§57. 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 centre are calculated using the position and the time data obtained by the position measurement units (PMU).

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

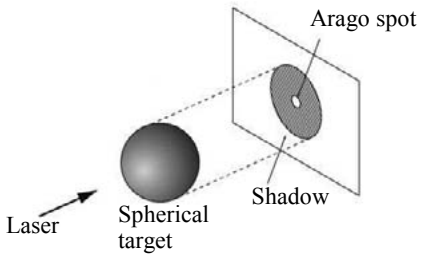

Fig. 1. Schematic diagram of Arago spot.

The diameter of the Arago spot D_A is proportional to the distance between the target and the screen z' and the wavelength of the incident laser λ, and is inversely proportional to the radius of the target *a*, that is,

$$D_A = 2Kz' \lambda/a \qquad (K=0.38). \qquad (1)$$

In the case that a = 2.5 mm, λ = 633 nm and z' = 0.5 m, 5 m, 50 m, the diameter of the Arago spot is ~100 μm. ~1 mm, ~10 mm, respectively. The position measurement unit (PMU) are placed along the target injection path for the flying target position measurement in the injection tube and are set out of the reactor chamber for the flying target position measurement in the reactor chamber. In 2013, we demonstrated the possibility of the position measurement method at a large distance (~50 m). Experiment was done in the long tunnel under the Center for Astronomy of Ibaraki University.

A He-Ne laser (Melles Griot 05LHR111) is used as the light source that emits unpolarized light at a power of 5 mW with a wavelength of 633 nm. A divergent laser beam is produced using a spatial filter (SF) and uniformly illuminates the entire region of the steel ball with a diameter of 5 mm. The distance between the spatial filter and the steel ball is 0.25 m. Arago spot images are recorded by the CCD camera (Canon EOS Kiss Digital X) with 3888 × 2529 pixels and 8-bit gray level.

Figure 2 shows the recorded Arago spot at the distances from 5 m to 50 m. In summary, we have demonstrated a position measurement method using a divergent laser beam and Arago spot at a large distance. This enables the position measurement of the flying target in a reaction chamber with high measurement accuracy.

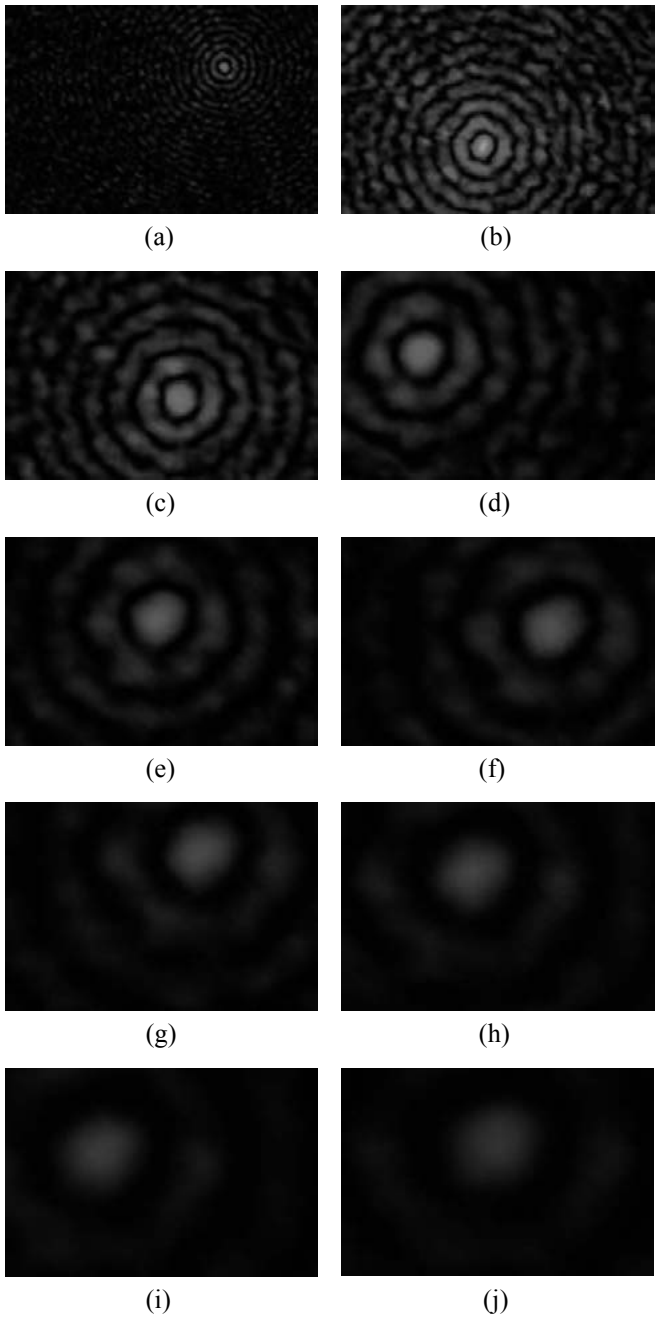

Fig. 2. Arago spot in the shadow for the steel ball at distances z' of (a) 5, (b) 10, (c) 15, (d) 20, (e) 25, (f) 30, (g) 35, (h) 40, (i) 45 and (j) 50 m.

1) Goodin, D. et. al.: Fusion Eng. Des. **60**(2002)27.
2) Saruta, K., Tsuji, R.: Jpn. J. Appl. Phys., **47**(2008)1742.