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ハイブリッドコードを用いた相対論的電子ビーム伝播の解析

Analysis of a relativistic electron beam transport using a hybrid code

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A relativistic electron transport in a high density plasma is one of the important issues in plasma physics. Especially, such energetic electrons play a central role in a fast ignition scheme in a laser fusion program. When an ultra-short extremely powerful laser is irradiated on a high density target, a bunch of relativistic electrons are generated and pass through the highly compressed plasma region. The energetic electrons heat up a compressed fuel and they initiate the fuel burning.

One of the problems in the analysis of the electron beam transport in a high density plasma is the large density ratio between the beam electron and background plasma. In the fast ignition scheme, for instance, the density of beam electrons is about the critical density of the incident laser, the order of $10^{21}cm^{-3}$, while the background plasma density is 100-1000 times higher than the critical density. If we analyze the phenomena by using particle-in-cell (PIC) simulation, huge amount of numerical particles should be used to express the entire plasma system, since sufficient number of particles must be used to the description of beam electrons.

In order to solve the problem, we have proposed a hybrid description for the analysis of the electron beam transport in a high density plasma. Our simulation code couples PIC code and fluid codes. The dilute electron beam is described by PIC calculation in order to retain the kinetic properties of electrons, while the background plasmas, both ions and electrons, are described as fluids. The fluid description for the background plasma is valid because the density of the background plasmas is high and they are supposed to be close to an equilibrium state. This method allows us to use enough number of particles to the beam electrons with keeping sufficient resolution in the analysis.

When the relativistic electrons pass through the high density region, the resultant large electric current produces strong magnetic field. The mechanism of the magnetic field generation is called as the Weibel instability. The instability breaks the electron beam into many current filaments. On the other hand, in order to maintain the charge neutrality, the background electrons evacuate from the region of the electron filaments. As the result, in the view from the background electrons, many narrow channels are formed. In order to capture such a fine structure, the plasma fluid should be solved by a high precision method. We employed 4th order CWENO(central weighted non-oscillatory) method for the fluid analysis.

One of the advantages of using hybrid simulation is that the fluid part can easily include various kind of additional physical processes such as radiation transport or nuclear reactions. As the

consequence, the code has a capability of the analysis of wide scale range of physical processes. As an example, we added a drag term in the fluid motion and check the effects of resistivity on to the beam propagation.

We will show the details of the hybrid description and some of the results of our hybrid code which is applied to the electron beam transport in the fast ignition scheme.

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