Macroscopic AFM – Results

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Results

Fundamental frequency

b, d and l were measured to be 3.65 ± 0.005 mm, 1.59 ± 0.005 mm and 232 ± 1 mm respectively. A micrometer was used to record the values for b and d so its error is relatively small, ± 0.005 mm, for l however a ruler was used, giving a larger error of ± 1 mm, this is still low however. The calculated value of f_1 was then determined to be 24.45 ± 2.32 Hz.

The fundamental frequency resonance curve was plotted, using this calculated value as rought starting point. The uncertainty in the frequency and amplitude were too low to see on the graph.

$$f_1 = 21.07\,\mathrm{Hz}$$

The amplitude of f_1 is roughly 25 cm, so for Q the bandwidth was calculated at 17.67 cm.

$$Q = \frac{21.07}{21.33 - 20.85} = 43.896$$

Frequency $\pm$ 0.005/ Hz	Amplitude ± 0.1 / cm
12.19	0.4
14.12	0.5
17.01	1.1
18.09	1.5
18.43	1.6
19.05	2
19.31	2.2
19.83	2.9
20.05	3.3
20.15	3.7
20.35	4.5
20.46	5.1
20.67	7.6
20.85	17.8
21.07	24.9
21.14	22.3
21.31	17.5
21.58	9.2
21.80	6.2
22.01	4.9
22.68	2.7
23.05	2.1
23.66	1.7

The error of the frequency recorded is dependent upon the oscillator, it measures to 2 d.p. so the absolute error is ± 0.005 Hz. When measuring the amplitude the error is from my ability to accurately read the laser on the graph paper, it could be faint and shakey at times giving a less accurate reading. It was divided into 1 mm squares, however I would say the error is 1 mm. Given these errors I would say that my data is trustworthy in that a curve was formed with a clear peak.

f_1 was smaller than expected, with a percentage error of 16%. This is because the moment of inertia that's used for the frequency calculation does not take into account the tip, magnet and mirror at the end of the cantilever, these decrease the moment of inertia making the frequency lower than calculated.

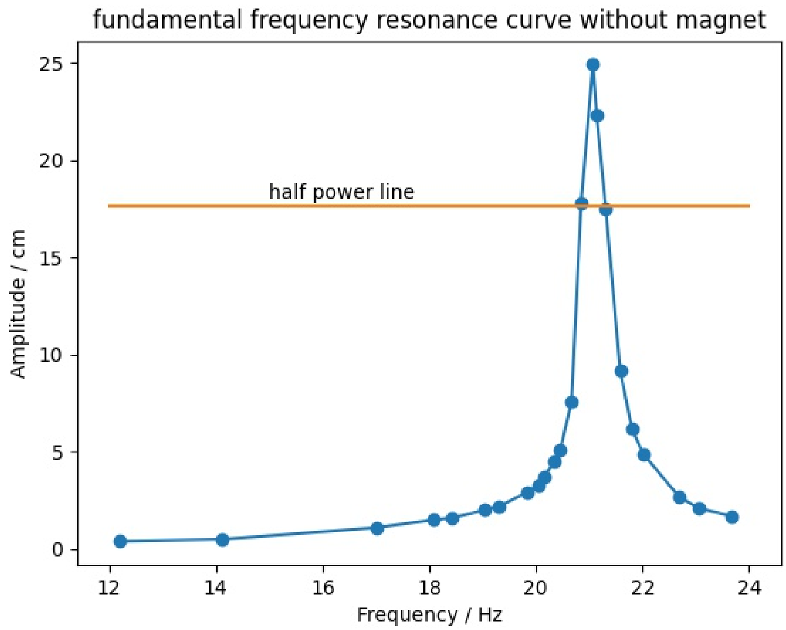

Figure 1: Resonance frequency curve of f_1

Fundamental frequency with magnet

For the next step the magnet was moved under the tip, it appeared to push the tip upwards, this is repulsive. In Figure: it can be seen that the fundamental frequency is shifted to the right when the magnet is beneath it. This is due to the force of the magnet increasing the effective spring constant, giving it a slightly higher fundamental frequency. The cantilever is ”stiffer” and so it takes more energy to make it resonate. The Q value calculated from this was 44.28, this is higher than without the magnet, indicating that it would drop off slower.

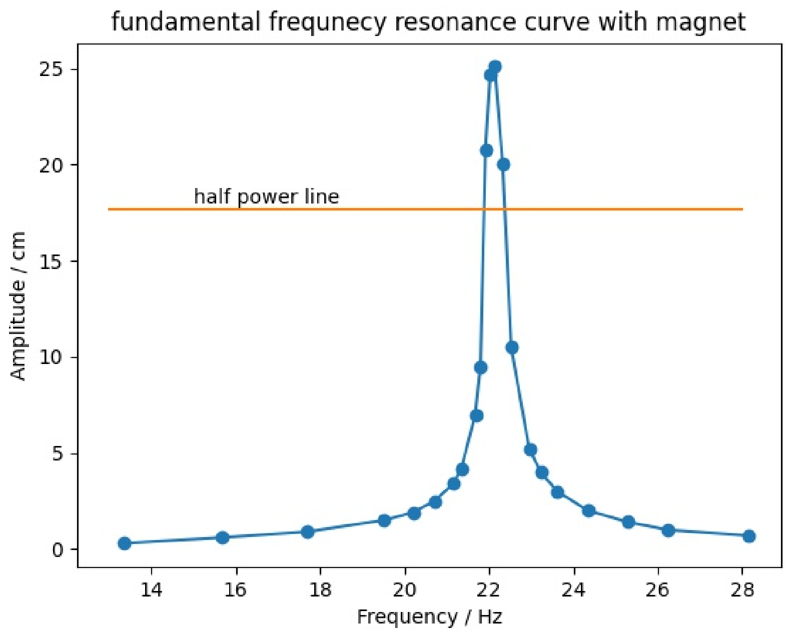

Figure 2: Resonance frequency curve of f_1 with a magnet

Second harmonic frequency

As seen in Figure: a clear fundamental frequency was obtained for the second harmonic frequency. $f_2 = 141.9\,\mathrm{Hz}$. The uncertainty in the frequency and amplitude is once again too low to see on the graph. Q was found to be 126.517, this is much higher than for f_1, meaning that an oscillation inat f_2 would last for much longer.

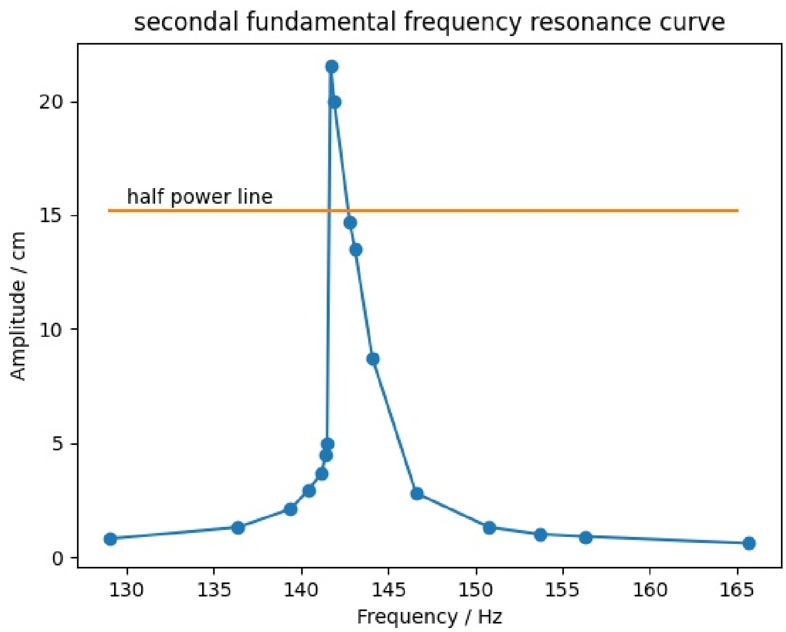

Figure 3: Resonance frequency curve of f_2