Dichroic Atomic Vapor Laser Lock

Chris Carlin

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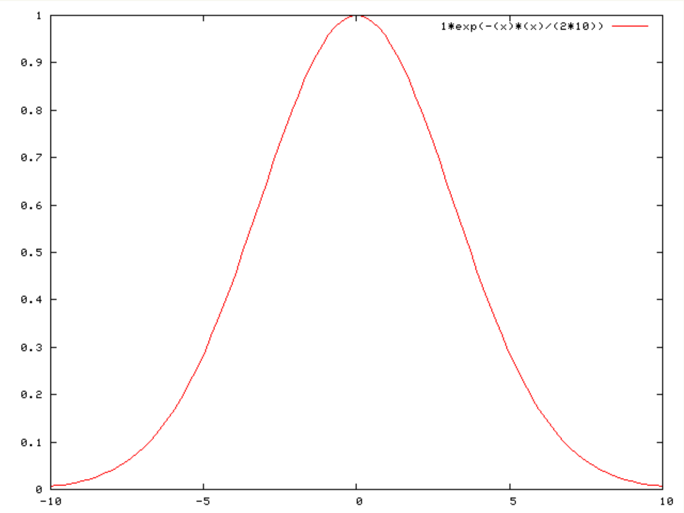
Feedback Signal Development I

An obvious place to start: a standard, Doppler-broadened absorption signal



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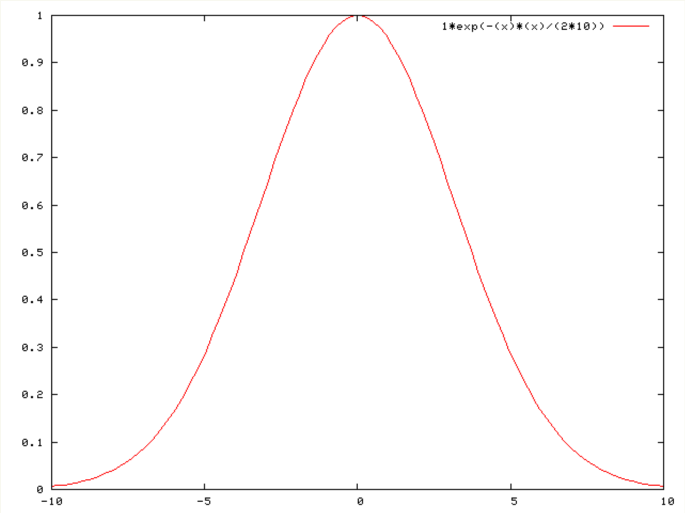


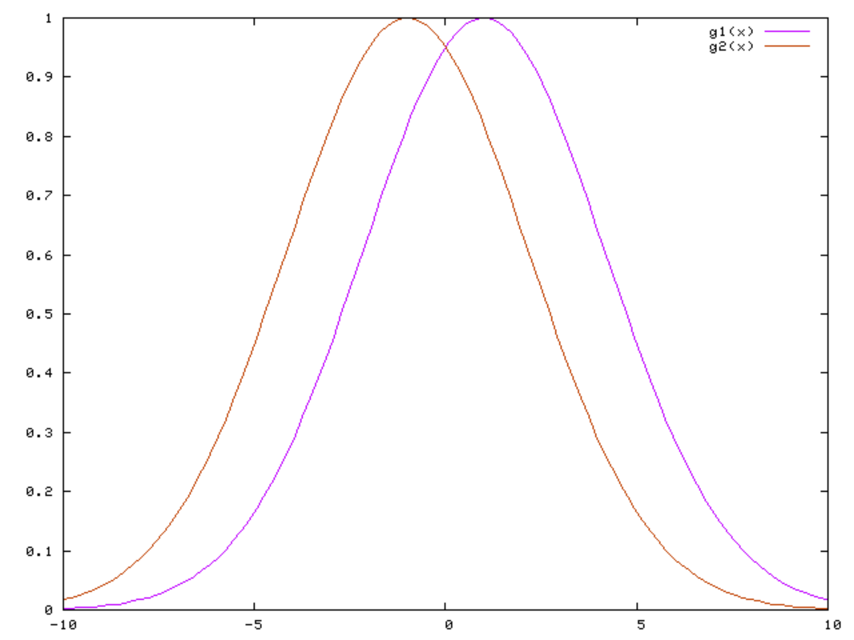
But this is not so good:

- Gentle slopes near the peak will fail to correct drifts
- Steep slopes on the sides are too short for long range recovery
- Symmetry of sides hides direction of detuning
- Fluctuations in laser intensity and optics will cause the lock to demand drifts

We'd like a longer, steeper, asymmetric slope that somehow cancels non-frequency fluctuations.

Feedback Signal Development II

Solution: find two curves offset equal amounts from the target frequency



Feedback Signal Development II

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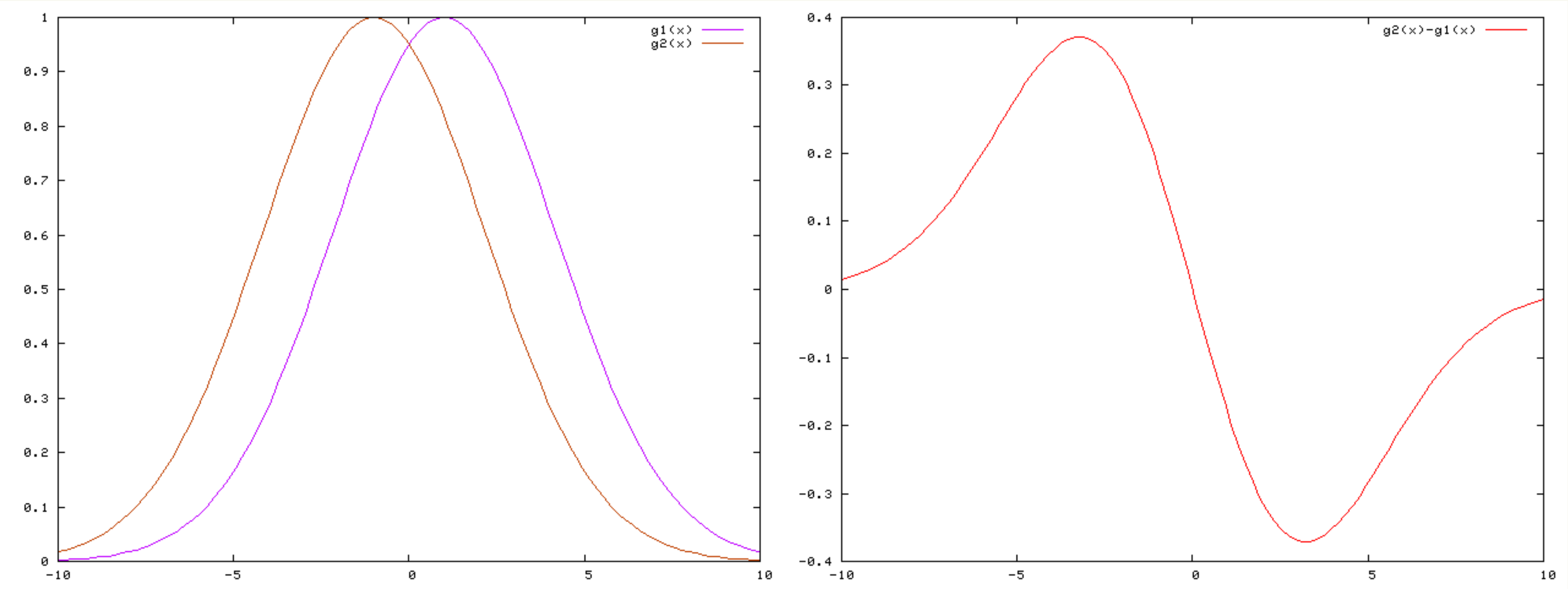


and subtract them electronically

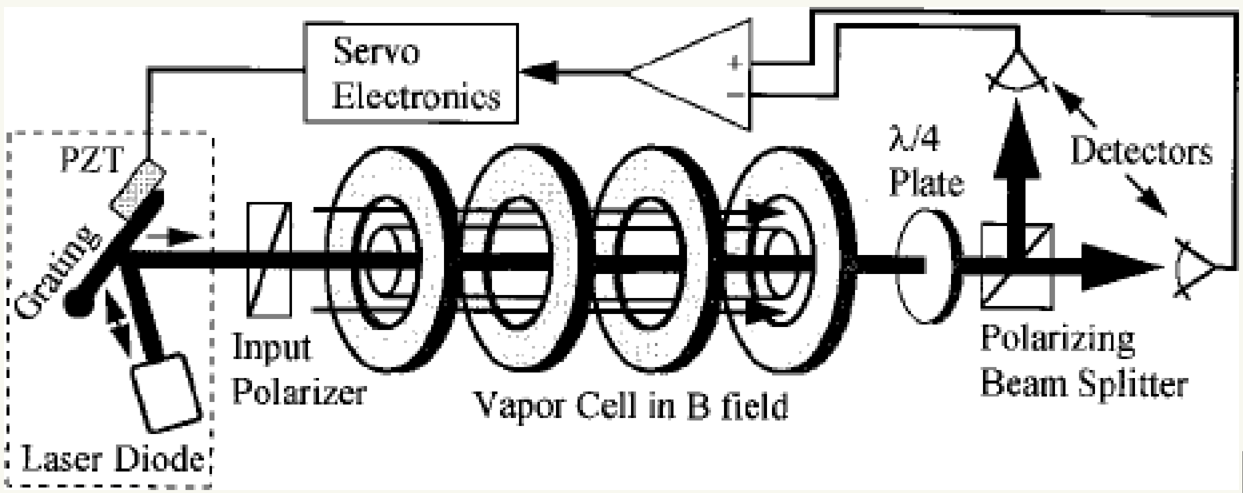
- Convenient zero crossing to lock is perfect for feedback signal
- Long, steep slope gives plenty of recapture range
- So long as offsets are equal, bias from non-frequency sources cancel

And to create this offset? Zeeman shifting.

Zeeman Shifting Apparatus

How to put Zeeman shifting to use

1. Generate a linearly polarized laser beam
2. Pass it through a Rb cell along the axis of a weak (100-200 gauss) magnetic field, causing the clockwise and counter-clockwise components of the linear polarization become frequency shifted
3. Sort it out through a combination of a 1/4 wave plate, a polarizing beam splitter, and a couple of photo diodes

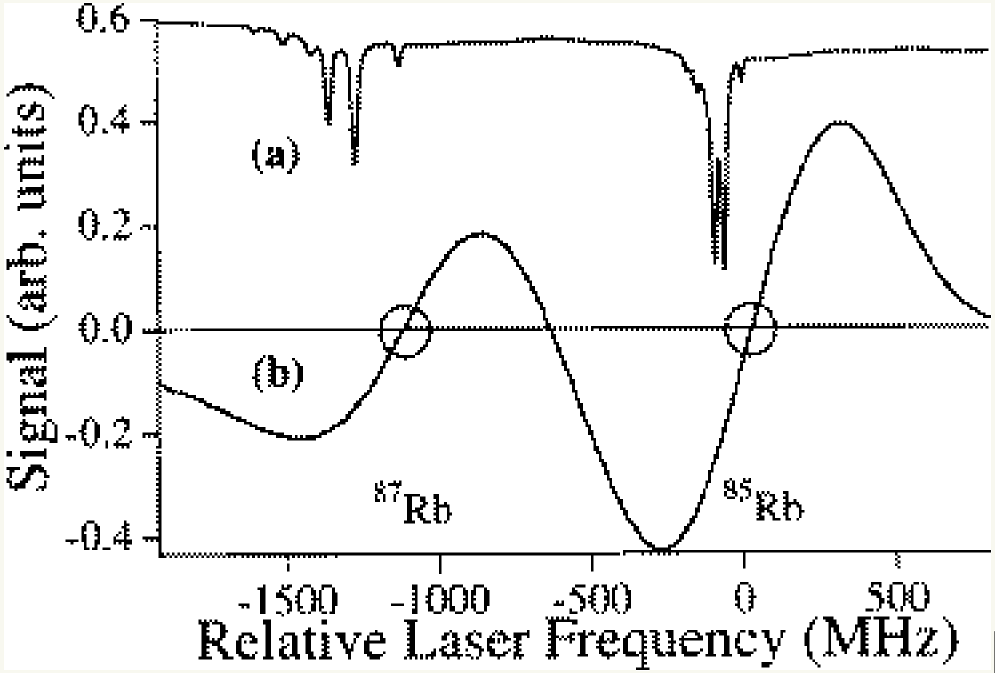


[1]

This splitting of laser light is the source of the word dichroic.

Benefits of DAVLL

DAVLL is often compared to saturated absorption methods, as in this image.

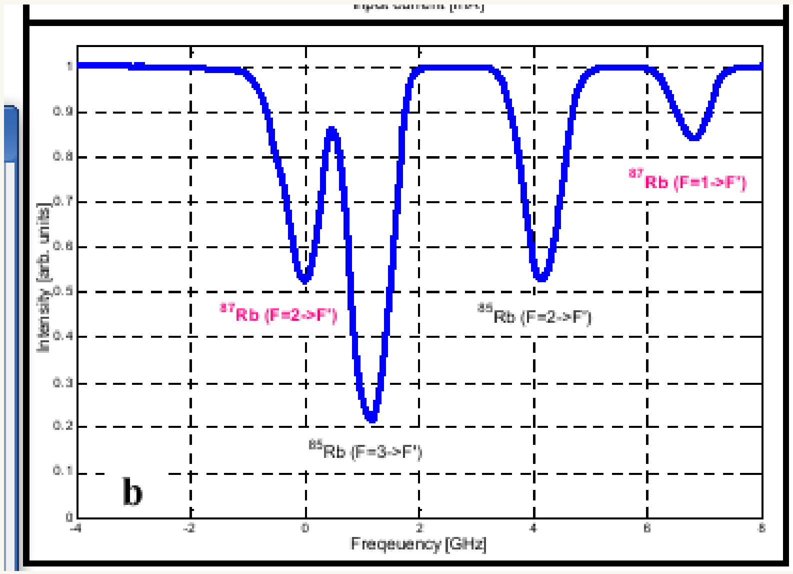


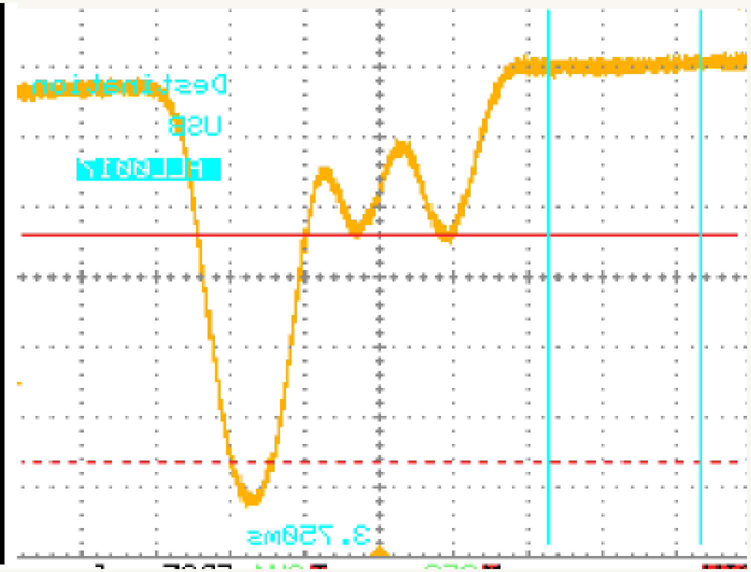
[1]

As can be seen, DAVLL offers a larger recapture range at the expense of slope. At the same time DAVLL is simpler, cheaper, and requires less support electronics.

Our Results

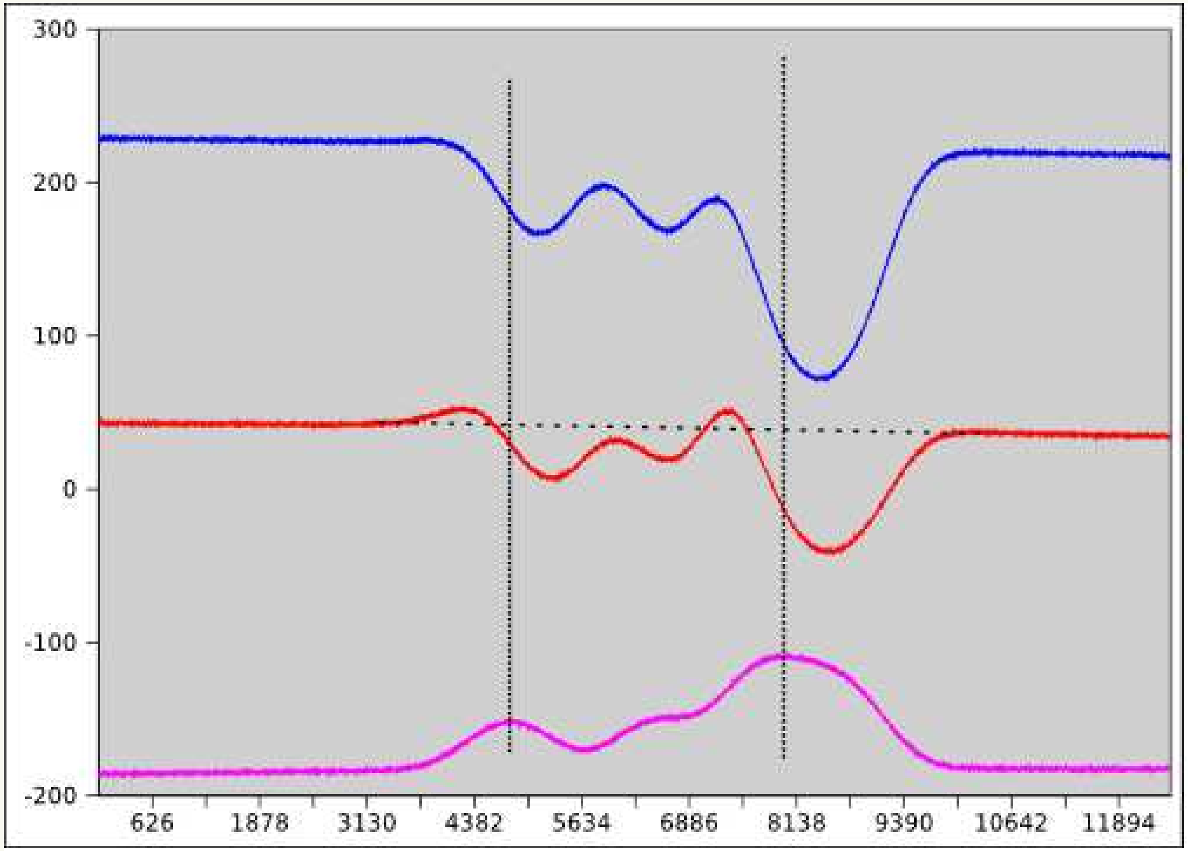
For reference, an absorption spectrum[2] of natural rubidium and our traces





Observed DAVLL Signal

- Blue and purple are individual signals
- Red is the differential DAVLL signal
- Vertical scale is in mV, horizontal scale is arbitrary frequency



References

[1] K. Corwin, Z. Lu, C. Hand, R. Epstein, and C. Wieman, «Frequency-stabilized diode laser with the Zeeman shift in an atomic vapor», Applied Optics (1998)

[2] I. Ben-Aroya and G. Eisenstein, «Characterizing Absorption Spectrum of Natura l Rubidium by Using a Directly Modulated VCSEL», IEEE (2005).