LOW-ENERGETIC METASTABLE HELIUM BEAM INJECTOR FOR ELECTRIC FIELD DIAGNOSTICS BY LASER-INDUCED FLUORESCENCE METHOD IN INETIAL ELECTROSTATIC CONFINEMENT PLASMAS

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Inertial Electrostatic Confinement (IEC) devices as fusion neutron/proton sources provide versatile potential applications such as explosives identification, radioactive isotope production for medical use, and so on, taking advantage of their compactness, robustness, and easy operation. In IEC researches aiming at enhanced fusion neutron/proton yields required for such applications and/or further extending their application, understanding the electric potential formation due to spherically converging ions within a gridded hollow cathode is no doubt one of the most intensive interests.

The Laser-Induced Fluorescence (LIF) method could be an efficient tool for this purpose, which utilizes a laser beam as a probe with least perturbation in IEC core plasmas within the gridded hollow cathode at negative high bias potential, where solid probes can hardly be applicable. Our LIF diagnostics system making use of the Stark effects in forbidden transition of He I[1] has successfully revealed potential profiles in helium discharge IEC plasmas under relatively high operating gas pressure[2], where ample 2^1S metastable atoms are provided by the IEC discharge itself. In order to extend its application to lower pressure operational plasmas, and deuterium plasmas as well, we intensively develop a pulsed beam injector of low-energetic 2^1S helium atoms.

The key issues in the present R&D are injection of an intense and convergent supersonic helium gas jet, and production of a highly efficient exciter plasma into 2^1S metastable state under a low operational gas pressure, both of which are essential for the minimal perturbation in the objective IEC plasmas. Recently by optimal arrangement and operation of the fast electromagnetic valve and the skimmer (with a 1-2 mm diameter pin hole), almost ten times dense gas jet has been obtained. A compact magnetron-discharge system has also been developed which can produce a race-track-shaped plasma with a 5 cm long straight section capable of strong interaction with the injected gas jet. Its accessible lowest pressure in preliminary dc experiments has reached 1.5 mPa which is as low as the achieved density of the supersonic gas jet. We are then carrying out experiments of pulsed operation of the magnetron-based excitation system by the pulsed gas jet injection. Also, spectroscopic measurements of the exciter plasma properties are being performed based on the Collisional-Radiative theory[3]. The results strongly imply a high excitation rate into 2^1S state of more than 10^{-4}, which is very encouraging compared with the typical rate of around 10^{-6} by conventional exciter plasmas.

[1] K. Takiyama, et al., Proc. 8th Int. Symp. Laser-Aided Plasma Diagnostics, Doorwerth, The Netherlands, 1997, pp. 81-84.
[2] K. Yoshikawa et al., Proc. 18th SOFE, Albuquerque, NM, USA, 1999, pp. 27-30.
[3] M. Goto and T. Fujimoto, NIFS-DATA-43 (1997).