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Construction and initial result of the 320 GHz interferometer system in Heliotron J

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Understanding high-density plasmas through advanced fueling techniques is crucial to realize better plasma confinement. In Heliotron J, several fueling techniques, such as pellet injection, supersonic molecular beam injection (SMBI), and short-pulsed high-intensity gas puffing (HIGP), can achieve high-density plasmas. Interferometers are a standard diagnostic to measure the electron density of plasmas. A new 320 GHz multi-channel interferometer with solid-state sources has been designed and is under development to understand the physics of high-density plasmas in Heliotron J [1].

A single-channel 320 GHz interferometer was constructed and operated as commissioning before the installation of the multi-channel system, as shown in Fig. 1 [2]. This interferometry system is a Michelson type, based on the heterodyne principle, with two independent solid-state sources delivering an output power of up to 50 mW. A high time resolution measurement of <1 μs is possible by tuning the frequency of one source in the frequency range of 312–324 GHz on the new system, which enables the fluctuation measurement.

The new single-channel interferometer has been applied to the Heliotron J plasma experiments. The initial results of the new interferometer are obtained in high-density plasma experiments using a pellet injection and an HIGP.

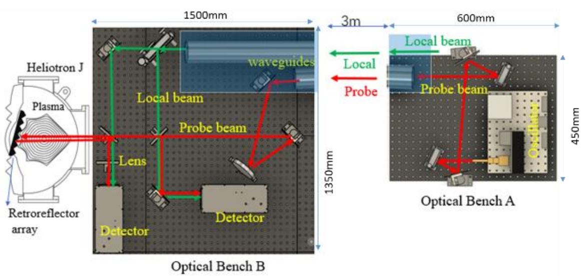

FIG. 1. Schematic of a single-channel interferometer. The sources are located on optical bench A. A submillimeter wave is transmitted to optical bench B through oversized dielectric waveguides.

As an example, time traces of the plasma discharge with pellet injection are shown in Fig. 2. The measurement result of the new interferometer agrees well with that of a conventional microwave interferometer (135 GHz) operating as a routine density diagnostic system in Heliotron J.

In addition, density fluctuations have been successfully measured in a high-density plasma achieved with the pellet injection. Coherent modes are observed in both spectrograms of the density and magnetic fluctuations measured with the new interferometer and magnetic probes.

The single-channel interferometer will be further upgraded to a multi-channel interferometer to reconstruct the electron density profile.

[1] S. Ohshima et al., Rev. Sci. Instrum. 92, 053519 (2021)
[2] P. Zhang et al., to be published in Revi. Sci. Instrum.

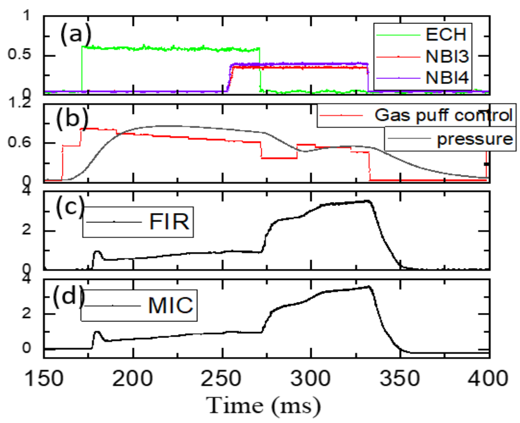

FIG. 2. Time trace of (a) heating power, (b) gas puff (c) line-averaged electron density measured with the new interferometer, and (d) line-averaged electron density measured with the microwave interferometer in ECH + NBI