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An Optical Alignment Equipment for Laser System

By

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Authors have developed an optical alignment equipment for laser systems for the purpose of speeding up of laser adjustment process. Optical alignment of a laser apparatus is generally troublesome especially for such a large-sized laser apparatus as optical elements are located separately. This equipment is designed to display tuning curves of laser power and evaluate the distinction and smoothness of the curves numerically. The optimum position of optical elements are found by monitoring changes of tuning curves before and after slight move of elements. The controller and the display of this equipment can be brought to the place of the optical element. After having applied this equipment for the optical alignment of the H_2CO stabilized He-Xe laser system, alignment time has been reduced to one hour from one day which was required in manual adjustment.

Key words: laser, optical alignment, micro computer.

1. Introduction

Authors have utilized a He-Xe laser at 3.51 μm for the high resolution Stark spectroscopy of H_2CO[1)] and for the stabilization of the laser frequency using a component of the spectrum. An optical alignment process of a laser is generally troublesome because of many optical elements to be adjusted. For the purpose of speeding up of this process, the authors developed a micro computer aided alignment equipment.

Figure 1 shows a diagram of the experimental apparatus for high resolution Stark spectroscopy. Stark effect of saturated absorption signal (inverted Lamb dip) is observed, as H_2CO of 10 mTorr is contained in the intracavity Stark absorption cell. The laser cavity is 155 cm long, the overall length of the apparatus is 2 m of some size. One of the cavity mirrors is mounted on a piezoelectric transducer (PZT) for frequency tuning and modulation. Since the frequency of the transition $5_{1,5}$ (v = 0) – $6_{0,6}$ (v_5 = 1) of H_2CO is about 180 MHz higher than the center of the gain curve of the He-Xe laser, axial magnetic field of 124 G is applied to the laser tube to compensate for this frequency gap using a solenoid. A quarter-wave plate and a polarizer is necessary to separate higher-frequency circularly-polarized Zeeman component from lower-frequency oppositely circularly-polarized one.

The full width of half maximum (FWHM) of inverted Lamb dip is about 500 kHz when using present apparatus. Resolution of several tens kHz is necessary for precise measurement of Stark effect because Stark shifts are order of 1 MHz at electric field of 4 kV/cm. This improvement in resolution power will be achieved by reducing

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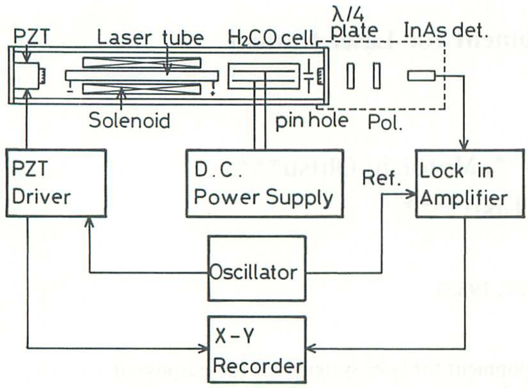

Fig. 1 A 3.51 μm He-Xe laser apparatus for high resolution Stark spectroscopy of H_2CO.

the depth of the laser frequency modulation and reducing the H_2CO gas pressure. On the other hand this improvement results in several tens times smaller spectrum intensity than usual, the laser must be carefully aligned to get the maximum intensity of the dip.

The usual procedure for alignment is as follows; bring optical elements such as a laser tube, a solenoid, an absorption cell, a detector and mirrors into line using a 633 nm He-Ne laser. Subsequently discharge the laser tube and adjust position and angle against the optical axis of elements, in order to get high laser oscillation and to get a distinct and smooth tuning curve of laser power. In case the tuning curve is indistinct or kinky, the inverted Lamb dip is not observed. This can be interpreted that saturation occurs unsuccessfully because higher order modes arise.

Conventionally, the tuning curve is recorded in an X-Y recorder in every slight move of optical elements, and the changes of both intensity and shape of the curve are checked manually. The optimum position of optical elements are searched after a lot of such process because there are many parameters in the positions of components. For instance, as shown in Fig. 1, there are four parameters of the position and angle against optical axis in a laser tube, an absorption cell, a solenoid and a detector, two of position in a pin hole, two of angle in each cavity mirrors; in total there are as many as 22 parameters. The difficulty of optical alignment process increases remarkably in such a large-sized laser equipment as in our system, because every optical elements are located separately. Furthermore measurement of beat signal of two lasers are planned in order to measure precise Stark coefficient, speeding up of the optical alignment process has been desired.

2. The Constitution and Function of the Equipment

This equipment is designed to draw two tuning curves before and after slight manual move of every optical elements on CRT display, and to indicate the distinction and smoothness of the curves numerically. The optimum position of every optical element can be easily found by indicated evaluation of curves.

Figure 2 shows the block diagram of the equipment. A micro computer (Apple II) with memory of 64 kBytes and display function of 280 x 192 dots, works under UCSD Pascal operating system. An A/D (analog to digital) and a D/A (digital to analog) converters are 12 bits of resolution power. The laser frequency is controlled by the computer through the D/A converter. Sweep of the laser frequency is controlled remotely using extended switch box. This device is useful, especially for large-sized laser apparatus because the remote switch and the CRT display can be brought to the place of the optical

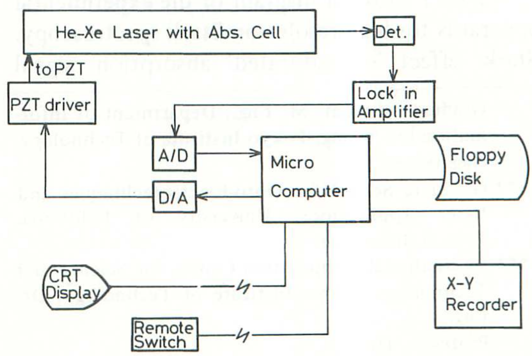

Fig. 2 The block diagram of the optical alignment equipment for laser system.

elements to be adjusted. A mini floppy disk driver is used to store data of tuning curves. The stored data is utilized for comparison to previous tuning curves and it can be applied for some kind of data processing.

Figure 3 shows typical examples of display on CRT. Indicated numbers are the maximum and minimum values of intensity and the maximum value of 2nd order finite differences of tuning curves, respectively. The latter can be considered to indicate a kinky point of the tuning curve usually. In the case inverted Lamb dips are observed, this value indicates the intensity of the dip. Figure 3 (a) shows a tuning curve when the optical alignment is not appropriate. An indistinct and kinky tuning curve results small intensity of inverted Lamb dips. Figure 3 (b) shows a tuning curve when optical elements have been adjusted to maximize inverted dips using this equipment. As distinction of a tuning curve and inverted Lamb dip is successfully evaluated on the display, an optimum optical alignment can be realized more easily than conventional process.

In addition to the function of repetitive laser frequency sweep, the function of automatically magnifying sweep around inverted Lamb dip is programmed in this equipment. Since the laser is Zeeman tuned to the inverted Lamb dip, dips appear at the top of tuning curves as shown in Fig. 3 (b). Using this function, the laser frequency is swept around the inverted Lamb dip after a gross sweep for detection of the top of the tuning curve. The inverted Lamb dip is automatically magnified on the display as in Fig. 3 (c), without influence of change in the tuning curve originated from temperature drift of the laser cavity length. The inverted Lamb dip shown in Fig. 3 (c) is 8 times magnification of Fig. 3 (b) in frequency axis. This function can be applied for investigating the change of a inverted Lamb dip against the change of some parameters.

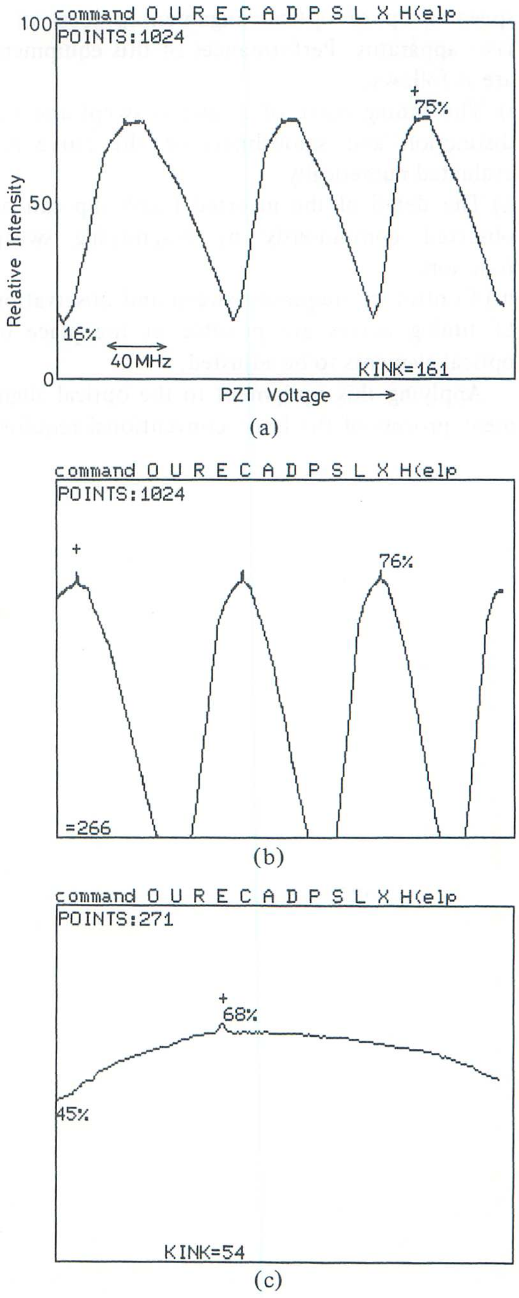

Fig. 3 Examples of display on CRT (a) before, (b) after alignment and (c) eight times expanded of (b), using the equipment. Alphabetic characters indicated upper are lists of commands for several data acquisition and processing.

3. Summary

The authors have developed a microcomputer aided alignment equipment for the prupose of speeding up of optical alignment process of a laser apparatus. Performances of this equipment are as follows;

i) The tuning curve of a laser is swept and the distinction and smoothness of the curve are evaluated numerically.

ii) The detail of the inverted Lamb dip can be observed continuously by magnifying sweep function.

iii) Control of frequency sweep and observation of tuning curves are possible at the place of optical elements to be adjusted.

Applying this equipment to the optical alignment process of the laser, conventional required time of over one day is reduced to one hour because time for manual operation of X-Y recorder and for evaluation of tuning curves are eliminated. Since such procedure as mentioned above includes common optical alignment processes, this equipment may be applicable to various kinds of laser apparatus especially to complex structured and large-sized laser systems.

Reference

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