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Labolatory experiments of generation plasma jets in a magnetic field by using high-power laser system
高出力レーザーを用いた磁場中でのプラズマジェット生成実験

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In recent years, the experiments simulated various astrophysical phenomena have been actively carried out. We perform an experiment to simulate astrophysical plasma jets generation by using high-power lasers.

The experiment was performd by using GekkoXII (GXII) HIPER laser system We shot CH plane ($\sim 10\ \mu$m) and observed high-speed plasma flow, opposite from main laser. In the experiment we generated un-uniform plasma by moving each beam focal spots. And we observed the plasma flow in external transverse magnetic field ($0.2 \sim 0.3$ T) to main laser on the GXII experiment. We used transverse diagnostics to observe the spatial and temporal evolution of plasma flows. For two-dimensional transverse images, we used Normarski type interferometry and shadowgraphy with a probe laser (wavelength: 532 nm, pulse length: $\sim$ 14ns). For the time evolution of plasma flow, we used self-emission streaked optical pyrometry, and streaked interferometry. And we used X-ray pinhole camera to confirm focal spot separations.

In the case we generated un-uniform plasma without magnetic field, the collimated plasma jets formation was seen. On the other hand we generated un-uniform plasma in external magnetic field, the more collimated plasma jets formation was seen. Un-uniform plasma and the perpendicular magnetic field are important to generate collimated plasma jets.

1 Introduction

In recent years, the experiments simulated various astrophysical phenomena have been actively carried out. These experiments are called laboratory astrophysics. We performed an experiment to simulate astrophysical plasma jets generation by using high-power lasers.

Labolatory experiments can help to study the observation and simulation astrophysics. Through the combined efforts of obseevation, simulation, and laboratory experiments, we can understand about astrophysical objects more deeply.

2 Experiment

The experiment was performed by GXII laser system at the Institute of Laser Engineering at the Osaka university. The laser conditions were; the wavelength was 351 nm, the pulse length was 500 ps, the focal spot diameter was 300 μm, the pulse energy was $\sim$ 100 J/beam $\times$ 12, the intensity was $(0.2 \sim 3.0) \times 10^{15}$ W/cm^2.

To produce uniform and un-uniform plasmas, a (CH)n plane target ($\sim$ 10 μm) was irradiated with the any laser beams moved focal spots. To perform experiment in magnetic field, we used neodymium permanent magnet ($0.2 \sim 0.3$ T). We set external magnetic field transverse to main laser axis. Figure 1 shows schematic drawing of the configurations of the laser and the target. The plasmas were observed by the transverse diagnostics with the probe laser and with the self-emission. The optical probe conditions were; the wavelength was 532 nm, and the pulse length was $\sim$ 14 ns. With the probe laser we obtained the density information of the two-dimensional snapshot interferometry and shadowgraphy by ICCD cameras (1.6 ns gate width and 250 ps gate width). We also measured the time evolution of the central plasma by streaked interferometry. Using 450 nm interference filters the self-emission was gated at the wavelength. We obtained the two-dimensional snapshot of the self-emission by ICCD (200 ps gate width) and of the time evolution by self-emission streaked optical pyrometer (SOP). And we used X-ray pinhole camera to confirm focal spot separations.

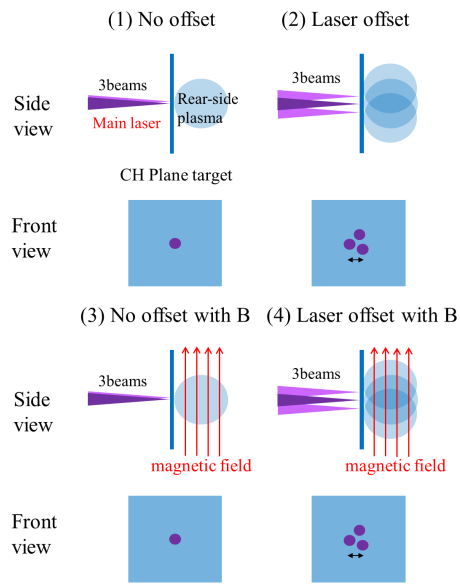

Figure 1: Laser off set means making beam separation to produce un-uniform plasmas. Beam separation was $200 \sim 300$ μm. The CH plane thick was $\sim$ 10 μm. The magnetic field was $0.2 \sim 0.3$ T.

3 Result

Fig.2 shows two-dimention interferogam. We can see the collimated plasmas in this figure.

The electron density at colimated plasmas is $\sim 10^{18}$ /cm^3. The plasma flow speed is $\sim$ 250 km/s and the electron temperature is $10 \sim 20$ eV from SOP image. Ionic charge Z is 3.5. The plasmas size is $\sim$ 15 mm. In ideal MHD the magnetic reynolds number is $\gg 1$. In the region of high reynolds number a magnetic field is frozen, and considered to move with plasma flow.

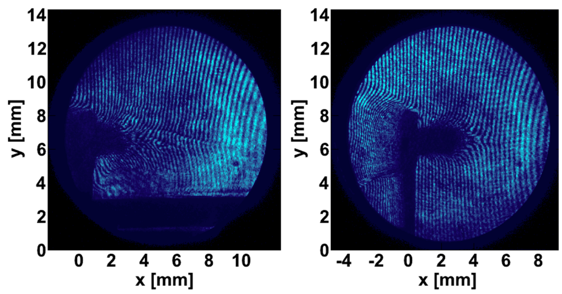

Figure 2: Laser came from left side. Left figure shows collimated plasma in a condition fig.1, (4) after 25 ns from main laser. Right figure shows un-uniform plasmas in a condition fig.1, (2) after 15 ns from main laser.

4 Conclusion

In the region of high reynolds number a magnetic field is frozen, and considered to move with plasma flow. The detail will be explained in my talk.