§46. Research on High Energy Density Plasma Physics with Peta Watt Laser

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1. Introduction

Since last April, 2003, a new project on peta watt laser plasma physics has started by the aid of science research fund of MEXT. In this project, we aim at making a comprehensive simulation system, which describes large scale relativistic laser plasmas produced by a peta watt laser to realize numerical experiments. In order to justify the simulation results, we are up-grating the GEKKO-MII laser to do precise and wider parameter range experiments. Namely, the precision GEKKO MII will install OPCPA and dielectric grating to deliver the 0.3 PW / 300fs pulse and the maximum intensity on target is expected to be 10^{21} W/cm^2.

2. Integrated code development and numerical experiment

With the simulation system, we will describe global phenomena of the high density plasma interactions with ultra intense laser and related high energy particle generations. When a peta watt laser is focused onto a solid target, the photon pressure of the order of 10Gb is applied to the plasma and a high density relativistic electron beam is generated on the surface plasma. The ultra intense relativistic electron beam (REB) induces very strong magnetic fields through the electro-magnetic two stream instabilities when it interacts with dense plasmas[1]. Furthermore, the REB produces hard X-ray g-ay, Mega eV electron and ion, and neutron and meson through collisions of high energy ions and electrons with high Z nucleus[2][3]. Those high energy photons and particles produced by peta watt lasers are applicable not only to fast ignition laser fusion[4][5][6], but also to nuclear science, laboratory astrophysics, positron emission tomography (PET), heavy ion cancer therapy, and so on[2][3]. Since the relativistic electron generation and subsequent electromagnetic phenomena occur in femto second time scale and sub-micron space scale, it is extremely difficult to measure and analyze the physical process precisely and directly by experiments. Therefore, the data analysis assisted by various simulations is very necessary for interpretation of experimental results and comprehensive understandings of peta watt laser plasmas. Since the high energy particles spread over the wide area and propagate for long distance in a long scale plasma before arriving detectors, the large scale plasma simulations are also necessary.

The precise laser plasma interactions are simulated by a microscopic simulation code like PIC, where the special resolution is smaller than the dense plasma skin depth which is less than 0.1μm. If a few hundreds μm scale plasmas are simulated by the PIC, the total number of mesh would be 10^{12} which will require the memory of the computer greater than 100Tbits. So, the speed of the computer would be required faster than 100T flops. Such a super computer does not exist yet. In order to overcome this difficulty, we are developing a new simulation system which consists of interconnected multi-simulation codes. The simulations of four codes; particle in cell code, PIC-electron fluid hybrid-code, Fokker Planck code, and hydro simulation code are coupled. The detail of the interconnection will be described in the following report.

3. Research pl an

The first phase of the simulation code development and the up-grating of the GEKKO MII laser will be completed before the end of 2004 fiscal year. Then fundamental experiments and the numerical experiments for compact 100MeV proton source, ignition and burn by fast ignition, and so on are planned. They are the goal of this project

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