§61. Development of Position Measurement Module for Flying IFE Target

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In laser fusion energy plant system, the spherical fuel target is injected to the reactor center and shot by the driver lasers. The engagement error of the driver laser beam to the target must be less than 20 μm[1]. The arrival time and the arrival position of the injected target at the reactor center are calculated using the position and the time data obtained by the position measurement units.

We have developed the position measurement method using Arago spot[2]. Figure 1 shows Arago spot appeared in the center of the spherical target shadow.

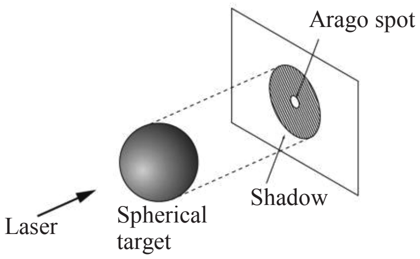

Fig. 1. Schematic diagram of Arago spot.

One of the key technologies to shot the flying target precisely is monitoring the laser focal point in the fusion reactor. We developed the method of monitoring the laser focal point using Arago spot. The principle of monitoring the focal point in the reactor from outside of the reactor is presented as follows. If we use convex lens (or parabolic mirror) to focus laser beam and generate divergent beam, then the focal point F and the center of the spherical object O and Arago spot A are on a line (solid line) as shown in Fig. 2.

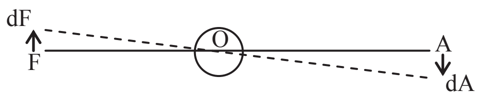

Fig. 2. Principle of monitoring the focal point.

If we fix a spherical object O outside of the fusion reactor, then the displacement of the focal point dF (upward arrow) causes the displacement of the Arago spot dA (downward arrow). Measurement of the Arago spot position enables us to monitor the focal point of the driver beam.

Figure 3 shows the experimental set up. The He-Ne laser beam is expanded by the beam expander and focused by a convex lens. The convergent beam is reflected by a flat mirror which rotates 44°~46°. The distance from the lens to the center of the mirror is 0.1 m. The distance from the mirror to the focal point is 0.1 m. The ball bearing O is set at the 5 m apart from the focal point. This means that the divergent laser beam illuminates the ball bearing placed outside of the fusion reactor. Arago spot is measured by the CCD camera at 10 m distance from the bearing.

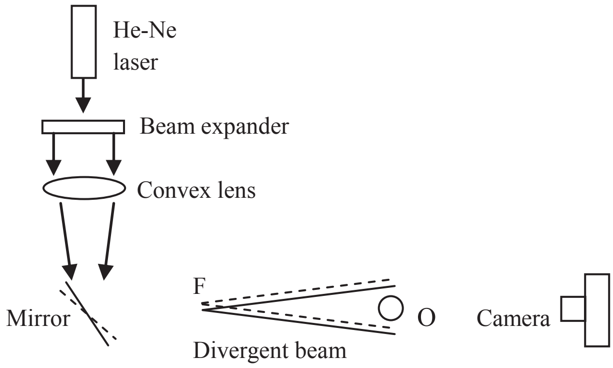

Fig. 3. Experimental set up. Mirror rotates 44°~46° and laser focal point F moves.

Figure 4 shows the displacement of the Arago apot .

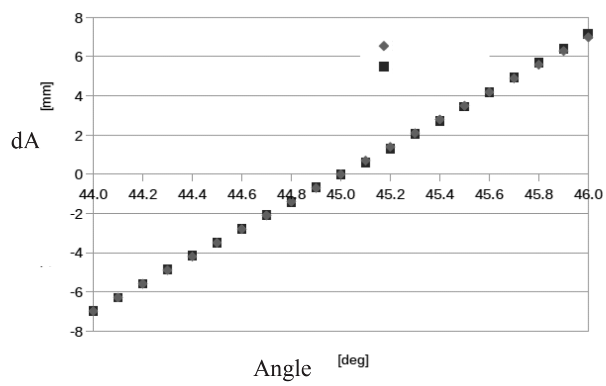

Fig. 4. Displacement of the Arago spot dA: Red diamond represents theoretical values. Blue square represents experimental values.

The displacement of the Arago spot dA is proportional to the displacement of the focal point of the laser beam dF (dA=2dF). The Arago spot can be detected at the distance of 50 m from the spherical objects[3]. This means that the focal point of the driver laser beam in the reactor can be monitored from outside of the reactor. The error between theoretical values and the experimental values are caused by the mechanical error of mirror's rotational angle. This was verified by another experiment in which two ball bearings are illuminated simultaneously by a single divergent laser beam.

1) Goodin, D. et. al.: Fusion Eng. Des. 60 (2002) 27.
2) Saruta, K., Tsuji, R.: Jpn. J. Appl. Phys., 47 (2008) 1742.
3) Tsuji, R., Norimatsu, T.: Ann. Report of NIFS, April 2012- March 2013 (2014) 556.