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A Compact Extended Laser Diode Cavity Centered at 780 nm for Use in High-Resolution Laser Spectroscopy

Authors : J. Alvarez, J. Pimienta, R. Sarmiento

Abstract : Diode lasers working in free mode present different shifting and broadening determined by external factors such as temperature, current or mechanical vibrations, and they are not more useful in applications such as spectroscopy, metrology, and cooling of atoms, among others. Different configurations can reduce the spectral width of a laser; one of the most effective is to extend the optical resonator of the laser diode and use optical feedback either with the help of a partially reflective mirror or with a diffraction grating; this latter configuration is not only allowed to reduce the spectral width of the laser line but also to coarsely adjust its working wavelength, within a wide range typically ~ 10nm by slightly varying the angle of the diffraction grating. Two settings are commonly used for this purpose, the Littrow configuration and the Littmann Metcalf. In this paper, we present the design, construction, and characterization of a compact extended laser cavity in Littrow configuration. The designed cavity is compact and was machined on an aluminum block using computer numerical control (CNC); it has a mass of only 380 g. The design was tested on laser diodes with different wavelengths, 650nm, 780nm, and 795 nm, but can be equally efficient at other wavelengths. This report details the results obtained from the extended cavity working at a wavelength of 780 nm, with an output power of around 35mW and a line width of less than 1Mhz. The cavity was used to observe the spectrum of the corresponding Rubidium D2 line. By modulating the current and with the help of phase detection techniques, a dispersion signal with an excellent signal-to-noise ratio was generated that allowed the stabilization of the laser to a transition of the hyperfine structure of Rubidium with an integral proportional controller (PI) circuit made with precision operational amplifiers.

Keywords : Littrow, Littman-Metcalf, line width, laser stabilization, hyperfine structure
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