§25. Stabilization of 57-μm CH_3OD Laser Pumped by 9R(8)CO_2 Laser

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For high density operation of LHD, we have been developing a two color interferometer/polarimeter using simultaneously oscillated 48- and 57-μm CH_3OD lasers pumped by 9R(8) CO_2 laser for the measurement of the vibration compensated electron density profiles[1]. In order to apply the FIR laser to the interferometer/polarimeter, high stability of the output power and the frequency is required. We have been developing the stabilization system of the pump 9R(8) CO_2 laser and the 48- and 57-μm CH_3OD lasers. The 9R(8) CO_2 laser was stabilized by an external Stark-cell modulation. We reported that the performances are power stability of ± 0.6 %/40 min. and frequency stability of ± 0.78 MHz/40 min. at the line center in the annual report in 2008-2009. By using the stabilized CO_2 laser, we have stabilized the 57-μm CH_3OD laser.

Figure 1 shows the feedback stabilization system of the pump CO_2 laser and the FIR laser. The FIR laser is twin type (A, B) owing to a heterodyne beat modulation for the interferometer. The laser tube is a 4.0-m long, 25-mm bore, Pyrex glass tube with a water jacket. The cavity mirrors consist of an Au coated input mirror with off-axis hole in order to reduce a back-talk from the FIR laser cavity to the CO_2 laser cavity and a Si hybrid output mirror. A change of the laser cavity length is main cause of the output and frequency instability. For passive output and frequency stabilization, the distance between the laser mirror mounts is fixed by using two Super Invar rods with low thermal expansion coefficient. For active feedback stabilization, the laser cavity length is controlled by a stepping motor. The output power of the FIR laser A is stabilized at the slope of the detuning curve. For a precise laser interferometry, high stability of the beat frequency produced by mixing of two laser beams (A, B) is necessary in addition to output stability. The beat frequency detected by a Ge:Ga detector is F-V (frequency to voltage) converted to yield the offset frequency control. The FIR laser B cavity is tuned so that the beat signal is locked to a set point value (~1 MHz) by the stepping motor.

Figure 2 shows temporal changes the output power of the CO_2 laser (Fig.2(a) and the output power (Fig.2(b)) and beat frequency (Fig.2(c)) of the 57-μm CH_3OD laser. The CO_2 laser frequency was locked so that the 57-μm CH_3OD laser has a peak power. Even if there was the back-talk, the power and frequency fluctuation of CO_2 laser were ± 2 %/80 min. and ± 0.8 MHz/80 min, respectively. The drifts of the output power and the beat frequency observed in free running operation of 57-μm laser can be removed by this stabilization as shown in Fig. 2 (b) (c). We have obtained the power stability of ± 2.4 % and the beat frequency stability of 765 ± 27 kHz for 40 minutes in the stabilized mode. This stabilization scheme for the pump 9R(8) CO_2 laser and the 57-μm CH_3OD laser is verified. But, the stability of the laser output power and the beat frequency is not sufficient to apply for the interferometer/polarimeter in plasma diagnostics. The improvements are proceeding now.

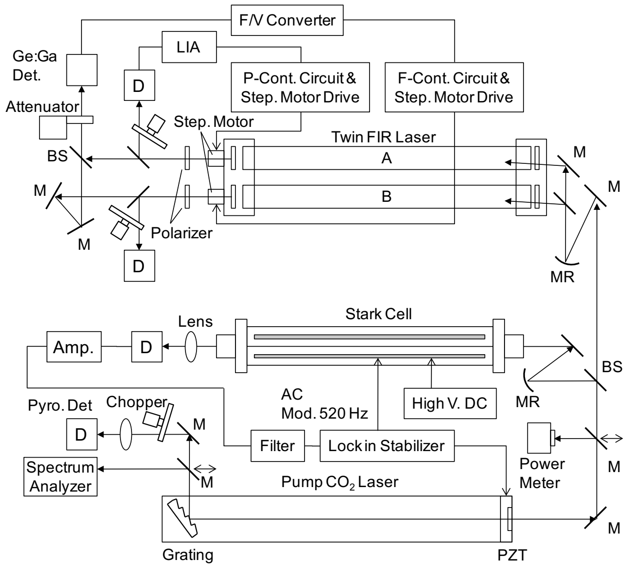

Fig. 1. Schematic diagram of the stabilization system of the pump CO_2 laser and twin type FIR laser.

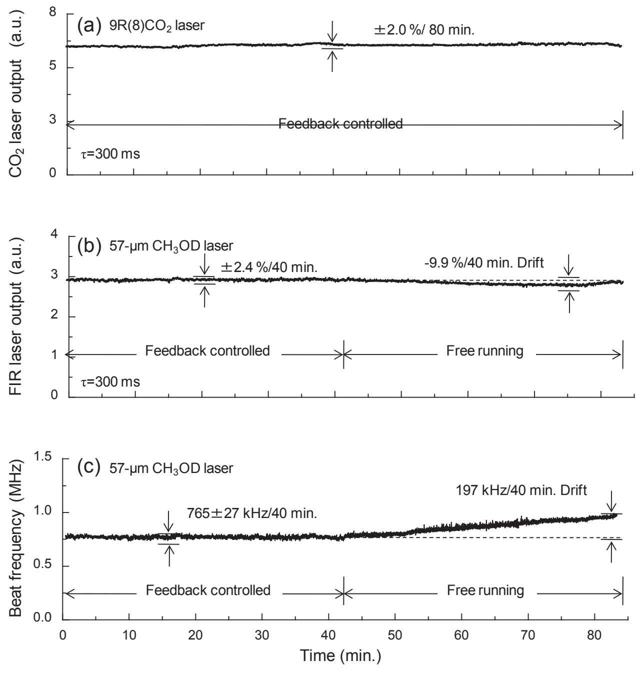

Fig. 2. Temporal changes of (a) the 9R(8) CO_2 laser output and (b) the output power and (c) the beat frequency of the 57-μm CH_3OD laser in the feedback controlled and free-running operation modes .

1) Kawahata, K. et al.: Rev. Sci. Instrum. **79** (2008) 10E707.