Modulation-free locking of a diode laser on the Cs resonance line

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A high spectral purity of the emission frequency of a diode laser has a fundamental importance in metrologic application. The emission line-width, which may be achieved in a diode laser system in an extended cavity configuration by using a grating as a frequency-selective mirror, is of the order of some hundreds kHz, for an integration time of the order of some ms. Narrower line-widths are usually achieved by locking the laser frequency to the peak of saturated absorption signal in a reference cell through a wideband servo loop. In this case the discrimination signal is obtained by modulating the laser frequency at high frequency (larger than the reference line-width) through injection current modulation or better through an EOM. We present here a locking scheme, which produces an effective discrimination signal without the use of any frequency modulation technique. For this purpose, we exploit the dichroism induced by a magnetic field on the reference cell vapor, as first suggested by Corwin et al. [1] in the case of Rb.

In our case we have applied the method to the D_2 Cs transition at 852.1 nm. The reference cell, filled with Cs vapor and thermalized around 43°C, is placed in a longitudinal 14 mT magnetic field. The magnetic field is high enough to separate the Zeeman components of the atomic Doppler broadened absorption signal. The difference between the σ^+ and σ^- components of the transmitted radiation is detected by a circular polarization analyzer (made by a $\lambda/4$ retardation plate, followed by a Rochon prism) which gives the error signal. Figure 1 shows the experimental setup, and Figure 2 reports an experimental record, referred to the F=4 $\rightarrow$ F' hyperfine component of the D_2 line.

In spite of the much larger line-width (about 500 MHz and about 20 MHz respectively for the two cases) of this signal as compared with the saturated absorption signal, its slope is about the same. The large line-width of the error signal warrants a large locking range, making robust the lock against external perturbation. The stability of this reference depends on the Cs cell temperature stability, magnetic field intensity, and birefringence of the optical elements.

The error signal is used to lock the frequency of a diode laser with grating feedback in Littman configuration. The error signal is sent to an intracavity EO device, in order to achieve a fast correction of the cavity length. We have numerically computed the line shape of the signal to evaluate the sensitivity to the field (about 5 kHz/μT) and to the cell temperature (lower than 300 kHz/°C). The measures of line-width and of the long-term stability of the system are now in proceeding, and will be presented at the conference.

[1] K.L. Corwin, Z.T. Lu, C.F. Hand, R. J. Epstein, C. E. Wieman, *Appl. Opt.* **37** 3295 (1999).

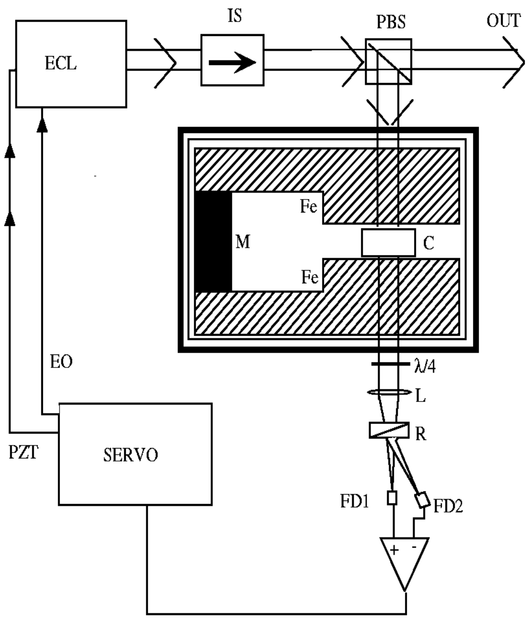

Figure 1: Experimental setup: M: magnet, Fe: Iron, L: lens, C: Cs vapour cell, ECL: extended cavity laser, IS:isolator, PBS: polarizing beam splitter, R: Rochon prism.

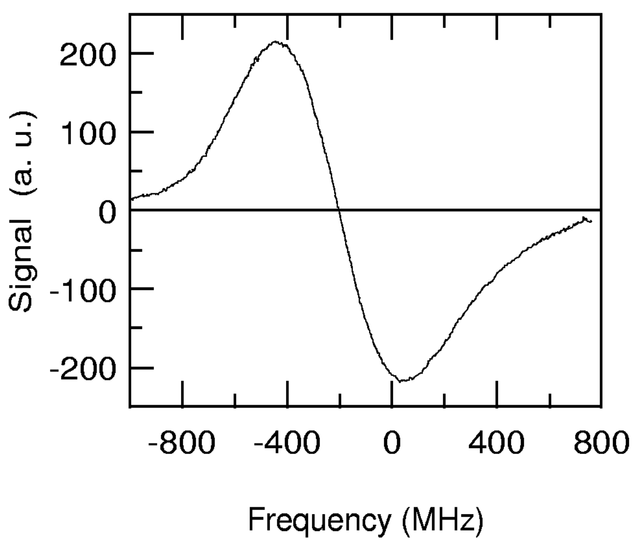

Figure 2: Dispersion signal referred to the F=4 $\rightarrow$ F' hyperfine component of the D_2 line, magnetic field value 14 mT.