

Ferrofluid oscillator: Data analysis

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Overview

Experimentally measured damping oscillations can be used to establish relationships between the dissipative forces and the droplet shape. This is done with Matlab using functions that can be found in MyCourses. After data analysis you will write a report of your work.

Before starting the data analysis, read the article *Free-decay and resonant methods for investigating the fundamental limit of superhydrophobicity* to get necessary background information. The article is in MyCourses.

If you have any questions relating to the data analysis or writing the report, do not hesitate to contact the assistant. This can be done through MyCourses or e-mail (fereshteh.sohrabi@aalto.fi).

Data analysis

Download the function package from MyCourses and extract it in a folder that is included in the Matlab search path (you can also add a folder there using *Set path* –button). Alternatively you can just change the Matlab working directory to the folder where the functions are located.

Basic instructions for each function can be viewed with *help* –command (e.g. *help CalcMagField*). The functions are commented and you are expected to read them through to get **basic understanding** of how they work. You do not have to understand all the details (e.g. the formulas in *CalcCoeff*). However, *CalcMagField* contains a lot of information that will be needed when writing the report.

Please note that the functions are not perfect. They might contain bugs or work poorly with some data sets. If you get errors or weird results, first check the code to see if you can find the cause. If not, contact assistant either through MyCourses or e-mail with detailed information about the problem. If you find an error in the code, please let the assistant know, even if you manage to fix it yourself.

Remember to save the output of each function for each measurement. Most of them will be needed when writing the report.

Effects of the Normal Force

To calculate the droplet shape (i.e. contact line length and contact area) in each measurement, you need to know the magnetic field strength and the normal force. These are calculated with *CalcMagField* from the distance between the magnet and the bottom of the droplet, which is recorded in your notes. The thickness of the glass slide is 1 mm, in case you measured the distance from the bottom of the slide. After you know the normal force, you can calculate the contact line length using *CalcContactLine*.

Oscillations

Load in Matlab the data file you created in the teaching laboratory. Use the function *AnalyzeCoordinates* to fit the general harmonic oscillator model to your data points. You might need to tune the starting values of the fitting coefficients in order to achieve a nice fit (type *help AnalyzeCoordinates* for details). Assess the goodness of the fit from the plot (Fig. 1) and save it (each plot will be added to the appendix of the report). Please note that it might be impossible to achieve good fit with some datasets, especially when the substrate has been very near or very far from the magnet.

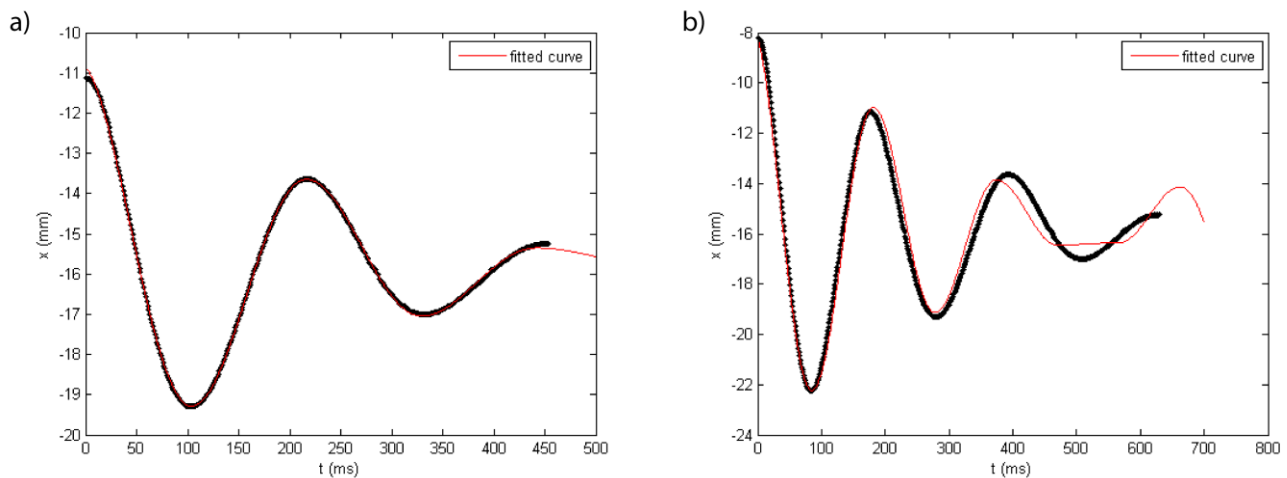


Figure 1: a) a good fit, b) a poor fit due to nonharmonic oscillations (too large a value for maxamplitude)

Assembling the Results

Multiple measurements were performed at each field strength. Use these to evaluate the random error in F_μ and β by calculating their standard deviation for every droplet shape.

According to the theory the CAH-force F_μ depends linearly on the contact line length l . Check if this is true by plotting F_μ as a function of l in a single plot (use data from all of the measurements). Correspondingly viscous

dissipation coefficient β should depend linearly on the contact area A . A can be easily calculated from l (l can be estimated to be the perimeter of a circle). Make a linear fit in both datasets, if it seems reasonable.

However, it is possible that your results deviate from these theories. This is not a serious problem, you just need to think about the reasons for this and discuss them in your report. If your data seems to indicate a different model, feel free to describe it.