# §36. Development of Position Measurement Module for Flying IFE Target

Tsuji, R. (Faculty of Eng., Ibaraki Univ.),
Norimatsu, T. (Institute of Laser Eng., Osaka Univ.)

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). The accuracy of the trajectory calculation of the injected target depends on (i) the accuracy of the position measurement method and (ii) the accuracy of the placement of the PMU.

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

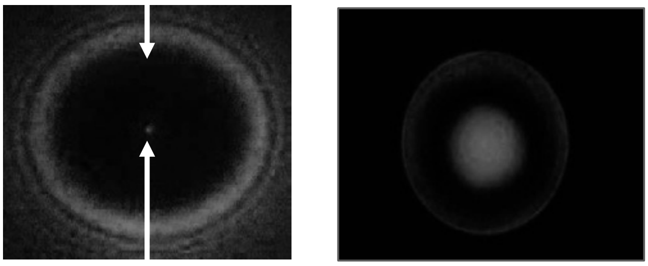


Fig. 1. Arago spot in the shadow of the ball.

The diameter of the Arago spot $D_A$ is proportional to the distance between the ball and the screen z' and the wavelength of the incident laser λ, and is inversely proportional to the radius of the ball 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], the diameter of the Arago spot is ~100 [μm]. The centre of the Arago spot, $X_C$ and $Y_C$, can be calculated using the intensity of each pixel as a weighting factor. The centre of the Arago spot can be determined within the error of ~ $10^{-2}\times D_A$. The position measurement unit (PMU) are set along the path of the injected target. In the PMU, flying target is irradiated by the orthogonal pulsed laser beams. Arago spot image is recorded by the image sensor. The laser flash time T and the position of the target (x,y,z) are obtained within the accuracy of 10 [ns] and 1 [μm]. Detailed design of PMU is under preparation.

To describe the motion of vertically injected target, the global coordinate system is defined as shown in Fig. 2. We place N PMUs along the injection path. The gravitational acceleration g is directed to the minus Z. The local position (0,0,0) defined in the N-th PMU, the local origin $O_N$, is defined as the global origin of the global coordinate system O(0,0,0).

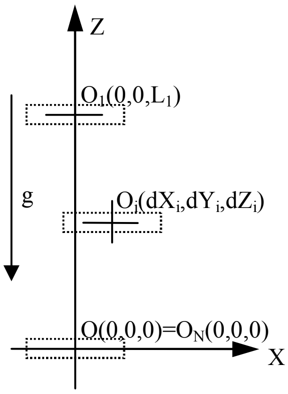


Fig. 2. Coordinate system and PMU (box).

The target injector is set on the Z axis and the target is injected to minus Z direction. Injected target is shot near the reactor center O. We set 1-st PMU so that the local position (0,0,0) defined in the 1-st PMU, $O_1$, is agree with $(0,0,L_1)$ of the global coordinate system. The local position (0,0,0) defined in the i-th PMU, $O_i$, is represented by the global coordinate $(dX_i,dY_i,dZ_i)$. A heavy reference target is injected from the target injector. When heavy reference target passes through the i-th PMU, the target is irradiated by the pulsed laser and the local position $(x_{iR},y_{iR},z_{iR})$ of the reference target in the i-th PMU is recorded with the flashing time $T_{iR}$. We obtain the local data sequence of reference target. The X, Y and Z coordinate of the local origin of the i-th PMU can be obtained[3]. After the global coordinate of the local origin of the i-th PMU, $(dX_i, dY_i, dZ_i)$, are determined, we can convert data sequence of the local position variables to global position variables. When injected target passes through the i-th PMU, the injected target is irradiated by the pulsed laser and the local position $(x_i, y_i, z_i)$ of the injected target in the i-th PMU is recorded with the flashing time $T_i$. We can obtain the local data sequence of the injected target. So, the time and the global position of the injected target can be obtained. The arrival time $T_A$ that the fuel target reaches z=0 can be calculated by the equation of motion. The target position at the time $T_A$ can be also calculated by the equation of motion[3].

1) Goodin, D. et. al.: Fusion Eng. Des. **60**(2002)27.
2) Saruta, K. and Tsuji, R.: Jpn. J. Appl. Phys., **47**(2008)1742.
3) Tsuji, R. et. al.: Presented at CIFE'12, Yokohama, Japan, CIFE5-3, Apr. 2012.