October 10, 2010

Red fiber laser (3)

Wavelength vs. temp scan suggests that the currently considered diode hops over the desired transition; the closest offset (near modehopping event, as well) seems to be about 0.2nm, whereas the injection locking range from Vainio is on the order of 0.002nm, so yesterday's scan doesn't look too promising with regards to injection locking applications.

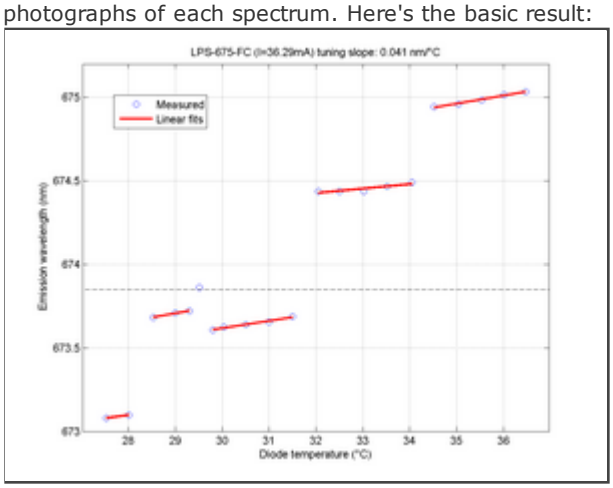
Today, I will try scanning the wavelength at a different diode current level. I will run at ~1.2mW output after oi, so that I should not be in the "very low injection current" regime. (Perhaps it will help with single mode selection?) It will also let me know in general how much influence the current can have on tuning gap location.

(For completeness, I would also like to investigate the wavelength variation as a function of current at a fixed temperature. Should be quick.)

From testing the fiber splicer with Christian, he brought over a "throwaway" red fiber laser that I salvaged. (Don't know how old it is -- but supposedly it was Ed's first BEC2 project, so a few years at least.) I did a quick check with the HP analyzer, and it also seems to be a 675nm fiber (lithium has a 670nm dipole transition), so I may scan the wavelength of this laser, if it turns out the current fiber remains unfavorable in terms of 674nm locking range.

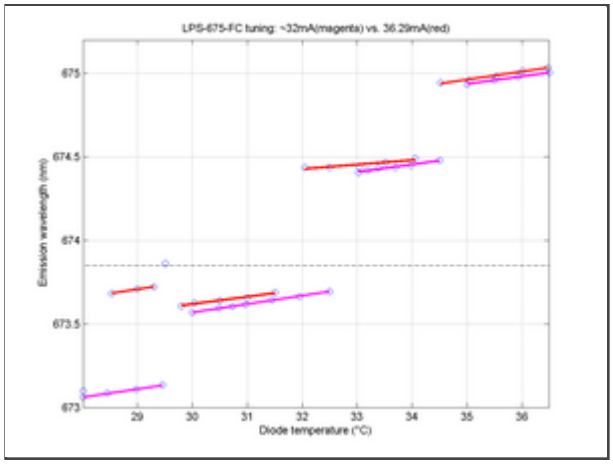
Turned on laser at 32.64mA and 36.47C, which is the last measurement I took yesterday. I find 675.005nm as opposed to the recorded 675.003nm of yesterday. But, the peak location is moving around in the last digit. Furthermore, given the resolution of the instrument, it seems that I can basically "pick up" at the same operating point within few minutes of turning the laser on.

Moved up current to 36.29mA, for which power after oi is 1.2mW. I want to leave it here for now, since I will be scanning down in temperature; for fixed current, the power will increase in this direction. For interest of time, I will not be taking photographs of each spectrum. Here's the basic result:



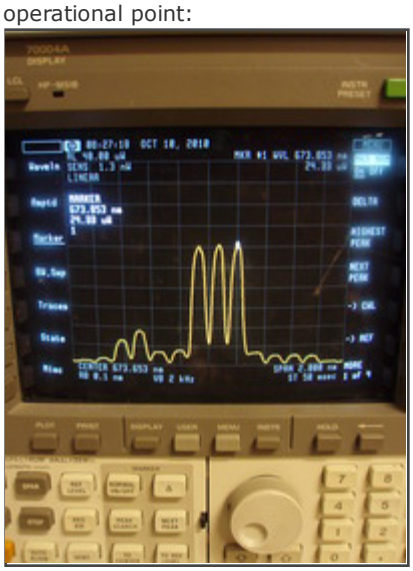
Remark about the solitary dot in the vicinity of (T=29.5,I=673.85) later.

Oh boy, these things are very complicated. The shift in diode current is evident in the tuning gap locations and behavior:



The new measurements at higher power (1.2~1.6mW over temp tuning after oi) is shown in red, and the lower power (~0.6mW) measurements of yesterday in magenta. Although the location (in temp) of the tuning gaps are affected by the diode current, it seems that the range of frequencies that are accessible with clear single-mode operation (i.e. near centers of each segments) hasn't too dramatically changed.

Now, with regards to that solitary dot ~29.5C that seems to give the desired wavelength. That temp range 29~30C is a multimoding region, and there are three diode longitudinal modes fighting. Here's a photograph of the spectrum at that operational point:



These three modes are the ones fighting for dominance in the 29~30C part of the plot. I checked to see if I can make the right one dominate by changing current at a fixed temperature of 29.5C but all three modes grow together, and no selection. The current does have an effect on the relative heights of the three modes, but they are always comparable.

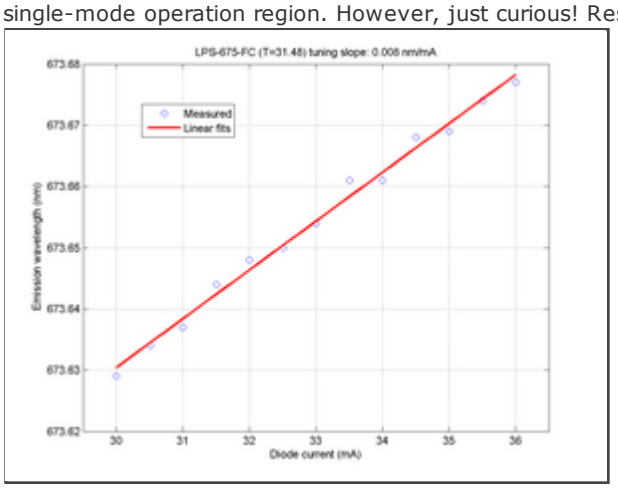
Another variable is "optical feedback" which people tell me is so important, but one that I do not know how to control. However, to see if I could control the shape of the spectrum by any possible back-reflections into the laser, I tried a few techniques:
1) Tried loosening the laser fiber connector to the collimator, in case there was any effect of backreflections from the collimating lens.
2) Tried slightly tilting the collimator face wrt to the input pbs face of the isolator which could also scatter.
3) I tried modifying the mechanical stress of the fiber paddles -- not sure how it would effect any feedback, actually.
In all three cases, the only effect that I observed is in the overall amplitude of the same spectrum -- since I'm modifying the coupling into the fiber that goes into the analyzer (after oi), I did not see any effect of the above in reshaping the spectrum.

4*) Per Ike's suggestion, I also tried putting a nd filter outside of the fiber prior to the oi (I would've thought that the oi is a much better thing to have than the nd filter). I held the oi at an angle... no effect on spectrum shape.

Perhaps injection would be possible into the diode even though the fiber is, at this operating point (T=29.49C,I=36,32mA,l=673.860nm) lasing into three modes simultaneously. Presumably, there are performance repercussions of such operation.

Laser diodes are complicated. Given this amount of variation in the operation of the bare diode itself, io wonder why some of the lab's lasers are extremely good and stable from day to day, whereas some others are extremely finnicky.

For today, I want to finish up the basic measurements for my own sake. I want to see what is the typical wavelength tunability due to dc current modulation when the temperature is controlled independently. It's pretty apparent that it's not going to give me control over ~0.1nm ranges, which is what I would need to access the desired wavelength from a good, single-mode operation region. However, just curious! Results:



Since the motion of the peak is so small (reference to the analyzer) I had to use an average of 100 shots to determine the mean with sufficient precision to produce the above results. Tuning slope of 0.008nm/mA (~5GHz/mA); about an order of magnitude lower than temp tuning (per C). Both are still gigantic wrt atomic linewidths, but maybe the "fine tuning" to get close to the injection lock frequency can be done with current, rather than the temperature.

Again, the Wieman review is super helpful: "For typical AlGaAs diode lasers the variation in the laser's frequency is ~ -3GHz/mA [=0.005nm/mA] for frequencies below about 1MHz..."

I find that with this diode, it is fairly good about being able to return to the same operating point. I haven't yet observed any hysteric effects. Returned to the state where the desired wavelength is one of three multimoding modes. Played around in this temp vicinity with even higher currents (~2mA after oi); no indication that there will be a magic setting for single mode lasing into 673.85nm around this operating point.

Time to go home and do some homework. My impression so far with this laser is that:
1) The desired wavelength lies in the tuning gap of the laser,
2) There is one operational point where the laser multimodes into three fiber modes of which one is the desired wavelength.

My plan is to either (a) try out the spare fiber laser, or try injecting the multimoding laser.

In any case, Wieman tells me: "The spectral 'gaps' encountered in the laser tuning as it jumps from one step to the next are the biggest drawback to using diode lasers in atomic physics"... and "If you are starting an experiment with diode lasers, buy several lasers at once. Because of the difficulties and delays in purchasing lasers, combined with the possibility that some lasers may never reach the desired transition and others may die abruptly, it is highly advisable to keep a number of spares on hand." :(

Posted by kimt at October 10, 2010 12:40 PM

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