§15. Development of THz Laser Diagnostics

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Over the last ten years much progress has been made in magnetically confined devices for the improvement of plasma performance. In LHD, we have successfully achieved super high density plasmas of over 10^{21} m^{-3}, so-called SDC plasmas[1], which were achieved by the formation of a transport barrier. In these high density plasmas we observe fringe jumps on the density traces measured by a 118.8-μm CH_3OH laser interferometer[2]. In order to solve these difficulties we have been developing THz laser diagnostics around 50 μm. In these short wavelength laser diagnostics it is a critical issue how to compensate the effects of the mechanical vibrations on the interferometer, since the fringe shift caused by the mechanical vibrations is inversely proportional to the laser wavelength. In order to solve this problem the most convenient way is the application of a two color laser interferometer. But, the conventional two color interferometer consists of two independent laser interferometers in generally. In this type of the two color system, a fringe shift caused by the mechanical vibrations cannot be canceled out ideally since the optical path difference between the two interferometers remains and the effect of optically dispersive components are significant when the wavelengths of the two laser lights differ significantly. In order to overcome these difficulties, we have been developing a two color laser interferometer[3] in the THz range, using simultaneous oscillations at 57.2 μm and 47.6 μm of a CH_3OD laser.

The two color interferometer system consists of a twin THz laser, beam splitters, beam combiners and Ge:Ga photoconductors. For the optical axis alignment, both a visible He-Ne and a 1.06-μm YAG lasers are used since the beam splitters and combiners are made of non-doped silicon which is a low absorption material in THz wavelength, but opaque to visible light. The detectors are specially designed unstressed Ge:Ga detectors. The beat frequencies can be changed with the cavity length and pressure of the FIR laser cavity. It is important to know how high a beat frequency is available since the larger frequency modulation enables us to measure the electron density with a higher time resolution. Figure 1 shows intermediate frequency signal levels of two color laser oscillations as a function of frequency shift Δf. Here, the Δf is obtained by changing the length of one laser cavity of the twin laser system via stepping motor with a minimum step size of 0.02 μm, while that of another laser cavity is fixed. Each beat frequency moves simultaneously with the laser cavity length, for instance, from 0.1 MHz (48 μm) and 0.8 MHz (57 μm) to 2.0 MHz (48 μm) and 2.5 MHz (57 μm).

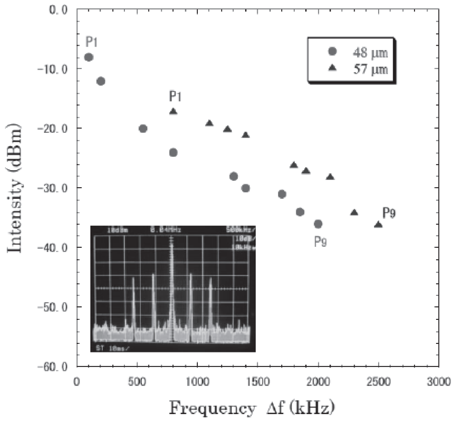

Fig.1 Intermediate signal levels of a 57.2 μm laser and a 47.6 μm laser as a function of frequency shift Δf.

These IF signals are introduced into phase comparators for phase measurements. In order to simulate mechanical vibration, a reflecting mirror was modulated by means of a piezoelectric transducer, and the mirror holder was shocked mechanically to give high frequency mechanical vibrations. Figure 2 shows that the low (~0.3 Hz with the amplitude of 100 μm)and high frequency (~140 Hz with the amplitude of ~ 26 μm) components of the phase shifts caused by mechanical vibrations were cancelled out completely.

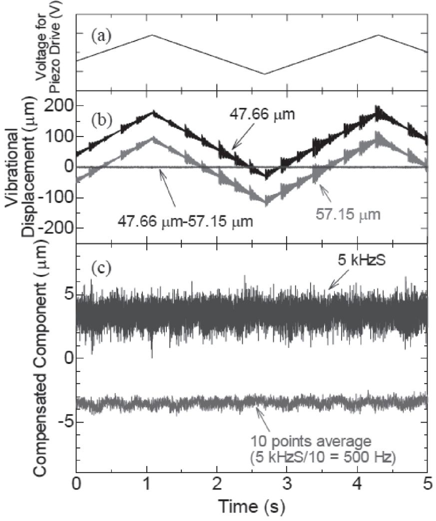

Fig.2 Typical experimental results from the two color laser interferometer.

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[2]K. Kawahata, et al., Rev. Sci. Instrum. **70**, 1 (1999) 707.
[3]K.Kawahata, et al., Rev. Sci. Instrum. 77, 10 (2006) 10F132.