Oscillation frequency stabilization of a semiconductor laser by an indirect modulation method using the Faraday effect

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1. Introduction

While semiconductor lasers' longevity, efficiency, compactness and light weight are taken for granted, the single, most formidable obstacle to progress in the field has been the stabilization of the diodes' oscillation-frequencies. When we find the way to circumvent it, the limitless potential of these devices as light sources for precision laser interferometers be opened to exploitation by scientists the world over.

Research using tandem satellites' on-board tracking laser interferometers, is aimed at gauging the infinitesimal variations in the relative velocities of these orbiting bodies, to accurately measure fluctuations in earth's gravitational field. And because these interferometers, and the satellites that carry them were purpose-built to withstand the rigors of deep space, their light sources should be durable. And, if frequency stability of better than 10^{-13} in the square root of Allan variance σ in the averaging time τ from 1 to 100 seconds can be obtained, the relative velocity of satellites flying in tandem can be measured at better than 10 nm/s.

Thus far, we have succeeded in stabilizing semiconductor lasers' frequencies to Rb absorption lines, by means of negative electrical feedback. Because of the Rb absorption line's stability over the long term, we succeeded in stabilizing the frequency of a semiconductor laser. This process, which uses the Faraday- (a type of magneto-optical-) effect, has no more tendency to widen an oscillation spectrum, than does direct modulation.

2. Experiment

Figure1 describes the experimental setup used in Faraday PEAK. The laser beam was collimated by a lens and divided by beam splitter 1 (BS1). The beam that passed BS1 and optical isolator was subsequently transmitted through the linear polarizer (LP1) and cell 1, in the modulated magnetic field, and divided by BS2. The beam reflected BS2 passes LP2, is set at +45 degrees. The beam through BS2 passes LP3, is set -45 degrees. Each beams are focused onto avalanche photodiode 1, 2 (APD1, 2) respectively.

Also, in order to measure the beat frequency between two independently stabilized lasers, both laser beams split by BS1, 4 in each optical setup, was focused onto APD3. The frequency is used to estimate the stabilities.

3. Experimental results and conclusion

Using Faraday PEAK method, we were able to confirm improvement of the stability in comparison with Faraday Normal method.

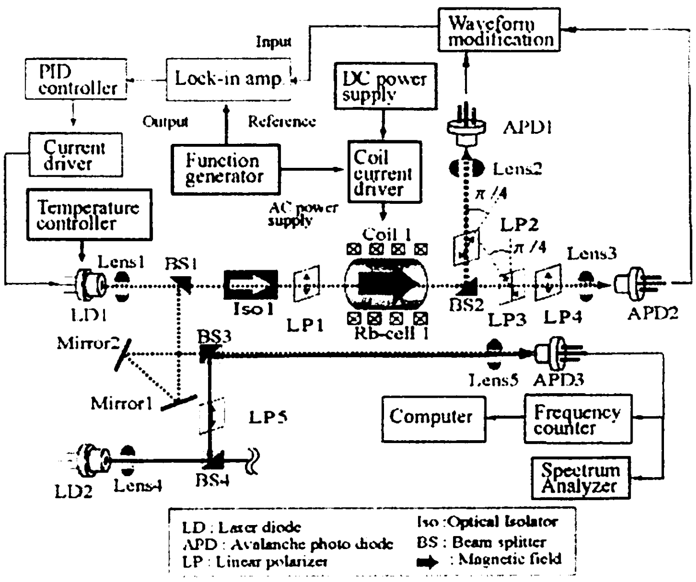

Fig.1 Experimental setup.

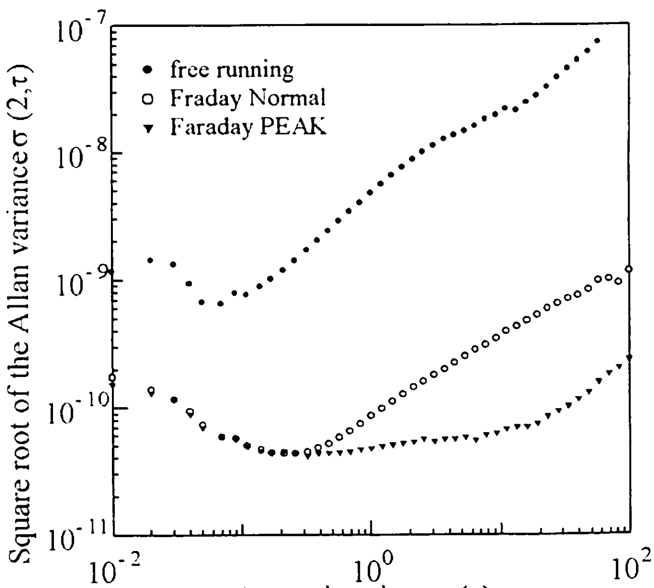

Fig.2 Stabilities of oscillation frequency