Franck-Hertz Experiment

1 Objective

- Measuring the excitation energy of both neon and mercury.
- Understanding the physics behind atomic nature and excitation energy.

2 Prelab Questions

1. Explain the Bohr model of the atom.
2. Discuss how the Franck-Hertz experiment supports it.
3. How do you expect the relationship between the current and voltage in the experiment to look like? Plot it.
4. Which factors do you suggest should be controlled in order to make sure that your results are accurate and reliable?

3 Principles

In April 24th, 1914 James Franck and Gustav Hertz preformed a revolutionary experiment that clearly showed the quantum nature of atoms, transforming the current understanding of the atomic world to new unprecedented areas of knoweldge.

In their experiment, electrons were accelerated in a tube filled with mercury vapour gas by an adjustable electric potential, and the resultant current at the anode was

recorded. The current was plotted against the electric potential and the excitation energy of the atoms of the vapour was discerned.

On December 10th, 1926 Franck and Hertz were awarded the 1925 Nobel Prize in Physics for their discovery of the laws governing the impact of an electron upon an atom.

4 Apparatus

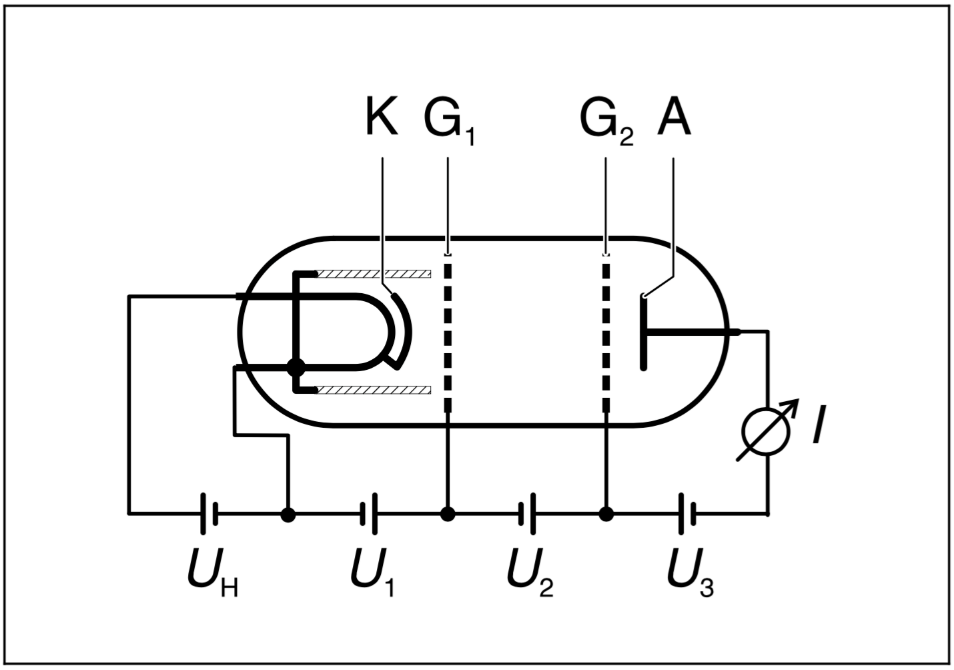

Fig. 1: Schematic representation of the Franck-Hertz tube:
U_1: Driving Potential.
U_2: Accelerating Potential, varied.
U_3: Braking Potential.

5 Precautions

- As a result of variations in the oven temperature, different levels (values) of collection current may be obtained for repeated measurements at the same acceleration voltage. However, the position of the maxima remains unaffected by this.

- When the oven is switched on or off, a change of load on the AC mains occurs. This causes a small change in the acceleration voltage. Oven switching should be noted if it takes place while the curve is being recorded.
- Do not stare at the mercury vapour tube for prolonged periods of time, it produces short ultraviolet light which is harmful to your eyes.

6 Experimental Steps

Note: Steps in blue are performed on the computer, steps in red are done on the Franck-Hertz control unit.

6.1 Mercury Vapour:

1. On the Franck-Hertz control unit, choose PC for the Function.
2. On the computer, run the programme Measure and choose New Measurement.
3. On the Franck-Hertz Experiment window, set the following parameters: $U1 = 60$, $U2 = 2$, $UH = 6.3$ and Temperature TSoll= 175.
4. Click on Continue.
5. Wait approximately 30 minutes while the oven heats up.
6. While your oven is heating up, move on to subsection 6.2 and preform the experimental steps there.
7. Once the oven temperature reaches 175 degrees, start your measurement.
8. Once you obtain the recorded measurement, click on the Maxima and Minima button to obtain the extrema of your measurement.
9. Print the diagram and table you obtained.

6.2 Neon Gas:

1. On the Franck-Hertz control unit, choose PC for the Function.
2. On the computer, run the programme Measure and choose New Measurement.

3. On the Franck-Hertz Experiment window, set the following parameters: $U1 = 99.99$, $U2 = 8$, $U3 = 3$ and $UH = 8$.

4. Click on Continue and start your measurement.

5. Observe the glowing regions in the Neon tube.

6. Once you obtain the recorded measurement, click on the Maxima and Minima button to obtain the extrema of your measurement.

7. Print the diagram and table you obtained.

7 Evaluation

Note: All literature values can be found in the clickable links below.

7.1 Mercury Vapour:

1. Using the values of the minima you obtained in the table, calculate the potential difference ΔU_{Hg} between each successive minima.

2. Find the average of the potential difference $\Delta U_{Hg,avg}$.

3. Using the result you obtained, find the average energy difference ΔE_{avg} between each successive minima in units of eV.

4. Knowing that the excited mercury atom releases the energy it obtained in the form of a photon, calculate the wavelength of the emitted photon λ_{Hg}.

5. Find the error in your measurement.

7.2 Neon Gas:

1. Using the values of the minima you obtained in the table, calculate the potential difference ΔU_{Ne} between each successive minima.

2. Find the average of the potential difference $\Delta U_{Ne,avg}$.

3. Using the result you obtained, find the average energy difference ΔE_{avg} between each successive minima in units of eV.

4. Knowing that the excited mercury atom releases the energy it obtained in the form of a photon, calculate the wavelength of the emitted photon λ_{Ne}.

5. What does this wavelength correspond to on the electromagnetic spectrum?

6. Explain the origin of the orange visible light, considering your calculated wavelength. (Hint: refer to the quantum energy levels of neon)
7. Find the error in your measurement.

8 Helpful Sites (clickable links)

- Franck-Hertz experiment with Hg-tube.
- Franck-Hertz experiment with Ne-tube.
- LD Physics Leaflets: Franck-Hertz experiment with neon.