3. Operating principle

The Franck–Hertz tube in this instrument is an electron tube filled with argon. Figure 1 shows the symbols of all electrodes and the voltageson them.

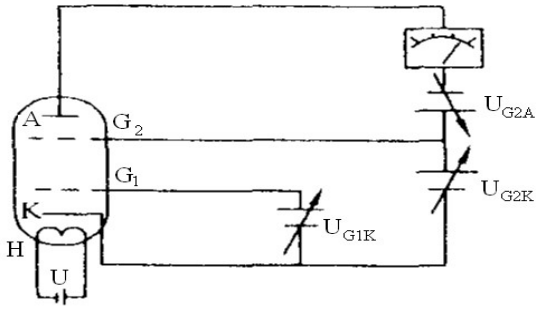

Figure 1 Schematic of Franck–Hertz tube

A voltage of about 4.5 V is applied between the 1st grid (G_1) and the cathode (K) to eliminate the effect of spatial charge on cathode scattering electrons.

When the filament heats the cathode, the electrons emitted by the cathode are accelerated in the electric field between the 2ndgrid (G_2) and the cathode, obtaining more and more energy. At the beginning, the electron energy is low due to the low voltage applied between the 2nd grid and cathode. Thus, the exchanged energy is little even if electrons collide with the atom.

Plate current (I_A) formed by electrons penetrating the 2nd grid increases with the increase of U_{G2K}.When U_{G2k} reaches the 1st excitation potential of argon atom, electrons collide with argon atoms near the 2nd grid (non-elastic collision) and transfer their total energy obtained in the accelerating field to Argon atoms. Thus, Argon atoms are excitedfrom ground state to the 1st excitation state. On the other hand, the electrons that transferred all energy to argon atoms cannot overcome the reverse exclusion field, and are hence drawn back to the 2nd grid even if some of them penetrated the 2nd grid. As a result, plate current I_A decreases.

With the increase of U_{G2k}, the electron energy increases again so that the electrons can overcome the reverse exclusion field and reach plate A leading to an increase in current $I_A$until U_{G2K} is twice of argon atom's 1st excitation potential. Under such condition, the electrons between G_2 and K lose their energy again due to the 2nd non-elastic collision causing the 2nd decrease of plate current I_A.

By plotting the U_{G2K} ~I_A curve as shown in Figure 2, the voltage difference between adjacent valleysor peaks can be found, representing the 1st excitation potential of the argon atom. This experiment illustrates that the slow electrons in Franck-Hertz tube collide with argon atoms, excite the atoms from low energy level to high energy level. By measuring the argon's 1st excitation potential, known as a constant of 11.62 V, we can demonstrate the existence of Bohr atomic level, meaning the energy absorbed and transmitted is discrete.

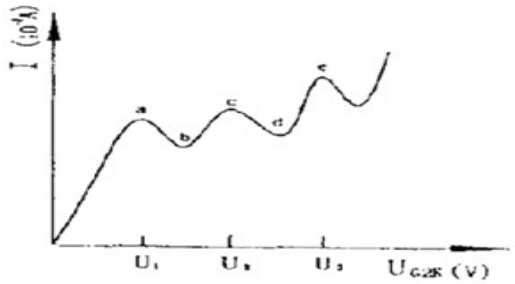

Figure 2 Relationship curve between plate current and accelerating voltage