Laser Energy Dependence of Plasma Instability by Solenoid Magnetic Field†

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A very high current beam is required for heavy-ion inertial fusion (HIF), and therefore the use of a laser ion source using a solenoid is proposed. By using a solenoid magnetic field, the spread of plasma can be suppressed. However, it has been found that a certain range of field strength triggers unstable plasma condition.[1)]

Figure 1 shows the experimental setup. The plasma generated by the laser on the target is measured by a Faraday cup after it is transported through a 3000 mm long solenoid coil located 315 mm from the target. Nd:YAG laser was used with an incident angle of 20°.

Figure 2 shows the example of Au target when the laser energy is 411 mJ. The vertical axis and horizontal axis show the beam current and time of flight, respectively. In the figure, waveforms of the beam current for 40 shots are overlaid on each other. Figure 2 (a) shows the case without the solenoid. Figure 2 (b) shows the case when the solenoid magnetic field is 28.6 G. It is found that the waveform of Fig. 2 (b) is more unstable than the waveform of Fig. 2 (a).

Figure 3 shows the experiment result of the Au target. The vertical axis represents the instability of the plasma, and the horizontal axis represents the solenoid magnetic field. In this experiment, the plasma instability was evaluated based on the standard deviation of the half width over peak current. By using this method, it is possible to know the degree of collapse of the waveform. In Fig. 3, the larger the value on the vertical axis is, the more unstable the plasma is. The energy of the Nd: YAG laser was 312 to 411 mJ. The laser spot size was 3.84 mm. From Fig. 3, it can be seen that the range of the magnetic field where the beam current becomes unstable varies depending on the laser energy.

Moreover, it was found that the unstable range changes also when the target is changed from another experiment. For example, in the case of Fe, the magnitude of the solenoid magnetic field where the plasma became unstable became smaller than that of Au. From these experimental results, it can be said that the unstable range of plasma varies with the speed and type of plasma.

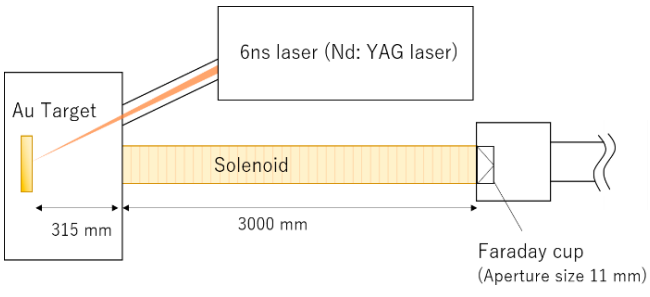

Fig. 1. Experimental equipment.

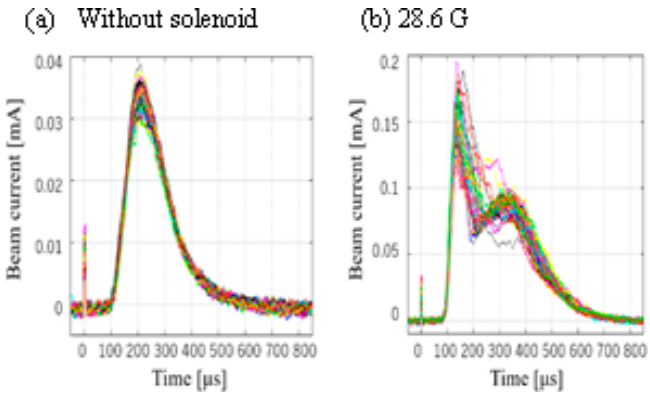

Fig. 2. Waveform of current beam (Laser energy is 411 mJ).

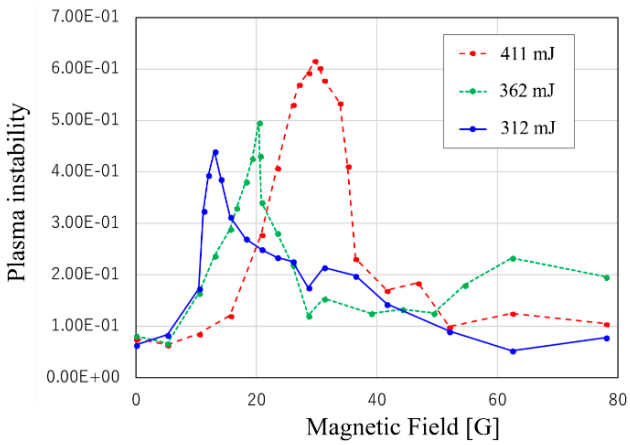

Fig. 3. Experiment result of gold target.

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Reference

1) K. Takahashi *et al.*, AIP Conf. Proc. **1525**, 241 (2013).