§15. Frequency Stabilization of a Pump 9R(8)CO_2 Laser for 48- and 57-μm CH_3OD Lasers

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In the Large Helical Device (LHD) at NIFS, the electron density profile has been measured by a beat-modulated interferometer using a 119-μm CH_3OH laser pumped by 9P(36) CO_2 laser, routinely. For high density operation of the LHD, we have been developing a two color interferometer 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 lasers to the interferometer, high stability of the frequency and power of the FIR laser is required. The fluctuation of the FIR laser output power is strongly dependent on the fluctuation of the pump CO_2 laser frequency. Therefore, we have tried the frequency stabilization of the 9R(8) CO_2 laser by an external Stark-cell modulation method[2]. This method has advantages that can be stabilized at the optional frequency in the free spectral range and does not require the internal frequency modulation of the CO_2 laser.

Figure 1 shows the feedback stabilization system of the pump CO_2 laser. The laser cavity consists of a ZnSe output mirror (55 % reflectivity, 20 m radius of curvature) attached on a PZT and a grating of 150 lines/mm. The cavity length is a 2.5 m. The free spectral range is 60 MHz. A change of the laser cavity length is main cause of the frequency instability. For passive frequency stabilization, the distance between the laser mirror mounts is fixed by using Neoceram grass rods. For active feedback stabilization, ac and dc Stark effects of an external Stark cell are used. In the Stark-cell, a pair of Al parallel plate electrodes 1.3 m long and 10 mm apart is placed. Dc Stark field (< 400 V/cm) and ac Stark filed (150 Vpp/cm, 520 Hz) are applied to the electrodes. The Stark field is applied perpendicularly to the direction of the **E**-vector CO_2 laser light. The transmitted and Stark-modulated light is detected by a pyroelectric detector, and the signal is fed back to a lock-in stabilizer for control to the PZT. Figure 2 shows the output of CO_2 laser and the lock-in output of the Stark-modulated signal as a function of the CO_2 laser cavity length. Since the modulated signal for the feedback control was not sufficiently obtained in CH_3OD, CH_3OH was used in this experiment. The zero crossing point can be selected by changing the cell pressure and the applied dc Stark filed. The CO_2 laser frequency is locked so that the 57-μm CH_3OD laser has a peak power. Figure 3 shows a typical temporal change of the CO_2 laser output power and the Stark-modulated signal around the line center. The power fluctuation of the CO_2 laser is within ± 0.6 %/40 min. The frequency stability is estimated about ± 0.78 MHz/40 min. It was found from the results that the external CH_3OH Stark-modulation method is effective in the stabilization of the pump 9R(8) CO_2 laser.

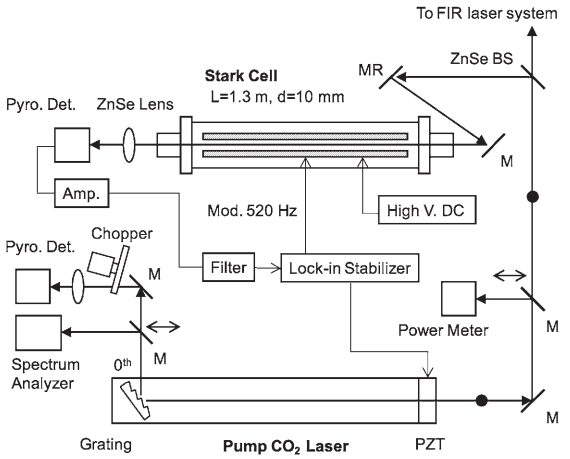

Fig. 1. Schematic diagram of the stabilization system of the pump 9R(8) CO_2 laser.

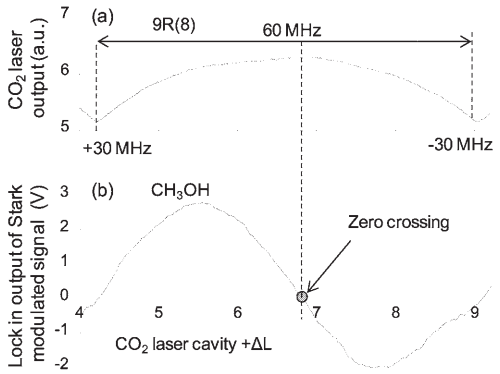

Fig. 2. (a) Detuning curve of the 9R(8) CO_2 laser, (b) the Stark-modulated signal as a function of the laser cavity length (CH_3OH pressure=45.5 Pa, dc Stark field =200 V/cm, ac Stark field=150 V_{pp}/cm).

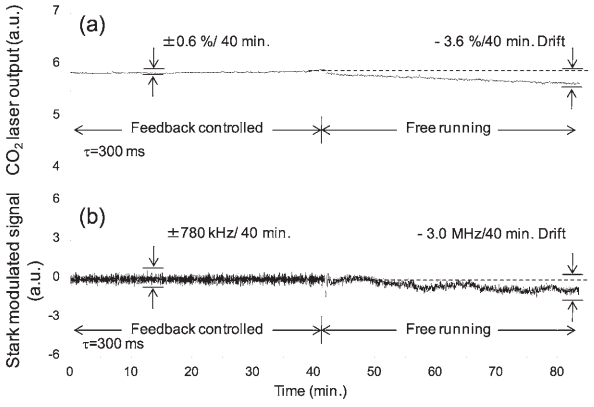

Fig. 3. Fluctuation of (a) the output power and (b) the Stark-modulated signal at the CO_2 laser line center in the feedback control and free-running operation modes.

1) Kawahata, K. et al.: Rev. Sci. Instrum. **79** (2008) 10E707
2) Okajima, S. et al.: Infrared Phys. **25** (1985) 569