Summary of the quantum analogon experiments with a PC

**Introductory measurements (Ch.1)**

1. Start the program SpectrumSLC.exe and use the computer to collect an overview spectrum from 100 to 10000 Hz of a tube made from 8 tube-pieces each 75 mm long. Use coarse steps (~10 Hz) and a short time per step (~50 ms) for this investigation.
2. Take a spectrum of the 150 mm long tube, a sweep from 5000 Hz to 14000 Hz, 5 Hz steps, and 50 ms per step. Fit the acquired data with SpectrumSLC. Check the repeatability of your data.

**Modeling a hydrogen atom (Ch.2)**

1. Set the hemispheres so that the scale angle $\alpha = 180°$. Start the program SpectrumSLC.exe and measure an overview spectrum from 100 to 10000 Hz. You use coarse steps (~ 10 Hz) and a short time per step (~50 ms). Change the angle between the upper and the lower hemisphere several times and observe the how the spectrum changes. Be sure to look at the spectrum for $\alpha = 0°$.
2. Go back to $\alpha = 0°$ and look in more detail at the peak near 5000 Hz. In a slow sweep take a detailed spectrum of the narrow range around this peak. Also, take spectra for this range at $\alpha = 20°$ and $\alpha = 40°$.
1. Measure the wavefunctions of the different resonances and visualize them by a polar plot of the amplitude $A(\theta)$. Take a spectrum with $\alpha = 180°$ from 2000 Hz to 7000 Hz sufficiently slowly. Adjust the hemispheres to $\alpha = 0°$, and measure the amplitude in steps of 10°. Create polar-plots for the prominent peaks and identify the quantum numbers.

**Modeling one dimensional solid (Ch.4)**

a) **Particle in a periodic potential**

1. Measure the resonances in tubes of different length and analyze the distance between the resonances $\Delta f$ as function of tube length d. Vary length between 75mm and 600mm, using 75mm tubes and adjust the sweep bandwidth to clearly distinguish the resonances (~ 6-9kHz). Calculate the actual speed of sound by fitting the dependence $\Delta f \sim 1/d$.

2. Take an overview spectrum (100-12000 Hz) of a tube made from 12 tube-pieces each 50 mm long. Plot the frequency as function of wave number *k*.

3. In the same frequency range (100-12000 Hz) measure the spectra for 8 50mm tubes separated by irises of 16, 13 and 10mm diameter. Plot the dispersion curves for these results. From the dispersion curves define the width of the bands and gaps, summarize the results in a table. What can you conclude?

4. Measure a (100-12000 Hz) spectra for 12 and 10 50mm tubes with Ø16mm irises. Compare these spectra with previously acquired spectrum for 8 tubes with Ø16mm irises. Describe the way the spectrum changes. Are there any mathematical patterns?

5. Take a (100-12000 Hz) spectrum with 8 pieces 75mm long and Ø16mm irises. Compare this spectrum with the one of 8 50mm long pieces and Ø16mm irises. What difference in the spectra do you observe?

Reminder: use the spectrum of 8 50mm tubes with 16mm irises to determine the density of states.

**b) Atom-molecule-chain approach**

6. Take an overview spectrum (100-22000 Hz) in a single 50 mm long tube-piece. Identify the longitudinal and radial modes. Check the separation of the longitudinal modes $\Delta f$ corresponds to the theoretically expected.

7. Measure a spectrum (100-22000 Hz) in a longer tube-piece (75 mm). Check the separation of the longitudinal modes $\Delta f$ corresponds to the theoretically expected.

8. Take a spectrum (100-12000 Hz) in a combination of two 50 mm long tube-pieces with an iris Ø10 mm between them. Repeat the experiment with Ø13 mm and Ø16 mm irises.

9. Take spectra (100-12000 Hz) with an increasing number of unit cells (3,4,6) and Ø16, Ø13, Ø10 irises. Observe how bands develop. In a table compare the difference between bonding and antibonding states with the width of the corresponding band in a setup with large number of unit cells.

10. Make a setup of 12 tube-pieces 50 mm long and alternating Ø13 mm and Ø16 irises. Measure a (100-12000 Hz) spectrum. Compare with the spectrum of 12 50mm tubes with Ø13 mm irises, taken in experiment 3.

11. Make a setup of 5 unit cells with each unit cell made of a 50 mm tube, a Ø16 mm iris, a 75 mm tube, and Ø16 mm iris. Measure a (0.4-12 kHz) spectrum and plot the band structure. Compare the “atomic” levels of the of 50mm tube and 75mm tube, taken in experiments 7 and 8, with this band structure.

12. Make a setup of 12 tube-pieces 50 mm long and Ø16 mm irises. Replace one tube-piece by a 75 mm long piece and measure the (100-6000 Hz) spectrum. Put the defect at other positions within the one-dimensional lattice and measure the spectra produced. Use other tube lengths as a defect. You can try 25 mm, 37.5 mm and 62.5 mm for example.

    **This summary is not intended to summarize all the analysis tasks of the experiment, please refer here to the original student manual.**