Score

Physical Experiment II

Physics Lab Report 10

Experiment Title:	The Franck-Hertz Experiment
Student Number:	2017200602011
Chinese Name:	张立澄
Teaching Assistant:	Hao Wen
Instructor:	Jing Wu
Lab Date:	2018.10.25

UESTC Student Number: 2017200602011 Email: 928023250@qq.com Date: 2018.10.29

Score

Abstract (About 100 words, 3 points)

The purpose of the Frank-Hertz experiment is to determine the first excitation potential of argon atoms by manual or computer. By changing the retarding voltage and the accelerating voltage, we can obtain different relationship between the electron current and the acceleration voltage shown in a graph, which is helpful to prove the theory that atom exists discrete energy levels. And analyzation of the data also helps us digest the first excitation potential of argon atoms by manual or computer, and be more familiar with the Bohr Model and the experiment apparatus.

Score

Introduction (3 points)

①Background: this experiment was presented on April 24,1914 by James Franck and Gustav Hertz. And it provided an indication that atoms had discrete energy levels;

②Physical principle: use the Bohr Model to analyze this experiment;

③Objective: to determine the first excitation potential of argon atoms by manual and computer understanding the process of electron collision and quantized excitation of argon atoms.

Score

Experimental Procedure (State main steps in order of performance, 3 points)

1. Turn on the computer and connect the apparatus with it;
2. Turn on the power and preheat the apparatus for at least five minutes;
3. Start the software XDPF V2.0;
4. Set data on the computer, including V1, V2, V3, V4;
5. Run the program and find the graph which is shown on the computer;
6. Measure the current-accelerating voltage relationship;
7. Repeat the above steps and record the results for 3 times;
8. Clear the apparatus and close the computer.

Score

Results (Data tables and figures, 2 points)

Data Tables

DATA TABLE 3-1 (Measured by manual mode. *purpose*: to determine the first excitation potential of argon atom)

V_1= *2.2V* ; V_2= *1.0V* ; V_3= *8.0V* ;

(The unit of the current in the following table is 1μA)

	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
0	0	0	0	0	0	0	0	0	0	0
10	0	0	1	1	1	1	1	1	1	1
20	1	1	2	2	2	2	2	2	3	3
30	3	3	3	3	3	3	4	4	5	5
40	6	6	6	6	5	4	4	6	7	8
50	10	11	11	11	11	10	9	7	7	9
60	12	14	17	18	19	19	19	17	15	12
70	12	14	18	22	25	28	30	31	31	29

DATA TABLE 3-2 (Measured by computer. *purpose*: to determine the first excitation potential of argon atom)

V_1= *2.2V* ; V_2= *1.2V* ; V_3= *8.2V* ;

(The unit of the current in the following table is 1μA)

	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	1	2	3	3	4	5
20	6	6	7	8	8	9	11	12	13	15
30	16	16	17	16	16	16	19	23	27	31
40	35	37	39	38	35	30	26	28	37	50

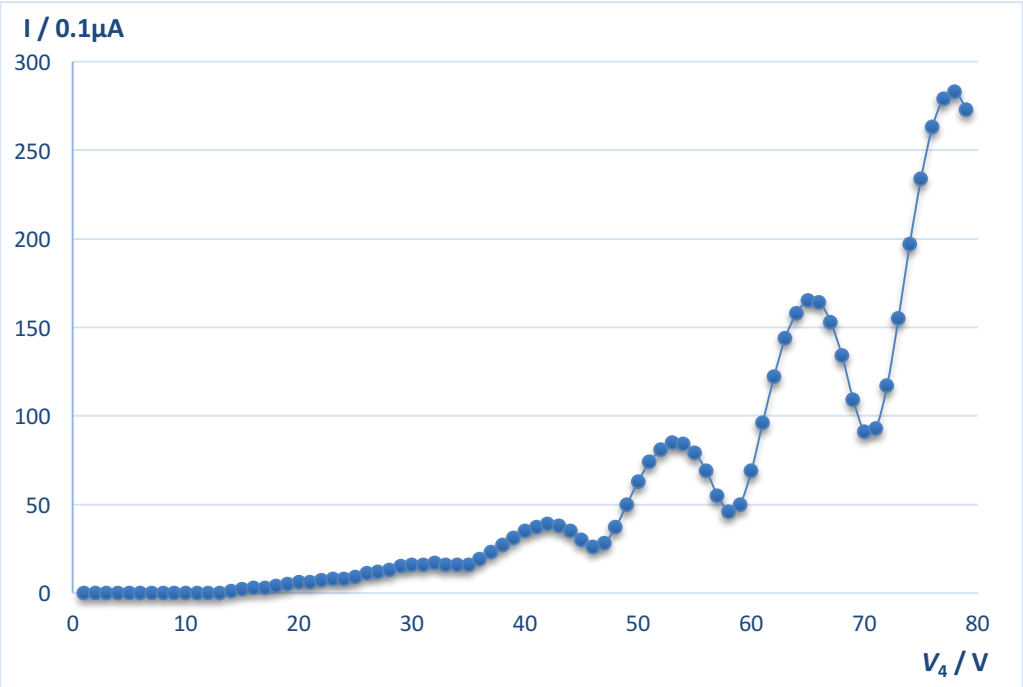
50	63	74	81	85	84	79	69	55	46	50
60	69	96	122	144	158	165	164	153	134	109
70	91	93	117	155	197	234	263	279	283	273

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

V_1= *2.0V* ; V_2= *1.0V* ; V_3= *7.8V* ;

(The unit of the current in the following table is 1μA)

	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	1	1	2	3	3	4
20	4	5	6	6	7	8	9	10	12	13
30	14	14	14	14	13	14	17	22	26	31
40	34	37	37	36	32	27	24	28	39	53
50	67	77	84	87	86	80	68	53	46	55
60	79	108	135	155	169	175	171	159	136	110
70	96	105	137	179	222	259	286	300	301	288



Score

Discussion (More than 150 words, 5 points)

Based on the Bohr Model and the theory that atom exists discrete energy levels and atoms can only absorb or emit certain level of the energy, we can obtain different relationship between the electron current and the acceleration voltage and determine the first excitation potential of the argon atom by changing the retarding voltage and the accelerating voltage and analyzing the crests of the data. After analyzing the data, we can determine the first excitation potential of argon atoms. However, comparing with the expected result, the relative error of my measurement is about 16%, and I think one of the influencing factors is that the voltages value I chose is not perfect, which means the obtained value of V_4 is not accurate completely, and caused some lines is relatively low so that effect the precision of the result.

Score

Conclusions (About 50 words, 2 points)

After this experiment, I understand more about the Bohr Model and its application. Besides, by analyzing and computing the data, we can determine the first excitation potential argon atoms is about 11.0v(with the relative error about 16%)

Score

References (1 points)

Haofu, Esmond Agurgo Balfour, Introductory Physics Experiments for Undergraduates, Science Press, Beijing, 2017

Score

Answers to Questions (6 points)

(1) The voltages do not affect the first excitation potential of argon atom, because the real value of the first excitation is fixed.

(2) The most important conclusion for the frank-hertz experiment is that there are discrete state energy levels in the atomic internal structure which directly proves Bohr's atomic quantized model.

(3) There will be transitions. We can use excitation voltage to detect it. There will be energy exchange after the collision between argon atoms and electrons, and argon atomic will have transitions to the first excited state since the energy level of the atom is discrete. And we can detect that the wavelength will be decreased.

(4) When the V1 voltage rises, the electrons have higher energy so that there are collisions with argon atoms. And the number of excited electrons become more, which means the current become higher.

Appendix

Score

(Calculations, 15 points)

Calculations

Compute the first excitation potential, U_0, from the graph.

(1) Choose one trace and read the horizontal coordinates of the crests. Put the voltages in the following table.

Crest	1	2	3	4	5
Voltages, U (V)	32	42	53	65	78

(2) Compute the difference of the voltages

$U_{01}=U_2-U_1=42V-32V=10V$;
$U_{02}=U_3-U_1=53V-32V=21V$;
$U_{03}=U_4-U_1=65V-32V=33V$;
$U_{04}=U_5-U_1=78V-32V=46V$;

(3) Compute to the first excitation potential U_0.

$$\boldsymbol{U_0=\frac{U_{01}+U_{02}+U_{03}+U_{04}}{1+2+3+4}=\frac{10V+21V+33V+46V}{1+2+3+4}=11V}$$

(4) The accepted value of the first excitation potential of argon is 13.1 V. Compute the relative error of you measurement.

$$\boldsymbol{\sigma=\frac{U_0-U}{U}=\frac{11V-13.1V}{13.1V}=-16.0\%}$$

Appendix

(Scanned data sheets)

Data Table 3.10-1 ***Purpose*: To determine the first excitation potential of argon atoms by manual measurement**

V_1=2.2V; V_2=1.0V; V_3=8.0V

Measurement range of the picoammeter: 1μA

V_4/V	0	1	2	3	4	5	6	7	8	9
I_A(Unit:0μA)	0	0	0	0	0	0	0	0	0	0
V_4/V	10	11	12	13	14	15	16	17	18	19
I_A(Unit:0μA)	0	0	1	1	1	1	1	1	1	1
V_4/V	20	21	22	23	24	25	26	27	28	29
I_A(Unit:0μA)	1	1	2	2	2	2	2	2	3	3
V_4/V	30	31	32	33	34	35	36	37	38	39
I_A(Unit:0μA)	3	3	3	3	3	3	4	4	5	5
V_4/V	40	41	42	43	44	45	46	47	48	49
I_A(Unit:0μA)	6	6	6	6	5	4	4	6	7	8
V_4/V	50	51	52	53	54	55	56	57	58	59
I_A(Unit:0μA)	10	11	11	11	11	10	9	7	7	9
V_4/V	60	61	62	63	64	65	66	67	68	69
I_A(Unit:0μA)	12	14	17	18	19	19	19	17	15	12
V_4/V	70	71	72	73	74	75	76	77	78	79
I_A(Unit:0μA)	12	14	18	22	25	28	30	31	31	29

Student's name and number: 张玉洁 2017200602011 Instructor's initial: Jing Wu

Data Table 3.10-2 ***Purpose***: **To determine the first excitation potential of argon atoms by computer**

V_1= 2.2 V; V_2= 1.2 V ; V_3= 8.2 V

Measurement range of the picoammeter: 1 μA

V_4 / V	0	1	2	3	4	5	6	7	8	9
I_A(Unit: 0.1 μA)	0	0	0	0	0	0	0	0	0	0
V_4 / V	10	11	12	13	14	15	16	17	18	19
I_A(Unit: 0.1 μA)	0	0	0	0	1	2	3	3	4	5
V_4 / V	20	21	22	23	24	25	26	27	28	29
I_A(Unit: 0.1 μA)	6	6	7	8	8	9	11	12	13	15
V_4 / V	30	31	32	33	34	35	36	37	38	39
I_A(Unit: 0.1 μA)	16	16	17	16	16	16	19	23	27	31
V_4 / V	40	41	42	43	44	45	46	47	48	49
I_A(Unit: 0.1 μA)	35	37	39	38	35	30	26	28	37	50
V_4/V	50	51	52	53	54	55	56	57	58	59
I_A(Unit: 0.1 μA)	63	74	81	85	84	79	69	55	46	50
V_4 / V	60	61	62	63	64	65	66	67	68	69
I_A(Unit: 0.1 μA)	69	96	122	144	158	165	164	153	134	109
V_4 / V	70	71	72	73	74	75	76	77	78	79
I_A(Unit: 0.1 μA)	91	93	117	155	197	234	263	279	283	273

Student's name and number: 张玉洁 2017200602011 Instructor's initial: Jing wu

Data Table 3.10-3 ***Purpose*: To determine the first excitation potential of argon atom by computer**

V_1= 2.0V ; V_2= 1.0V ; V_3= 7.8V

Measurement range of the picoammeter: 1μA

V_4 / V	0	1	2	3	4	5	6	7	8	9
I_A(Unit:0.1nA)	0	0	0	0	0	0	0	0	0	0
V_4/ V	10	11	12	13	14	15	16	17	18	19
I_A(Unit:0.1nA)	0	0	0	0	1	1	2	3	3	4
V_4/ V	20	21	22	23	24	25	26	27	28	29
I_A(Unit:0.1nA)	4	5	6	6	7	8	9	10	12	13
V_4/ V	30	31	32	33	34	35	36	37	38	39
I_A(Unit:0.1nA)	14	14	14	14	13	14	17	22	26	31
V_4/ V	40	41	42	43	44	45	46	47	48	49
I_A(Unit:0.1nA)	34	37	37	36	32	27	24	28	39	53
V_4/ V	50	51	52	53	54	55	56	57	58	59
I_A(Unit:0.1nA)	67	77	84	87	86	80	68	53	46	55
V_4/ V	60	61	62	63	64	65	66	67	68	69
I_A(Unit:0.1nA)	79	108	135	155	169	175	171	159	136	110
V_4/ V	70	71	72	73	74	75	76	77	78	79
I_A(Unit:0.1nA)	96	105	137	179	222	259	286	300	301	288

Student's name and number: 张志澄 2017200602011 Instructor's initial: Jing Wu