4 - 19 State Parameter Diagnosis of a Theta Pinch Plasma*

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Magnetic confinement has been applied to the inertial confinement fusion (ICF) to improve performance of fusion reaction, named the magneto-inertial fusion (MIF)[1]. Some physical processes in MIF are crucial to theta pinch plasma too, thereby the studies based on the theta pinch plasma can help people understanding the MIF physics. An experimental diagnosis has been carried out to characterize the state parameters of the plasma in a theta pinch device. Furthermore, the experimental data are also used to investigate the plasma dynamics.

A theta pinch device was newly developed at the IMP, CAS. The device was composed of a thyristor switch, a 64 μF capacitor bank, and a glass tube surrounded by a 6-turn copper solenoid coil. These formed a closed circuit with an oscillation frequency of 8.0 kHz. A needle leak valve was used to control the pressure of hydrogen gas which was monitored by a vacuum gvage. In the experiment, the hydrogen plasmas were generated at the pressure of 20 Pa and discharge voltage of 20 kV. The photo of the theta pinch device is shown in Fig. 1. An oscilloscope combining with a Rogowski coil and a photodiode was used to synchronously record the signal of the luminosity and drive current. A streaked optical spectrometry (SOS) diagnostic system consisting of a spectrometer and a streak camera was applied to diagnose the plasma parameters, including electron density and temperature.

Electron density of the plasma was determined by measurement of the H_β line broadening. Electron temperature was determined by the plasma line-to-continuum thermometry technique, which also uses the hydrogen H_β lines. The time-dependent RAW image of the H_β spectra measured by SOS diagnostic system is shown in Fig. 2. The horizontal axis of the image is time, and the vertical axis is wavelength. Thus, the temporal profiles of the density and temperature can be extracted from the H_β spectra. Figure 3 shows the combination of the four measured parameters: temperature (red), density (blue), drive current (yellow), and luminosity (black) in the specific plasma period (6th half-cycle). The data are simultaneously measured in one discharge corresponding Fig. 2. The maximum density of 4.3×10^{16} cm^{-3} and the maximum temperature of 4.1 eV are observed, respectively. It is worth mentioning that the density peak reaches later than the temperature peak by several microseconds and the density profile has two peaks. These features would be used to characterize the plasma dynamics in future.

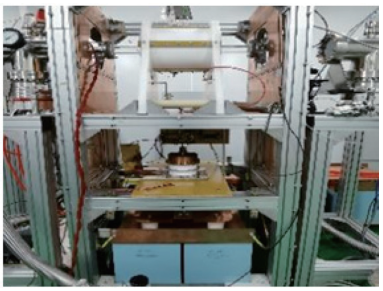

Fig. 1 (color online) Photo of the theta pinch. It consists of a thyristor switch, a capacitor bank, and a glass tube surrounded by a copper coil.

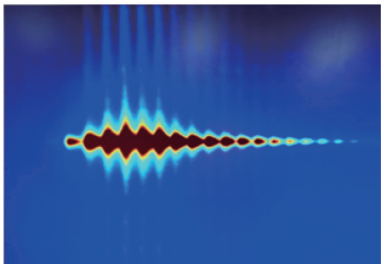

Fig. 2 (color online) The time-dependent image of the H_β spectra measured by streaked optical spectrometry system at the discharge of 20 kV and 20 Pa.

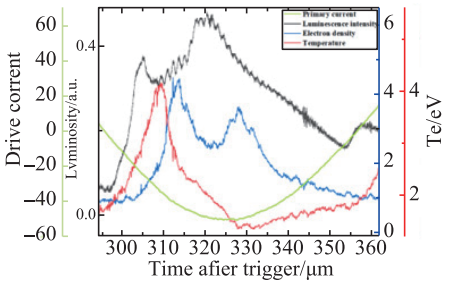

Fig. 3 (color online) Drive current, luminosity, electron density and electron temperature in 6th discharge half-cycle at 20 kV and 20 Pa.

Reference

[1] A. H. Boozer Rev. Mod. Phys., 76(2004)1071.

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