Effects of strong external magnetic fields on laser-plasma-interactions

Masayasu HATA [1], Hitoshi SAKAGAMI [2], Yasuhiko SENTOKU [1] and Hideo NAGATOMO [1]
1) Institute of Laser Engineering, Osaka University, Japan
E-mail: hata-m@ile.osaka-u.ac.jp
2) National Institute of Fusion Science, Japan

Fast Ignition Realization Experiments project phase-I (FIREX-I) [1] has been being furthered in Institute of Laser Engineering, Osaka University. The goal of FIREX-I is to achieve the core temperature of 5 keV. There are some critical issues on recent experiments. First, fast electrons that are generated by the LFEX heating laser are too energetic to collide and heat the core efficiently. Second, the electron beam has large divergence angle and they are difficult to reach the core. First issue can be solved by producing dense core and decreasing the fast electron temperature via adjusting laser conditions. About second issue, the guiding of the fast electrons via strong external magnetic fields has been proposed [2,3], but the influence of these magnetic fields on laser-plasma-interactions and characteristics of the generated fast electrons is not fully clarified yet. Especially, interactions between ultrahigh intense laser and long rarefied plasma that is generated by laser prepulse under the strong external magnetic fields have not been investigated yet. Therefore we investigate its effects and dependence on the magnetic field strength.

Two-dimensional Particle-In-Cell simulations about interactions between high intensity laser and magnetized plasma have been conducted. The laser profile is flattop in time and Gaussian in space. The intensity and spot diameter of laser are set to 4×10^{18} W/cm^2 and 20 μm full width at half maximum. Uniform external magnetic fields of 0.5, 1, or 5 kilo-tesla are imposed to simulated target. The target plasma consists of preformed plasma with the scale-length of 20 μm and flat plasma of 40 n_{cr}, where n_{cr} indicates the critical density for 1 μm laser wavelength. Comparing cases with and without external magnetic fields, the process of laser propagation is different. In the case with external magnetic fields, laser filaments grow relatively straight compared to the no magnetic field case. In addition, the compression of external magnetic fields outside the filaments that is due to plasma compression via laser ponderomotive force. In contrast, inside the filaments, the external magnetic field is rejected with the plasma. Our PIC simulation shows more than 5 times enhancement of initial external magnetic fields outside the filaments. Fast electron beam guiding can be clearly seen because Larmor radius of 1 MeV electrons under the 0.5 kilo-tesla magnetic field is around 8 μm and sufficiently less than the laser spot. Furthermore, spatial profile of fast electron beam intensity reflects the filament patterns in the case with external magnetic fields of 5 kilo-tesla because of small electron Larmor radius.

References

[1] S. Fujioka et al., Physics of Plasmas **23**, 056308 (2016)
[2] T. Johzaki et al., Nulcear Fusion **55**, 053022 (2015)
[3] S. Fujioka et al., Scientific Reports **3**, 1170 (2013)