Study of Fast Electron Beam Transport in High Density Plasma using 3D Hybrid-Darwin Code

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Abstract

1. Introduction

Recent interest in the laser fusion program is focused on the fast ignition scheme. Once after a target filled by gas or liquid DT fuel is compressed by uniformly irradiated long pulse laser, a very intense and ultra-short pulse laser is shone on the compressed target. The ultra-intense laser produces a large number of relativistic electrons at the critical density, and they get through the overdense region to reach into the compressed fuel region, where they initiate the ignition.

We will report in the conference about our recent studies of the fast electron beam dynamics in overdense region analyzed by our newly developed three dimensional hybrid-Darwin code. Our hybrid code treats the beam electrons and background electrons separately. Electrons forming the fast electron beam are described as particles, and their kinetic properties are all retained. On the other hand, the background plasma, both electrons and ions, are treated as fluids, and their fluid description reduces the total memory consumptions in comparison with full PIC codes and makes the code parallelized easily. The other feature of our code is the use of the Darwin approximation for the electromagnetic field calculation. The Darwin approximation neglects the transverse component of the displacement current in the Maxwell's equation; as a result, it drops fast electromagnetic modes such as electromagnetic waves, while it keeps slow modes such as the Weibel instability, which plays a crucial role in a large current propagation in a plasma. Our code uses the RCIP (Rational CIP) scheme in the fluid advancing to analyze the fine structure in the background plasma.

2. Simulation results

We have performed several runs of our 3D code to get the temporal evolution of the periodically loaded cylindrical electron beam. The large current flow in the overdense plasma forms an anisotropic velocity distribution and results in the transverse two stream instability (the Weibel instability). The simulation shows that the instability makes the initially solid beam break up into a number of fine beamlets. Since the beamlets contains net current, a pair of the beamlets attract each other and merge into a single beam. After many merging events take place, they form a large structure, which carrys a current more than the initial beam. In addition, the energy distribution in the merged beam is much different from the initial distribution.