Mini Review

Frequency modulation of an extended cavity diode laser for 2D raman cooling in a cesium clock

Abstract

We used frequency modulation of an extended cavity master diode laser in an optical set-up for an atomic clock experiment at NIST. We modulated at low frequencies from 3.2GHz to 4.8GHz at different powers in order to generate sidebands at those frequencies to inject in laser beams which trap and cool cesium atoms in an atomic clock.

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The 2D Raman cooling in an atomic fountain clock has been a fashion in the 90s in order to reduce the transverse velocity of the cesium atoms when being launched under gravity in a fountain experiment. The launched cesium atoms undergo a ballistic flight through a 1D moving molasses method in high vacuum and pass through a microwave cavity where they are submitted to two $\pi / 2$ microwave pulses. We could use a commercial electro-optical modulator at 9.2GHz and could inject the carrier and one sideband into the cooling laser beams. Or at 4.6GHz too but these EOMs were hard to build at this low frequency and were not usual in the market.[1,2] They were not very efficient. We have opted for a frequency modulation of the master laser which injected three slave laser diodes through optical isolators. The three slave diode lasers gave three pairs of laser beams which served to trap, launch and cool the cesium atoms in a fountain clock.[3]

We have built a microwave antenna to modulate the frequency of the ECDL. The peltier cooler had to be replaced by a stronger one in order to decrease the heating of the laser diode due to radiofrequency power. This heating measured with a thermistor added noise. We noticed that there was some created amplitude modulation and high frequency noise. We added a filter and a stub tuner built with BNC connectors in order to eliminate low frequencies and parasites (Figure 1). The hole problem was to couple the RF power to the diode laser. The diode had an impedance of about 1Ω (or few Ω). The impedance matching consisted to reduce the impedance of the RF connector from 50Ω (output of the RF synthesizer).

The idea was to make many short circuits of variable length and adjust their length to make the impedance matching with the laser diode and avoid its damage. We noticed that the maximum frequency is at 3.6GHz (Figure 2).

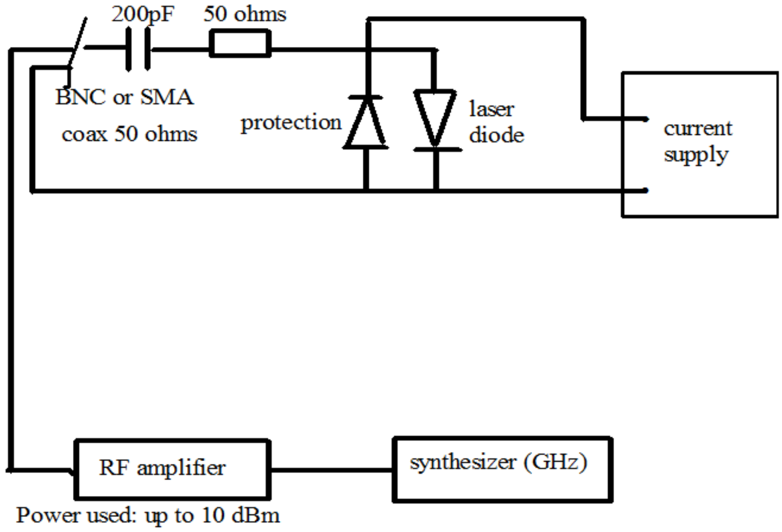

Figure 1 Set-up for the frequency modulation of an ECDL.

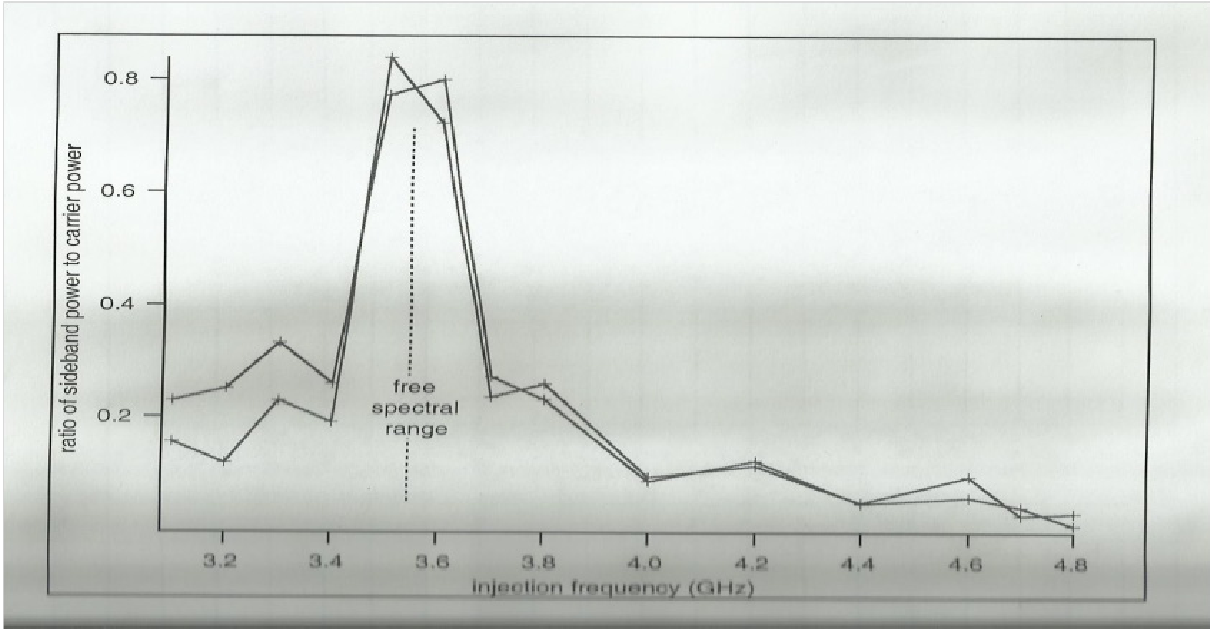

Figure 2 Efficiency of the FM of the ECDL against the injection frequency.

This frequency was close to the free spectral range of the ECDL which is inversely proportional to the distance d between the external face of the laser diode and the coupling mirror of the ECDL. We have concluded that we had to shorten the distance d from originally 4.06cm to 2.90cm to reach an optimum frequency modulation at 4.6GHz (the half width of the clock transition in the cesium atom). We coupled a set of amplitudes at 3.6GHz and noticed that we could reach 28 dbm at this optimum frequency without destroying the laser diode (Figure 3). We could obtain an efficiency of 80% in each sideband at this optimum frequency.[4] This work has been undergone at NIST almost two decades ago.

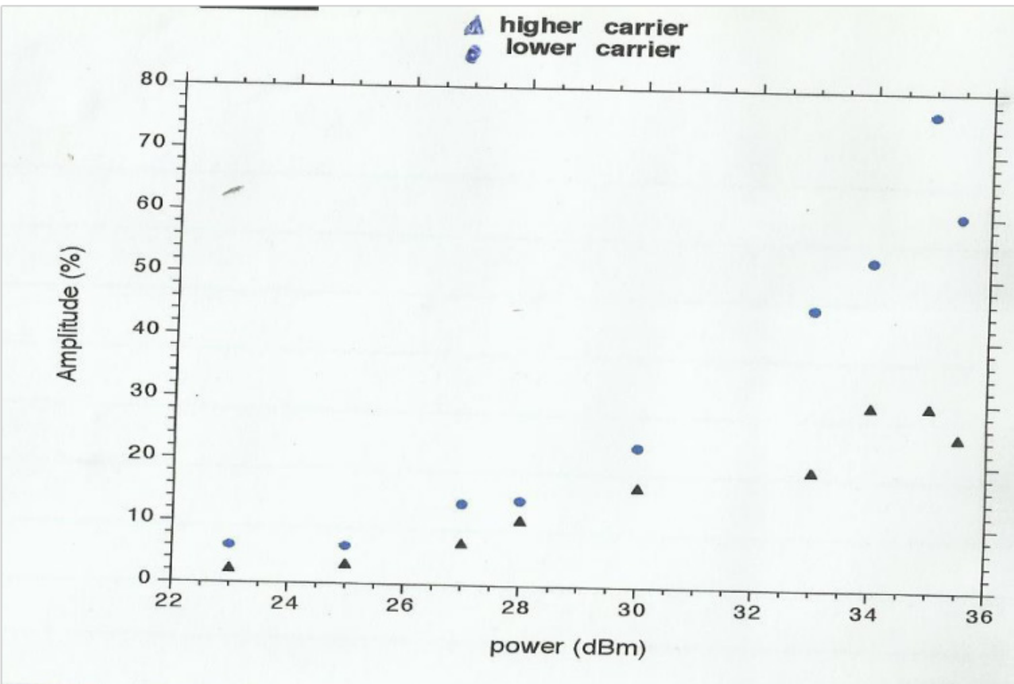

Figure 3 The relative amplitude of the sidebands against the injection power.

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Conflict of interest

Author declares there is no conflict of interest.

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