Acoustic Levitation

Project-oriented Physics Lab for Undergraduate Students

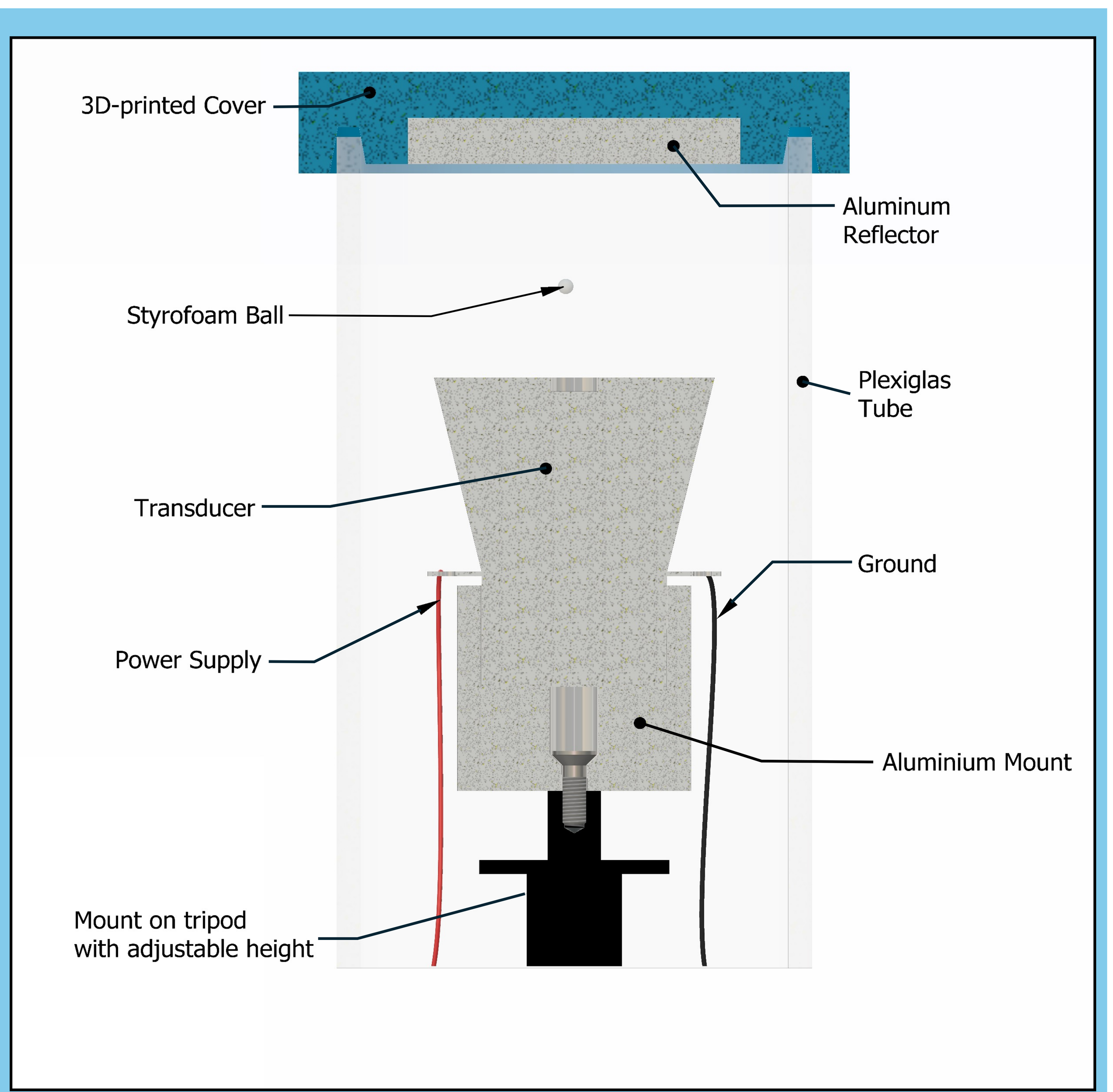
Physics Lab ETH zürich

Theory

- We produced a standing air wave, which is formed by the superposition of two waves propagating in opposite directions with the same frequency.
- We observed a phenomenon where small particles are "levitating" in the nodes of this wave. We trapped Styrofoam particles in these nodes.
- The distance between two nodes is equal to 2 times the wavelength λ. Knowing the driving frequency of the oscillator f, we then calculated the speed of sound of the medium of propagation using the distances measured between the particles and $c=\lambda f$.

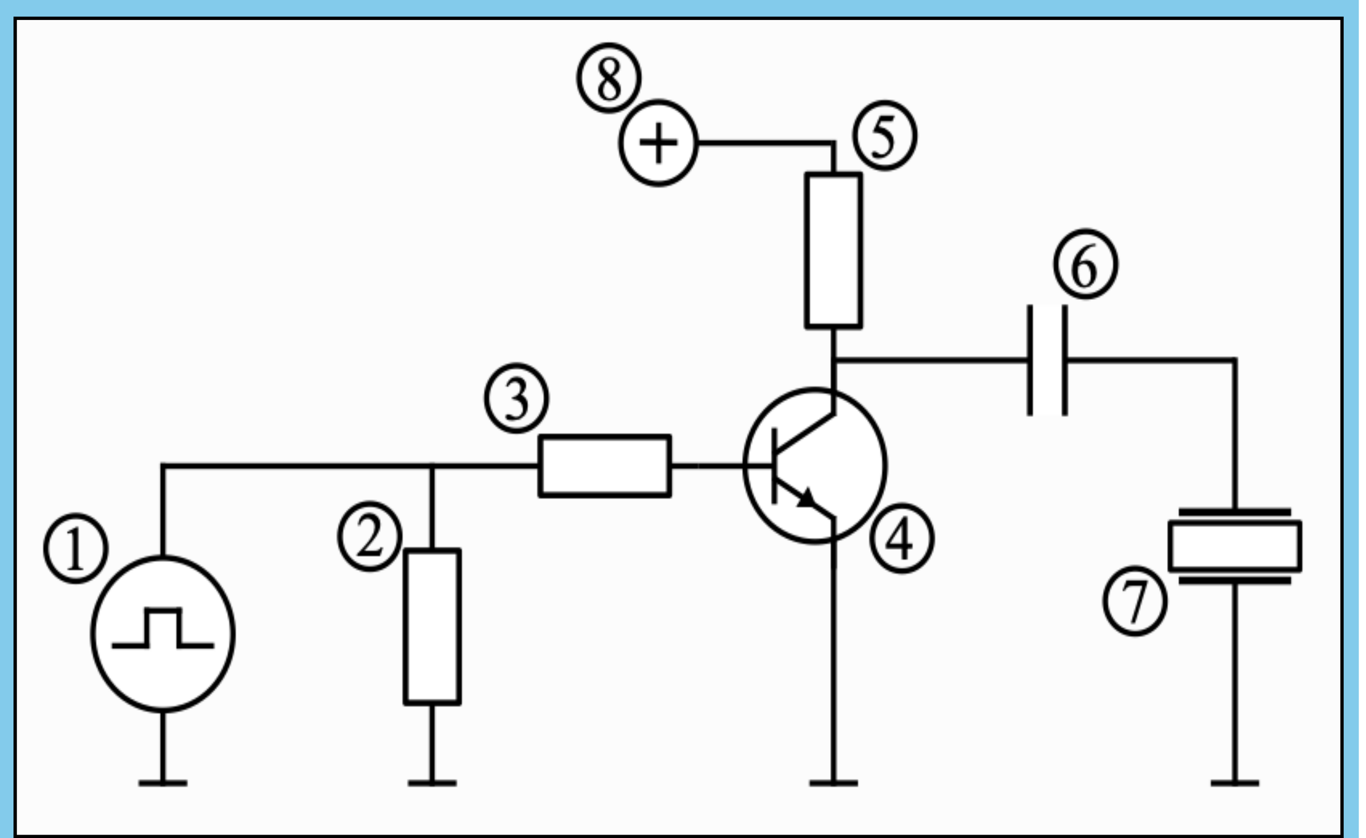
Setup and Experiment

- The idea of the setup was to make it possible to measure the speed of sound in different gases (Atmospheric air and Helium).
- The scheme on the right shows our setup. The transducer oscillated at its resonance frequency of f = 28.740 kHz.
- The sound waves were produced by an ultrasonic transducer and reflected by an aluminium plate mounted parallel to the transducer.
- Using a construction laser, we projected a horizontal laser line onto the particles and marked their relative distances to each other on an external sheet of paper, from which we later measured the distances manually.
- Because we wanted to be able to let multiple particles float, we needed to operate the transducer at a relatively high power. This necessitated the construction of a custom circuit, which is pictured in the bottom right.



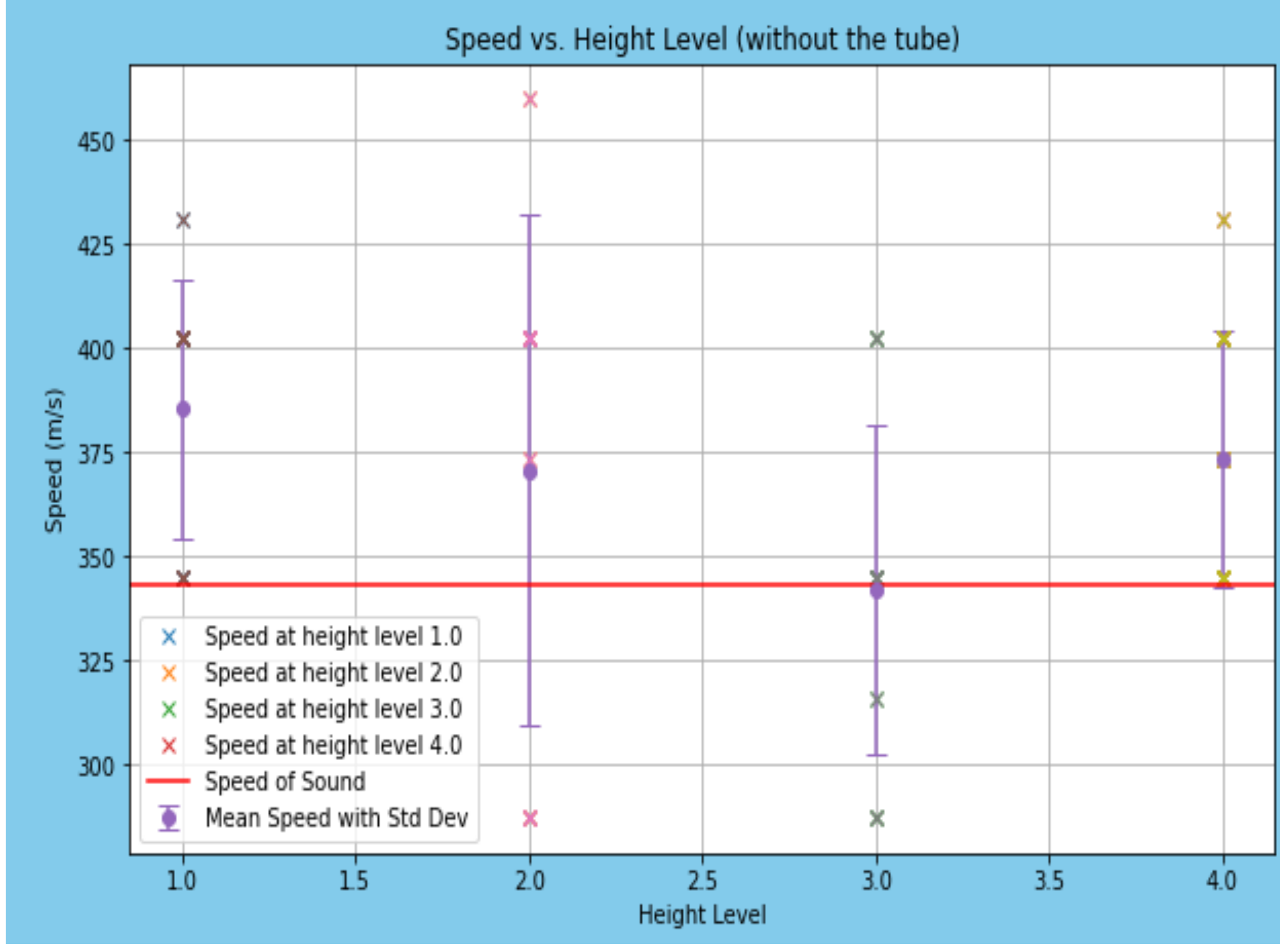
Circuit

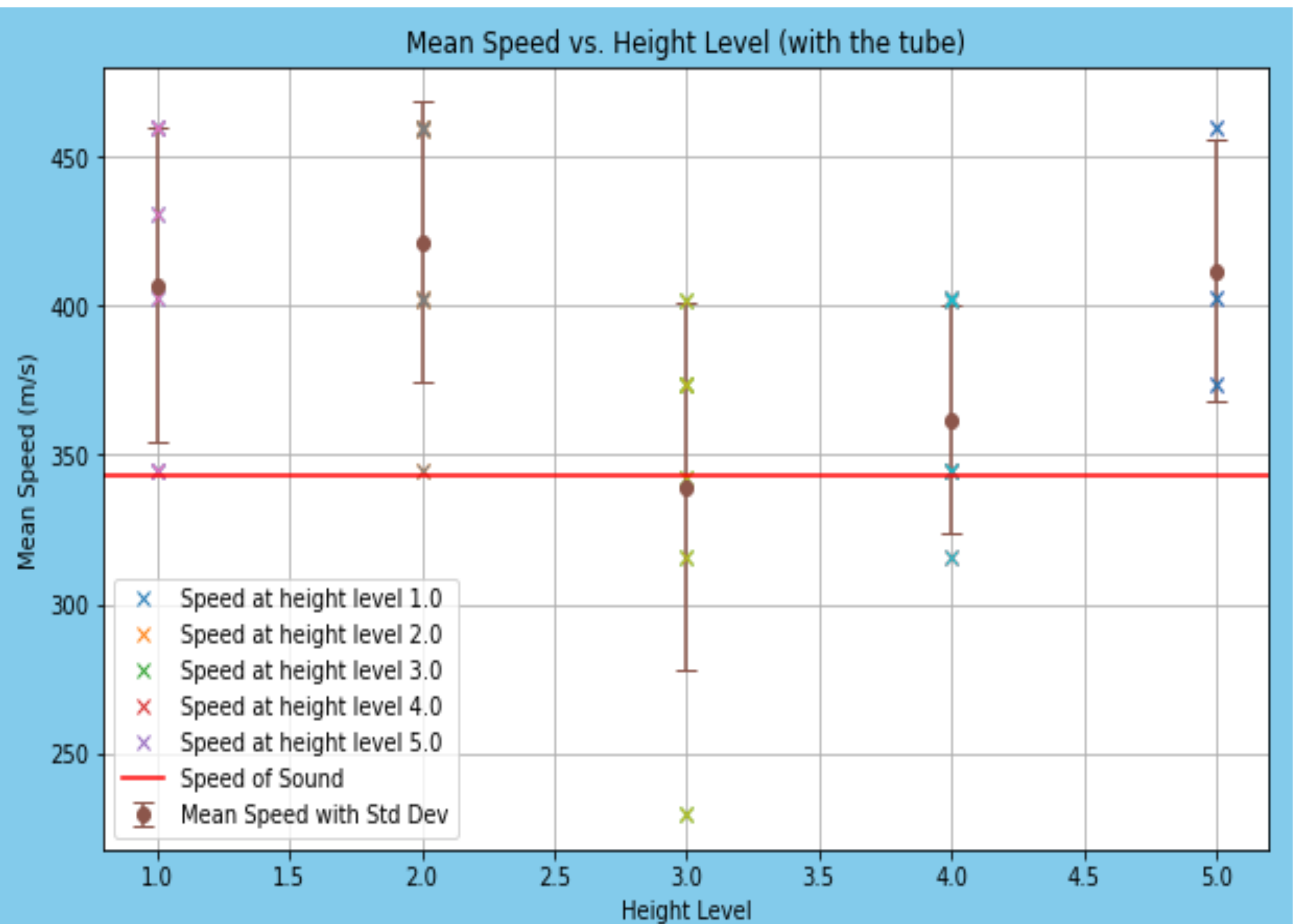
- The signal generator (1) produces an oscillating square current, which triggers the transistor (4). During these cycles, either the power source charges the capacitor (6), or the current flows into the ground. Consequently, we have the same signal as produced by (1), but with a stronger intensity to power our transducer (7). Resistors (2), (3) and (5) were included to limit the current and avoid short-circuits.



Results

- We measured the speed of sound in air with and without the Plexiglas tube (P.T.).
- The literary value of the speed of sound is 343m/s, our averaged results are:
  - (398 +- 80)m/s (without P.T.)
  - (368 +- 43)m/s (with P.T.)
- Due to us only being able to levitate a single particle in Helium, we were unable to take any measurements and determine its speed of sound.





Errors

- Our uncertainty is very large. This is caused by the width of the construction laser, which was about 2mm, which is about 1/3 of the distance between the nodes $\lambda/2$.
- While [1] predicted that multiple styrofoam balls should be able to levitate with our set-up, we were not able to achieve this. This could potentially be due to a higher-than-anticipated loss of power over the transducer.

Sources

[1] L. Wortsmann, Stability of a Particle Levitated in an Acoustic Field, (University of Illinois Urbana-Champaign, Urbana, 2016)

Gruppe 8: "Violet and Ultra": – L. Barth, L. Haydenreich, S. Kazak, T. Schoeber Spautz, M. Weitering, Ö. S. Yildiz, A. Fauquex

Frühjahrssemester 2024