Internship at USP in Brazil

Manuel Nonnenmacher
Bachelorstudent Physik 6th semester
manuel-tobias.nonnenmacher@student.uni-tuebingen.de

Supervisor: Prof. Philippe Courteille

29.07.2014-02.10.2014

Internship at USP in Brazil

Introduction

My project for my internship at the institute of Physics of Sao Carlos(Insituto de Física de Sao Carlos, IFSC) in sao Paulo was to lock an external cavity laser with the Pound-Drever-Hall-technique. The lasers I was using were external cavity lasers build with the concept of Steck which he published.The lasers are later used in a project to measure the gravity continuesly with Bloch-oscillations.

Aligning the laser

The first thing I had to do was to align the laser beam inside the Stecklasers and exchange the broken parts. Therefore I exchanged the AD590 temperature sensor and the diode(number 4 with a number 6) because the pins where broken. Then I had to align the laser beam inside the external cavity.
After aligning the laser the threshold had to be done. This is a procedure were the alignment of the laser changed to achieve a threshold current as low as possible. The threshold current of the laser diode itself was 51,6 mA. After aligning the external cavity I achieved a threshold current of 46,25 mA. One big problem in aligning the laser was, that the horizontal alignment could be done very easily due to two screws in the front and back of the laser diode but the horizontal alignment was much harder because these screws where both on the same side of the laser diode.
This issue forced me to use the grating to change the horizontal position of the beam. Another problem I had to face was that after putting the top of the laser back in place, fixing the screws changed the threshold current a lot.
Also probably due to mechanical interaction the threshold current seemed to change after a day or two. This change might have been caused by the two horizontal screws which seemed to be a bit loose.

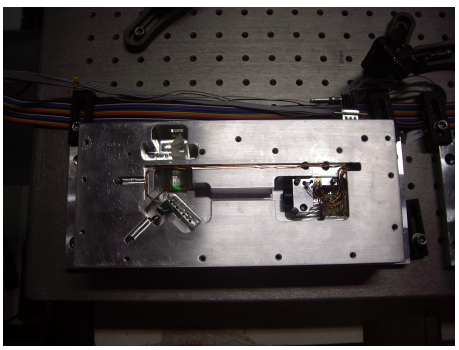

Abbildung (1)
This was the Steck-laser I was using

The optical Set-up for the PDH locking

After leaving the external cavity laser the laser beam was adjusted to a hight of 5 cm. Then the beam passed an isolator to prevent any reflections and a polarizer. The next step was to couple the laser into a confocal cavity with a lent which had a focal length of 10 cm. The cavities length was 5cm the same value the radius of curved mirrors had, which is a typical property of a confocal cavity. The lent with a focal length of 10 cm was used to achieve a very good mode matching. Therefore I tried to put the focus of the lent to the middle of the cavity. Behind the cavity there was a photo diode which measured the intensity if the transmitting light.
After achieving a nice signal with a finesse of almost 200 we started installed another photo diode next to the cavity due to measure the reflected signal. To separate the reflected signal from the incoming signal I used a lambda/4 plate and beam splitter. This Signal was the inverse signal of the transmitted signal. Both of the Photodiodes exaggerated/overwrought very fast so I used resistors to shortcut the diodes which solved the problem. For the diode which monitored the transmitted signal I used 8,2 kOhm and for the diode monitoring the reflected signal 31 Kohm.

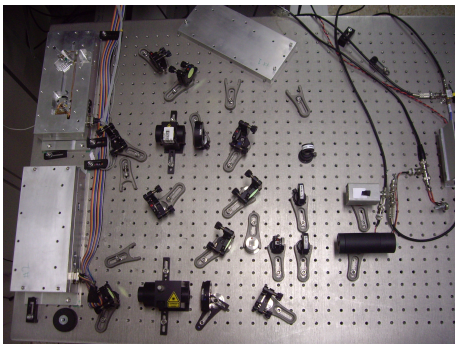

Abbildung (2)
This is the actual alignment I build up

The Temperature control

For the temperature control of the Stecklasers there were three Peltier elements installed underneath the case of the laser. These peltier elements were adjusted by a PID-control which was receiving the temperature of the diode from a thermistor installed inside the Stecklaser. In addition to the thermistor there was also an AD590 to measure the exact temperature but it was not used for temperature control.
In the beginning the temperature control was not working properly which led to a small fluctuation in the diode temperature. To avoid this fluctuation I reset the adjustdment of the PID control. I couldn't fix it completely because it seemed like the I-share wasn't working properly. So I continued to work without the I-share which worked quite fine and the temperature was stable enough.

Producing side-bands and the PDH Signal

To produce the side-bands I was using a direct modulation of the laser current. This modulation can be expanded in the basis of Bessel-functions and then approximated to a total of two additional peaks on both sides of the main original peak. These two peaks are called side-bands. The distance between the main peak and the side-bands depends on the frequency of the current modulation. The higher the frequency of the modulation the bigger is the distance between the sidebands and the main peak. This drifting dosen't work for high frequencies because the intensity of the sidebands drops after it reaches higher values than the cut-of-frequency. The signal with sidebands is then reflecet from the first cavity and can be detected reversed in the second photo detector. This reversed signal is then amplified connected the mixer together with the current modulation.

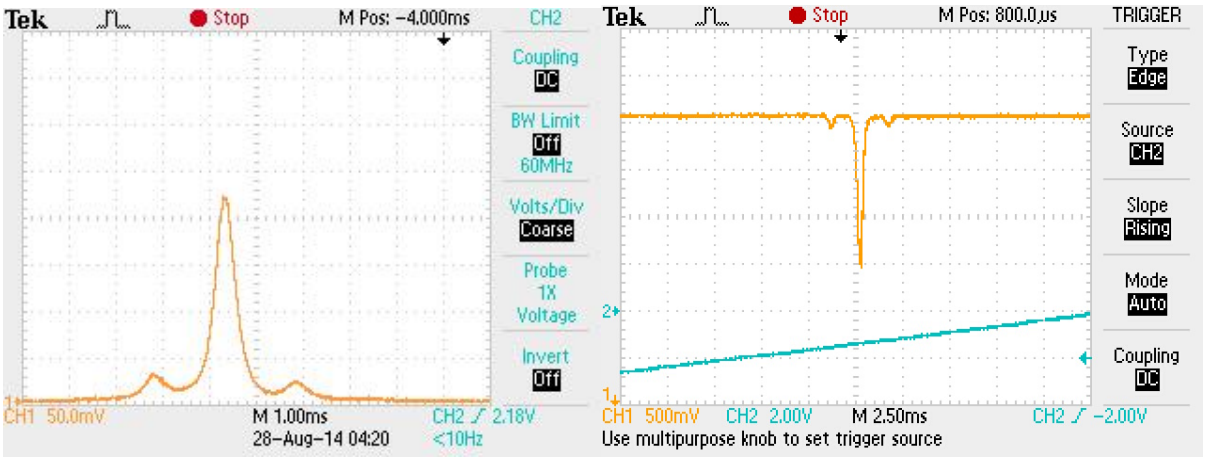

Abbildung (3)

Sidebands in the transmitted and reflected signal

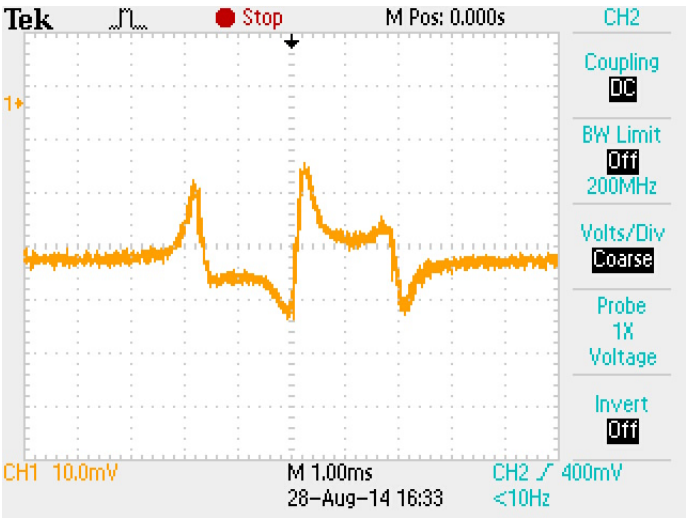

Abbildung (4)

This are the Sidebands measured

Confocal Fabry-Perot Cavity

At last I was working on an other confocal cavity. First I clued the mirrors to the case of the cavity. Then I tried to see the diffraction pattern of the cavity and aligned the reflected laser beams to one single one. After achieving this I adjusted the screws at the front of the cavity in a way that the diffraction pattern turned into one single point. For the last fine adjustments I connected a photo diode to the back of the cavity and put a ramp to the piezo. The photo diode was connected with an oscilloscope.
In the end I was able to achieve a finesse of 100. This was less then I expected because in the beginning I measured the reflectivity of the mirrors and calculated a finesse of 400. I think the finesse can still be improved by shortening the base of the cavity because I had to fix al the screws to the limit to achieve the best finesse.

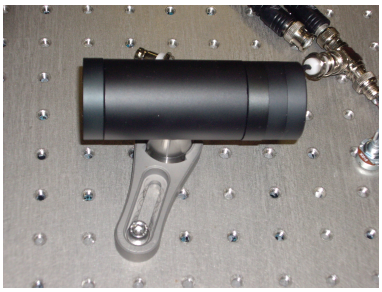

Abbildung (5)
The Cavity I used in the expirement