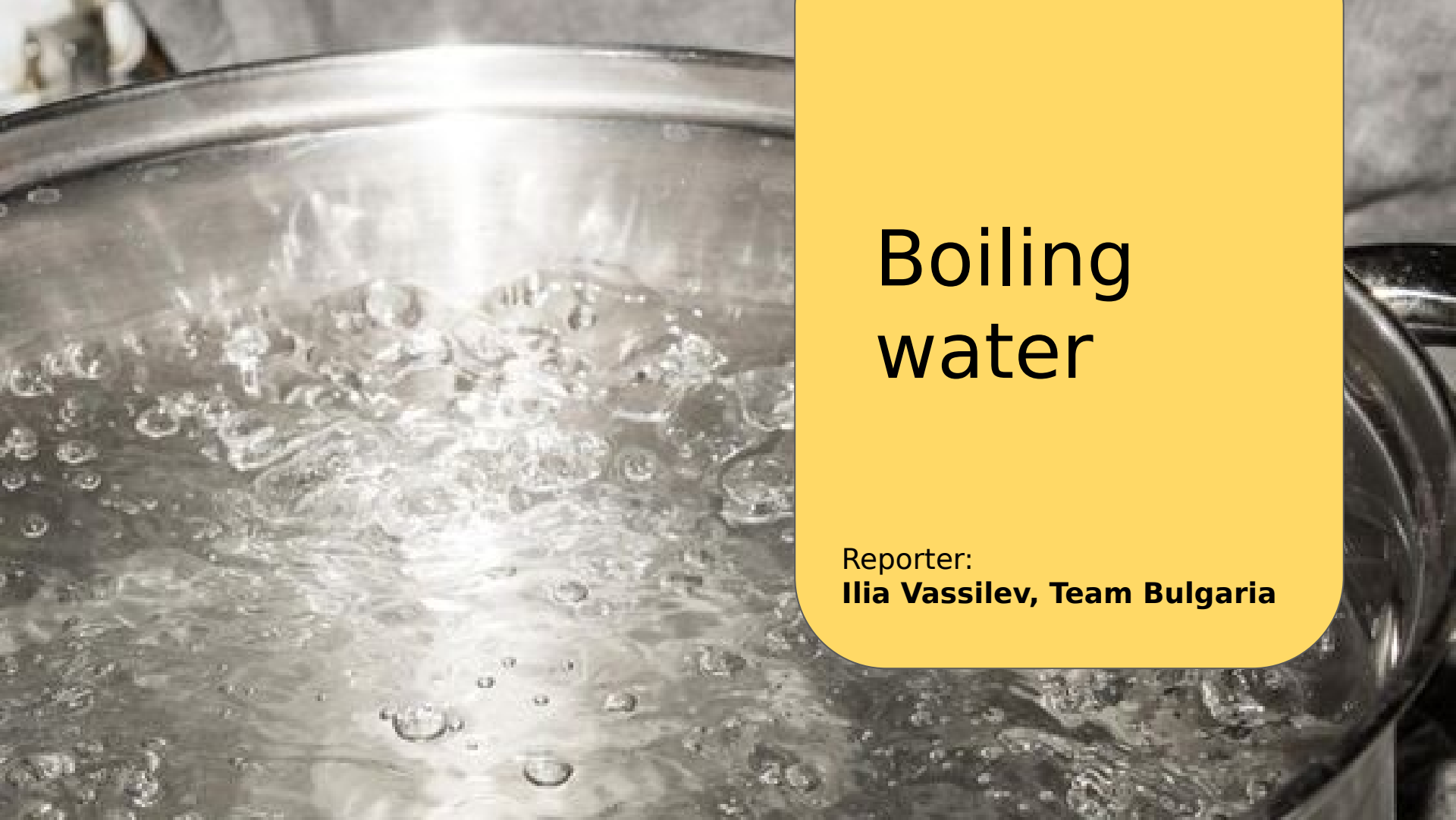

Boiling water

Reporter:
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26. Boiling water

A noise is heard is **water is boiled in a kettle**. Investigate how this **noise changes with time**.

Contents

Theoretical background

1. **Nucleation:**
   Dissolved air forms air bubbles on the bottom of the kettle
   - 70 - 100 Hz
2. **Cavitation:**
   Small air bubbles are formed at the bottom - 70 - 100 Hz
   Bubbles cool down at the surface and collapse - 400 Hz - 1 kHz
3. **Surface collapsing:**
   Collapsing of air bubbles produces sound at the

https://www.sciencealert.com/nature/why-is-water-loudest-just-before-it-boils.html

Theoretical background

- **Thermal capacity -** the quantity of heat necessary to produce a unit change of temperature in a unit mass of a material.
  Thermal capacity of water: 4200 J/kgK

$$\Delta Q = cm\Delta T$$

c – thermal capacity per unit mass

- After exceeding this heat amount, water starts **boiling.**

https://www.scienceabc.com/nature/why-is-water-loudest-just-before-it-boils.html

Hypothesis

The noise produced by the boiling water is caused by forming and collapsing air bubbles at the bottom and top part of the kettle.

This can be observed by the values of the peaks in frequency in the sound spectrum.

Materials

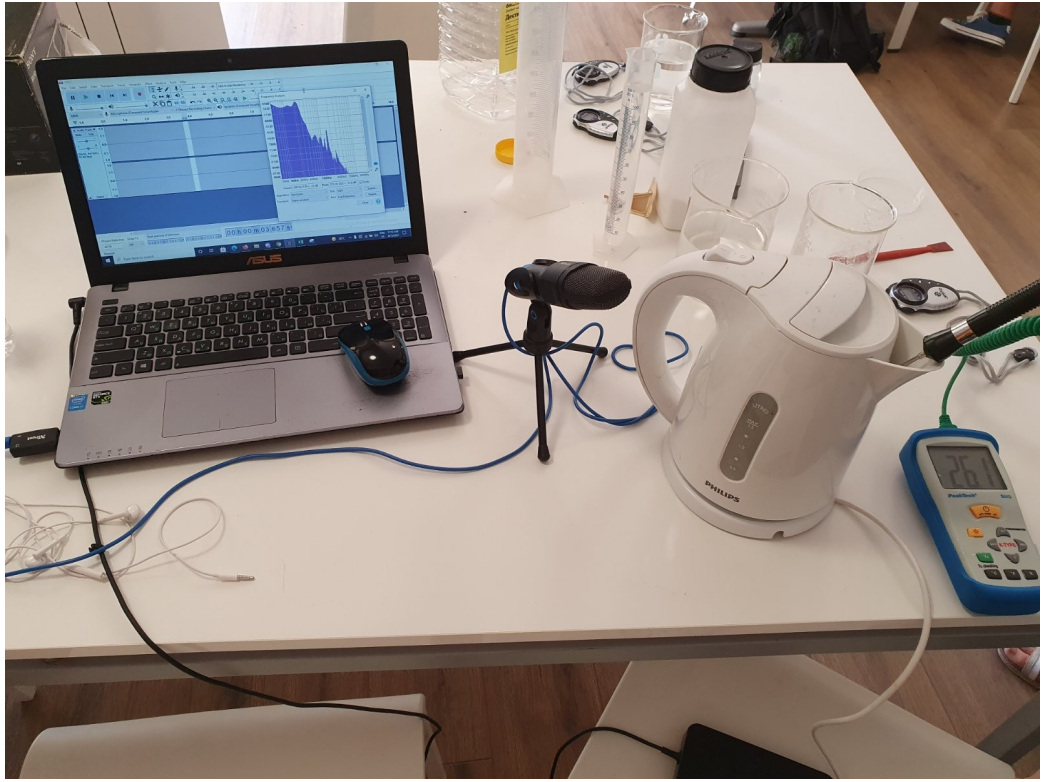
1) Kettle
2) Microphone
3) Thermometer
4) Stopwatch
5) Measuring cylinder
6) Distilled water

Experimental method

- Boil water in kettle
- Measure sound and temper
- Plot spectrum
- Make correlation between:
  - Time
  - Temperature
  - Sound frequency

The experiment

- Distilled water
- 3 volumes of water (0.5 L, 0.75 L, 1L)
- 3 tries for volume
- Estimate result for each volume
- Analyse the obtained data

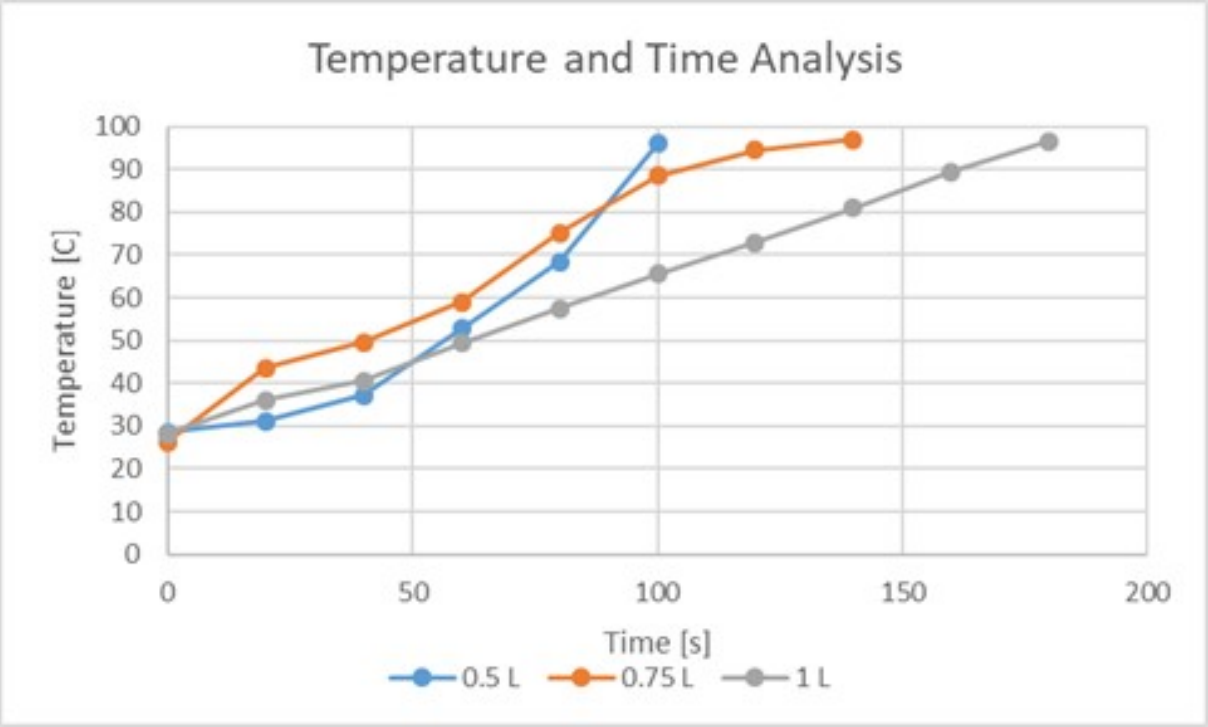


Temperatures (Celsius)

Distilled water

Time (s) / Volume of water (l)	Initial	20s	40s	60s	80s	100s	120s	140s	160s	180s
0,5	28.5	31.1	37.1	52.7	68.4	96	-	-	-	-
0,75	26.3	43.6	49.6	59	75.2	88.4	94.5	97	-	-
1	28.1	36	40.6	49.4	57.4	65.6	72.9	80.9	89.5	96.6

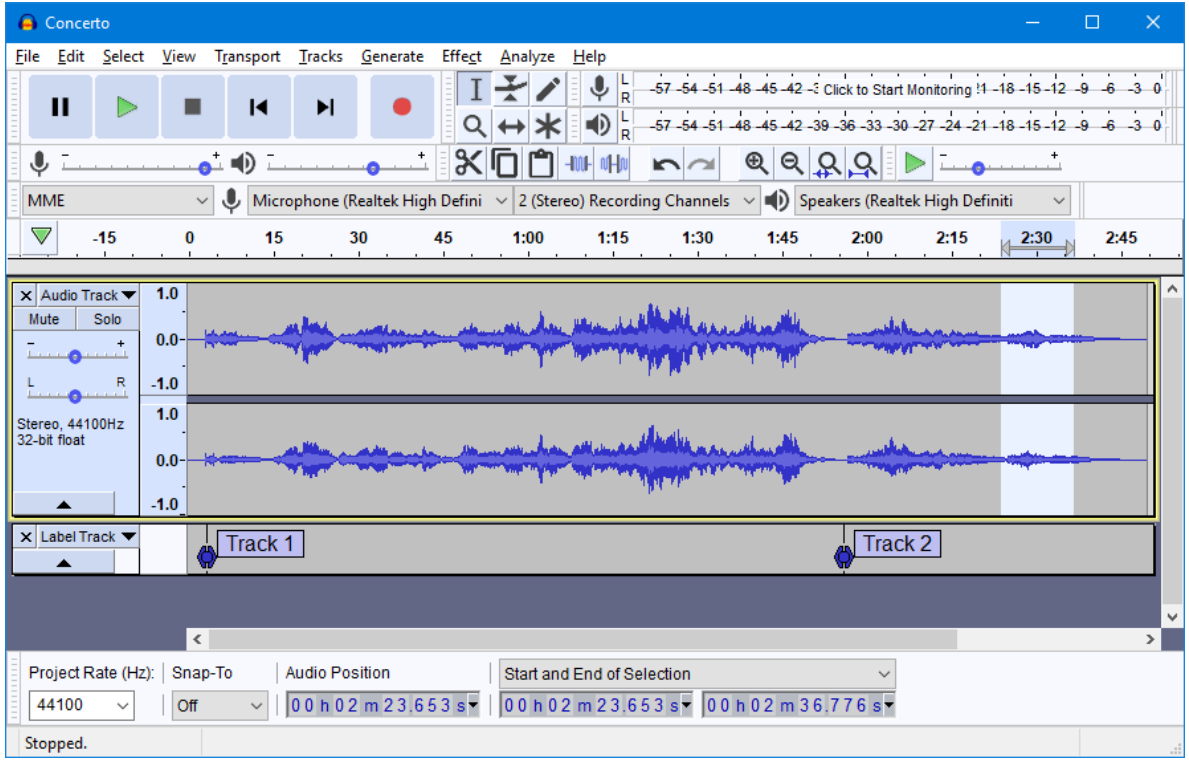
Temperatures (Celsius)



- Starting temperature of the water is 28.3 degrees Celsius
- The less the mass of water in the kettle is, the faster it reaches its boiling point

Software used

Audacity

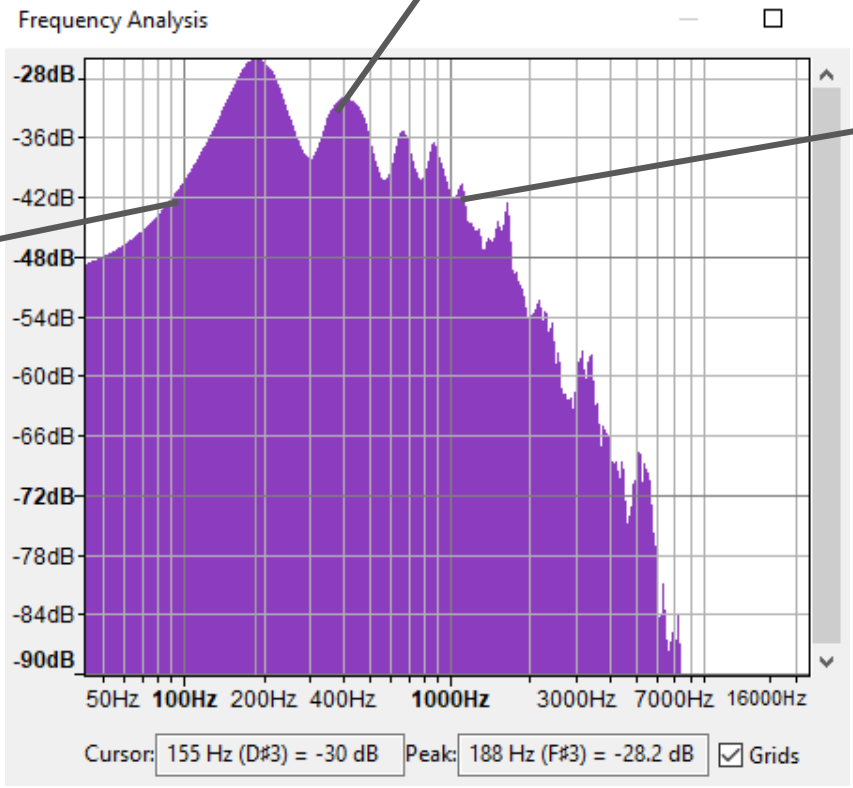


Results and analysis

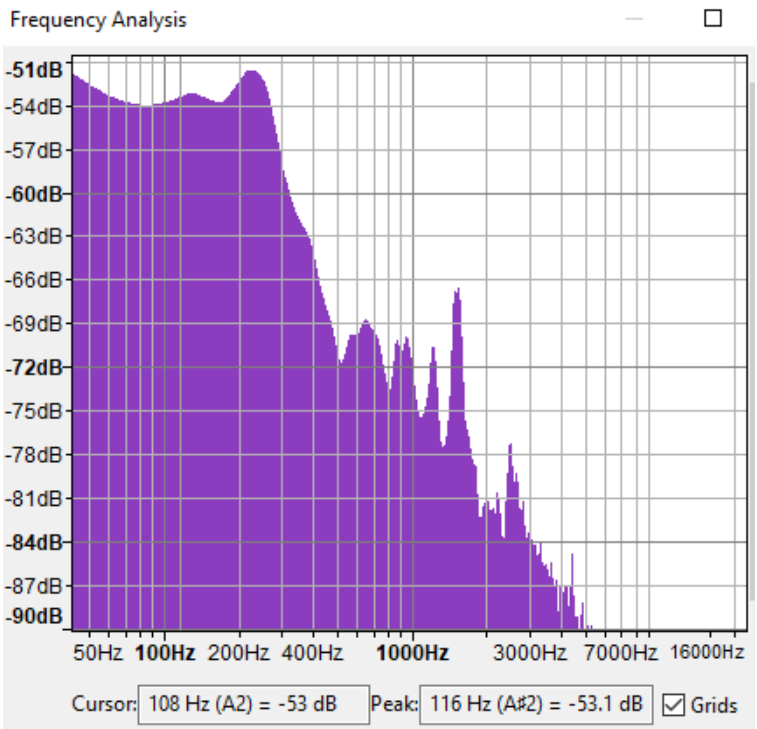
Peak at 400 Hz

Peak at 1kHz

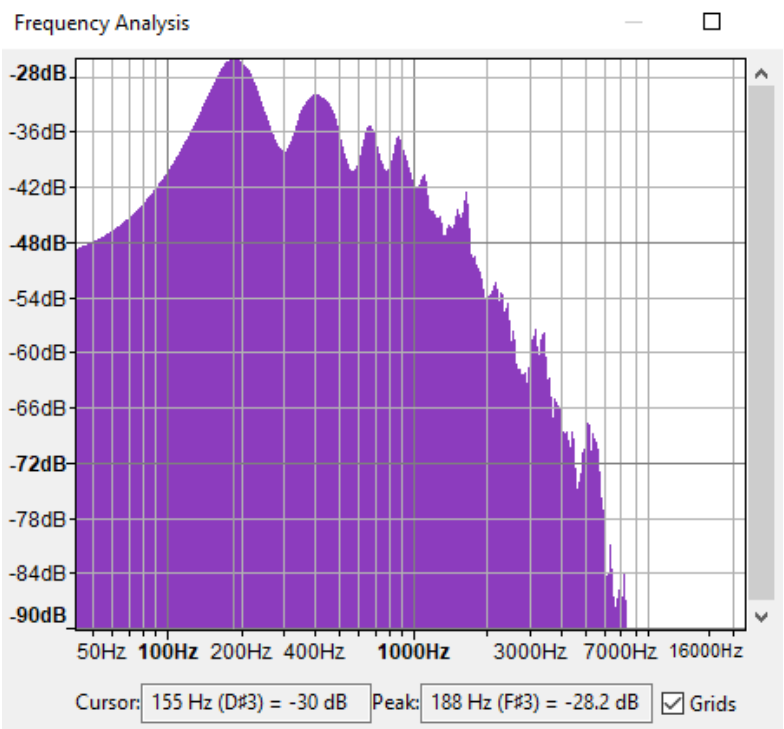
100 Hz - increase in the intensity of the sound



Results and Analysis



Background noise

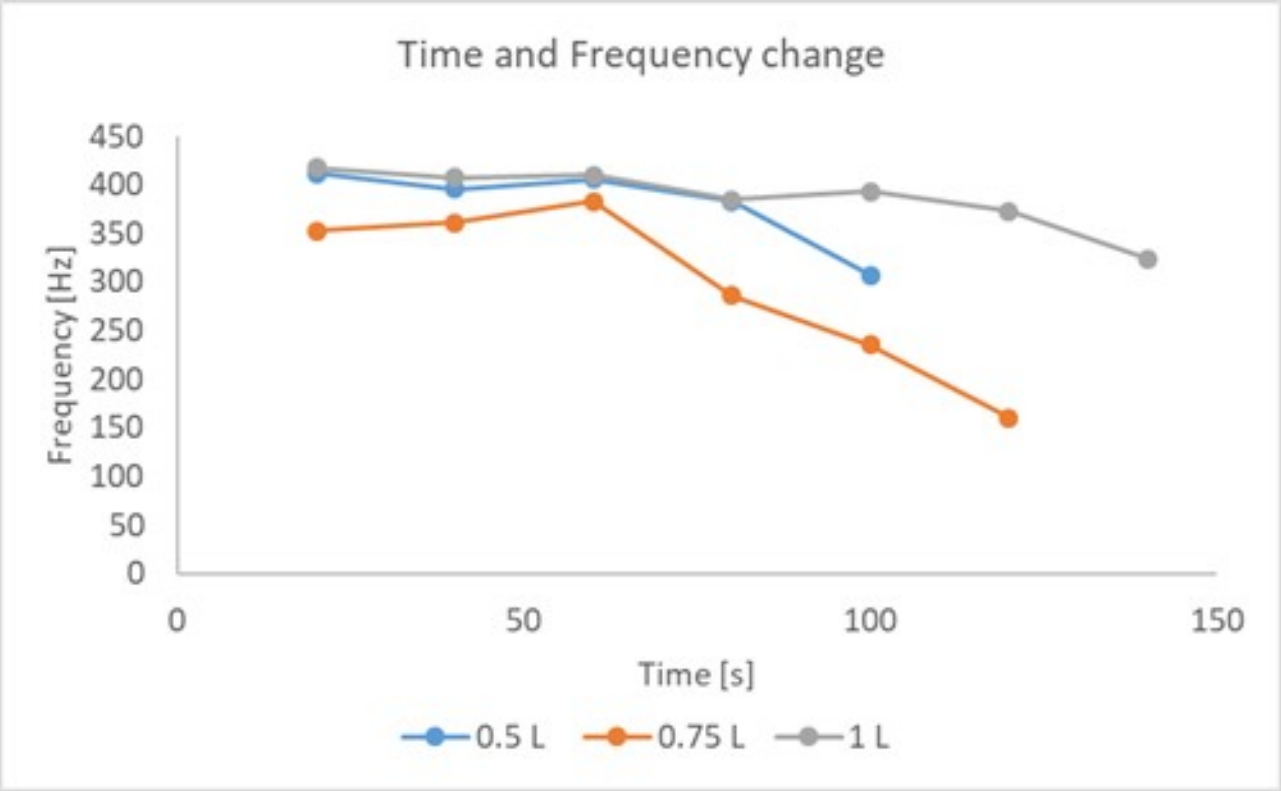


Boiling water sound analysis

Registered frequencies

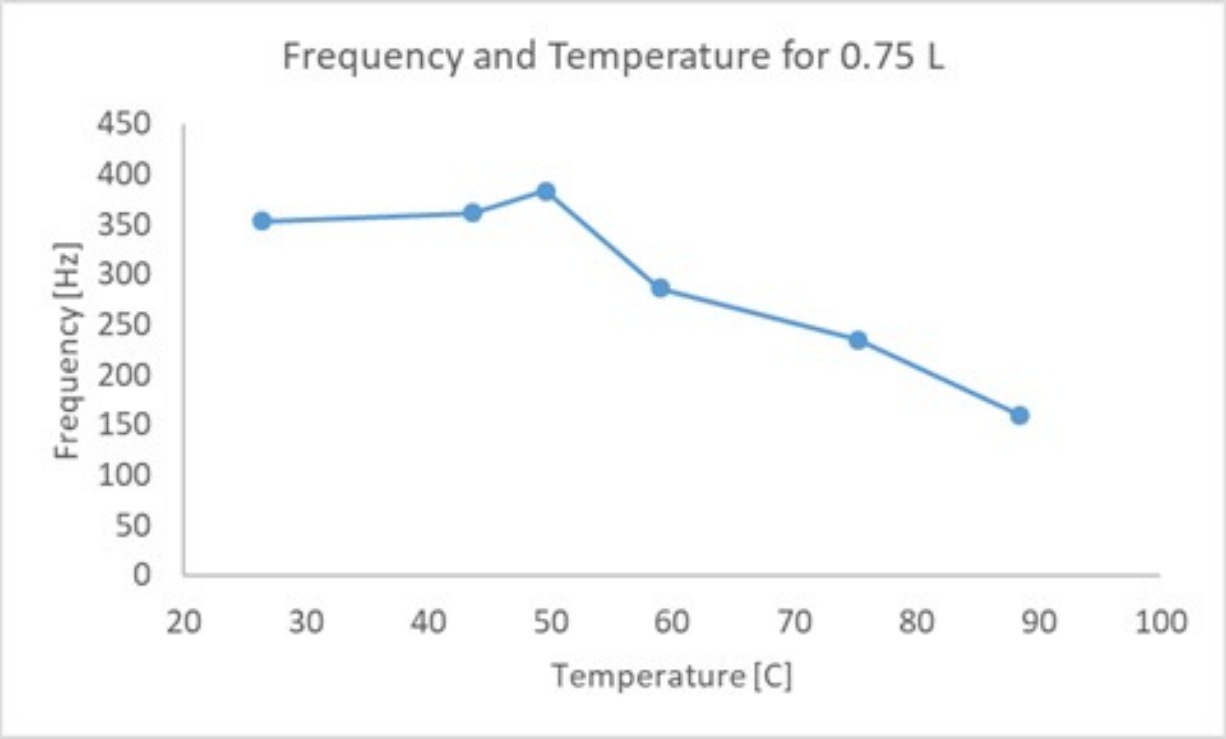
frequencies(Hz)	Time [s]							
Volume of water (l)	starting time of the sound (s)	20	40	60	80	100	120	140
0.5	3	412	396	406	383	307	-	-
0.75	6	353	361	383	286	235	160	-
1	9	418	408	410	385	393	373	324

The experiment



- Frequency of the sound decreases with time
- When the water starts boiling the frequency decreases significantly

Temperatures and Sound



- At first frequency rises slowly
- Peak in frequency around 50 degrees Celsius
- After exceeding the thermal capacity of water, boiling starts
- This coincides with the decrease in

Conclusion

Thank you!

As time passes the leading frequency decreases.

When water starts boiling, the registered frequency decreases, coinciding with the end of the **cavitation phase.**

Obtained results match theoretical predictions for points of peak frequencies in 3 stages of boiling.