INTRODUCTION

FRANK-HERTZ

From the early spectroscopic work it is clear that atoms emitted radiation at discrete frequencies; from Bohr's model, the frequency of the radiation ν is related to the change of energy levels through $\Delta E = h\nu$. It is then to be expected that transfer of energy to atomic electrons by any mechanism should always be in discrete amounts. One such mechanism of energy transfer is through inelastic scattering of low-energy electrons.

Frank and Hertz in 1914 set out to verify these considerations.

(i) It is possible to excite atoms by low energy electron bombardment.

(ii) The energy transferred from electrons to the atoms always had discrete values.

(iii) The values so obtained for the energy levels were in agreement with spectroscopic results.

Thus the existence of atomic energy levels put forward by Bohr can be proved directly. It is a very important experiment and can be performed in any college or University level lab.

OPERATING PRINCIPLE

$\boxed{V = IR}$

The Frank-Hertz tube in this instrument is a tetrode filled with the vapour of the experimental substance Fig. 1 indicates the basic scheme of experiment.

The electrons emitted by filament can be accelerated by the potential V_{G_2K} between the cathode and the grid G_2. The grid G_1 helps in minimising space charge effects. The grids are wire mesh and allow the electrons to pass through. The plate A is maintained at a potential slightly negative with respect to the grid G_2. This helps in making the dips in the plate current more prominent. In this experiment, the electron current is measured as a function of the voltage V_{G_2K}. As the voltage increases, the electron energy goes up and so the electron can overcome the retarding potential V_{G_2A} to reach the plate A. This gives rise to a current in the ammeter, which initially increases. As the voltage further increases, the electron energy reaches the threshold value to excite the atom in its first allowed excited state. In doing so, the electrons lose energy and therefore the number of electrons reaching the plate decreases. This decrease is proportional to the number of inelastic collisions that have occurred. When the V_{G_2K} is increased further and reaches a value twice that of the first excitation

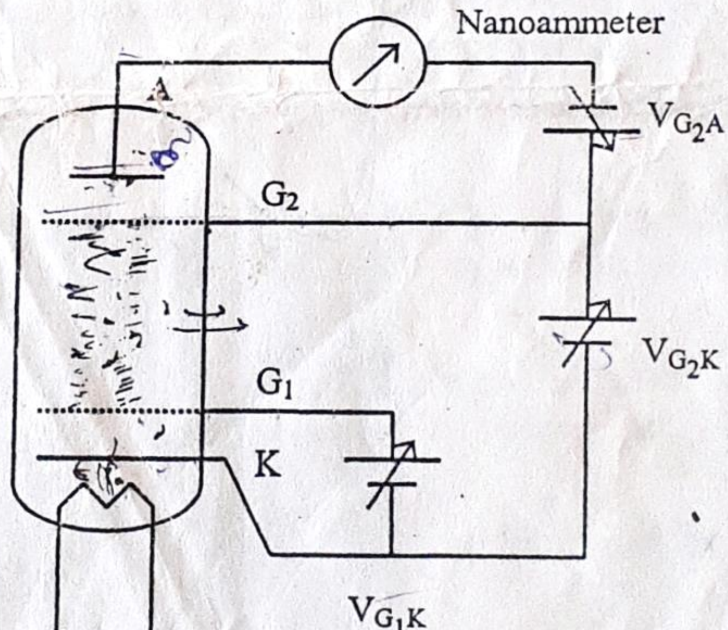
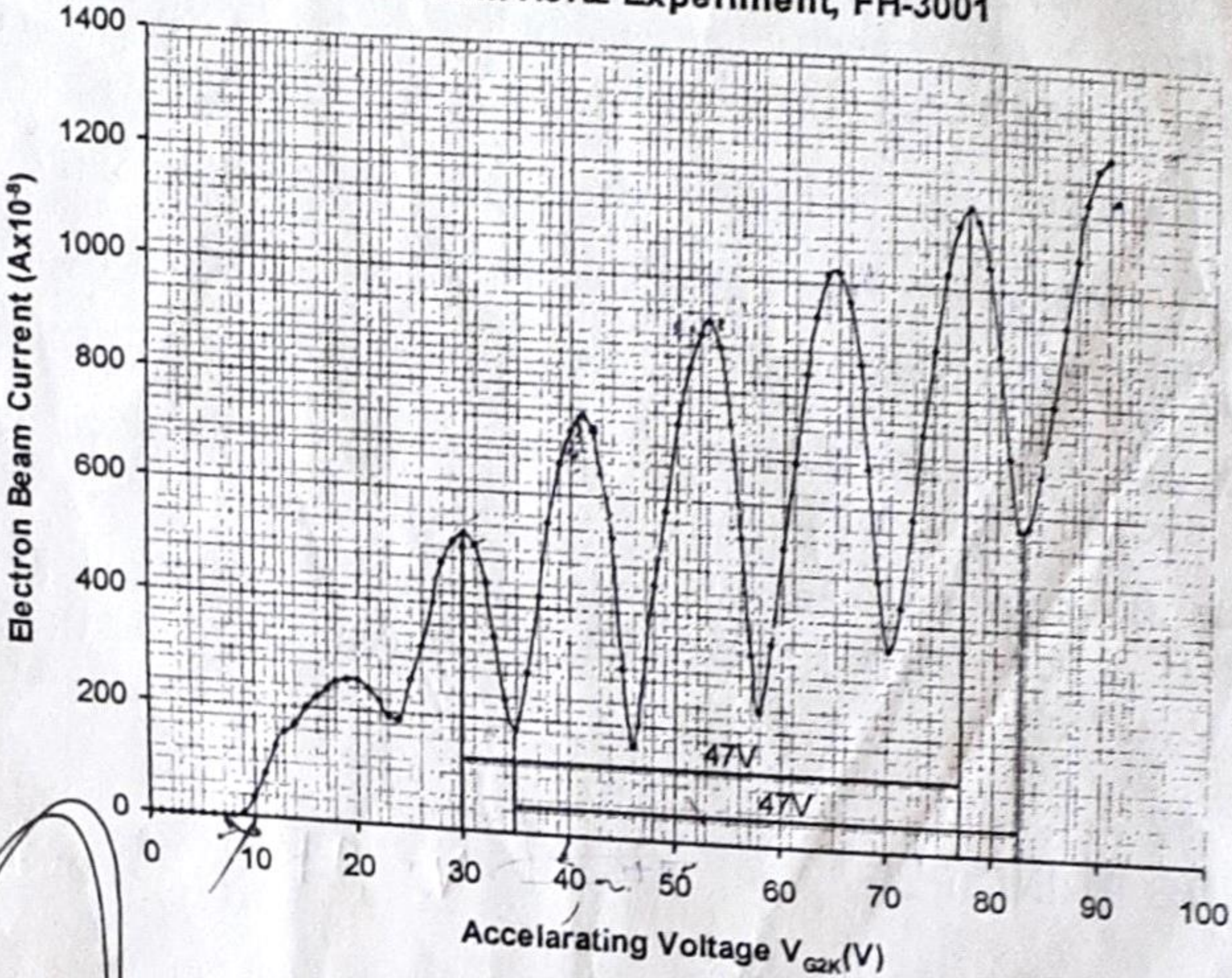


Fig 1

Fig. 3 Plot of Beam Current Vs. Accelarting Voltage in Frank Hertz Experiment, FH-3001



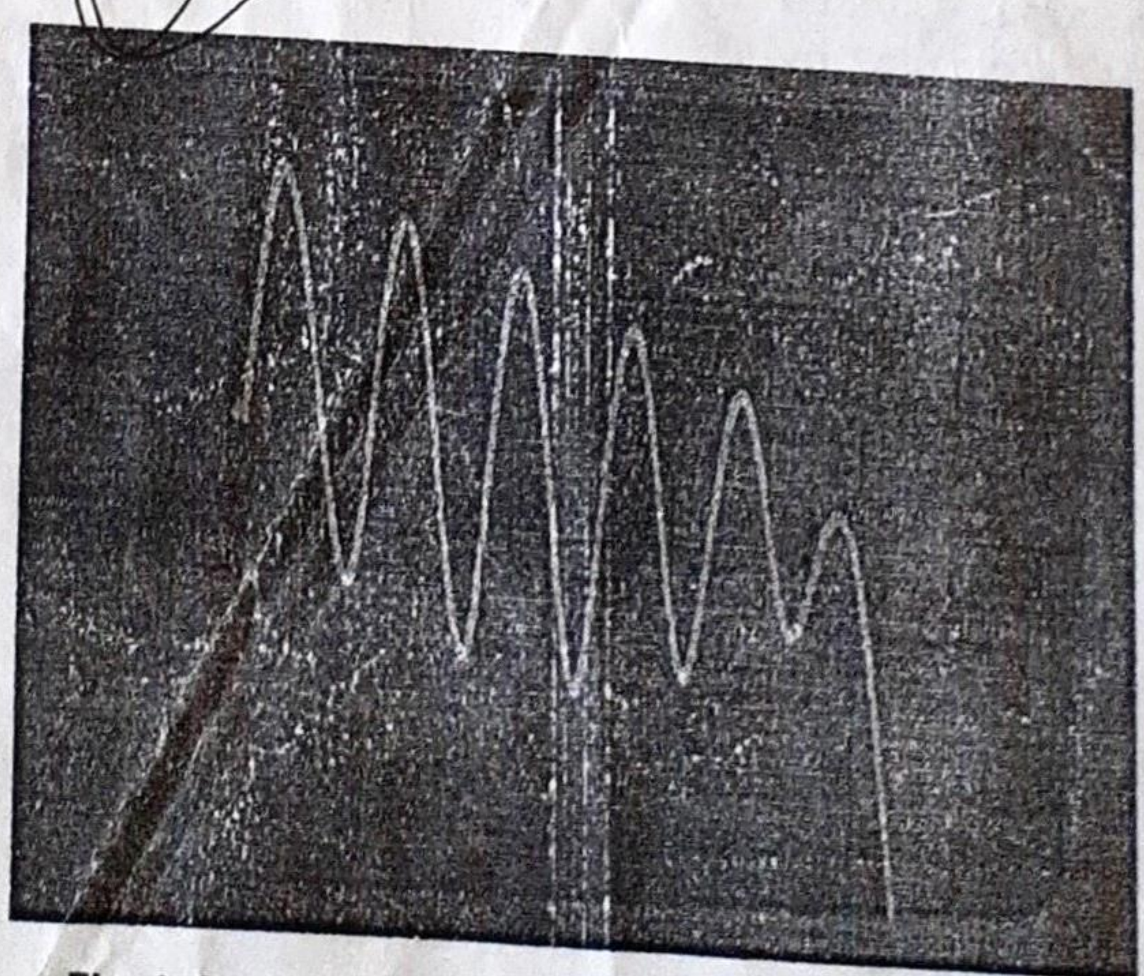


Fig. 4 Oscilloscope display of Frank-Hertz Experiment

Vs1

Plot the graph with output current on Y-axis and accelerating voltage V_{G_2K} at X-axis.

7) Turn the Manual-Auto switch to 'Auto', connect the instruments Y, G, X sockets to Y, G X of oscilloscope. Put the Scanning Range switch of oscilloscope to X-Y mode/external 'X'. Switch on the power of oscilloscope, adjust the Y and X shift to make the scan base line on the bottom of screen. Rotate the 'Scanning Knob' of the instrument and observe the wave-form on the oscilloscope screen. Adjust the 'Y-gain' and 'X-gain' of oscilloscope to make wave-form clear and Y amplitude moderate. Rotate the scanning potentiometer clockwise to end. Then the maximum scan voltage is 85V. Measure the horizontal distance between the peaks. The distance of two consecutive peaks (count the grids) and multiply it by V/grid factor (X-gain) of oscilloscope. This would give the value of argon atom's first excitation potential in eV.

PRECAUTION

1) Before taking the systematic readings, gradually increase the value of V_{G2k} to a maximum. Adjust the filament voltage if required such that max. readings is about 1000 on $X10^{-8}$ range. This will insure that all the readings could be taken in the same range.
2) During the experiment (manual), when the voltage is over 60V, please pay attention to the output current indicator, If the ammeter reading increases suddenly, decrease the voltage at once to avoid the damage of the tube.
3) Whenever the Filament Voltage is changed, please allow 2/3 minutes for its stabilisation.
4) **When the Frank-Hertz Tube is already in the socket, please make sure the following before the power is switched 'ON' or 'OFF', to avoid damage to the tube.**
    a) Manual - Auto switch is on Manual and Scanning and Filament Voltage knob at its minimum position (rotate it anticlockwise) and Current Multiplier knob at 10^{-7}.
    b) V_{G_1K}, V_{G_2A}, and V_{G_2K} all the three knobs are at their minimum position.