University Dr. Tahar Moulay Saida

Faculty of Science

Department of Physics

Practical work of Atomic and Nuclear Physics

Presented by:

Dr. Smain Kouidri

2023/2024

Contents

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UNIVERSITY DR MOULAY TAHAR OF SAIDA ALGERIA
SCIENCES FACULTY
DEPARTMENT OF PHYSICS
2023/2024

Presented by Dr. S. Kouidri[1]

[1] *Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 16, 2023)

Abstract: These practical work notes in atomic and nuclear physics represent an experience of my teaching at the University of Saida-ALGERIA, Science faculty and physics department. They have several objectives :

- Make available to license and master students all practical work including a complete set of lectures notes.

- To familiarize students with doing practically in order to verify their theoretical formulas.

Keywords: Atomic physics; Nuclear physics.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. INTRODUCTION

II. RUTHERFORD EXPERIMENT WITH GOLD

III. RUTHERFORD EXPERIMENT WITH AL

IV. THE SPECIFIC CHARGE OF ELECTRON E/M

V. MILIKAN EXPERIENCE AND CHARGE E

VI. FRANCK HERTZ EXPERIENCE WITH HG-TUBE

VII. FRANCK HERTZ EXPERIENCE WITH NE-TUBE

VIII. DETERMINATION OF THE PLANCK CONSTANT

IX. EFFECT COMPTON WITH MULTICHANNEL MEASUREMENT

X. EFFECT COMPTON ENERGY DISPERSIVE DIRECT MEASUREMENT

XI. THE PHOTOELECTRIC EFFECT

XII. DETERMINATION OF THE RYDBERG CONSTANT RY

XIII. THE TWO ELECTRON SYSTEM HELIUM ATOM

XIV. MOSELY LAW

XV. ELECTRON DIFFRACTION AND LOUIS DE BROGLIE RULE HESEINBERG PRINCPLE

XVI. STERN GERLASH EXPERIMENT

XVII. NORMAL ZEEMAN EFFECT

XVIII. ELECTRONIC SPIN RESONANCE

XIX. HALF LIFE AND RADIOACTIVE EQUILIBRUM

Dr Smail Kouidri

begindocument/before

PRACTICAL WORK IN ATOMIC AND NUCLEAR PHYSICS 2023/2024

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

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THE PRACTICAL WORK IN ATOMIC AND NUCLEAR PHYSICS

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 16, 2023)

Abstract: We present in this work certain practical work in atomic and nuclear physics. A module that really plays an important role in the best formation of the license and master students. Although this discipline: atomic physics provides the best possible information on the composition of atoms electrons + nucleus and on the transition of electrons between different energy levels. It remained incomplete without the study of the stabilities of the nuclei and nuclear physics..

Keywords: Atomic physics; Atom composition.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. INTRODUCTION

The objective of this work is to present certain practical work in atomic physics. A module that really plays an important role in the best formation of the license and master students. Although this discipline: atomic physics provides the best possible information on the composition of atoms electrons + nucleus and on the transition of electrons between different energy levels. It remained incomplete without the study of the stabilities of the nuclei and nuclear physics. Its history begins before the birth of quantum mechanics with the successive discoveries of the best physicists in the world at the time, notably TJ. J. Thonson (determination of the specific charge e/m); Milikan (determination of the charge e of electron and deduction of their mass m), Maxwell and Young (wave nature of light) Compton (interaction between photon and electron and problem of relativistic mechanic discovred by A. Einctein) A.Einsetin (its best explication of the photoelectric effect and corpuscular nature of light) Ernest Rutherford and his famous discovery on the composition of the atom during its impact with other atoms and the calculation of the effective section of the energetic particles diffused as a function of the atomic number Z which led Mendeliev to discover his famous table of chemical elements. Then by Franck and Hertz and their discovery of the successive potentials acquired by the electron when we heat the mercury atom.

Based on these conclusions we find in first time Niels Bohr and his work of the study of the hydrogen atom which take his name and with his famous semi-empirical relation of the transition of electron from one level to another: 1. In term of the path a natural number produced with a universal constant Planck's constant. 2. In term of the energy the constant h produces with the frequency of the radiation emitted or absorbed. Secondly we find Balmer, Pashen and Rydberg and their reformulation of the energy difference *via* its constant Ry.

This discipline was reorganized with the contribution of quantum mechanics and a reformulation of these equations based on the famous relationship of Louis de Broglie $\lambda = \frac{h}{p}$ (h is the Planck constant and p cojugate momentum) led Schrdinger, Heseinberg and Dirac to rewrite their relationship and see their behavior when we inject an atom and an electron into a zone with presence of the electromagnetic field, hence the Zeeman effect and nuclear resonance [1-9].

[1] Atomic Physics by Max Born London 1935.
[2] Phywe systeme GmbH Robert-Bosh-Breite 10 D-37079 Gottingen Germany.
[3] Abragam, E. Bleaney Electron paramagnetic resonnance of transitions ions Oxford Univ. Press London and New York 1970.
[4] leybod standard book.
[5] Cohen Tannaudji and *al.* Atom-photons interaction New York Wiley 1992.
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RUTHERFORD EXPERIMENT WITH GOLD

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

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Abstract: In this practical work Rutherford help us to better understand the atom of what is formed?. His experience is based on the calculation of the Gross-section σ of scatter particles.

Keywords: Rutherford scattering; Gross-section, Atom.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. RUTHERFORD EXPERIMENT

In order to test Thonson's atomic model, Rutherford used the α particles emitted by the radon gas in the T tube and collimated them through the narrow channel D. The nearly parallel beam of α particles then passes through a thin gold foil and the scattered α particles produce faint flashes of light on a phosphorous screen S were observed under a microscope [10] see in the following Fig 1.:

A. Objective

Establish the relationship between the scattering angle θ and the Gross-section σ using a semiconductor detector.

B. Formalism

Rutherford bombarded with alpha articles the Or atom in order to demonstrate the existence of a nucleus concentrated at the center and a vacuum between the nucleus and the electronic orbit which justifies the correct definition of the atom. The Rutherford experiment find its explanation with the quantum mechanics where the diffusion amplitude is after using the Green function :

$$f_k^{\theta}(\theta,\varphi) = -\frac{1}{4\tau}\frac{2\mu V_0}{\hbar^2}\int d^3 r e^{-ikr}\frac{1}{r}, \tag{1}$$

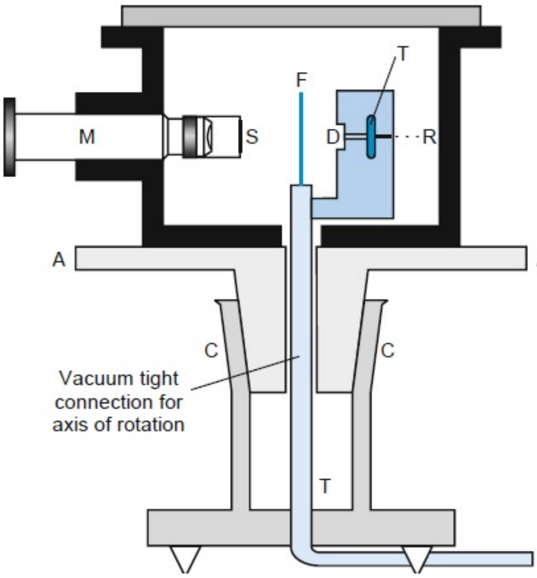

FIG. 1: The Rutherford instrument captured from [10]

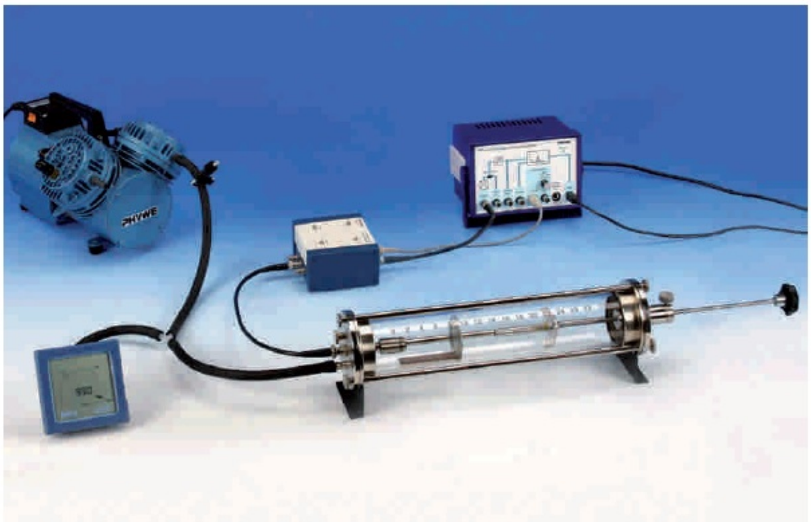

FIG. 2: The Rutherford instrument captured from [2,4]

Where $V_0 = Z_1 Z_2 e^2$ is the constant of Colombian potential, $e^2 = \frac{q^2}{4\pi\varepsilon_0}$ is the charge and $\mu = \frac{m_1 m_2}{(m_1+m_{2})}$ is the reduced mass.

The gross-section $\sigma(\theta)$ take the following expression :

$$\sigma(\theta) = |f_k^\theta(\theta, \varphi)|^2, \tag{2}$$

By injecting the expression of the scatter amplitude in Eq.(2), we obtain:

$$\sigma(\theta) = \frac{4\mu^2}{\hbar^2} . \frac{Z_1^2 Z_2^2 e^4}{16k^4 sin^4(\theta/2)}. \tag{3}$$

C. Experience

The detector has a detection probability of 1 for alpha-particles and virtually no zero effect, so that the number of pulses agrees exactly with the number of alpha particles striking the detector. In order to obtain maximum possible counting rates, a measurement geometry is used. It is also possible in this case to shift the foil and source in an axial direction, so that the angle of scattering can be varied over a wide range.

For a better manipulate the experience see in picture (Fig.1) we will have to prepare the following material;
- Alpha detector,
- Multi channel analyzer,
- Radioactive source Am-241,
- Safeaty connecting lead, - Pre-amplifier,
-

1. Plot the number of pulses N as function the scatter angle θ.
2. Plot $\sigma(\theta)$ as function as $\frac{1}{sin^4(\theta/2)}$.
3. we give $Z_1 = 2$ determine Z_2.
4. What present the scatter amplitude physically?

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RUTHERFORD EXPERIMENT WITH ALUMINIUM

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

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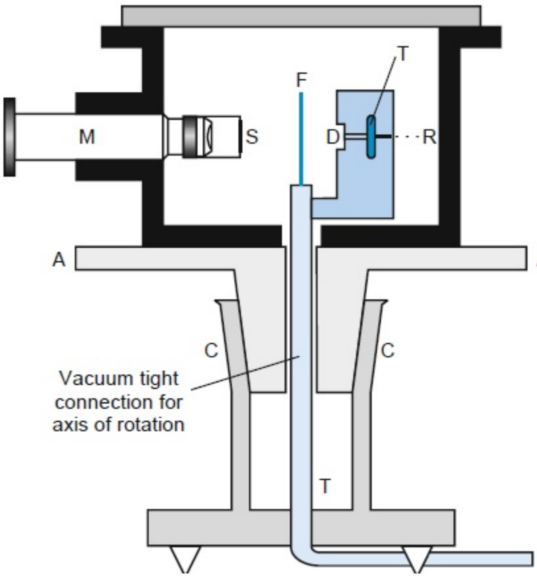

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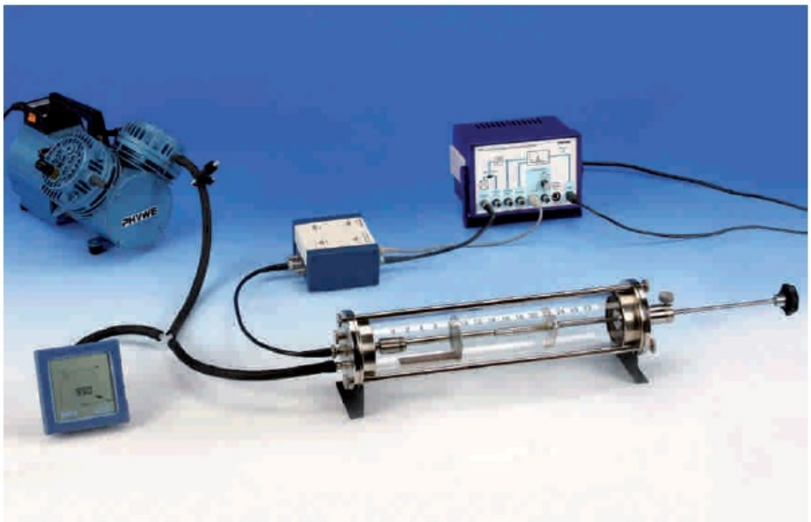

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THE SPECIFIC CHARGE OF ELECTRON $\frac{e}{m}$

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 11, 2023)

Abstract: We accelerate many electrons in a region where a magnetic field is present. We adjust the position of the ejection electrons in such a way that the magnetic field B is perpendicular to the velocity v of the electrons in order to have a circular orbit. We determine after certain measurements the ratio $\frac{e}{m}$ using the theoretical formula. We familiarize the student to observing this process.

Keywords: Atomic physics; Atom composition.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. THE SPECIFIC CHARGE OF ELECTRON $\frac{e}{m}$

Electrons are accelerated in an electric field and enter a magnetic field at right angles to the direction of motion. The specific charge of the electron is determined from the accelerating voltage, the magnetic field strength and the radius of the electron orbit.

A. Objective

Based of the circular movement of electron in presence the magnetic field, we determine the specific charge $\frac{e}{m}$. Our objective is to measure the different tension U and its current correspondent.

B. Formalism

We accelerate a electron beam by tension U in region where a magnetic field $\overrightarrow{B}$ is present. The electron will affected by a Lorentz force $\overrightarrow{F} = e(\overrightarrow{v} \wedge \overrightarrow{B})$. Based on circular trajectory the Lorentz force is equal to a centrifuge Force $m\frac{v^2}{r}$. The magnetic field B which diverts the electrons into the path with the given radius r is determined as a function of the acceleration voltage U. The Lorentz force caused by the magnetic field acts as a centripetal force. It depends on the velocity of the electrons, which in turn is determined by the acceleration voltage. The specific electron charge $\frac{e}{m}$ can thus be determined from the measurement quantities U, B and r according to the formula [1-9]:

$$evB = m\frac{v^2}{r}, \tag{1}$$

And in second, the kinetic energy is equal to the electric energy according to the following rule :

$$eU = \frac{mv^2}{2}. \tag{2}$$

From Eq.(1) and Eq.(2) we deduce the specific charge as :

$$\frac{e}{m} = \frac{v}{Br}, \tag{3}$$

$$\frac{e}{m} = \frac{v^2}{2U}. \tag{4}$$

C. Experience

For a better manipulate the experience see in picture (Fig.1), we will have to prepare the following material; - Fine beam tube,

FIG. 1: The specific charge captured from [2,4].

TABLE I: For the radius value $r = 4cm$

U(V)	100	150	200	250	300
I(A)					
e/m					

- Helmhotz coils,
- Multimeter,
- Safeaty connecting lead.

By using Fig.1 we reglue a tension U and we measure the correspondent current via a circular movement characterized by defined value of radius r :

1. For each radius we calculate the correspondent current;
2. We determine a theoretical expression of the specific charge $\frac{e}{m}$ by using the ampere theorem $\int \overrightarrow{B}.\overrightarrow{dl} = \mu_0 I$ we give $R = 20cm$ and $N = 154$.
3. Shows that $B = (\frac{4}{5})^{3/2}\mu_0 NI/R$

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[7] T.F. Gallagher Rydberg atoms 1994.
[8] Sobelman Atomic spectra 1996.

TABLE II: For the radius value $r = 5cm$

U(V)	100	150	200	250	300
I(A)					
e/m					

TABLE III: For the radius value $r = 2cm$

U(V)	100	150	200	250	300
I(A)					
e/m					

TABLE IV: For the radius value $r = 3cm$

U(V)	100	150	200	250	300
I(A)					
e/m					

[9] T. P. Sofetly atomic spectra Oxford University press 1994.

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MILIKAN EXPERIENCE AND CHARGE e

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 11, 2023)

Abstract: In this practical work we present a Milikan experiment which practically completes what we did in previous experiment of the determination of the specific charge e/m. So after having determined this ratio e/m and with the results of this experience (the study of the movement of the droplet of charge e) we deduce our primordial quantity called here mass m

Keywords: Milikan experiment; The specific charge.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. MILIKAN EXPERIENCE AND CHARGE E

Charged oil droplets subjected to an electric field and to gravity between the plates of a capacitor are accelerated by application of a voltage. The elementary charge is determined from the velocities in the direction of gravity and in the opposite direction.

A. Objective

The measuring accuracy for the charge q can be increased by causing the oil droplet under study to rise and fall over a given distance several times in succession and measuring the total rise and fall times.

So, based on the value of the electrical field, the viscosity and law of Stokes we determine the value of the electron charge e.

B. Formalism

We study the movement of a charged oil droplet subjected to an electric field. Let r be the radius of the droplet, m its mass, q its charge, v its speed of fall, U is the voltage d is the distance between the armatures Four the forces acting on the droplet are :

$$F_1 = \frac{4}{3}\pi r^3 \rho g, \tag{1}$$

Where $\frac{4}{3}\pi r^3 \rho = m$ is the mass m. g the gravity acceleration.

$$F_2 = \frac{4}{3}\pi r^3 \rho' g, \tag{2}$$

Where $\frac{4}{3}\pi r^3 \rho' = m'$ is the mass m'. g the gravity acceleration.

$$F_3 = 6\pi r \eta v, \tag{3}$$

is the force given by Stokes.

$$F_4 = qE. \tag{4}$$

is the electric force.

The sum of the forces disappears if the electric field E is parallel to the gravity acceleration g. So to proceed we consider a electric filed no parallel to g the equation of movement of the droplet is therefore [1-9]:

$$m\frac{dv}{dt} = \frac{4}{3}\pi r^3(\rho - \rho')g - qE - 6\pi r \eta v, \tag{5}$$

TABLE I: Measure of the different droplets in order to determine the charge e are the descent and ascent times.

U	150	300	400	500
r($10^{-7}m$)				
e ($10^{-19}As$)				

where its solution can be written as:

$$v = \frac{\frac{4}{3}\pi r^3(\rho - \rho')g - qE}{6\pi r\eta}(1 - e^{-\frac{6\pi r\eta}{m}}). \tag{6}$$

with the unknowns are q and r and we proceed to measure v and E as: In first step, we take $E = 0$ and we measure v of the free fall of the droplet in the area according to the following equation:

$$v = \frac{\frac{4}{3}\pi r^3(\rho - \rho')g}{6\pi r\eta}. \tag{7}$$

In second, we take now $v = 0$, we immobilize the droplet by the action of calculable electrical field E according to the new equation :

$$\frac{4}{3}\pi r^3(\rho - \rho')g = qE. \tag{8}$$

this allows us to calculate r.

We write the force F of a ball of radius r and velocity v is affected in a viscous medium of viscosity η as:

In region where the electrical field is present $E = U/d$ (U is the tension and d is the distance which separate the plaque)the ball is considered as a particle of mass m, charge ne and density ρ).

C. Experience

For a better manipulate the experience see in picture we will have to prepare the following material;

-Millikan apparatus; M

Power supply,

- Multi-range meter w.overl.prot.

-Polarity Switch for Millikan Apparatus

-Tripod base PHYWE -Stop watch, interruption type 0

Stand tube

The drop is placed on the edge of the electric field E and brought to the center by rotating the instrument of measure. Note that the tension allows the drop to be perfectly immobilized. We cut the voltage U and we simultaneously measure the descent time for the determination of the velocity v and consequently we deduce the charge e.

1. Complete the following table.
2. Plot v in Eq.(7) as function t.
3. What conclusion you deduce?.

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FIG. 1: The Milikan experience instrument captured from [2,4].

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FRANCK-HERTZ EXPERIENCE WITH Hg-TUBE

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 13, 2023)

Abstract: In 1914, J.Franck and G.Hertz reported observing discontinuous energy emission when electrons passed through mercury vapor, and the resulting emission of ultraviolet spectra line ($\lambda = 254nm$) of mercury. This experience gave Bohr a point of support to express his famous semi-empirical law and consequently the relations of emission and absorption during the electronic transition between two different energy levels.

Keywords: Planck rule; A.Einstein rule; corpuscular nature of the light.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. FRANCK-HERTZ EXPERIENCE

A. Objective

Determination of the successive potential affected by the electron.

B. Formalim

for a tension U_A between the cathode and the anode we have:

$$U_A = U + (\phi_{anode} - \phi_{cathode}), \tag{1}$$

Where ϕ_{anode} and $\phi_{cathode}$ are the output tensions. The production of a tension U_A increasing with time t is achieved with the auxiliary device actuated by a constant tension source of $U_0 = 50V$

$$U_A(t=0) = \frac{U_0 R_2}{R_1 + R_2} = \frac{50.100}{10.1k\Omega} = 0.50V, \tag{2}$$

And when we time increase the U_A take the following expression [1-9]:

$$U_A(t) = U_0(1 - e^{-\frac{t}{R_1 \cdot C}}). \tag{3}$$

C. Experience

For a better manipulate the experience see in picture (Figs. 1-2) we will have to prepare the following material;
- Hg Franck-Hertz tube,
- Temperature probe,
- Digital storage oscilloscope,
- Safeaty connecting lead.

The Franck-Hertz tube is at approximately $210C$, the thermometer being placed to measure this temperature T. After about 15 to 30 minutes the quantity of mercury evaporated is sufficient and the system becomes operational.

1. Plot U_A as function as time t.
2. What conclusion you deduce of a difference between the successive tension?.

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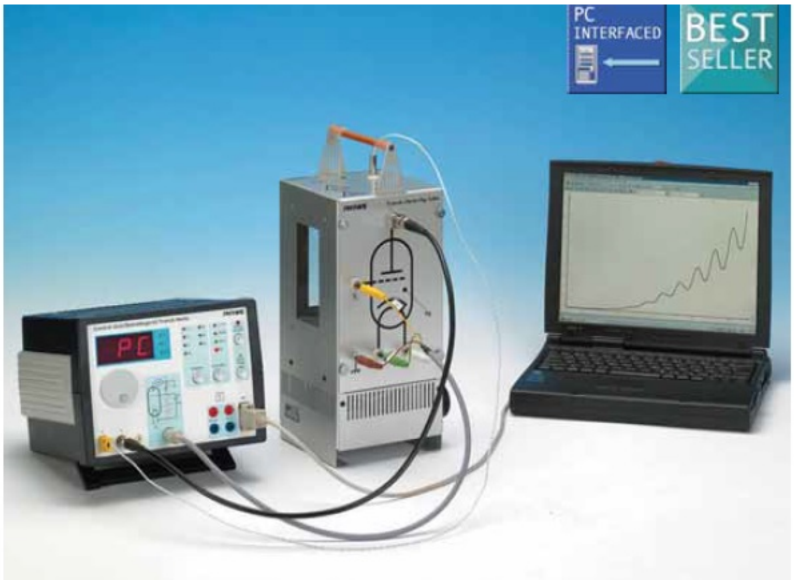

FIG. 1: The Franck-Hertz experience captured from [2,4].

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Abstract: In 1914, J.Franck and G.Hertz reported observing discontinuous energy emission when electrons passed through Neon vapor, and the resulting emission of ultraviolet spectra line ($\lambda = 254nm$) of mercury. This experience gave Bohr a point of support to express his famous semi-empirical law and consequently the relations of emission and absorption during the electronic transition between two different energy levels.

Keywords: Planck rule; A.Einstein rule; corpuscular nature of the light.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. FRANCK-HERTZ EXPERIENCE

A. Objective

Determination of the successive potential affected by the electron.

B. Formalim

for a tension U_A between the cathode and the anode we have:

$$U_A = U + (\phi_{anode} - \phi_{cathode}), \tag{1}$$

Where ϕ_{anode} and $\phi_{cathode}$ are the output tensions. The production of a tension U_A increasing with time t is achieved with the auxiliary device actuated by a constant tension source of $U_0 = 50V$

$$U_A(t=0) = \frac{U_0 R_2}{R_1 + R_2} = \frac{50.100}{10.1k\Omega} = 0.50V, \tag{2}$$

And when we time increase the U_A take the following expression [1-9]:

$$U_A(t) = U_0(1 - e^{-\frac{t}{R_1 \cdot C}}). \tag{3}$$

C. Experience

For a better manipulate the experience see in picture (Figs. 1-2) we will have to prepare the following material;
- Hg Franck-Hertz tube,
- Temperature probe,
- Digital storage oscilloscope,
- Safeaty connecting lead.

The Franck-Hertz tube is at approximately $210C$, the thermometer being placed to measure this temperature T. After about 15 to 30 minutes the quantity of neon evaporated is sufficient and the system becomes operational.
1. Plot U_A as function as time t.
2. What conclusion you deduce of a difference between the successive tension?.

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[1] Atomic Physics by Max Born London 1935.

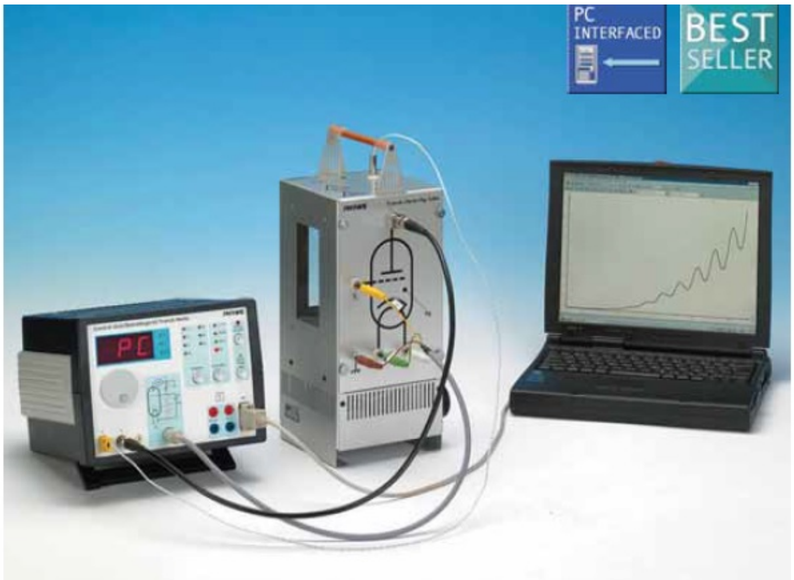

FIG. 1: The Franck-Hertz experience captured from [2,4].

FIG. 2: The Franck-Hertz instrument captured from [2,4].

[2] Phywe systeme GmbH Robert-Bosh-Breite 10 D-37079 Gottingen Germany.
[3] Abragam, E. Bleaney Electron paramagnetic resonnance of transitions ions Oxford Univ. Press London and New York 1970.
[4] leybod standard book.
[5] Cohen Tannaudji and *al.* Atom-photons interaction New York Wiley 1992.
[6] R. D. Coway The theory of atomic structure, Berkely 1981.
[7] T.F. Gallagher Rydberg atoms 1994.
[8] Sobelman Atomic spectra 1996.
[9] T. P. Sofetly atomic spectra Oxford University press 1994.

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DETERMINATION OF THE PLANCK CONSTANT

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 11, 2023)

Abstract: In this practical work, we present the procedure for calculating a fundamental constant called h (discovered by the best physicist Planck) and the starting of the new mechanics called here quantum mechanics. This constant is linked to the frequency to inform us that although light is undulatory, it also has a corpuscular aspect.

Keywords: Planck constant h; Corpuscular nature of the light.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. DETERMINATION OF THE PLANCK CONSTANT

A. Objective

Based of the fundamental Bragg relation $2dsin\theta = n\lambda$ (d is the spacing of lattice planes, θ is the angular aperture of diffraction), we determine the Planck constant value. Our objective is to measure this constant.

B. Formalism

Max Planck in 1900 has proposed that light with frequency ν is emitted in quantized lumps of energy that come in integral multiples of the quantity,

$$E = h\nu = \hbar\omega, \tag{1}$$

Albert Einstein stated that the quantization was in fact inherent to the light, and that the lumps can be interpreted as particles, which we now call photons. This proposal was a result of his work on the photoelectric effect, which deals with the absorption of light and the emission of elections from a material. So, Planck relation becomes [1]:

$$P = \frac{E}{c} = \hbar k, \tag{2}$$

C. Experience

The experiment is carried out according to the diagrams see in picture ,the anode voltage is determined directly from the millimeter. The LiF crystal is placed inside the refractometry. A GM counter measures the number of impulsions N/s. We adjust the voltage to $20Kv$ with ($10\mu m \equiv 1Kv$). We place the absorption on the path of the rays between the crystal and the GM counter

For a better manipulate the experience see in picture we will have to prepare the following material;

- GM counter,
- Refractometry,
- Multimeter,
- Safeaty connecting lead. - Cristal LiF.

By using Fig.1 we measure the number of impulsion by seconde *via* diffraction angle θ chosen. Based on the fundamental Bragg relation $2dsin\theta = n\lambda$ we complete the following table :

1. Plot $N = f(U)$;
2. By extrapolation we determine the critical tension U_{cri} which give zero number of impulsion number.
3. Plot $U_{cri} = f(\theta)$ and deduce the Planck constant.

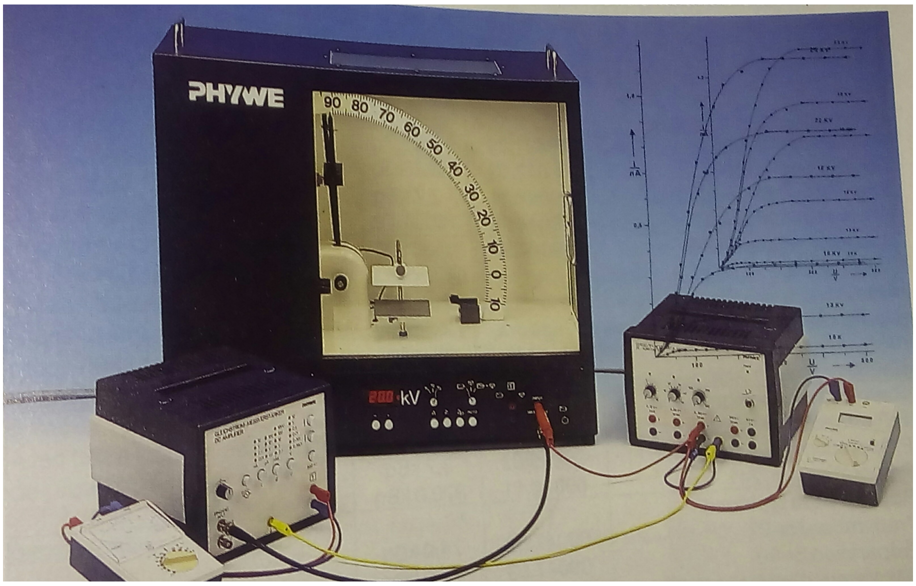

FIG. 1: The diffraction instrument captured from [2,4]

TABLE I: The impulsion number for each $\theta = 5°, 10°, 15°$.

Tension U(kV)	20	18	16	14	12	10
The impulsion number N(imp./s)						

4. Plot $N = f(\theta)$.

[1] Atomic Physics by Max Born London 1935.
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[4] leybod standard book.
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COMPTON EFFECT ENERGY-DISPERSIVE DIRECT MEASUREMENT

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 11, 2023)

Abstract: A. H. Compton investigated the scattering X-rays passing trough matter. According to the classical mechanic the frequency of radiation should not be changed by the scattering process. However A. H. Compton observed a frequency change for scattered X-rays. He interpreted it as model of scattering the X-ray photons by an electron of the material.

Keywords: A. H. Compton effect experiment; X- rays: The wave length of Compton.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. COMPTON EFFECT ENERGY-DISPERSIVE DIRECT MEASUREMENT

A. Objective

Based of the several measure of the wave length *via* the critical tension, we determine the Compton wave length.

B. Formalism

Arthur H. Compton in 1923 has given a justification for the photon nature of light came from its experiment conducted directed an x-ray beam of wavelength toward a block of graphite. He found that the scattered x-rays had a slightly longer wavelength than the incident x-rays, and hence the energies of the scattered rays were lower. The amount of energy reduction depended on the angle at which the x-rays were scattered. The change in wavelength between a scattered x-ray and an incident x-ray is called the Compton shift. Its given by :

$$\lambda = \frac{h}{mc}(1 - cos\theta). \tag{1}$$

where m is the mass of the electron and θ is the angle between the directions of the scattered and incident photons. So, assuming that the total energy E and momentum to be conserved, energy is transferred from photon to the electron. Then the energy E of the scattering photon depends on the angle θ following the process of equations:

$$E_0 + h\nu_0 = E_\theta + h\nu_\theta, \tag{2}$$

$$\overrightarrow{p} + \frac{\overrightarrow{h\nu_0}}{c} = \overrightarrow{p'} + \frac{\overrightarrow{h\nu_\theta}}{c}. \tag{3}$$

And according to the fameuse Einstein relation :

$$E^2 = p^2c^2 + m_0^2c^4, \tag{4}$$

With p is the momentum conjugate of electron, c is the celerity of light and m_0 is the mass of electron correspondent to zero velocity. We determine a fundamental expression of wave length of photon called also the Compton wave length $\lambda = \frac{\hbar}{m_0 c}$.

C. Experience

The experiment is carried out according to the diagrams see in picture ,the anode voltage is determined directly from the millimeter. The LiF crystal is placed inside the refractometry. A GM counter measures the number of impulsions N/s. We adjust the voltage to $20Kv$ with $(10\mu m \equiv 1Kv)$. We place the absorption on the path of the rays between the crystal and the GM counter.

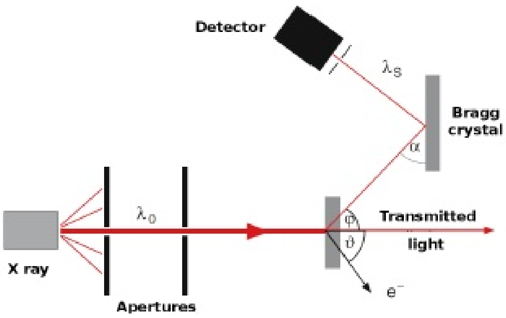

FIG. 1: The Compton effect process[1]

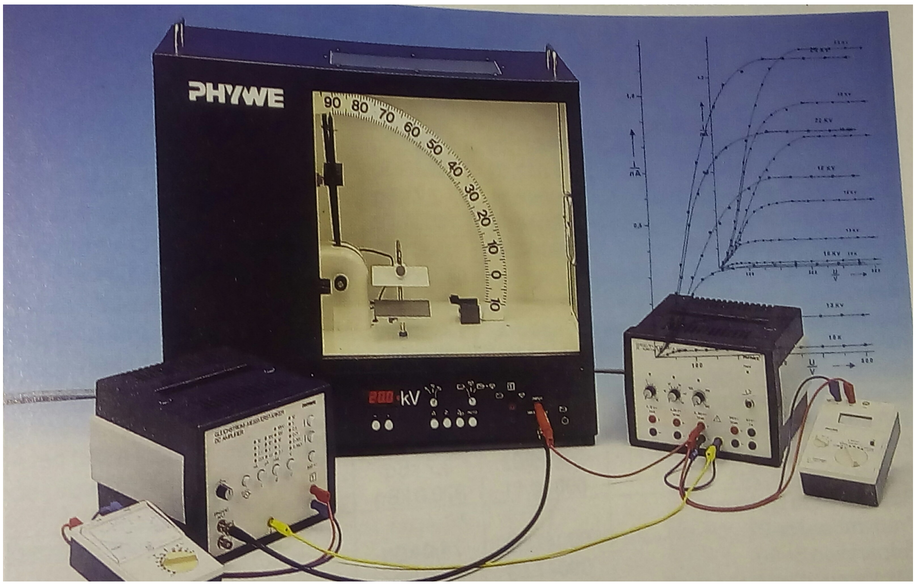

FIG. 2: The Compton effect instrument[2,4]

For a better manipulate the experience see in picture we will have to prepare the following material;
- GM counter,
- Refractometry,
- Multimeter,
- Safeaty connecting lead. - Cristal LiF.

By using Fig1 we measure the number of impulsion by seconde *via* different angle θ chosen and based on the fundamental Bragg relation $2dsin\theta = n\lambda$ complete the following table 1 :

1. Plot $N = f(U)$;
2. By extrapolation we determine the critical tension U_{cri} which vanished the impulsion number N.
3. Plot $N = f(\theta)$.

After determined this critical tension, complete the following second table II:

1. Plot $\lambda = f(1 - cos\theta)$;
2. Deduce the Compton wave length λ_c.

TABLE I: The impulsion number for each $\theta = 5°, 10°, 15°, 0°$.

Tension U(kV)	20	18	16	14	12	10
The impulsion number N(imp./s)						

TABLE II: The wave length Compton *via* $\theta = 5°, 10°, 15°$.

angle	5	10	15
(1-cosθ)			
λ			

4. Verify that the total energy E of the scattered photons at different angle θ) (θ) is the scattering angle) follows the fundamental relation :

$$E_\theta = \frac{E_0}{1 + \frac{E_0}{mc^2(1-cos\theta)}}. \tag{5}$$

we give $d_{LiF} = 12pm$.

[1] Atomic Physics by Max Born London 1935.
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[3] Abragam, E. Bleaney Electron paramagnetic resonnance of transitions ions Oxford Univ. Press London and New York 1970.
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[5] Cohen Tannaudji and *al.* Atom-photons interaction New York Wiley 1992.
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THE COMPTON EFFECT WITH MULTICHANNEL MEASUREMENT

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 11, 2023)

Abstract: A. H. Compton investigated the scattering X-rays passing trough matter. According to the classical mechanic the frequency of radiation should not be changed by the scattering process. However A. H. Compton observed a frequency change for scattered X-rays. He interpreted it as model of scattering the X-ray photons by an electron of the material.

Keywords: A. H. Compton effect experiment; X- rays: The wave length of Compton.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. THE COMPTON EFFECT WITH MULTICHANNEL MEASUREMENT

A. Objective

The energy of scattered gamma-radiation is measured as a function of the angle of scatter. The Compton wavelength is determined from the measured values.

B. Formalism

Arthur H. Compton in 1923 has given a justification for the photon nature of light came from its experiment conducted directed an x-ray beam of wavelength toward a block of graphite. He found that the scattered x-rays had a slightly longer wavelength than the incident x-rays, and hence the energies of the scattered rays were lower. The amount of energy reduction depended on the angle at which the x-rays were scattered. The change in wavelength between a scattered x-ray and an incident x-ray is called the Compton shift. Its given by :

$$\lambda = \frac{h}{mc}(1 - cos\theta). \tag{1}$$

where m is the mass of the electron and θ is the angle between the directions of the scattered and incident photons.

So, assuming that the total energy E and momentum to be conserved, energy is transferred from photon to the electron. Then the energy E of the scattering photon depends on the angle θ following the process of equations:

$$E_0 + h\nu_0 = E_\theta + h\nu_\theta, \tag{2}$$

$$\overrightarrow{p} + \frac{\overrightarrow{h\nu_0}}{c} = \overrightarrow{p'} + \frac{\overrightarrow{h\nu_\theta}}{c}. \tag{3}$$

And according to the famous Einstein relation :

$$E^2 = p^2c^2 + m_0^2c^4, \tag{4}$$

With p is the momentum conjugate of electron, c is the celerity of light and m_0 is the mass of electron correspondent to zero velocity. We determine a fundamental expression of wave length of photon called also the Compton wave length $\lambda = \frac{\hbar}{m_0 c}$.

C. Experience

This effect *via* the multichannel analyzer is used to analyze the voltage pulses which are truly proportional to the energy which helps us determine the pulse rate and intensities in conjunction with an x-ray detector, an alpha detector or gamma detector. The analog pulses from the detector are shaped by the analyzer, digitized and summed

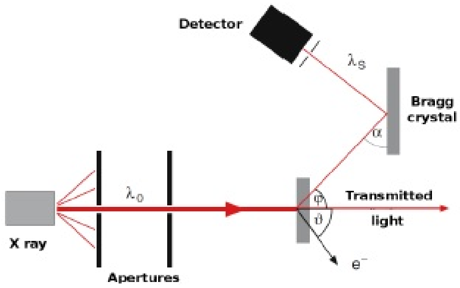

FIG. 1: The Compton effect *via* process[1]

FIG. 2: The Compton effect *via* multichannel instrument[2,4]

per channel based on pulse height. This results in a frequency distribution of pulses detected as a function of radiation energy.

For a better manipulate the experience see in picture we will have to prepare the following main articles :
- Gamma detector.
- Radioactive source Cs-137,
- Multi channel analyser.
-Screening cylinder for gamma detector
-Radioactive source Am-241,
-Operating unit for gamma detector

By using Fig1 we measure the number of impulsion by seconde *via* different angle θ chosen.

1. Calibrate the measuring set-up with the aid of a Cs-137 calibrating source and a Na-22 source.
2. Measure the energy of the Cs-137m 661.6 KeV peaks scattered at different angles and calculate the Compton wavelength from the readings taken.

TABLE I: The scattered gamma-radiation *via* $\theta = 5^\circ, 10^\circ, 15^\circ$.

angle	5	10	15
Ra			

1. Plot the scattered gamma-radiation as a function of the angle of scatter :$Ra = f(\theta)$
2. Deduce the Compton wave length λ_c.
4. Verify that the total energy E of the scattered photons at different angle θ) follows the fundamental relation :

$$E_\theta = \frac{E_0}{1 + \frac{E_0}{mc^2(1-cos\theta)}}. \tag{5}$$

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[9] T. P. Sofetly atomic spectra Oxford University press 1994.

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THE PHOTOELECTRIC EFFECT

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 11, 2023)

Abstract: In this practical work we describe the corpuscular nature of the light *via* the photoelectric effect. This experience which has explain by the best scientific A. Einstein. A. Einstein have used the Planck rule $E = h\nu$ and writing its rule $h\nu = h\nu_0 + T$ (where T is the kinetic energy of electron). Its explanation say that the electrons in metal absorb the energy of the light field in quanta. **Keywords**: Planck rule; A.Einstein rule; corpuscular nature of the light.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. THE PHOTOELECTRIC EFFECT

A. Objective

Based on the wave nature of light we deduce the Planck's constant which expresses the proportionality relationship between the energy and the frequency of a quantum of light. X-ray spectra are

B. Formalism

In 1905; A. Einstein proposed an explanation using the corpuscular concept of light based on Planck's idea where the exchange of light takes place by emission/absorption of light This explanation awarded him a Nobel Prize in 1912 and gave a starting point for a new mechanics called quantum mechanics.

So to proceed, we bombard a Tn filament with ultraviolet light connected to a circuit composed of an anode and a cathode, a variable resistance and an multimeter we notice a current which appears. Then the light will tear the electrons from the filament and will communicate to them a kinetic energy which will move them towards the anode and consequently the multimeter will indicate a current which passes relative to the following relation in first step [1-9]:

$$\frac{1}{2}mv^2 = h\nu - W, \tag{1}$$

where $W = h\nu_0$ is the work function from the cathode surface, v is the velocity and m is the mass electron.

In second step the electrons will thus only reach the anode as long as their energy in the electric field is equal to the kinetic energy :

$$eU = \frac{1}{2}mv^2, \tag{2}$$

With U is the voltage between anode cathode.

C. Experience

For best knowledge, the X-ray spectra are recorded as a function of the anode voltage. The short wavelength limit is used to determine Planck's "quantum of action". For a better manipulate the experience see in picture we will have to prepare the following material;

- Photoelectric apparatus,
- Voltage apparatus,
- Multimeter,
- Safeaty connecting lead.

In experience see Fig. an additional contact potential ϕ occurs because the surfaces the anode cathode are different:

$$eU + \phi = \frac{1}{2}mv^2, \tag{3}$$

FIG. 1: The photoelectric effect instrument captured from [2,4]

Now we assume that W and ϕ are independent on the frequency ν then a linear relationship appears between voltage U (to be measured) and the light frequency:

$$U = -\frac{(W + \phi)}{e} + \frac{h}{e}\nu. \tag{4}$$

1. Give for each frequency ν the corresponding voltage H and plot $U = f(\nu)$.
2. What is the nature of the curve?
3. Determine by the curve the corresponding values of ϕ and h.

[1] Atomic Physics by Max Born London 1935.
[2] Phywe systeme GmbH Robert-Bosh-Breite 10 D-37079 Gottingen Germany.
[3] Abragam, E. Bleaney Electron paramagnetic resonnance of transitions ions Oxford Univ. Press London and New York 1970.
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DETERMINATION OF THE RYDBERG CONSTANT Ry

S. Kouidri[1]

[1] *Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 11, 2023)

Abstract: A few month of the discovered of Franck-Hertz results, Niels Bohr recognized that their experiment supported his model of the hydrogen atom. He invents his famous semi-empirical formula $\int pds = n\hbar(p$ is conjugate momentum, s is the path). He say that when the electron passes between two different energy levels it emits or absorbs a photon $h\nu$ and spectrum of atoms which present it signature.

Keywords: Semi-empirical rule of N.Bohr: The Rydberg constant.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. DETERMINATION OF THE RYDBERG CONSTANT Ry

A. Objective

Based on the fundamental relation of the frequency between the level 1 and level 2 we determine the Rydberg constant R_y.

B. Formalism

The origins of atomic physics are linked to the development of quantum mechanics, a mechanic that has upset all of physics since the first model of hydrogen Bohr atom to the discoveries of spin via the magnetic resonance.This Works of Atomic Physics reviews some of the early ideas, including Einstein's treatment of the interaction of atoms with radiation and the treatment described by P. Zeeman *via* the splitting of energy band. These treatments, developed before the advent of Schrodinger's equation, remain useful as an intuitive way to think about atomic structure and transitions between energy levels but not complete via the absence the description in terms of atomic wave functions. ”

Although the spectrum of light emitted by an element like sodium produces a characteristic yellow light. This crude form of spectroscopy, in which color is seen with the naked eye *via* the use of a prism to scatter light shows that the characteristic spectrum of atoms is composed of discrete lines which are the fingerprint of the element. In 1888, the Swedish professor J. Rydberg discovered that the spectrum [1-9];

$$\nu_{12} = R_y(\frac{1}{n_2^2} - \frac{1}{n_1^2}), \tag{1}$$

where n and n are whole numbers; R is a constant that has become known as the Rydberg constant. Based of the fundamental Bragg relation $ksin\theta = n\lambda$, we determine the wave length of the Hg lamp. Our objective is to measure the different wave length of mercury.

So, based on the fundamental relation of the frequency between the level 1 and level 2 *via* the Rydberg constant which is writing as:

$$\nu_{12} = R_y(\frac{1}{n_2^2} - \frac{1}{n_1^2}) = \frac{c}{\lambda_{12}}, \tag{2}$$

and using the value of the grating constant $k = 10^{-6}$ we calculate the wave length λ of the color observed and consequently we deduce the frequency ν correspondent.

$$\lambda = ksin\theta = k\frac{l}{\sqrt{l^2 + d^2}}.$$

(3)

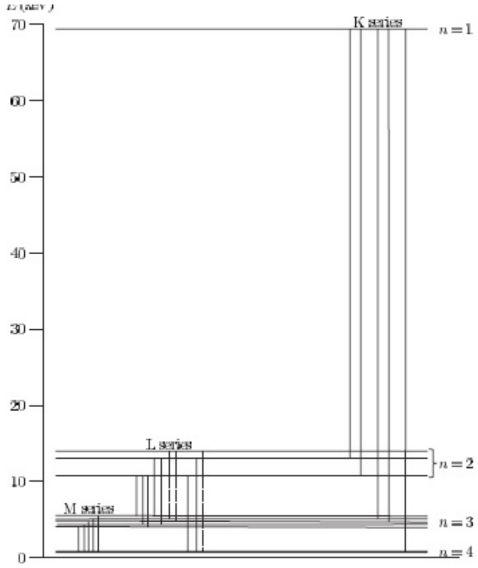

FIG. 1: The selection rule of spectra lines captured from [1].

FIG. 2: The spectra lines captured from [2,4].

C. Experience

For a better manipulate the experience see in picture we will have to prepare the following material;
- Spectral lamp of Hg,
- High voltage supply unit,
-Object holder,
-Spectrum tube, hydrogen
- Spectrum tube, mercury
-Diffraction grating,
-Tripod base PHYWE 1 Insulating support
- Safeaty connecting lead.
1. For each color determine the possible transition;
2. Based on the fundamental relation $\nu_{12} = R_y(\frac{1}{n_2^2} - \frac{1}{n_1^2})$ deduce the value of the Rydberg constant.

TABLE I: The value of the wave length for different color.

color	blue	green	red	yellow
$\lambda(nm)$				

3. By taking the relativistic effect : $E = \gamma mc^2$ with $\gamma = \frac{1}{\sqrt{(1-\frac{v^2}{c^2})}}$, $\Delta E = (\gamma - 1)mc^2$ show that $\frac{\Delta E}{E} \simeq \frac{v^2}{c^2}$.

4. Shows that $\frac{\Delta E}{E}$ can also be written as function as fine factor structure $\alpha = \frac{1}{137}$.

5. Determination of the visible lines of the Balmer series in the H spectrum, of Rydberg's constant and of the energy levels.

[1] Atomic Physics by Max Born London 1935.
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THE TWO ELECTRON SYSTEM HELIUM ATOM

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 11, 2023)

Abstract: In this practical work we present the experience of the spectrum of the Helium atom, an atom which contains 2 electrons and we want to verify the Bohr model by comparing it with the formula of quantum mechanics. We compare our results found by experiment with quantum mechanics calculations where we consider the repulsive term in hamiltonian of Helium as small perturbation.

Keywords: Bohr model; Quantum mechanics; repulsive term.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. THE TWO ELECTRON SYSTEM HELIUM ATOM

A. Objective

Based on the wave length λ of each color we determine by what levels transition is possible?. We determine the corresponding energy and we comare it with the energy calculated by the quantum mechanic.

B. Formalism

A light ray of wavelength λ passes through a prism it will be deflected. The angle of deviation θ depends on the geometry of the prism as well as the angle of incidence. The refractive index n of a prism depends on the wavelength λ and the angle of deviation θ. The activation of atoms is caused by the collision of electrons. The energy difference during the return of electrons from the activated level to the initial level is emitted in the form of a photon of frequency $\nu = \frac{c}{\lambda}$ [1-9].

$$E_F - E_I = h\nu, \tag{1}$$

With $h = 6.62.10^{-34} J.s$ is Planck constant. The hamiltonian of system of two electron of Helium atom is :

$$H = -\frac{\hbar^2}{2m}\Delta_1 - -\frac{\hbar^2}{2m}\Delta_2 - \frac{2e^2}{r_1} - \frac{2e^2}{r_2} + \frac{e^2}{|r_1 - r_2|}, \tag{2}$$

where we have supposed that $4\pi\epsilon_0 \equiv 1$.

Sine $\frac{e^2}{|r_1-r_2|} \ll 1$ we trait a system in perturbation theory.

The total energy of system in one order is :

$$E = E^0_{l,m} + \langle\varphi_{n,l,m}|\frac{e^2}{|r_1 - r_2|}|\varphi_{n,l,m}\rangle. \tag{3}$$

where $\varphi_{n,l,m}$ are the wave function solution of the no perturbed Hamiltonian.

In our case the orbital kinetic moment of the single electron l is equal to the total kinetic moment of rotation resulting from the two electrons since we consider that the activations of a single atom and that the second electron remains in the initial state (l=0). By using selection rule of the total orbital kinetic moment $\Delta J = 0, \pm 1$:

Now, according to the results of the previous experiment where our formulas are:

$$\nu_{12} = R_y(\frac{1}{n_2^2} - \frac{1}{n_1^2}), \tag{4}$$

where n_1 and n_2 are whole numbers; R_y is a Rydberg constant.

So to proceed, we use the fundamental Bragg relation $ksin\theta = n\lambda$ for determining the wave length of the He lamp.

FIG. 1: The spectra lines captured from [2,4].

TABLE I: The $H_{espectra}$.

color	blue	green	red	yellow
$\lambda(nm)$	438.8	504.8	706.5	587.6
Transition				
relative intensity				

And by using the Bohr model the fundamental relation of the frequency between the level 1 and level 2 *via* the Rydberg constant is :

$$\nu_{12} = R_y(\frac{1}{n_2^2} - \frac{1}{n_1^2}) = \frac{c}{\lambda_{12}}, \tag{5}$$

and using the value of the grating constant $k = 10^{-6}$ we calculate the wave length λ of the color observed and consequently we deduce the frequency ν correspondent.

$$\lambda = ksin\theta = k\frac{l}{\sqrt{l^2 + d^2}}. \tag{6}$$

C. Experience

For a better manipulate the experience see in picture Fig. 1, we will have to prepare the following material; - Fine beam tube,
- Spectral lamp of He,
- Graduation regle,
- Prism
- Safeaty connecting lead.
1. Complete the following table.
2. How many red lines, yellow line and blue lines?. 3. What transition correspond the wave length?.
4. You compare your results found by experience to the results calculated by the quantum mechanic.

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MOSELY'S LAW

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 11, 2023)

Abstract: In order to measure the transmission coefficient of X-rays when it penetrates a material of thickness x. Mosely used the diffraction system where he uses a material of thickness x to measure it and study their evolution *via* its charge Z. In this practical work we will study the behavior of the scattered rays when he pass through the material via its charge Z.

Keywords: X-rays; Mosely rule; Transmission coeficient.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. MOSELY'S LAW

A. Objective

Measurement of the transmission of a monochromatic X-ray beam through Al plates as a function of the absorber thickness and the determination of the absorption coefficient.

B. Formalism

H. G. J. Moseley measured the X-ray spectra of many elements.He established that the square root of the frequency ν of the emitted lines is proportional to the atomic number Z (that he defined as the position of the atom in the periodic table, starting counting at Z = 1 for hydrogen), i.e.[3]:

$$\sqrt{\nu} \propto Z, \tag{1}$$

Where its experimental variation is showed in Fig.2. For best knowledge of the Mosely law, we stars by the the Bohr formula:

$$\nu = R_\infty(\frac{1}{n^2} - \frac{1}{n'^2}), \tag{2}$$

with $hcR_\infty = \frac{(e^2/4\pi\varepsilon_0)^2 m_e}{2\hbar^2}$ is the Rydberg constant, the factor hc is conversion coefficient between energy and wave number (generally the Rydberg constant value is given in cm^{-1}). To explain the experimental curve of Mosely we need to replace $(e^2/4\pi\varepsilon_0)$ in the Borh formula by $((Z-\sigma)^2 e^2/4\pi\varepsilon_0)$ where σ is the screen effect. Then the Eq.() take the following form and precise the transition form K to L shell:

$$\nu = R_\infty(\frac{(Z-\sigma_K)^2}{n^2} - \frac{(Z-\sigma_L)^2}{n'^2}). \tag{3}$$

We consider an electron beam having an energy E interact with an anode of a specific material.A part of its kinetic energy eU (U is the applicant tension) is released in the form of radiation. It ionize target atoms by removing electrons from the K state, we obtain the K_α, K_β lines. So, by using the Bragg relation :

$$2dsin\theta = n\lambda, \tag{4}$$

where d is the distance between (hkl) plane of crystal LiF. The decrease of the radiation intensity dI in the absorber thickness x is expressed by the following relation:

$$dI = -\mu I dx, \tag{5}$$

gives

$$I = I_0 e^{-\mu x}. \tag{6}$$

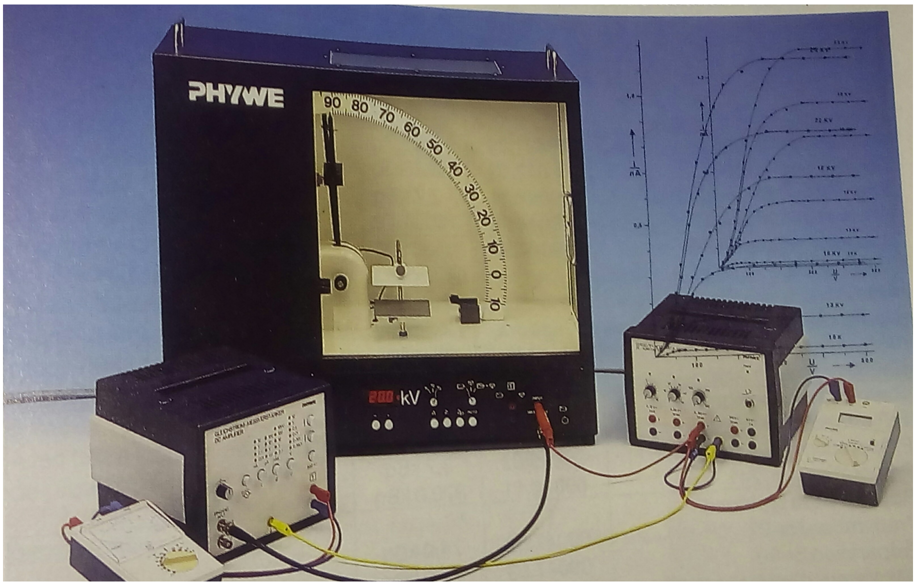

FIG. 1: Mosely instrument captured from [2,4]

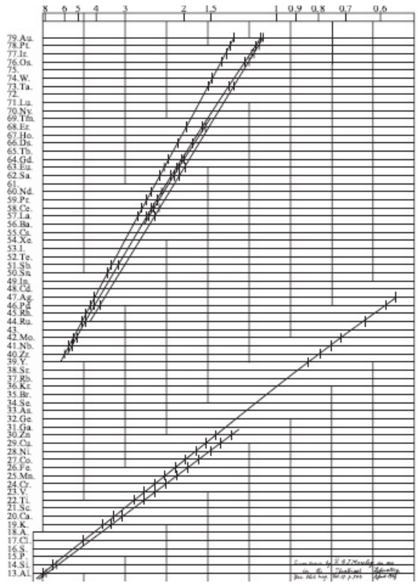

FIG. 2: Experience data of Mosely plot of square root of frequency as function as Z [5].

C. Experience

The experiment is carried out according to the diagrams see in picture ,the anode voltage is determined directly from the millimeter. The LiF crystal is placed inside the refractometry. A GM counter measures the number of impulsions N/s. We adjust the voltage to $20Kv$ with $(10\mu m \equiv 1Kv)$. We place the absorption on the path of the rays between the crystal and the GM counter where its thickness is $0.2mm - 0.3mm$.

For a better manipulate the experience see in picture (Fig.1) we will have to prepare the following material;

- GM counter,
- Refractometry,
- Multimeter,
- Safeaty connecting lead, - Cristal LiF, -Set of absorber. -

1. Plot the transmission coefficient I of radiation X as function of thickness x.
2. Plot the transmission coefficient I of radiation X as function of wave length λ.

3. Plot the square root of frequency as function as Z.
4. According to the Eq. (2) prove that $(\frac{E_n 8\hbar^2}{me^4})^{1/2} = Z - \sigma$.

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ELECTRON DIFFRACTION AND LOUIS-DE-BROGLIE RULE HESEINBERG PRINCPLE

S. Kouidri[1]

[1] *Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 11, 2023)

Abstract: A fast electrons are diffracted from a poly-crystalline layer of graphite: interference rings appear on a fluorescent screen. The inter-planar spacing in graphite is determined from the diameter of the rings and the accelerating voltage.

Keywords: Graphite; Wave length of electron and Louis de Broglie rule; Heisenberg principle

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. ELECTRON DIFFRACTION AND LOUIS DE BROGLIE RULE

A. Objective

This practical consist in first step to measure the diameter of the two smallest diffraction rings at different anode voltages. In second we calculate the wavelength of the electrons from the anode voltages and we determine the inter-planar spacing of graphite from the relationship between the radius of the diffraction rings and the wavelength.

B. Formalism

The discovery of the wave nature of electrons was made by Louis de Broglie during the debate between the best researchers on the exact nature of light: -There are among them who supported Maxwell and Young on their definition of wave nature of light. -and there are others who supported A. Einstein and Planck on their definition of corpuscular nature of light. In order to not divide this physics, Louis de Broglie and with his intelligence gave the right to two natures with his famous formula which allows us to connect the two natures by the following rule:

$$\lambda = \frac{h}{mv}. \tag{1}$$

when h is the Planck constant and mv is the conjugate momentum. This relationship gave Schrodinger a point of support to formulate its equation :

$$(\frac{2m}{\hbar^2}\Delta + (E - V))\varphi(r) = 0. \tag{2}$$

With E is the total energy of system and V is its interaction.

C. Experience

For a better manipulate the experience see in picture Fig.1, we will have to prepare the following material;

-Electron diffraction tube;

- High voltage supply unit;
- Power supply,
- High-value resistor,

-Connecting cord, 30 kV, 500 mm;

-Vernier caliper, plastic

1- Determine the diameter of the two smallest diffraction rings at different anode voltages U.

2- Calculate the wavelength of the electrons from the anode voltages.

3- Determine the inter-planar spacing of graphite from the relationship between the radius of the diffraction rings and the wavelength.

FIG. 1: The electron diffraction instrument captured from [2,4].

3- From the Louis De Borglie rule deduce the Heiseinberg rule $\Delta x.\Delta p \sim \hbar$.

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STERN-GERLASH EXPERIMENT

S. Kouidri[1]

[1] *Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 11, 2023)

Abstract: This experiment, first performed in 1922, has long been considered a quintessential experiment illustrating the fact that the electron has an intrinsic momentum spin. In this practical work we familiarize the student to use this quantity which subsequently reformulated all physics
Keywords: Stern-Gerlash experiment; Spin up; Spin down; Magnetic field.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. STERN-GERLASH EXPERIMENT

A. Objective

In this practical work we accelerate a beam of Potassium atom in a hot-walled along a specific trajectory in an area where a magnetic field is present. The interaction with this field will cause them splitting via two orientation called here : spin up and spin down.

B. Formalism

This angular momentum of spin has no analogue in classical mechanics, it is a purely quantum magnitude. This practical work presents the most beautiful in all of physics because it reveals to us a famous spin. So when the atoms passes via the zone where the magnetic field B is present they will be subjected to a force F relative to the following expression:

$$F_z = -\frac{\partial U}{\partial z}, \tag{1}$$

Where $U = -\mu.B = -\mu_z.B_z$ is the potential energy of the potassium atom in the magnetic field B. The dipole moment of electron is :

$$\mu_s = -\frac{e}{2m} g.S, \tag{2}$$

With S is the spin momentum.

C. Experience

By measuring the beam density in a detection plane behind the magnetic field B, it is possible to draw conclusions about the direction of the magnetic field of the potassium atoms.

For a better manipulate the experience see in picture Fig. 1, we will have to prepare the following material;
- Stern-Gerlash apparatus,
- Matching transformer,
- Difital storage oscilloscope,
- Safeaty connecting lead.
- Vacuum pumping station,
- Magnetic System, variable,
- Potassium lamp,

1. Determine the distribution of the density of atoms of P in the absence of B.
2. Determine the distribution of the density of atoms of P in the presence of B.

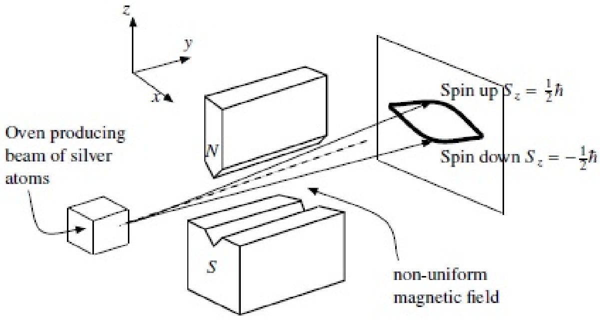

FIG. 1: The Stern-Gerlash apparatus captured from [1].

FIG. 2: The Stern-Gerlash apparatus captured from [2,4].

3. What conclusion can you draw?.

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NORMAL ZEEMAN EFECT

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 10, 2023)

Abstract: The Zeeman effect is the splitting of atomic energy in an external magnetic field B, as a consequence, the splitting of the transition between levels. The effect was predicted by H. A. Lorentz and confirmed experimentally by P. Zeeman. In the red spectral line of cadmium $\lambda_{red} = 643.8nm$ P. Zeeman observed a triplet perpendicular to the magnetic field and doubled parallel to the magnetic field.

Keywords: Zeeman effect; splitting spectral line; Magnetic field.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. NORMAL ZEEMAN EFFECT

A. Objective

Based of the several measure of the radius of the line spectral of the Cadmium atom, we determine the Bohr magneton factor μ_B.

B. Formalism

We will now discuss the comportment of the Hydrogen atom in an external magnetic field, so based on the semi classical model where the electron motion is described by a classical circular orbit. The effect that the electron move with the velocity v and the circular frequency $\nu = \frac{v}{2\pi r}$ an electric current occur $j = -ev$ which causes a magnetic moment

$$\mu = j.\pi r^2, \tag{1}$$

where πr^2 is the area belayed by the electron. By using the relation of the angular momentum $l = mvr$, we obtain a new relation between a magnetic moment and L:

$$\mu = -\frac{e}{2m}L \tag{2}$$

This later moment causes also the potential energy via the presence of an external magnetic field B as:

$$\mu = -\mu.B = \frac{e}{2m}L.B \tag{3}$$

For simplicity we take B into the z direction $B = (0, 0, B_z)$

$$\mu = -\mu.B = \frac{e}{2m}L_z.B_z \tag{4}$$

In this step and by using the quantum mechanic law we obtain:

$$\mu = -\mu.B = \frac{e}{2m}\hbar m_z.B_z \tag{5}$$

where m_z is called the magnetic quantum number, it take the values $-l \leq m_z \leq +l$ The constant factor $\frac{e}{2m}\hbar m_z$ is the Bohr magneton.

FIG. 1: The Zeeman effect instrument captured from [1,4].

C. Experience

Zeeman effect is the subdivision of the spectral lines of atoms within an external magnetic field. Then with the a cadmium lamp and under the effect of the magnetic flux which passes through it the red line of the Cd is subdivided. The measurement of the successive rays is done using the Fabry-Perot interferometer.

For a better manipulate the experience see in picture we will have to prepare the following material; - BNC cable 1m,

- Pair of Helmhotz coils,
- Difital storage oscilloscope,
- Safeaty connecting lead.
- Fabry-Perot interferometer,
- Magnetic System, variable,
- Cadmium lamp,
- Power supply for spectral lamps,
- Sliding device, horizontal,
- Optical profile-bench,

1. By using the telescope determine the radius of the red line.
2. By using the current intensity deduce the value of the magnetic field B_z.
3. Using the Fabry-Pt interferometer and a telescope measure the division of the central line into different lines in wave number as a function of magnetic field flux density.
2. Based on the results of 3, evaluate the Bohr magneton.
3. Study theoretically the light emitted in the direction of the magnetic field.

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ELECTRONIC SPIN RESONANCE

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*
(Dated: November 11, 2023)

Abstract: In this practical work and based on the laws of quantum mechanics and more particularly the spin of the electron we will try to calculate the magnetic field which comes for a resonance with the spin of the electron. Based on the formulas of quantum mechanics, the $S.B$ interaction is expressed *via* a famous factor called here the Landctor g.
Keywords: Spin electron; splitting energy; Magnetic field.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

A. Objective

Determination of the intensity of the magnetic field as a function of the current after resonance and consequently the measure of the Lande factor g.

B. Formalism

To begin this practical work you will need to have some knowledge of the following title: 1- Zeeman effect : which is the splitting up of the spectral lines of atoms within a magnetic field. 2- Energy quantum : corpuscular nature of the light. 3- Quantum number : from him we deduce m and l 4- Resonance : they have the same phase 5- g-factor

The hamiltonian of electron in electromagnetic field is:

$$H = -\frac{(P - (-eA)/c)^2}{2m} + \mu_B S.B), \tag{1}$$

where $\mu_B = \frac{e\hbar}{2mc}$ is the Bohr magneton, A is the vector potential relied to magnetic field by $B = rot(A)$. the eigen-value of H are $E = E_0 + \mu_B 2Sz.Bz$ for thus case. In general case where we take into account in first the spin momentum of electron the total kinetic momentum $J = L + S$ and in second the spin orbit interaction $S.L$, the eigen value of hamiltonian are here:

$$H = E_0 + \mu_B g m j_z.B_z, \tag{2}$$

with $g = 1 + \frac{j(j+1)+s(s+1)-l(l+1)}{2j(j+1)}$ is Lande factor.$mjz = +j, j-1, ..., -j$ we suppose that the system verified the absorption condition $\mu_B g(\Delta m_{jz}).Bz = \Delta E = h\nu$ noted here that $\Delta mjz = \pm 1$ satisfied the rule selection.

C. Experience

The experience of electronic spin resonance (see in picture Fig.1) verifies electron spin resonance in (DPPH : diphenylpicrylhydrazyl). (DPPH) is the radical in which a free electron is present in nitrogen atom. The magnetic field B which fulfills the resonance condition the resonance frequencies ν can be set in a continuous range from 13 to 130 MHz where its aim is to determine g [1-9].

For a better manipulate the experience see in picture Fig.1, we will have to prepare the following material;

- BNC cable 1m,
- Pair of Helmhotz coils,
- Difital storage oscilloscope,
- Safeaty connecting lead. -diphenylpicrylhydrazyl (DPPH) radical.
-ESR apparatus.

1. We take Helmotz coils with number of spire is 250 and radius R=0.054m calculate B.
2. Determine the g-factor (Landactor) of the DPPH (Diphenylpicrylhydrazyl) specimen.

FIG. 1: The Electronic spin resonance instrument captured from [2,4].

3. Determine the FWHM (Full Width at Half Maximum) of the absorption line.

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HALF-LIFE AND RADIOACTIVE EQUILIBRUM

S. Kouidri[1]

[1]*Department of Physics, University of Saida, 20000 Saida, Algeria*

(Dated: November 11, 2023)

Abstract: In this practical work we begin to the nuclear physics part, a discipline which consists of studying the disintegration of nuclei according to several processes. We familiarize students to better calculate the half-life of certain nuclei and verify the theoretical law.

Keywords: Nuclear physics; Half-life.

PACS numbers: 21.10.Pc,21.60.-n,21.60.Jz

I. HALF-LIFE AND RADIOACTIVE EQUILIBRUM

A. Objective

Based on the period of the product $Ba - 137$ extracted by washing and from a Cs isotope generator we measure the radioactive activity A.

B. Formalism

The Cesium $Cs - 137$ disintegrates via β giving the barium $Ba - 137$. Then we have a series of disintegration according to the following process :

$$N_1 \rightarrow byelectron\beta(-1)^{\lambda_1} N_2 \rightarrow byphoton\gamma(0)^{\lambda_2} N_3, \tag{1}$$

where N_1, N_2, N_3 are the nucleus of Cs, Ba, Ba and λ_1, λ_2 are the disintegrations constants. We have our equations as:

$$\frac{dN_1}{dt} = -\lambda_1 N_1, \tag{2}$$

and

$$\frac{dN_2}{dt} = -\lambda_1 N_1 - \lambda_2 N_2 \tag{3}$$

By using the initial condition we obtain the following expressions :

$$N_2(t) = N_1(0)\frac{\lambda_1}{(\lambda_2 - \lambda_1)}(e^{-\lambda_1 t} - e^{-\lambda_2 t}). \tag{4}$$

C. Experience

The counting rate is recorded for constant activity A of the isotope generator (radioactive equilibrium) as a function of the voltage U of the counter tube. We measure the activity A of the isotope generator as a function of time t. For a better manipulate the experience see in picture we will have to prepare the following material;

- Generator of isotopes $Cs137/Ba137$,
- Voltage apparatus,
- Multimeter,
- Safeaty connecting lead.

1- Determine the constant activity A of the isotope generator (radioactive equilibrium) as a function of the voltage U.

FIG. 1: The radioactive instrument captured from [2,4]

2- Determine the activity A of the isotope generator as a function of time t.
3- Verify your results with theoretical law.

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Abstract

Basing on my teaching experience at the University of Saïda-ALGERIA, Faculty of Sciences and Department of Physics, we present in our practical work of atomic and nuclear physics certain experiments allowing us to understand atom and its constituents. Our work is based on the results given by Rutherford, Thomson, Franck Hertz; Bohr, Planck Compton A. Einstein; Louis de Broglie and Zeeman. With the new instruments of atomic and nuclear physics, we have established how to determine the fundamental constants **e/m, e; m, Ry; h, lamda?**

However, these practical works familiarize our students in license and master's for understanding all the practical available, including a restricted set of lectures notes, and having their theoretical formulas verified with the results found.