The Frank-Hertz Experiment

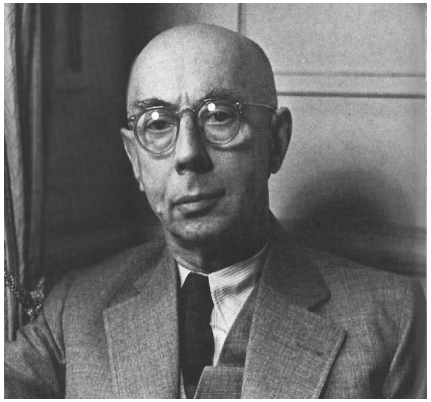
University Physics Experiment Center UESTC

Content

1 Background

- In 1911, Rutherford put forward the atomic nucleus model according to the alpha particle scattering experiment.
- In 1913, Bohr applied the Planck's quantum hypothesis to the atomic nucleus model, and established two important concepts.
- That were contrary to the classical theory: atomic stationary state energy level and energy level transition concept.

(JAMES FRANCK)



(GUSTAV HERTZ)

2 Theoretical basis

- According to Bohr atom theory, atoms can only be in a series of discrete state of stability.
- Each state corresponds to a certain energy value Ei (i = 1,2,3 ··), and these energy values are called energy level.
- The state corresponding to the lowest level is called the ground state, and the state corresponding to the other high energy levels is called the excited state.

Energy level transition

$$h\nu = E_n - E_m$$ (*h* is planck constant)

In this experiment, we use energy of electron and atom to exchange energy, and meet the energy transition rule:

$$eV = E_n - E_m$$

3 Experiment set-up

Features: Adopt argon Frank-Hertz tube

Argon gas for experiment measurement

Fig F-H experiment equipment

4 Experiment principle

- The electrons are emitted from the cathode K.
- Accelerating voltage VG1K between K and G1.
- Accelerating voltage VG2K between G2 and K.
- Deceleration voltage VG2A between A and G2.

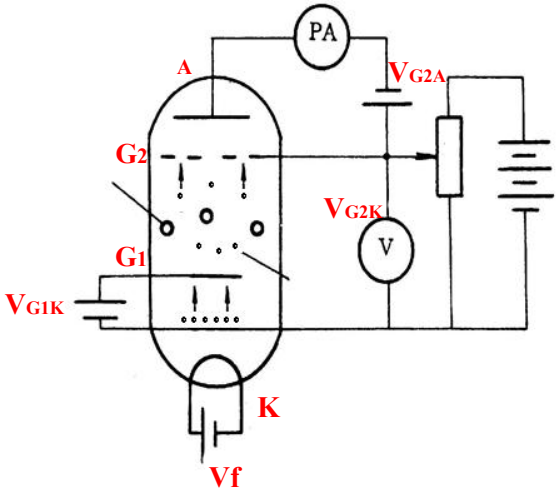


Fig. Structure diagram of F-H tube

4 Experiment principle

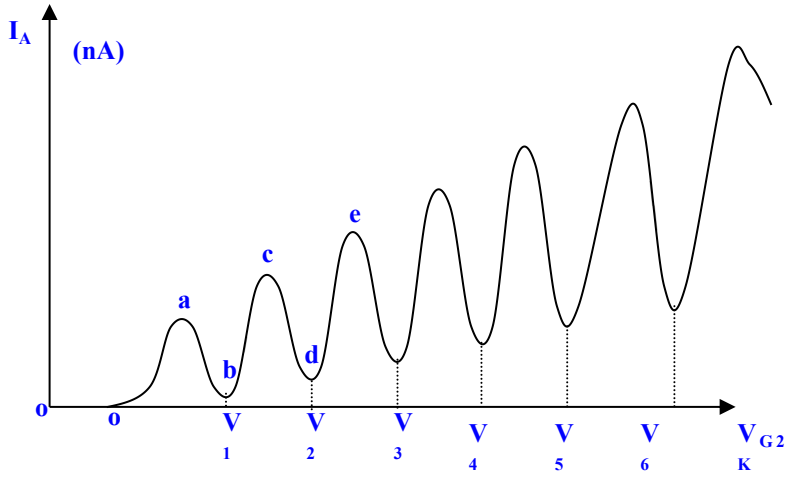


Fig curve of F-H, Gradually increase the VG2K, ammeter current IA, as shown in the above changes in the curve.

1. The ground state energy of the argon atom is E0, and the energy of the first excited state is E1.

2. The electron with the initial velocity of zero is accelerated by potential V for energy eV.

3. When electron energy $eV<E_1-E_0$, Electrons and argon atoms can only occur elastic collision, no electron energy lost。

4. If $eV\geqslant E_1-E_0=\Delta E$, Electrons and argon atoms can occur non-elastic collision , argon atoms could get energy from electrons for ΔE, to the excited state E1, $\Delta E=eV_C$.

5. V_C is the fist excited state of argon!

5 Experiment content and operation process

☞ The first excitation potential of the argon atom is measured by manual and computer-on-line test, and the comparison is made.

☞ Analyze the influence of filament voltage **Vk** and rejection voltage **VG2A** on the F-H experimental curve

☞ understanding of computer data collection, data processing methods

Steps

☞ Correct understanding of circuit connections and principles;

(VG2K = 80 V according to the parameter setting of the instrument);

☞ Start to preheat; (Note: before preheating, you must set the following values:

☞ Formal measurement; manual testing; online testing.

6 cautions

☞Do not connect the incorrect circuit in order to avoid short circuit and damage.

☞ The value must be set within the given range or range. If it is out of range, it may cause the instrument to burn out or can not be displayed accurately.

7 Data process (by difference method)

$$\bar{V}_c = [(V_6 - V_1) + (V_5 - V_1) + \ldots / 1 + 2 + 3 + 4 + 5$$

$$E = \frac{\left|\bar{V}_C - V_{C0}\right|}{V_{C0}} \times 100 \Big/ 100$$

☞The first excitation potential of the argon should be solved.

The relative error should be calculated.

Difficulties and Emphasis: the measurement process should be slow, to ensure smooth curve and a wide range of data sampling.

Data and process

DATA TABLE 3-3 (Measured by computer. *purpose*: to determine the first excitation potential of argon atom)

V_1=_____; V_2=_____; V_3=_____;

(The unit of the current in the following table is _____)

	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
0										
10										
20										
30										
40										
50										
60										
70										