Thermal Noise Lab Advice

You need to read both the Lab assignment and Lab Module document BEFORE starting the lab. In the course packet, there is "Lab #2" under "Labs" and "mod 2" under "Lab Modules". *Lab Assignment #2* explains what is specifically required of you during this lab. *Module 2* gives detailed instructions to accomplish it. *Module* 2 provides a description of the AFM system and three lab experiments. You are only doing "Experiment 3: Measuring Boltzmann's Constant".

Corrections and Advice:

- *Module* 2 says to use 'scannergui' to perform Z-modulation. We are now using 'AFMControlPanel' instead. ('scannergui' will NOT work).
- You are required to perform the experiment with 2 cantilever lengths. Do the entire experiment with each cantilever before changing it. After you save the force curve and move the sample out of contact, do not move anything else and immediately record the thermal-mechanical noise spectra with the Labview spectrum analyzer. It is important that you do not change anything in your setup (like move the laser, detector, or cantilever) because you need the calibration data you took to match-up to the PSD data.
- Make sure to record the gain of the amplifier during calibration and noise spectrum measurement. You will need to know these values for data analysis.
- Pay attention to the units of the spectrum analyzer. The PSD (y-axis) is in V^2/Hz. This will also be important for data analysis.

Note about the Cantilevers:

There are two cantilever geometries, the imaging cantilever and the differential cantilever pair. (See section 3.1.3 and 3.1.4 in *Module* 2 for information about both types) Even though you will get a better noise spectrum with the differential cantilever, we suggest that you start the lab using an imaging cantilever. They are easier to use and we have an adequate supply of them. You should use these cantilevers for familiarizing yourself with the machine, and run through the experiment with it (the actual experiment is very short).

Then we suggest that you use the differential cantilevers to do the experiment and record data.

Note about the Force Curve:

An ideal force curve would look like the one in *Module* 2 figure 9c. The Y-axis is the detector's output voltage and the X-axis corresponds to the piezo (and sample) movement. The curve shows the changing intensity of *one* of the diffraction modes. The flat line is when the cantilever is out of contact (so the cantilever is not bending and the intensity is not changing). The $\sin^2$ part is when the cantilever is in contact and bending. However your curve will not look exactly like the figure. This is because the piezo is hysteretic and the cantilever sometimes sticks to the sample.

Directions overview:

(This is just a general overview of the procedure. You should refer to *Module* 2 for more details)

Experiment Setup: see section 3.2

1. Insert cantilever holder with imaging cantilever in the AFM
2. Insert an appropriate sample for calibration (imaging cantilever: silicon sample, differential pair: glass sample with step edge)
3. Focus the microscope on the cantilever of interest.
4. Turn on laser, and use the laser adjustment knobs to focus the laser on the diffraction fingers of the cantilever. (you should be able to see the diffraction modes clearly on the detector)
5. Move the detector so that one of the modes is centered in the slit. (the 0^{th} or center mode generally works best)

Engaging the tip and Calibration: see section 3.2.5 and 3.2.6 (and 6.2 for differential cantilever)

1. Use "AFMControlPanel" in Matlab to run the Z-Mod scan.
2. *Carefully* raise the sample while using the microscope. Use the coarse adjustment first. When it is close you will see the reflection of the cantilever on the sample (if the sample is silicon). Use the joystick to bring the sample into contact. When it is in contact you should see an immediate change in the output curve. You will also see the modes changing on the detector.
    a. *For the differential pair cantilever, only one side should be in contact. This means you have to line it up with the step edge. The sample is not reflective so this is more difficult. Please ask for help when bringing this cantilever into contact.*
3. Make adjustments to the curve bias, the Z-mod frequency, the Z-mod amplitude, and the DC offset until you are happy with the curve. Save.

PSD : see section 6.3

1. Bring the sample out of contact.
2. Set the amplifier to AC, and turn up the gain of the amplifier ~100-1000
3. Run the Labview Spectrum Analyzer and experiment with different types of averaging. Save your PSD data.