§16. Development of Terahertz Time-Domain Spectroscopy for Large-Size High-Temperature Plasma Measurements

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In the future burning plasma experiment, the electron density will be quite high and up to the order of 10^{22} m^{-3}. In such high dense plasmas, the conventional diagnostic technique of electromagnetic wave is still expected to measure the electron density profile, its fluctuation, etc. The demanding and utilizing frequency is getting into terahertz regime (0.1 THz-10 THz) shown in Fig. 1. However, the generation and detection of terahertz waves are not a well-developed technology at present. In addition, since the transmission of terahertz wave is one of the development issues, the terahertz diagnostic system have to be set adjoined to the plasma apparatus. A terahertz time domain spectroscopy (THz-TDS) configuration is a possible candidate, where the generator and detector mounted in small units are activated by femto-second optical pulses delivered via optical fibers. To keep the pulse width in 100 fs order after a propagation of more than several meters distance, one need to use the optical pulses in telecom band (~1.5 μm wavelength). The aim of this research is to develop the terahertz generators and detectors exciting by a fiber laser at 1.5 μm. THz-TDS test system have been developing at the diagnostic building in NIFS.

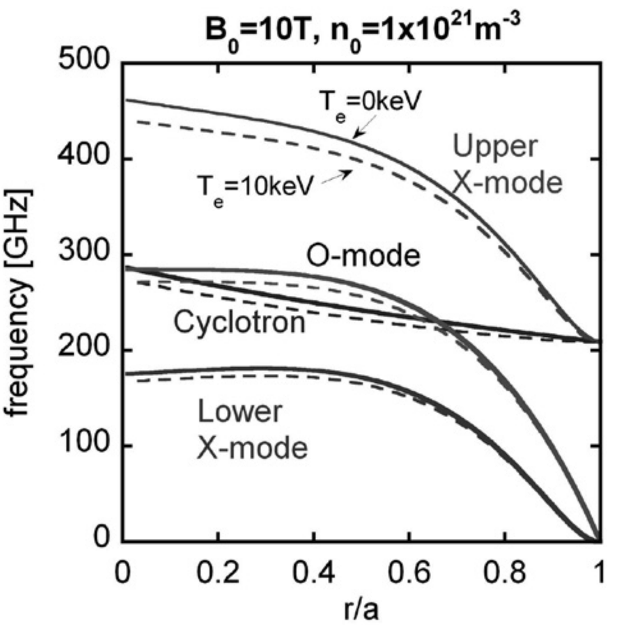

Fig. 1. Radial profile of characteristic frequencies in a typical plasma parameter of helical DEMO. Dotted line includes the higher temperature effect (relativistic effect).

The characteristics of femto second laser pulse through optical fiber were studied. Figure 2 shows the arrangement to measure a 1.5 μm wavelength laser light shape. A mode-lock fiber laser (Menlo T-light 780) is used as a source. This laser can launch both 780 nm and 1.5 μm wavelength light simultaneously. The laser light focuses into and travels through optical fiber. Example of the femto second laser pulse shape is shown in Fig. 3. The autocorrelator (APE Mini IR model) is used to measure the pulse shape. The pulse width around 100 fs can be obtained. The characteristics of dispersion effect and transmissivity of several optical fibers will be tested.

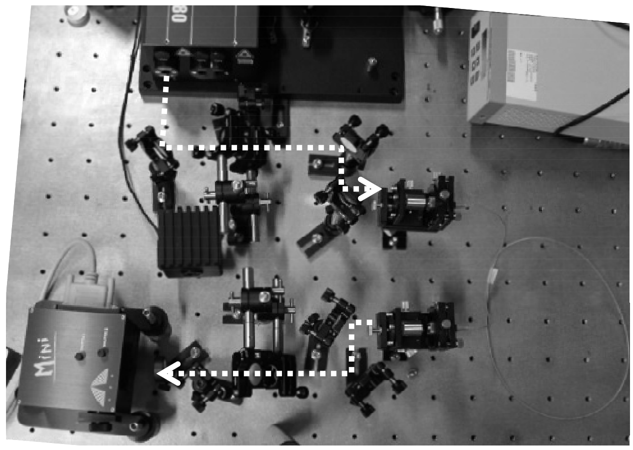

Fig. 2. Photograph of femto-second laser pulse characteristics measurement system.

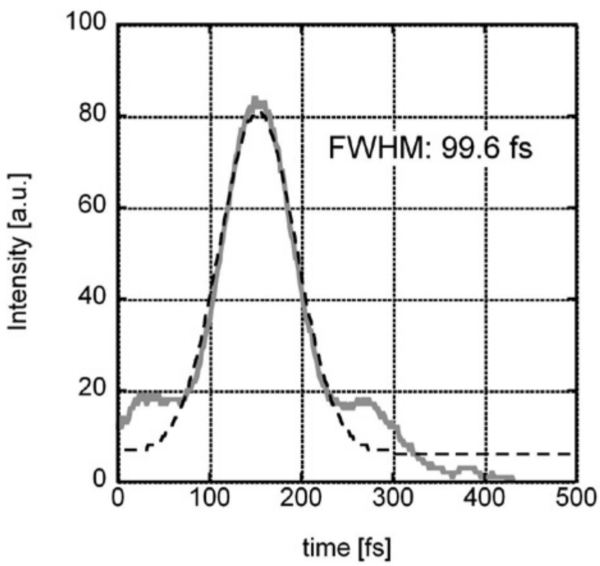

Fig. 3. The pulse shape of femto-second laser light measured by an autocorrelator. Dotted line is a Gaussian fitting calculation.