Introduction

The mathematical model is discussed for the description of relativistic electron beam dynamics in rarefied plasma. Such model may be applied for the analysis of the relativistic electron beam (REB) behavior in conventional and novel accelerators. The study of the peculiarities of REB behavior in rarefied plasma may be useful for some tasks of space physics too.

The character of the beam interaction with rarefied plasma depends on the relations between the densities of the beam and plasma, on energy of the beam, its geometry and some other parameters. Here we consider the case of the beam current before the Alvén limit. Mathematical model is based on the method of Vlasov equation solution which represents the kinetic distribution function as a function of integrals of particle motion [1]. Modified model is used to study the beam oscillations before the state of the pinch [2].

Numerical solution of the equation for relativistic electron beam radius oscillations

Equation 1 describes the oscillations of the relativistic electron beam interacting with rarefied plasma before the pinch.

\[
\sqrt{1 + \frac{R'^2}{2} + \frac{\varepsilon^2}{2R^2}} dz = \left( R^0 \sqrt{1 + \frac{R'^2}{2} + \frac{\varepsilon^2}{2R^2}} + \frac{i}{R} \right) - \frac{\varepsilon^2}{R^3} = 0
\]  

The beam with axial-symmetrical geometry is considered. The equation of the beam radius oscillations is nonlinear and requires the numerical solution. Solution of the Eq.1 was obtained by means of MATLAB.

The Figures 1 and 2 illustrate the evolution of the relativistic electron beam radius with time for different initial conditions, obtained by means of numerical solution of the Eq.1. Fig.1 illustrates the betatron oscillations of the beam radius for the case of the beam current far from Alfvén limit. Fig.2 illustrates the case of strong current near the limit of the model application.

CONCLUSIONS

The mathematical model based on exact solution of the Vlasov equation is used to predict the dynamics of relativistic electron beam in rarefied plasma. The case of axial-symmetric beam with the current before Alfvén limit is considered. Dynamics of such beam is essentially nonlinear. The equation for the beam radius is solved numerically with the help of MATLAB. The analytical model considered allows to predict the beam behavior with most physical generality and scalability. The results obtained show the scale of the beam oscillations dependent on the initial beam parameters and determine the limits of the model applications.

References