§8. Development of a Powerful and Stable Pump 9R(8) CO_2 Laser for 48-μm and 57-μm CH_3OD Lasers

Nakayama, K., Okajima, S. (Chubu Univ.),
Kawahata, K., Tanaka, K., Akiyama, T.

For high density operation of the LHD and future plasma devices such as ITER, simultaneously oscillated 48-μm and 57-μm CH_3OD lasers have been developed as optical sources of two-color interferometer and polarimeter. The pump 9R(8) CO_2 laser requires a powerful and stable oscillation with a single mode. These are of considerable importance in the simultaneous oscillation of the 48-μm and 57-μm CH_3OD lasers. We have previously obtained the power stability of 45 ± 0.3 W/40 min. and the frequency stability of ±780 $kHz_{p\text{-}p}$/40 min. in the stabilized mode[1]. In this study, the pump CO_2 laser system was improved so as to increase the output power and steady the output power and frequency.

Figure 1 shows the configuration of the pump CO_2 laser stabilization system using an external Stark-cell. The pump CO_2 laser is an internal-cavity type with no Brewster window. The laser cavity consists of a ZnSe output mirror (55 % reflectivity, 20 m radius of curvature) attached on a PZT and a Al coated grating of 150 lines/mm. By extending the cavity length at 3 m, the output power of 150 W at 9R(8) line was achieved. The free spectral range (FSR) is about 50 MHz. In this experiment, the pump CO_2 laser operated at about 110 W from points of view of the oscillation mode, the stability, and the consumption of laser gases. In the Stark-cell, a pair of Al parallel plate electrodes 1.0 m long and 7 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 pyro electric detector, and the signal is fed back to a lock-in stabilizer for control to the PZT. This method has advantages that can be stabilized at the optional frequency in the FSR and does not require the internal frequency modulation. Although Stark-modulated signals were observed from CH_3OH, CH_3OD, C_2H_5OH, and HCOOH, we selected CH_3OH from the S/N of the modulated signal. Figure 2 shows the Stark modulated signal when the CO_2 laser frequency is swept through its tuning range. The laser frequency is stabilized at the zero crossing point. The zero crossing point can be selected by changing the cell gas pressure and the applied dc Stark filed. Because the offset frequency of 48-μm and 57-μm CH_3OD lasers is about 1 - 2 MHz, the pump CO_2 laser was stabilized around the center frequency.

As a result, the performances are the power stability of 107.9±0.5 W/60 min. and the frequency stability of ±420 $kHz_{p\text{-}p}$ /60 min. at the line center. Plasma diagnostics requires that both output and frequency are kept as constant as possible throughout the long time. The pump 9R(8) CO_2 laser system is capable of long term stability of 10 hours without mode jumping. The results are shown in figure 3. We tried an improvement of the frequency stability by Lamb dip. In this experiment, the steep absorption signal was obtained by passing the Stark-cell twice as shown in figure 2. The frequency fluctuation was estimated at ±230 $kHz_{p\text{-}p}$ per hour in the stabilized mode. The output power stability was 108.2±0.6 W per hour.

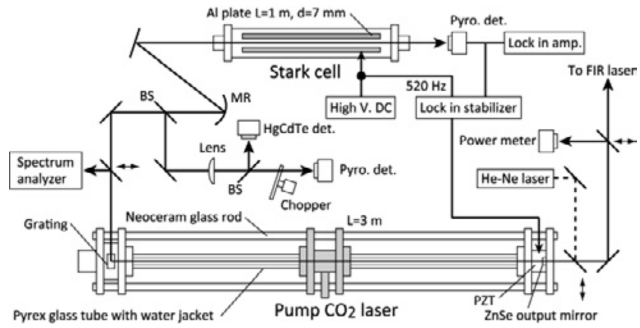

Fig. 1. Pump 9R(8) CO_2 laser device including the frequency stabilization system

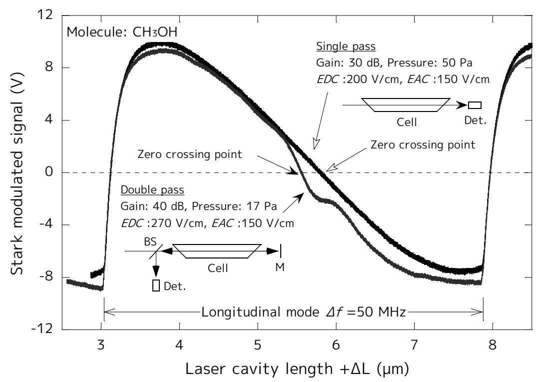

Fig. 2. Stark modulated signal for a change in the laser cavity length

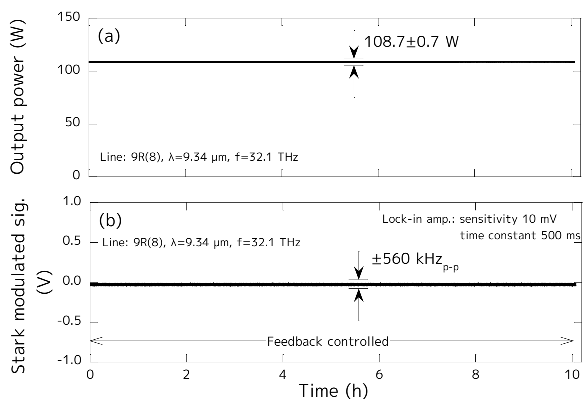

Fig. 3. Long term stability of (a) the output power and (b) the frequency of the pump 9R(8) CO_2 laser

1) K. Nakayama *et al.*, *Proc. of IRMMW-THz2009*, W5E57.0358, 2009.