南京邮电大学
Nanjing University of Post & Telecom

物理实验教学中心

Physics Expeiment Center

Frank-Hertz Experiment

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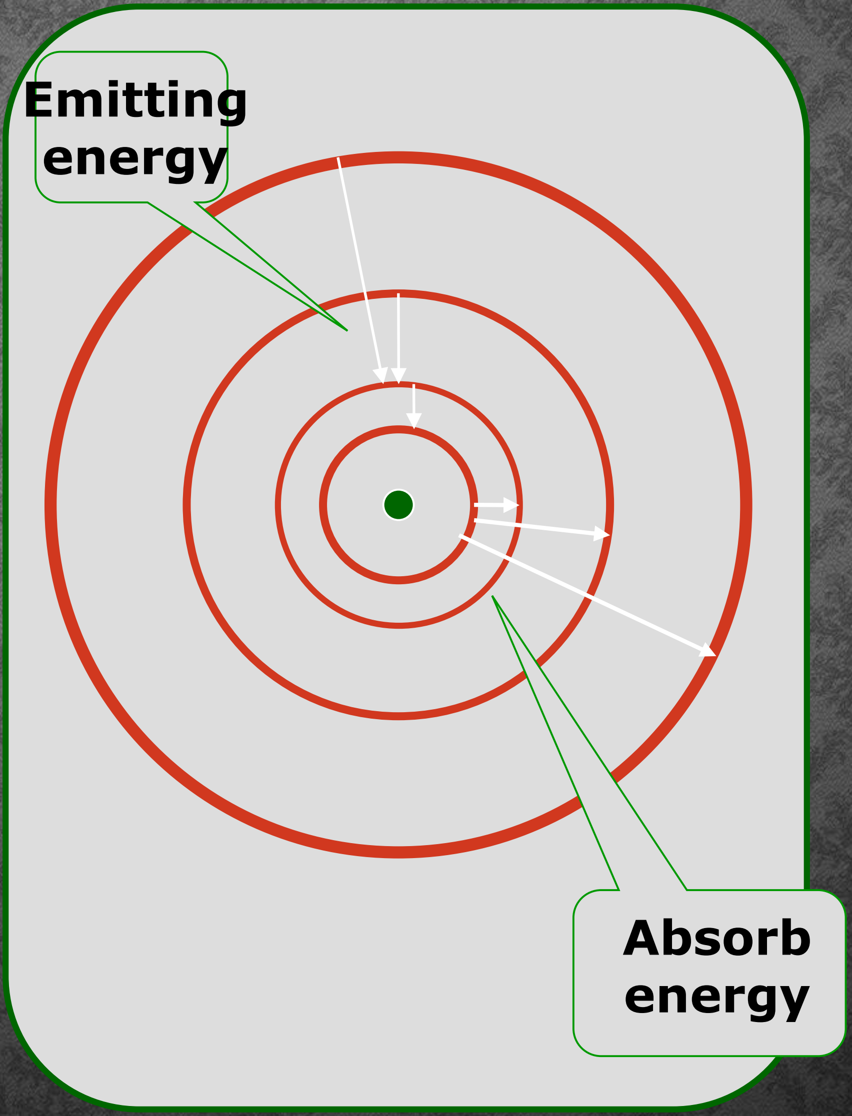
NJUPT

History

- Niels Bohr（1885-1962）**was a Danish physicist who made foundational contributions to understanding atomic structure and quantum theory, for which he received the Nobel Prize in Physics in 1922. Bohr was also a philosopher and a promoter of scientific research.**

Quantum theory of Bohr’ s atomic structure

- Bohr developed the Bohr model of the atom, in which he proposed that energy levels of electrons are discrete and that the electrons revolve in stable orbits around the atomic nucleus but can jump from one energy level (or orbit) to another. Although the Bohr model has been supplanted by other models, its underlying principles remain valid. He conceived the principle of complementarity: that items could be separately analyzed in terms of contradictory properties, like behaving as a wave or a stream of particles. The notion of complementarity dominated Bohr's thinking in both science and philosophy.


Emitting energy
Absorb energy

Experimental verification of Bohr theory

- Is there really an energy level in the atom? Does atomic energy really not continuous change? The Bohr's hypothesis need to be further tested through the experiments. This experiment does exist, which is completed in 1915 by Franck and Hertz, namely Franck-Hertz experiment. And they won the Nobel prize for physics in 1925.

(James Franck ,1882-1964)   (Gustav Hertz ,1887-1975)

1925 Nobel Prize

Purposes

- 1. Learn the principles and methods of Franck-Hertz experiment.
- 2. Determine the first excited energy of argon atom and verify the existence of atomic energy levels.

E_2

Principles

- Set E_2 and E_1 as the first excited state energy and ground state energy, respectively. The energy of an electron in the electric field U_0 is eU_0. If
- $eU_0 = 1/2mv^2 = E_2 - E_1$
- When the electron and atom collide, the atom will jump from the ground state to the first excited state. The U_0 is called the first excited potential.

If the accelerating voltage of electron U_{G2K} $<$ Atomic first excitation potential U_0,

There is no exchange between kinetic energy and internal energy during the electronic and atomic collision . It’ s called "elastic collision"

After the collision, the electron speed unchanged.

If the accelerating voltage of electron U_{G2K}> Atomic first excitation potential U_0,

Electronic and atomic collision causes exchange between kinetic energy and internal energy. It’ s called “inelastic collision"

After the impact, the electron speed is slow down, and the atom jump from the ground state to the first excited state.

The Franck-Hertz Instrument

positive plate

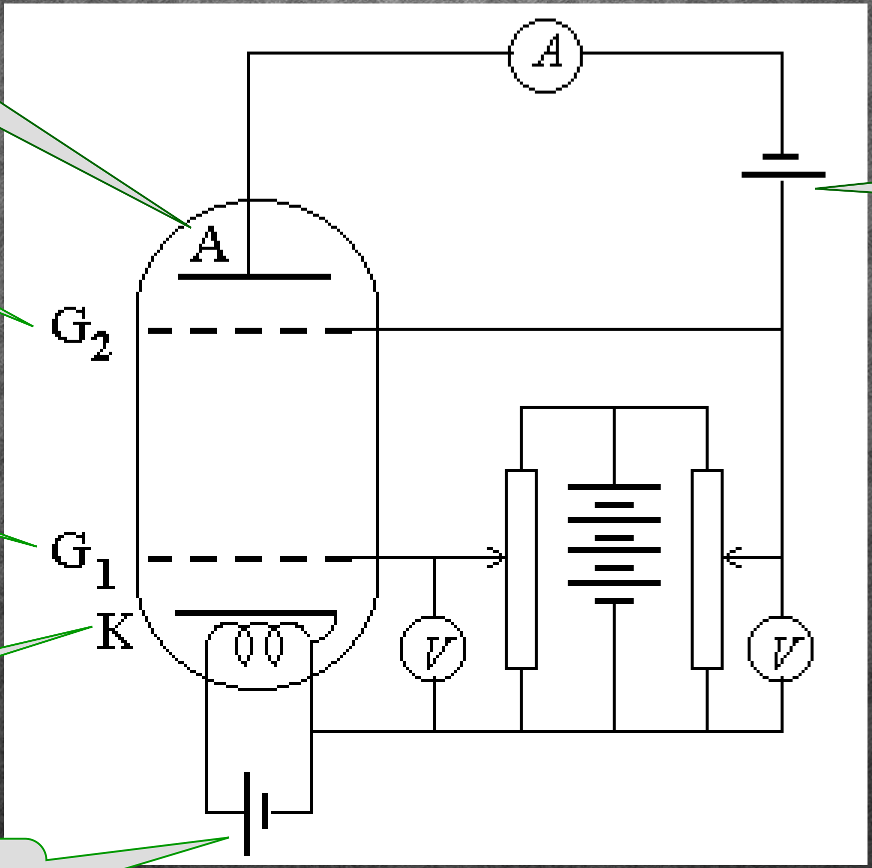
Second grid

First grid

negative pole

filament voltage

Reverse voltage



U_{G1K}:First grid voltage; U_{G2K}: accelerating voltage ; U_{G2A}: Reverse voltage

Steps

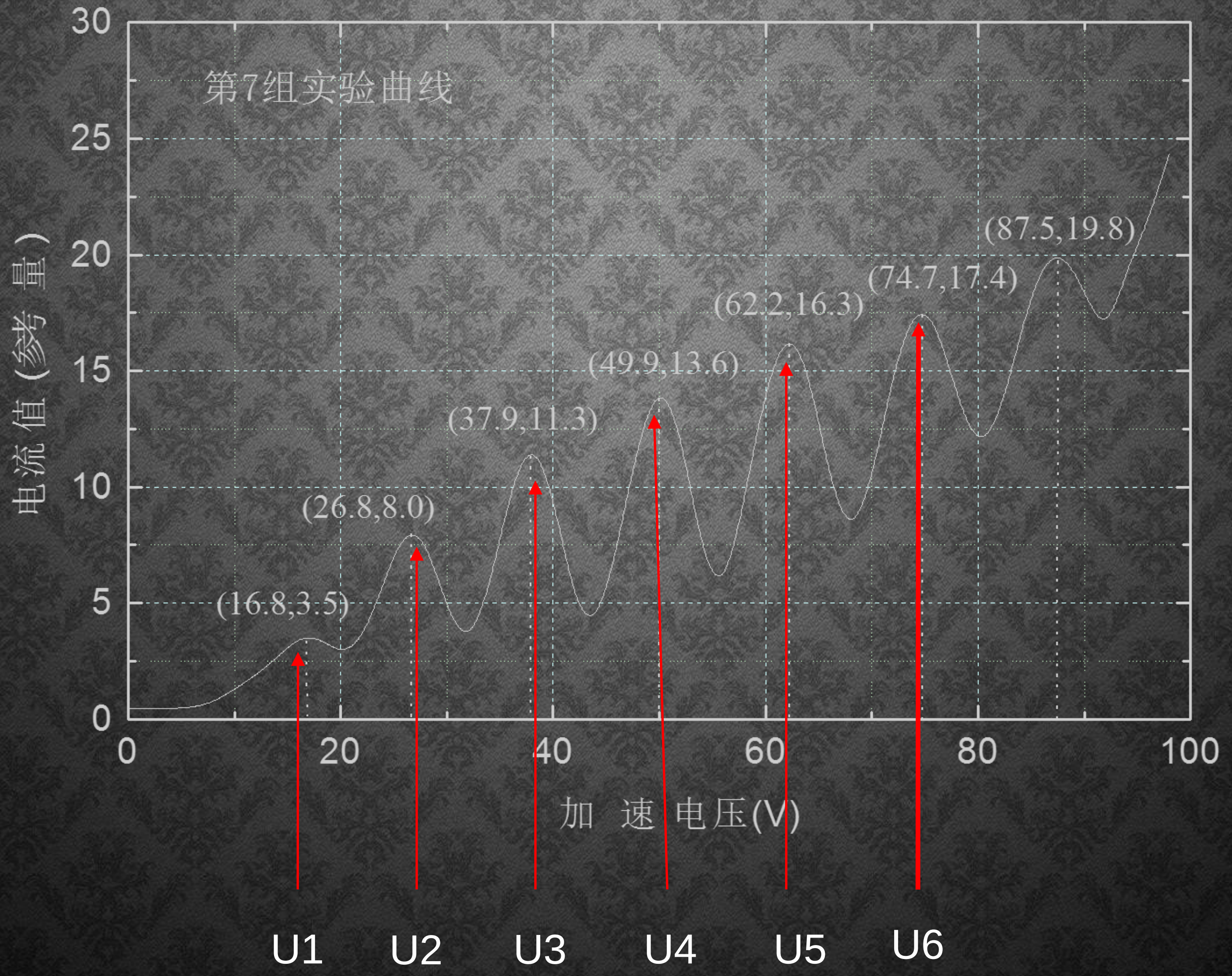
1. Power on.
2. Set three voltages according to the nameplate:

U_{G1K}: First grid voltage; U_{G2A}: Reverse voltage; & Filament voltage.

3. Increase U_{G2K} from zero to the maximum value (about 80 V, shown on the nameplate). The step size is 0.5 V.
4. Plot U_{G2K}-I graph.
5. Calculate the atomic first excitation potential U_0, use

$$U_0=((U_4-U_1)+(U_5-U_2)+(U_6-U_3))/9.$$

U_{G2K}-I relations



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