangular elements [1].

The second step is to calculate the trajectories of the charged particles. In order to do this it is necessary to interpolate the electric fields (calculated at the previous step and attributed to the baricenters of the triangular mesh elements) to the position of the particles. Boris method is used for the solution of the equations of motion of the particles [2]. However, it is important to remember that the movement of the charged particles could be relativistic.

Due to the complexity of the problem it is necessary to perform the verification calculations. In the work several examples are solved numerically using the programs like SIMION and CPO and our code. The obtained results are compared and reasonable agreement is found for all of the considered problems.

In the second part of the work the influence of the space charge of the accelerated particle bunch on the distribution of the electric potential and fields in the system is taken into account. In order to achieve this it was necessary to calculate the charge density in the baricenteres of the triangular mesh elements and solve the Poisson equation with the corresponding right hand side (therefore the PIC method was developed). The verification of the mentioned approach was achieved by modeling the volt-ampere characteristic of the ideal diode operating in the space-charge limited regime (Child-Langmuir law).

The computer codes verificated in the work could be used for the analysis of various ion-optical systems as well as constituent parts for the development of kinetic model of plasma based on the particles-in-cell method.

References

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