Instruction Manual

Franck-Hertz Apparatus (Argon)

SS20801

Instruction Manual
for
Franck-Hertz Apparatus
Model SS20801

1. Applications

The Franck-Hertz Apparatus (Model SS20801) is designed for college students to demonstrate the existence of quantized states. The experiment can be performed in less time because the use of Argon tube eliminates the need for tube heating (as in the case of a Mercury filled tube). The data can be recorded manually, or directed to an oscilloscope or computer for display.

2. Identification

The controls on the panel of the device are shown in Fig.1.

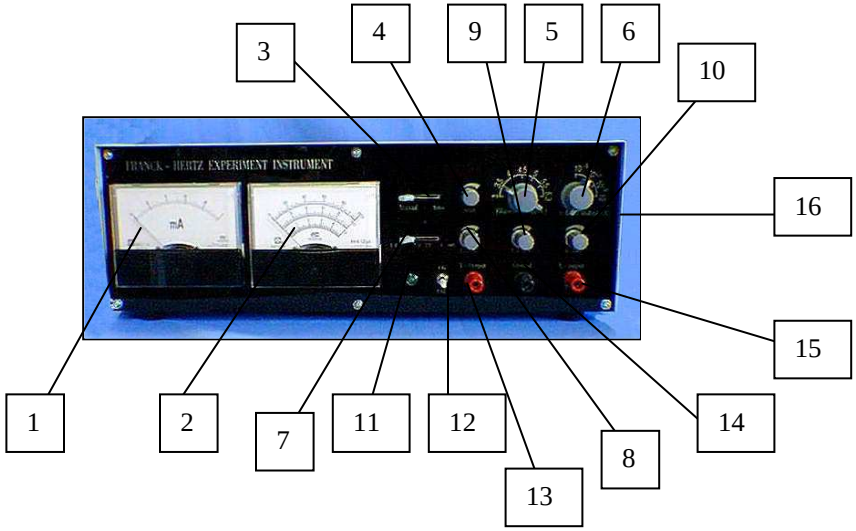

Fig.1

1	Current Meter	2	Voltmeter	3	Manual/Auto Switch
4	Scan Control	5	Filament Voltage Selector	6	Current Multiple Selector
7	Voltage Range Selector	8	1.3 –5V Adjustment	9	1.3–15V Adjustment
10	0-100V Adjustment	11	Power Indicator	12	Power Switch
13	Y-output Terminal	14	Ground	15	X-output Terminal
16	Observation Window				

When U_{G2K} reaches the first excitation potential of the Argon atom, electrons collide with Argon atoms near the second grid (it is a non-elastic collision), and transfer total energy obtained in the accelerating field to Argon atoms, exciting them from ground state to the first excitation state. But electrons themselves, transferring all energy to Argon atoms, can't overcome the reverse field. They are drawn back to the second grid even if some of them penetrated the second grid. Therefore the plate current I_A decreased. Then, with the increase of $U_{G2K,}$ the electron energy increases too. There will be enough energy left after the collision with Argon atom. Thus they can overcome the reverse field and reach plate A. And at this time current I_A begins to increase again, until U_{G2K} is 2 times the voltage of Argon atoms first excitation potential, when electrons between G2 and K lost energy again because the second non-elastic collision causes the second decrease of acceleration voltage $U_{G2K.}$ Let U_{G2K} be the horizontal ordinate and I_A the vertical axis. We can plot the spectrum amplitude curve. The voltage difference between two consecutive valley point (or peak point) is the first excitation potential of Argon atom. This experiment illustrates the fact that the slow electrons in the Franck-Hertz tube collide with Argon atoms, excite the atoms from a low level to high level. By measuring Argons first excitation potential (13.1V, which is constant) We can verify that the energy absorbed and transmitted is discrete, not continuous.

8.Working Principle

The Franck-Hertz tube in this instrument is a tetrode filled with Argon. Figure 2 describes the symbols of every electrode and relations between voltages.

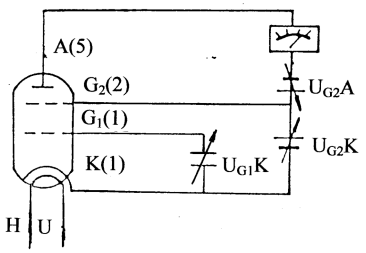

Fig.2

A voltage of about 1.5V is added between the first grid (G1) and the cathode (K) to dismiss the effect of space charge on cathode scattering electrons. When the filament is heated, the electrons transmitted by the cathode oxide are accelerated in the electric field between the second grid (G2) and the cathode, obtaining more and more energy. At the beginning, because of the low voltage between the second grid and cathode, the electron energy is low. Thus the energy exchanged is little even if the electrons collide with the atom. Therefore the plate current I_A formed by electrons penetrating the second grid will increase with the increase of $U_{G2K.}$ (segment OA in Figure 3)

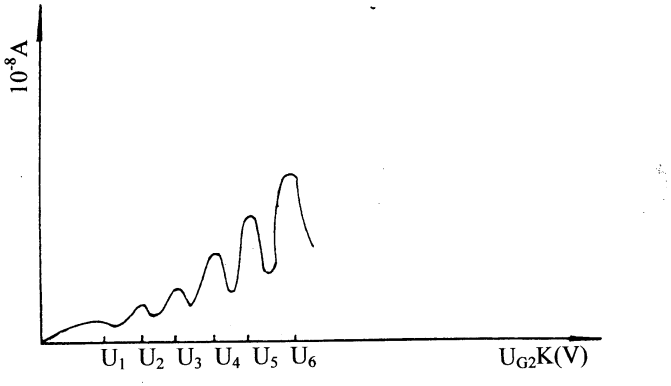

Fig. 3

When U_{G2K} reaches the first excitation potential of the Argon atom, electrons collide with Argon atoms near the second grid (it is a non-elastic collision), and transfer total energy obtained in the accelerating field to Argon atoms, exciting them from ground state to the first excitation state. But electrons themselves,

3. Manual Operation

1. **Read warnings** on the following page, **making sure to pay attention to the current indicator**, keeping an eye out for sudden current spikes that may damage the tube at higher voltages. To prevent damage to the tube, we do not recommend exceeding 5 volts (filament voltage).
2. Making sure that the unit is **unplugged**, remove the side cover of the instrument and place the Franck-Hertz tube in the lamp socket. Make sure to remove all packing material/foam from the bulb compartment and replace the side cover prior to use.
3. **Note:** The 0 ~ 100V knob is continuously adjustable with a soft stop. Use care to slowly rotate this knob during use and when zeroing. Turn all voltage adjustment knobs (3 smaller gray knobs in a row) fully counterclockwise and **set the filament voltage to 3.5V** and the "Current Multiple" selector to **10^{-8}**. Turn the "Manual-Auto" switch to "Manual", and rotate the Scan knob counter-clockwise to end. Turn on the device - the green power indicator will glow. **Preheat the bulb for 2 minutes prior to experimentation.**
4. **IMPORTANT: NEVER change the "current multiple" selector with the instrument powered on.** When turning the unit off, the current meter will dip and hold under zero momentarily while the device is powering down.
5. Move the "Voltage Stepper" switch to 1.3 ~ 5V, and rotate the 1.3 ~ 5V adjustment knob until the voltmeter reads 1.5V to set U_{G1K} =1.5V.
6. Move the "Voltage Stepper" switch to 1.3 ~ 15V, and rotate the 1.3 ~ 15V adjustment knob until the voltmeter reads 7.5V to set U_{G2A} =7.5V (rejecting voltage).
7. Move the "Voltage Stepper" switch to 0 ~ 100V, and rotate the 0 ~ 100V adjustment knob until the voltmeter reads 0V to set U_{G2k} =7.5V(accelerating voltage). Normally this is fully counterclockwise. Remember that this knob is continuously adjustable with a soft zero.

   When you have finished steps 3 ~ 5, with U_H=3.5V (Filament voltage), U_{G1K} = 1.5V (the voltage between the first grid and cathode), U_{G2A} =7.5V(The voltage between the second grid and anode) and installed the bulb, you are ready to do the experiment.

8. Complete step 7 above and then rotate the 0 ~ 100V adjustment knob clockwise, and observe the instrument for variation of current meter and voltmeter readings. You should observe peaks in the current meter on the left side of the instrument while rotating the 0 ~ 100V adjustment knob clockwise. Normally no peaks will be observed at this low filament voltage of 3.5V while in manual mode (you start at low filament voltage to avoid

damaging the tube). You can return the 0 ~ 100V adjustment knob back to zero and increase the filament voltage to 4V. Note: Do not move the 1.3 ~ 5V or 1.3 ~ 15V knobs. Rotate the 0 ~ 100V knob clockwise and observe the current readings. You can keep increasing the filament voltage using the steps above until a nice waveform is observed on the . You can also increase the current multiple of the device. **Before changing the "current multiple" knob to higher sensitivity (10^{-9}), the power should be turned off, and all voltage knobs turned fully counterclockwise. The voltage stepper should be returned to the 1.3 ~ 5V position.** When this is complete, only then do you change the "current multiple" setting to 10^{-9} and turn on the instrument, repeating steps 3 ~ 8. Observe the current indicator on the left for peaks.

With the increase of U_{G2K} (accelerating voltage), the rheometer's reading appear to peak and valley periodically. Record the corresponding voltage and current. Let the output current be the vertical ordinate, and U_{G2K} the horizontal ordinate. Plot the spectrum amplitude curve.

4. Use with an Oscilloscope

1. Turn "Manual-Auto" switch to "Auto", and connect the instrument's Y, ground, X sockets to Y, ground, X sockets of an oscilloscope. Put the scanning range switch of oscilloscope to "external X". Switch on the power of oscilloscope, adjust the Y and X shift to make the scan baseline on the bottom of screen, and adjust "X Gain" to make scan baseline 10 grids. Rotate the scanning knob of this instrument, and observe the waveform on the oscilloscope's screen. Adjust the "Y gain" and "X gain" of the oscilloscope's attenuation to make the waveform clear and Y amplitude moderate. Rotate scanning potentiometer clockwise to end and set the maximum scan voltage to 50V. Measure the horizontal distance of two consecutive crests (count the grids). Multiply the distance by 5V/grid, to obtain the value of Argon atoms first excitation potential.

5. Warnings

1. **During the experiment, pay close attention to the output current indicator when the voltage is over 60V. This is especially important at the higher voltage (filament voltage) and sensitivity (current multiple) settings. If the current meter reading increases suddenly, decrease the voltage at once to avoid the damage to the tube.**
2. **If you want to change the value of U_{G1K}, U_{G2A} and U_H during the experiment, rotate the "0 ~ 100V" adjust knob counter-clockwise to end, before making the changes.**
3. The filament voltage of this instrument is 3V, 3.5V, 4V, 4.5V, 5V, 5.5V, 6.3V. You can do the experiment with these filament voltages. If skew occurs on the top of waveform (this means the anode output current is too strong and causes the amplifier to distort), the filament voltage should be decreased.

6. Package Content List

1.	Franck-Hertz Apparatus	1 each
2.	Argon Tube	1 each
3.	Oscilloscope Connecting wires (30")	3each
4.	Operating instruction manual	1 each

7. Specifications

1. Voltage supplied to Franck- Hertz tube.

U_{G1K}	1.3 ~ 5V
U_{G2A} (rejecting voltage)	1.3 ~ 15V
U_{G2K} point- measure observe	0 ~ 100V
Sawtooth wave on oscilloscope	0 ~ 50V
U_H (filament voltage)	AC: 3V,3.5V, 4V, 4.5V, 5V, 5.5V, 6.3V.

2. Sawtooth Wave Parameters

Scanning Voltage	0 ~ 50V
Scanning Frequency	115 ± 20Hz
Voltage amplitude of scanning output	≤ 1V

3. Low-current Measuring range

10^{-6} ~ 10^{-9} A(4 steps)

4. Observable numbers of spectrum amplitude

Point – measuring	∃5
Observe on universal oscilloscope	∃2

5. Operating conditions

Ambient temperature	-10 ~ 40°C
Relative humidity	≤85%(40°C)
Operating power	AC 110V ± 10V, 60H_z
Preheating time	≤5 min
Continuous operating time	8 hours
Rated input power	≤15W
Dimensions	l X w X h: 40cm X 23cm X 13cm