Mediterranean Journal of Basic and Applied Sciences (MJBAS)
Volume 6, Issue 3, Pages 01-34, July-September 2022

Mass & Quark Symmetry: Mass and Mass Cloud (The Yin Yang): Atom Binding Energy; Molecules Binding Energy; Binding energy between the nucleons in the nucleus; Particle Interaction Energy between particle and antiparticle; Quark Symmetry & Quark Confinement

Giovanni Alcocer

Independent Researcher, Guayaquil, Ecuador. Email: giov_alc_science@hotmail.com

Master in Physics with specialization in Astrophysics and Medical Physics, Professor of Physics, Advanced Mathematics and Science in general, Author of Recognized and Renowned Scientific Articles & Books, Inventor (Smart Glasses & Creator Football) New formulas and theory: Symmetry of Mass (Yin Yang) and Fundamentals of Mass: Gravitation, Electromagnetism, Atom, Cosmic Rays, Binary Stars, etc.

DOI: http://doi.org/10.46382/MJBAS.2022.6301

Article Received: 06 May 2022 Article Accepted: 24 July 2022 Article Published: 17 August 2022

ABSTRACT

The symmetry occurs in most of the phenomena explained by physics, for example, a particle has positive or negative charges, and the electric dipoles that have the charge (+q) and (-q) which are at a certain distance (d), north or south magnetic poles and for a magnetic bar or magnetic compass with two poles: North (N) and South (S) poles, spins up or down of the electron at the atom and for the nucleons in the nucleus In this form, the particle should also have mass symmetry. For convenience and due to later explanations, I call this mass symmetry or mass duality as follows: mass and mass cloud. The mass cloud is located in the respective orbitals given by the Schrödinger equation. The orbitals represent the possible locations or places of the particle which are determined probabilistically by the respective Schröndiger equation.

For example and for the proton, the positive charge is concentrated in its mass nucleus with an uncharged mass cloud around its nucleus distributed in the orbitals or mass clouds. For the electron, the negative charge is concentrated in its mass nucleus with an uncharged mass cloud around its nucleus distributed in the orbitals or mass clouds. Besides, in the formation of the hydrogen atom, a part of the mass cloud of the proton interacts with the mass cloud of the electron, and the total mass-energy lost in this interaction is transformed into electromagnetic energy according to Einstein's equation: $E=mc^2$ and the variant mass formula discovered and developed by myself: Giovanni Alcocer Variant Formulas. Therefore, the electron and proton are bound together in the hydrogen atom due to the electrostatic force between the two particles and the mass cloud of the electron and proton with some mass cloud lost in the interaction and converted to electromagnetic energy or photons. Then, it is right to assume this mass symmetry, since the electron and the proton in the interaction of the mass cloud lose mass but do not lose electric charge. In this form, it is justified the existence of a mass cloud.

Therefore, the main function of the mass cloud is the binding energy. The mass cloud interaction generates binding energy between the electrons and the nucleus in the atom through the protons and between the nucleons in the nucleus: protons with protons, neutrons with neutrons, and protons with neutrons. The nuclear force between two nucleons is characterized by being strong and short-range. Also, it can be justified by the existence of the mass cloud: the mass clouds of nucleons within the nucleus interact with each other without any effect on the proton charge.

In the same form and due to the quarks having mass and charge (and inclusive colors), the quarks have also the same mass symmetry: mass and mass cloud. Thus, the electrical charge is stored in the mass of the quarks and the mass cloud allows the confinement or the respective binding between quarks. Then, the following questions are explained and answered simply in this research article: why a particle does not exist with only one quark? why the quarks are confined to the nucleus? and which is the origin of the nuclear forces? On other hand, there are particles with two quarks (mesons), particles with three quarks (baryons) and then, it is very probable to find particles with more than three quarks (quaternions). This scientific research presents evidence of the existence of mass symmetry: mass and mass cloud and the interaction between the mass cloud of the particles (The Yin Yang Interaction) based on Einstein's equation and in the Variant Mass formula for the Electron in the atom discovered and demonstrated by myself where experimental results are detailed.

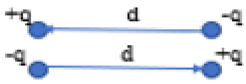
Keywords: *Mass symmetry, Mass Energy Einstein equation, Giovanni Alcocer Variant Mass fundament theory/formula, Hydrogen atom, Radial probability density, Schröndiger equation, Bohr model, Muonic atom, Ionized helium atom, Helium nucleus, Nucleons, Antiparticles, Proton antiproton, Muon antimuon, Neutral Pion and Neutral Antipion, Diatomic molecules, Hydrogen molecule* H_2*, Ionized hydrogen molecule* H_2^+*, Oxygen molecule* O_2*, Quark symmetry, Quark confinement, Origin of nuclear forces, The Yin Yang Interaction.*

1. Examples of Symmetries & Mass Symmetry Postulates

In this scientific article, the mass symmetry is researched, demonstrated, and explained with some known particles: electrons, protons, neutrons, pions, muons, nucleons, particle and antiparticles, atomic bonds, diatomic molecules, and quarks. In nature, the phenomena and interactions between particles follow a symmetrical pattern: positive charge and negative charge, the electric dipole which has two charges (+q) and (–q) which are at a certain distance (d), south and north poles of the magnetic field, a magnetic bar or magnetic compass with two poles: north (N) and south (S) poles, a magnetic field produced by a circular loop of carrier current (I), spins for electrons in the atom and nucleons in the nucleus which can be up or down, which are obvious examples of the existence of these symmetries in nature [7], [8], [9].

Electric Dipole:

Two Electric Dipoles:

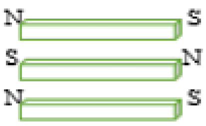


Three Electric Dipoles:

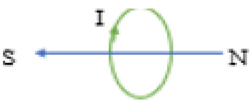
Magnetic bar (Magnetic Compass):

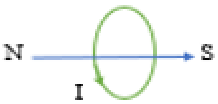
Two Magnetic bars:

Three Magnetic bars:



The magnetic field produced by an electric current:





Spins of the electrons at the atom or nucleons at the nucleus:

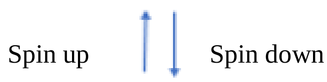


Fig.1. Electric Dipoles, Magnetic Bars, Magnetic field produced by an electric current, Spins of the electron at the atom or nucleons in the nucleus

Besides, an additional example of symmetry is that for each particle there is an antiparticle, such as for the proton particle (p), the antiparticle is ($\bar{p}$); and for the neutron (n), its antiparticle is ($\bar{n}$); and for (k^{o}), its antiparticle is ($\overline{k^{o}}$)

and so on. The difference between particle and antiparticle is that the particle is made up of quarks and the antiparticle is made up of antiquarks. Therefore, it seems justifiable the existence of mass symmetry [6].

The existence of mass symmetry established by the mass duality: mass and mass cloud is supported by two postulates:

(1) The value of the mass cloud of a particle is equal to the value of its mass. Thus, if "m" is denoted as the mass of a particle, the mass cloud m* of this same particle also has this mass. Then, m*=m for the same particle. In this form, the direction of the gravitational force for the mass and the mass cloud is the same because both masses are positives.

(2) The mass of a particle cannot interact with the mass cloud of the same particle, neither partially nor totally. However, the interaction occurs between the mass cloud of one particle and the mass cloud of another particle, either partially or totally.

In this mass symmetry, the charge of the particle is concentrated in its mass nucleus with an uncharged mass cloud around its nucleus. This mass cloud is located in the respective orbitals given by the Schrödinger equation where the orbitals represent the possible locations or places determined probabilistically by the respective Schröndiger equation. The existence of this mass symmetry is right because for example in the Hydrogen atom and in the electron transition from one shell to another shell, the electron and the proton lose mass in the interaction of the mass cloud (converted to photons or electromagnetic radiation) but do not lose electric charge. The interaction diagram for the binding of the two particles due to the mass symmetry (The Yin Yang) is as follows:

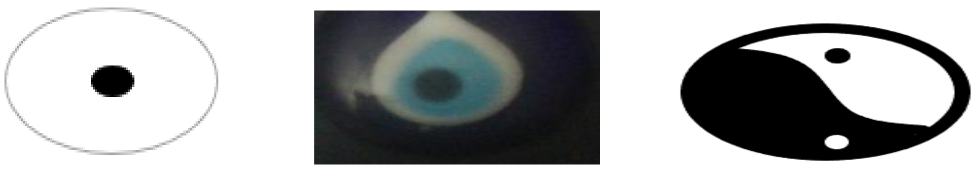


Fig.2. Particle with the mass symmetry (mass and mass cloud) and Interaction diagram between two particles where each particle is composed of mass (where it is deposited the charge) and mass cloud (which allows the binding of the particles!!): The Yin Yang

Then, the loss of mass cloud due to the interaction is converted into electromagnetic energy or photons based on Einstein's equation and the Giovanni Alcocer variant mass formula [1], [2], [3], [4], [5]. Thus, as a result of this interaction, electromagnetic radiation or photons will be emitted: $mc^2+m^*c^2 \rightarrow E_{\gamma} +E_{\gamma}$.

In this process, two or rarely three photons will be emitted. It is because two photons are needed at least to hold the conservation of momentum. The loss of mass cloud and converted into electromagnetic energy is given by the variant mass formula discovered and developed by myself in the article [1]: "The Fundament of the Mass: The Variant Mass of the Electron at the atom. Experimental results: Ionization energy of the electrons at the atom. Bound of the Diatomic Molecules. From Bohr to Schröndiger. Deduction of the radius formula with the analogy of the atom with the blackbody research from Planck and harmonic oscillators. Why do the electrons orbit around the nucleus with a specific radius for the case of the electron as a particle? Why the electron doesn´t radiate energy at the stationary levels as a wave and as a particle? Diffraction and Interference for the electron by using the Fourier Approach and Wave Properties".

Besides, the emission of electromagnetic radiation occurs for accelerated charged particles. Maxwell's theory showed that electromagnetic waves are radiated whenever charged particles accelerate [2],[10]. The electromagnetic radiation emitted is obtained with the formula of the variant mass of an accelerated charged particle developed by myself [2].

On other hand, there is an emission of gravitational energy for a particle orbiting a large object and for a binary star. The formula that describes the mass of a particle that emits gravitational energy is obtained and demonstrated by myself in the article [3]: The Fundament of the Mass and Effects of the Gravitation on a Particle and Light in the mass, time, distance, velocity, frequency, wavelength: Variant Mass for a Particle which emits Gravitational Energy for a particle orbiting a large Planet or Sun and for a Binary Star and Variant Frequency for the Light passing close a Gravitational Field from a Massive Object (Sun).

2. Hydrogen Atom

The Hydrogen atom consists of one proton and one electron. The value of the particle mass is equal to the value of its mass cloud as it was established in the first postulate. Thus, the sum of the mass and the mass cloud of the proton is 938.27 MeV/c^2 and the sum of the mass and the mass cloud of the electron is 0.511 MeV/c^2.

According to the Bohr model for the hydrogen atom [1], there are allowed orbits for the electron in which the angular momentum is $\frac{nh}{2\pi}$ where n is the principal quantum number: 1,2,3…. The theoretical results of the binding energy of the electron and the probabilistic distance r of the electron location are compatible with the Bohr model and spectroscopy experiments and with the solution of the Schrödinger equation in quantum mechanics which gives the maximum probability density versus r for the hydrogen atom [6]. According to the Bohr model and for the hydrogen atom and depending on the quantum number n, the velocity (v), energy (E) and radius (r) of the electron are [1]:

$$v = \frac{Ze^2}{2\varepsilon_o nh} \qquad E = \frac{-z^2e^4m_o}{8{\varepsilon_o}^2h^2n^2} \qquad E = \frac{-13.6z^2}{n^2}$$

$$r = \frac{n^2h^2\varepsilon_o}{\pi m_o Ze^2} \qquad a_o = \frac{\varepsilon_o h^2}{\pi m_o e^2} \qquad r = \frac{n^2 a_o}{Z}$$

Z: atomic number of the atom e: electron charge

ε_o: vacuum permittivity h: Planck constant m_o: electron rest mass

n: main quantum number, electron energy level, orbit of the electron

Values of constants:

Z=1 (Hydrogen atom) h=6.63*10^{-34} J-s ε_o=8.85*10^{-12} Farad/m π=3.1416 m_o=9.11*10^{-31} kg

e=1.602*10^{-19} C

r_o=a_o=0.529 $\dot{A}$ Bohr radius, radius for the first level of the Hydrogen atom

1 Ȧ= 10^{-10}m   1nm=10^{-9} m

For Z=1, it is obtained from the formula of E and r:

$$(E)(r)= \left(\frac{-z^2e^4m_o}{8{\varepsilon_o}^2h^2n^2}\right) \left(\frac{n^2h^2\varepsilon_o}{\pi m_o Ze^2}\right)$$

$$=\frac{-Ze^2}{8\pi\varepsilon_o} \quad Z=1$$

$$=\frac{-e^2}{8\pi\varepsilon_o}$$

(E)(r)=0.7194 eV-nm $E(eV) = \frac{0.7194}{r(nm)}$

For each quantum number n, the velocity (m/s), the radius (m), and the energy (eV) of the electron (ionization energy) in the respective shell or quantum level are [1]:

Table 1. Values of velocity (v: m/s), radius (r: m), electron ionization energy (E: eV) for each quantum number n

n	v (m/s)	r (m)	E=hf Ecinetica (ionization energy) (eV)
1	2186946.852	5.29636E-11	-13.61585307
2	1093473.426	2.118544E-10	-3.403963266
3	728982.2839	4.76672E-10	-1.512872563
4	546736.7129	8.47417E-10	-0.850990817
5	437389.3704	1.32409E-09	-0.544634123
6	364491.1420	1.90669E-09	-0.37828141
7	312420.9788	2.59522E-09	-0.277874552

The graph of E (eV) versus r (nm) is shown by using the formula: E(eV)=0.7194/r (nm), and data as in table (1):

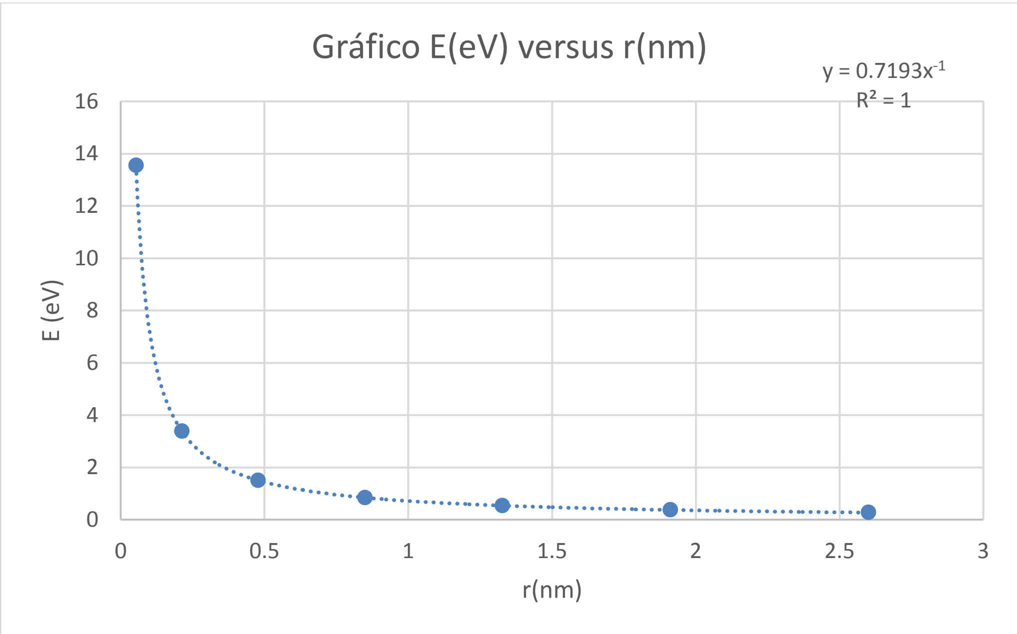


Fig.3. Energy Variation (eV) versus r(nm) for the different quantum levels n based on the Bohr model

This diagram is also obtained with data obtained through spectroscopy experiments performed on the hydrogen atom. The spectroscopy results are compatible with the Bohr model represented in the previous graph and the Schrödinger equation which gives the maximum value of the probability density of finding electrons as a function of r for the different shells or quantum levels of the hydrogen atom [6].

To test the development formula of the variant mass for the ionization emission energy of the electron for the Hydrogen atom, some calculations using Quantum Mechanics are done. Then, the mass results for both methods are compared [1].

First energy level Hydrogen atom: -13.6 eV n=1

Second energy level Hydrogen atom: -3.4 eV n=2

If the electron jumps from the second level to the first level, the energy emitted is (13.6 -3.4) eV=10.2 eV and the mass of the electron must lose this equivalent mass-energy. Thus, the lost mass of the electron which is equivalent to the mass-energy of the electromagnetic radiation emitted occurs during the transition from the second level to the first level. In mathematical formulation, it is as follows: $(m_o-m)c^2=hf=K$ where m_o is the electron mass before the transition and m is the electron mass after the transition, K is the kinetic energy of the electron and E=hf is the energy of the photon emitted (electromagnetic radiation) [1].

If the electron at the first level (n=1) (quantum level 1s) leaves the atom, it is necessary to add the energy of 13.6 eV. Also, it corresponds to the energy emission of the electron to bring the electron from the infinite to the first level. Therefore, the emission energy of the electron is: $hf= m_oc^2- mc^2=13.6$ eV where m_o is the electron mass before the transition and m is the electron mass after the transition [1].

It is in coincidence with the development formula for the emission energy of the electron at the atom: variant mass of the electron at the atom [1]. The mass electron calculation with the mass development formula is as follows:

$m = m_o e^{-\left(\frac{v^2}{2c^2}\right)}$ $m_o=511797.7528\ eV/c^2$

The velocity is given by this formula: $v = \frac{Ze^2}{2\varepsilon_o nh}$

It is interesting to mention that the velocity formula doesn't include the mass of the particle. Therefore, the orbits have specific values for the particle velocity independent of the mass of it. By replacing the values for Z (Z=1), e, ε_o, n (n=1), and h, it is obtained as:

v=2186946.852 m/s. By replacing this value with the mass formula, it is achieved: $mc^2=511784.1541$ eV

$m_oc^2=511797.7528$ eV (energy (eV): electron rest mass: $9.11*10^{-31}$ kg)

Then, it is obtained: $hf= m_oc^2- mc^2$

hf=511797.7528-511784.1541

hf=13.59 eV. It is the same value that the last calculation by using quantum mechanics for the energy emission of the electron.

It is possible to do the same for the second level of the Hydrogen atom. The ionizing energy for the electron at the second level is: -3.4 eV. Then, if the electron at the second level (n=2) leaves from the atom, it is necessary to add the energy of 3.4 eV. Also, it corresponds to the energy emission of the electron to bring the electron from the infinite to the second level. Therefore, the energy emission of the electron is: $hf= m_oc^2- mc^2=3.4$ eV where m_o is the electron mass before the transition and m is the electron mass after the transition [1].

It is in coincidence with the development formula for the energy emission of the electron at the atom: variant mass of the electron at the atom [1]. The mass electron calculation with the mass development formula is as follows:

$m = m_o e^{-(\frac{v^2}{2c^2})}$ $m_o=511797.7528$ eV/c^2

The velocity is given by this formula: $v = \frac{Ze^2}{2\varepsilon_o nh}$

By replacing the values for Z (Z=1), e, ε_o, n (n=2), and h, it is obtained as:

v=1093473.426m/s

By replacing this value with the mass formula, it is achieved:

$mc^2=511794.3531$ eV

$m_oc^2=511797.7528$ eV (energy (eV): electron rest mass: $9.11*10^{-31}$ kg)

Then, it is obtained: $hf= m_oc^2- mc^2$

hf=511797.7528-511794.3531

hf=3.39 eV. It is the same value that the last calculation by using quantum mechanics for the energy emission of the electron.

It is shown in the next table (2) the values of the velocities (m/s), radius (m), and energy of the ionization (eV) for the different levels of energy of the hydrogen atom. Also, it is showed the mass of the electron m (eV/c^2) after the emission of the electromagnetic radiation by using quantum mechanics ($mc^2=m_oc^2$-hf) and with the formula of the variant mass for the electron at the atom after the energy emission [1]: $mc^2 = m_oc^2e^{-(\frac{v^2}{2c^2})}$.

Table 2. Values of the velocities (v m/s), radius (r m), ionization energy (E eV), and mass of the electron m (eV/c^2) after the emission of the electromagnetic radiation, for the different quantum levels of energy (n) of the hydrogen atom

n	v	r	E=hf Ecinetica (ionization energy) (eV)	$mc^2 = m_oc^2 - hf$	$mc^2 = m_oc^2e^{-(\frac{v^2}{2c^2})}$
1	2186946.852	5.29636E-11	-13.61585307	511784.1370	511784.1541
2	1093473.426	2.118544E-10	-3.403963266	511794.3488	511794.3531
3	728982.2839	4.76672E-10	-1.512872563	511796.2399	511796.2418
4	546736.7129	8.47417E-10	-0.850990817	511796.9108	511796.9029
5	437389.3704	1.32409E-09	-0.544634123	511797.2082	511797.2089
6	364491.1420	1.90669E-09	-0.37828141	511797.3746	511797.3751
7	312420.9788	2.59522E-09	-0.277874552	511797.4749	511797.4753

The accuracy of the formula is demonstrated theoretically. Besides, table (2) shows that when the velocity decreases (at the different levels of energy of the Hydrogen atom) the mass increases because when the velocity decreases, the distance r of the electron increases, and there is less emission of electromagnetic energy for the electron to bind in the respective shell from the infinite or it is needed less emission of energy to eject the electron from the atom. Besides, levels that are closest to the nucleus (less distance r to the nucleus) have higher velocities than the farthest because it is needed more velocity and kinetic energy ($K = \frac{1}{2} mv^2 = m_o c^2 - mc^2 = hf$=energy of the photon emitted) so that the electron does not fall into the nucleus. Nevertheless, the potential energy ($V = -k\frac{e^2}{r}$) decreases (more negative) when the distance r decreases [1]. Then, it is necessary to add more energy to eject the electron from this shell since it is necessary to overcome greater potential energy (more negative).

V decreases (more negative) when r decreases. If we want to reduce the distance between the electron m and the nucleus M by doing a transition from one orbit to another orbit, the electron m must emit energy (emission as electromagnetic energy or photons) at this transition. The emission of this energy produces a decrease in the electrical potential energy (more negative) and thus, it is necessary to add more energy to eject the electron from this shell since it is necessary to overcome greater potential energy (more negative). It produces also an increase in the kinetic energy and the electron has more velocity [1].

V increases (less negative) when r increases. If we want to move the electron m from their respective orbit to another orbit increasing its distance from the nucleus, it is necessary to apply an external force or to give additional energy to the system. The work done by this force produces an increase in the electrical potential energy (less negative). Thus, it is necessary to add less energy to eject the electron from this shell since it is necessary to overcome lower potential energy. Part of the work done by this force or the additional energy given produces a decrease in the kinetic energy and the electron has less velocity. Nevertheless, the electron has restricted positions or radius to do the transitions from one orbit to another until it gets the stationary orbit with a stationary energy level. For this reason, the velocity of the respective shell doesn´t depend on the mass of the particle or the radius of the shell: $v = \frac{Ze^2}{2\varepsilon_o nh}$. Besides, in these stationary orbits or states, the electron doesn´t emit electromagnetic energy or photons. The electron only does the emission of electromagnetic energy or photons at the transition from one orbit to another [1].

3. Distribution of the mass cloud & radial probability density of the electron

It is necessary to examine the results of the solution of the Schrödinger equation to obtain the distribution of the mass cloud around the proton.

The radial probability density of the electron in the hydrogen atom is: $P(r) = r^2|R(r)|^2$.

The maximum probability occurs when the probability densities have spherical symmetry where $r_{max}=n^2a_o$ and for l=n-1. Therefore, there is a spherical distribution at n=1 l=0: $r_{max}=a_o$; n=2 l=1: $r_{max}=4a_o$; n=3 l=2 $r_{max}=9a_o$; n=4 l=3: $r_{max}=16a_o$. Besides, in addition to the states for which the probability densities have spherical symmetry, there are states whose probability density distribution is not spherical [6].

The radial wave function R(r) is shown below for some states:

$R(r) = \frac{2}{(a_o)^{3/2}} e^{-\frac{r}{a_o}}$ n=1 l=0 state 1s

$R(r) = \frac{2}{(2a_o)^{\frac{3}{2}}} (2 - \frac{r}{a_o}) e^{-\frac{r}{2a_o}}$ n=2 l=0 state 2s (no spherical distribution)

$R(r) = \frac{1}{\sqrt{3}\,(2a_o)^{3/2}} \frac{r}{a_o} e^{-\frac{r}{2a_o}}$ n=2 l=1 state 2p

$R(r) = \frac{4}{27\sqrt{10}\,(3a_o)^{3/2}} (\frac{r}{a_o})^2 e^{-\frac{r}{3a_o}}$ n=3 l=2 state 3d

$R(r) = \frac{1}{\sqrt{322560}\,(a_o)^{3/2}} (\frac{r}{2a_o})^3 e^{-\frac{r}{4a_o}}$ n=4 l=3 state 4f

The radial wave function R(r) versus (r/a_o) is shown in the next figure 4 for n=1 l=0 state 1s (r and a_o in A):

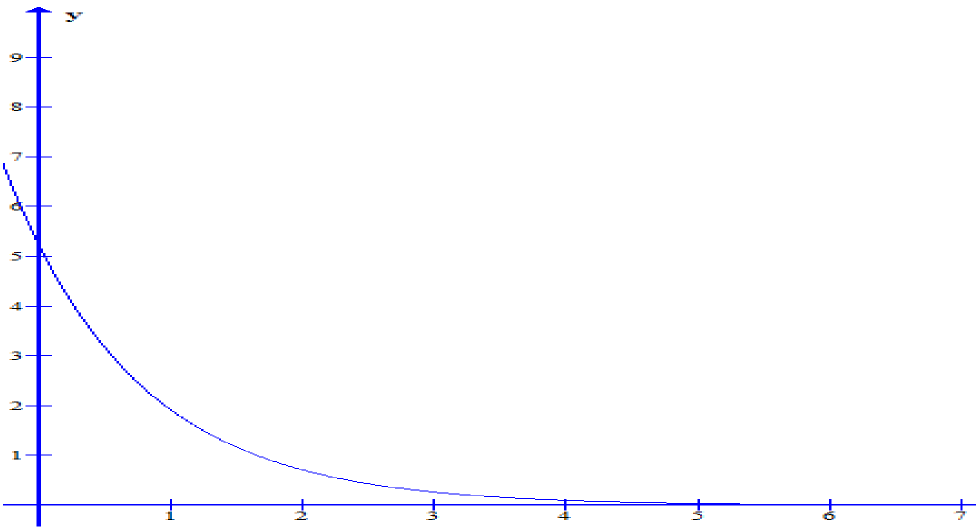


Fig.4. Radial wave function R(r) versus r/a_o (n=1 l=0, r and a_o in A)

It is possible to demonstrate that the most probable distance of an electron in the state n=1 l=0 is a_o.

$$P(r) = r^2|R(r)|^2 = r^2 \frac{4}{{a_o}^3} e^{-\frac{2r}{a_o}}$$

$$\frac{dP(r)}{dr} = \frac{4}{{a_o}^3}(-\frac{2r^2}{a_o} + 2r)e^{-\frac{2r}{a_o}}$$

$r=a_o$

Besides, it is possible to demonstrate that the most probable distance of an electron in the state n=2 l=1 is $4a_o$.

$$P(r) = r^2|R(r)|^2 = \frac{r^4}{24{a_o}^5} e^{-\frac{r}{a_o}}$$

$$\frac{dP(r)}{dr} = \frac{1}{24{a_o}^5}(-\frac{r^4}{a_o} + 4r^3)e^{-\frac{2r}{a_o}}$$

$r=4a_o$

In the same form, it is possible to demonstrate that the most probable distance of an electron in the state n=3 l=2 is $9a_o$ and in the state n=4 l=3 is $16a_o$. Thus, the maximum probability occurs when the probability densities have spherical symmetry where $r_{max}=n^2a_o$ and for l=n-1 as it was mentioned before.

The probability density function for n=1 l=0 is shown in the next figure 5: $P(r) = r^2|R(r)|^2$

$\int_{r1}^{r2} P(r)dr = \int_{r1}^{r2} r^2 |R(r)|^2 dr = \int_{x1}^{x2} 4x^2e^{-2x}dx$ where $x=r/a_o$ $dr=a_odx$

$P(x)=4x^2e^{-2x}$

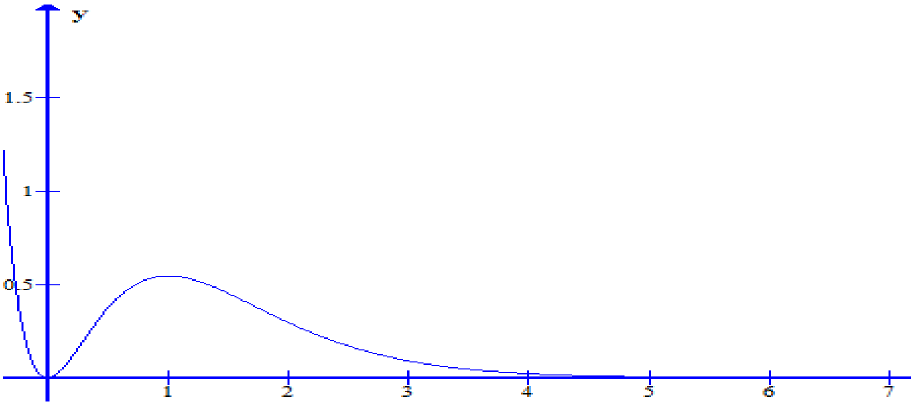


Fig.5. Probability density function P(x) versus $x=r/a_o$ for n=1 l=0

The probability density function for n=2 l=1 is shown in the next figure 6: $P(r) = r^2|R(r)|^2$

$\int_{r1}^{r2} P(r)dr = \int_{r1}^{r2} r^2 |R(r)|^2 dr = \int_{x1}^{x2} \frac{x^4e^{-x}}{24}dx$ where $x=r/a_o$ $dr=a_odx$

$P(x)=\frac{x^4e^{-x}}{24}$

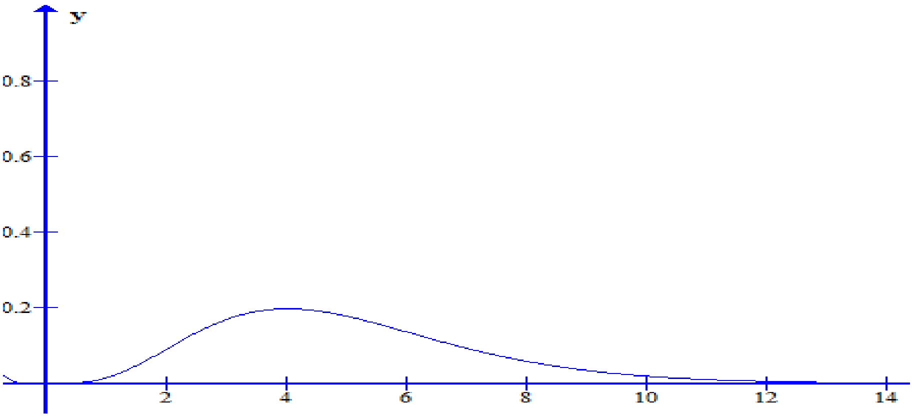


Fig.6. Probability density function P(x) versus $x=r/a_o$ for n=2 l=1

The probability density function for n=3 l=2 is shown in the next figure 7: $P(r) = r^2|R(r)|^2$

$\int_{r1}^{r2} P(r)dr = \int_{r1}^{r2} r^2 |R(r)|^2 dr = \int_{x1}^{x2} \frac{16x^6e^{-(2x/3)}}{(27)^3*10}dx$ where $x=r/a_o$ $dr=a_odx$

$P(x)=\frac{16x^6e^{-(2x/3)}}{(27)^3*10}$

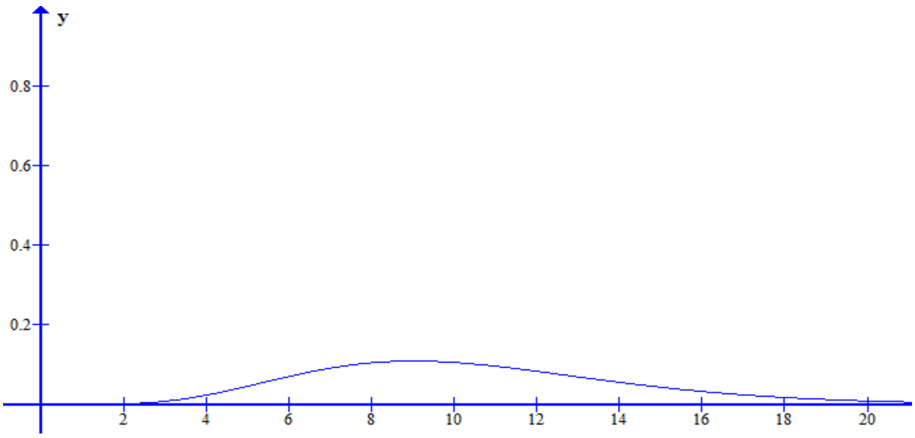


Fig.7. Probability density function P(x) versus $x=r/a_o$ for n=3 l=2

The probability density function for n=4 l=3 is shown in the next figure 8: $P(r) = r^2|R(r)|^2$

$\int_{r1}^{r2} P(r)dr = \int_{r1}^{r2} r^2\,|R(r)|^2 dr = \int_{x1}^{x2} \frac{x^8 e^{-x/2}}{322560*64} dx$ where $x=r/a_o$ $dr=a_o dx$

$P(x)=\frac{x^4 e^{-x}}{24}$

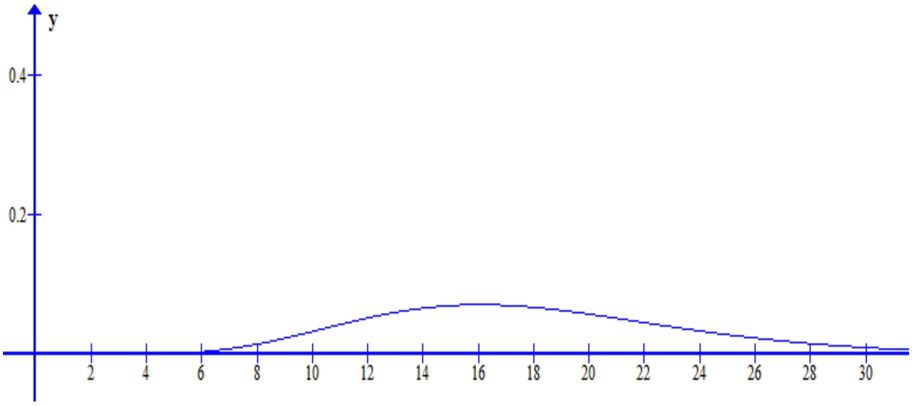


Fig.8. Probability density function P(x) versus $x=r/a_o$ for n=4 l=3

As an example, the calculation detail of the probability density of finding the electron between two distances r_1 and r_2 for the 1s state is given below. The radial wave function for 1s (n=1 l=0) is:

$$R(r) = \frac{2}{(a_o)^{3/2}} e^{-\frac{r}{a_o}}$$

$$\int_{r1}^{r2} P(r)dr = \int_{r1}^{r2} r^2\,|R(r)|^2 dr$$

$$= \int_{r1}^{r2} r^2 \frac{4}{a_o{}^3}\, e^{-\frac{2r}{a_o}} dr$$

For all radial wave functions of probability density, if $r_1=0$ and $r_2=\infty$, the answer is 1. For example, the probability density of finding the electron in the region $r_{max}-a_o \le r \le r_{max}+a_o$ ($r_{max}=n^2 a_o$) $r_{max}=a_o$ corresponding to n=1 l=0 (s) (l=n-1) $0\le r\le 2a_o$ is:

$r_o=a_o=0.529\,\acute{A}$ Bohr radius, radius for the first level of the Hydrogen atom

$$\int_0^{2ao} P(r)dr = \int_0^{2ao} r^2 \frac{4}{a_o{}^3}\, e^{-\frac{2r}{a_o}} dr$$

$$= \frac{4}{a_o{}^3}\left(-\frac{a_o}{2}r^2 - \frac{a_o{}^2}{2}r - \frac{a_o{}^3}{4}\right) e^{-\frac{2r}{a_o}} |^{2ao}{}_0$$

$=(1-13)*e^{-4}$

=0.76

The calculation detail of the probability density of finding the electron between two distances r_1 and r_2 for the 2p state is given below. The radial wave function for 2p (n=2 l=1) is:

$$R(r) = \frac{1}{\sqrt{3}\,(2a_o)^{3/2}} \frac{r}{a_o} e^{-\frac{r}{2a_o}}$$

$$\int_{r1}^{r2} P(r)dr = \int_{r1}^{r2} r^2\, |R(r)|^2 dr$$

$$= \frac{1}{24 a_o{}^5} \int_{r1}^{r2} r^4\, e^{-\frac{r}{a_o}} dr$$

For example, the probability density of finding the electron in the region r_{max}-a_o≤r≤r_{max}+a_o (r_{max}=n^2a_o) r_{max}=4a_o corresponding to n=2 l=1 (p) (l=n-1) 3 a_o ≤r≤5a_o is:

$$\int_{3ao}^{5ao} P(r)dr = \frac{1}{24 a_o{}^5} \int_{3ao}^{5ao} r^4\, e^{-\frac{r}{a_o}} dr$$

=0.375

The calculation detail of the probability density of finding the electron between two distances r_1 and r_2 for the 3d state is given below. The radial wave function for 3d (n=3 l=2) is:

$$R(r) = \frac{4}{27\sqrt{10}\,(3a_o)^{3/2}} \left(\frac{r}{a_o}\right)^2 e^{-\frac{r}{3a_o}}$$

$$\int_{r1}^{r2} P(r)dr = \int_{r1}^{r2} r^2\, |R(r)|^2 dr$$

$$= \left(\frac{4}{27\sqrt{10}\,(3a_o)^{3/2} a_o{}^2}\right)^2 \int_{r1}^{r2} r^6\, e^{-\frac{2r}{3a_o}} dr$$

For example, the probability density of finding the electron in the region r_{max}-a_o≤r≤r_{max}+a_o (r_{max}=n^2a_o) r_{max}=9a_o corresponding to n=3 l=2 (d) (l=n-1) 8a_o ≤r≤10a_o is:

$$\int_{8ao}^{10ao} P(r)dr = \left(\frac{4}{27\sqrt{10}\,(3a_o)^{3/2} a_o{}^2}\right)^2 \int_{8ao}^{10ao} r^6\, e^{-\frac{2r}{3a_o}} dr$$

=0.13

The calculation detail of the probability density of finding the electron between two distances r_1 and r_2 for the 4f state is given below. The radial wave function for 4f (n=4 l=3) is:

$$R(r) = \frac{1}{\sqrt{322560}\,(a_o)^{3/2}} \left(\frac{r}{2a_o}\right)^3 e^{-\frac{r}{4a_o}}$$

$$\int_{r1}^{r2} P(r)dr = \int_{r1}^{r2} r^2 \, |R(r)|^2 dr$$

$$= \left(\frac{1}{\sqrt{322560}\,(a_o)^{3/2}}\right)^2 \frac{1}{(2a_o)^6} \int_{r1}^{r2} r^8 \, e^{-\frac{r}{2a_o}} dr$$

For example, the probability density of finding the electron in the region $r_{max}-a_o \leq r \leq r_{max}+a_o$ ($r_{max}=n^2a_o$) $r_{max}=16a_o$ corresponding to n=4 l=3 (f) (l=n-1) $15a_o \leq r \leq 17a_o$ is:

$$\int_{15ao}^{17ao} P(r)dr = \left(\frac{1}{\sqrt{322560}\,(a_o)^{3/2}}\right)^2 \frac{1}{(2a_o)^6} \int_{15ao}^{17ao} r^8 \, e^{-\frac{r}{2a_o}} dr$$

$$= 0.021$$

In the following table (3), values of r_{max} and P(r) are given for some states with principal quantum number n and orbital quantum number l=n-1 (momentum angular orbital quantum number):

Table 3. Value of the probability density of finding the electron in the shells between the two radii: $r_{max}-a_o \leq r \leq r_{max}+a_o$ where $r_{max}=n^2a_o$

State	rmax	Probability density of finding the electron in shells between two radii: $r_{max}-a_o \leq r \leq r_{max}+a_o$ where $r_{max}=n^2a_o$
1s	1ao	0.8
2p	4ao	0.375
3d	9ao	0.13
4f	16ao	0.021

Therefore, the variation of the probability density of the electron P(r) concerning these shells in which the electrons are bound to protons is obtained from the solution of the Schrödinger equation. Besides, the mathematical solution of the Schrödinger equation for the Coulomb potential hydrogen atom depends on the quantum numbers n, l, m_l for different shells or energy levels [6].

In addition to the probability of finding electrons in the shells, these shells are related to the distribution of the proton mass cloud. Thus, the mass cloud of the proton interacts with the mass cloud of the electron resulting in the bonding of the two particles with loss of mass cloud and with no loss of electrical charge. It is because the charge of the particle is concentrated in its mass nucleus with an uncharged mass cloud around its nucleus and the mass clouds interact. This mass cloud is located in the respective orbitals which represent the possible locations or places determined probabilistically by the respective Schröndiger equation as it was calculated before. Therefore, this is evidence of the existence of the mass cloud.

The existence of this mass symmetry is right because for example in the Hydrogen atom and in the electron transition from one shell to another shell, the electron and the proton lose mass in the interaction of the mass cloud (converted to photons or electromagnetic radiation) but do not lose electric charge as it was mentioned before.

4. Particle Bonds

If two particles are close to each other, the mass cloud of one of them interacts with the mass cloud of the other particle. In this interaction, the loss of the mass clouds of the two particles will be converted into electromagnetic energy according to Einstein's equation: $E=mc^2$ and the variant mass formula discovered and developed by myself [1] Furthermore, as mentioned in the postulates, the mass m and the mass cloud m* of the same particle have the same value: m*=m. Besides, the mass of a particle cannot interact with the mass cloud of the same particle, neither partially nor totally. However, the interaction occurs between the mass cloud of one particle and the mass cloud of another particle, either partially or totally.

There are two kinds of particle bonds:

1.- When one particle is not the antiparticle of the other particle with partial interaction. When one particle is not the antiparticle of the other particle, the interaction between the two particles results in a partial loss of their mass clouds, and electromagnetic energy is radiated or emitted. Therefore, these two particles are joined together and one of these examples is the electron and the proton in the hydrogen atom.

2.- When one particle is the antiparticle of the other particle with full interaction. When one particle is the antiparticle of the other particle, the masses of the particles and antiparticles are equal and oppositely charged. In the interaction of these two particles, there is a total loss of mass (mass plus mass cloud) of both particles, which is converted to electromagnetic energy ($E=mc^2$).

Hydrogen Atom

Consider a free electron and proton, but not far from each other, two interactions will occur successively:

(1) The attraction between the positive charge of the proton and the negative charge of the electron causes the electron to move towards the proton.

(2) When the electron reaches the 1s state, the mass cloud of the proton interacts with the mass cloud of the electron. Thus, their masses will be reduced because the loss of mass cloud is converted to electromagnetic energy ($E=mc^2$), but these interactions have no effect on the electrical charge of the proton and the electron, which is concentrated in the mass nucleus of the particles and not in the mass cloud [1], [6].

During this analysis, the angular momentum orbital quantum number (l) and the orbital magnetic quantum number (m_l) have not been considered.

The Hydrogen Atom has one electron orbiting the nucleus which has one proton. The electronic configuration of the Hydrogen Atom is: $1s^1$. The positive charge of the proton (p+) is concentrated in its mass nucleus with an uncharged mass cloud around its nucleus. This mass cloud is located in the respective orbitals which represent the possible locations or places determined probabilistically by the respective Schröndiger equation. Furthermore, like the proton, this also occurs with the particles π^+, μ^+, e^+ for example. On other hand, the negative charge of the electron is concentrated in its mass nucleus with an uncharged mass cloud around its nucleus. In addition, like the electron, this also occurs with the particles π^-, μ^-, p^- (antiproton) for example.

The distribution of the mass cloud outside the proton occurs in such a way that, if a free electron enters one of the shells or allowed quantum energy levels of the hydrogen atom, a part of the mass cloud of the proton interacts with a part of the electron mass cloud. Thus, the mass of the interacting cloud is converted into electromagnetic energy or photons ($E=mc^2$), and the proton bonds with the electron. Therefore, the two particles are bound (join) together due to this interaction of the mass clouds and the electrostatic force between the two particles. In this form, it is right this mass symmetry and the existence of a mass cloud, since the electron and the proton in the interaction of the mass cloud lose mass but do not lose electric charge.

Besides, in the formation of the Hydrogen atom, the electron-proton system when approaching gets potential energy of V=- 27.2 eV (13.6 eV*2) but later when the electron bond occurs in the shell or quantum state n =1, the energy of 13.6 eV is emitted as electromagnetic energy or photons and the remaining 13.6 eV remains as kinetic energy of the electron. Thus, the mass-energy reduction of the proton and electron is 13.6/2 eV for each particle due to the emission of 13.6 eV as electromagnetic energy. Besides, the Hydrogen atom has 13.6 eV of additional mass energy (due to the kinetic energy of the electron) than the sum of the mass-energy of the proton plus the electron. In this form, it is needed 13.6 eV to ionize the Hydrogen atom and expel the electron from the atom. Therefore, the mass cloud of the proton keeps the electron in the 1s shell or ground state bound and the electron cannot leave this shell or the atom without receiving some energy from the outside of this atom which is 13.6 eV [1].

Muonic Atom

The muonic atom consists of one proton and one muon which has a negative charge. The mass of the muon is 105.7 MeV/c^2 or 207 m_e, the mass of the proton is 938.272 MeV/c^2 or 1836 m_e, and the reduced mass of the muonic atom is [6]: $m_\mu = \frac{207me*1836me}{207me+1836me}$ =186 m_e

The most probable radius and binding energy for the muon can be calculated from the equations:

$$r = \frac{n^2h^2\varepsilon_o}{\pi m_o Ze^2} \qquad m_o=m_\mu$$

$$r = \frac{n^2h^2\varepsilon_o}{\pi 186mZe^2}$$

$$a_o = \frac{\varepsilon_o h^2}{\pi me^2} \qquad r = \frac{n^2 a_o}{186Z}$$ (donde m es la masa del electrón, Z=1 y n=1)

$$r=\frac{a_o}{186}$$ (a_o: Bohr radius=5.3 *10^{-11} m) r=2.84*10^{-4} nm

$$E = \frac{-z^2e^4m_o}{8\varepsilon_o{}^2h^2n^2}$$

$$E = \frac{-z^2e^4 186m}{8\varepsilon_o{}^2h^2n^2} \qquad E = \frac{-186(13.6)Z^2}{n^2}$$ (Z=1 n=1) E(eV)=2533 eV

By applying the formula of E(eV) versus r(nm), it is obtained the same result: E(eV)=0.7194/r (nm) r=2.84*10^{-4} nm E=2533 eV

If the natural logarithm is used for smaller values of r and by applying the equation E(eV)=0.7194/r (nm) which gives the variation of energy (E eV) as a function of distance (r nm), the coordinates of the muonic atom coincide with the figure (3) of E versus r:

E(eV)=0.7194/r (nm) ln E(eV)=ln (1/r nm)+ln (0.7194)

ln E(eV)=ln (1/r nm)-0.3294

$r=2.84*10^{-4}$ nm: ln ($1/2.84*10^{-4}$ nm)=8.16

E=2533 eV ln (2533 eV)=7.84

For the muonic atom (as well as for the hydrogen atom), values of r and energy E can be obtained for the other shells or levels with a different quantum number (n), for example, for n=2:

$r = \frac{n^2 a_o}{186Z}$ n=2 a_o: Bohr radius=5.3 $*10^{-11}$ m Z=1

r=0.001136 nm

E=-186 (13.6) Z^2/n^2 (Z=1 n=2) E(eV)=633 eV

By applying the formula of E(eV) versus r(nm), it is obtained the same result: E(eV)=0.7194/r (nm) r=0.001136 nm E(eV)=633 eV

r=0.001136 nm: ln (1/0.001136 nm)=6.78

E=633 eV ln (633 eV)=6.45

The graph of ln (E eV) versus ln (1/r nm) is shown below:

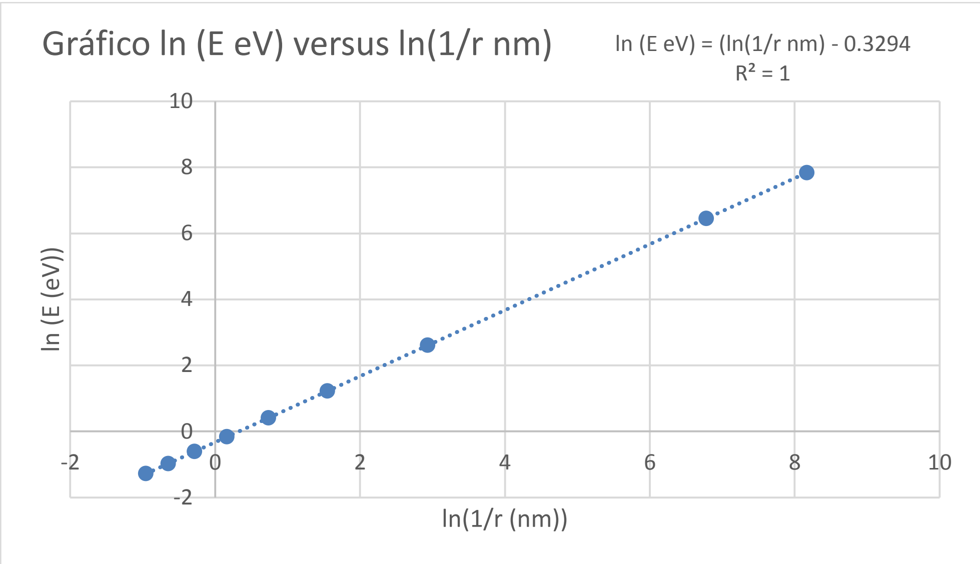


Fig.9. Variation of ln (EeV) versus ln(1/r(nm)) for the different shells or quantum levels n based on Bohr model

The radial wave function for the muonic atom in the first shell is:

$$R(r) = \frac{2}{{r_{max}}^{3/2}} e^{-\frac{r}{r_{max}}}$$

The probability density of finding the muon in the region between r=0 and $r=2r_o$ corresponding to n=1 l=0 (s) (l=n-1) ($r_{max}=n^2 r_o$ $r_{max}-r_o \leq r \leq r_{max}+r_o$)

$0 \le r \le 2r_o$ is:

$$R(r) = \frac{2}{(r_o)^{3/2}} e^{-\frac{r}{r_o}} \qquad P(r) = r^2 |R(r)|^2$$

$r_o = 2.84*10^{-4}$ nm

$$\int_0^{2ro} P(r)dr = \int_0^{2ro} r^2 \,|R(r)|^2 dr$$

$$\int_0^{2ro} P(r)dr = \int_0^{2ro} r^2 \frac{4}{r_o{}^3}\; e^{-\frac{2r}{r_o}} dr$$

$$= \frac{4}{r_o{}^3}\left(-\frac{r_o}{2} r^2 - \frac{r_o{}^2}{2} r - \frac{r_o{}^3}{4}\right) e^{-\frac{2r}{r_o}} \Big|_0^{2ro}$$

$=(1-13)*e^{-4}$

$=0.76$

Inside the muonic atom and in the orbits of the atom is the muon (like the electron in the hydrogen atom). The muon has a negatively charged mass nucleus and an uncharged mass cloud surrounding the mass nucleus. Besides, the proton has a positively charged mass nucleus and an uncharged mass cloud surrounding the mass nucleus. Thus, the mass cloud that interacts between the proton and the muon is converted into electromagnetic energy, and the proton bonds with the muon. In this form, when the muon bonds (in the shell or main quantum state n=1) with the proton, 2533 eV of energy is emitted. The mass cloud reduction of the proton and the muon is 2533/2 eV for each particle during the formation of the muon atom.

Deuteron

There is a strong nuclear interaction between proton with neutron, neutron with neutron, and proton with proton. In addition to the strong interaction between two protons, there is also a weak Coulomb repulsion between the two protons. The Deuterio Atom has one electron orbiting the nucleus which has one proton and one neutron. The electronic configuration of the Deuterio Atom is: $1s^1$. The Deuterio is an isotope of Hydrogen. The deuteron is the nucleus of deuterio which has two nucleons: one proton and one neutron and between which there is a strong interaction. It is possible to explain the strong interaction between these two nucleons utilizing the effect of the mass cloud of one particle with the mass cloud of the other particle.

The binding energy of the deuteron is 2.23 MeV, which is the energy released when a proton and a neutron join to form a nucleus. Experiments show that the radius of the proton is about 1.2 fm and the radius of the neutron is about the same radius. On the other hand, experiments show that the radius of the deuteron is about 2.21fm. The distance between the center of the two nucleons: proton and neutron is about 1 fm. Therefore, the proton and neutron in the deuteron are very close together and under this condition, the mass clouds overlap each other. Then, the mass cloud of the proton interacts with the mass cloud of the neutron and the mass of the interacting cloud is converted into electromagnetic energy or photons ($E=mc^2$), and the two nucleons bond [1],[6].

Then, as a result of the interaction between the mass clouds of the two nucleons, the two nucleons bind together tightly within this short-range distance. But if by some external effect the distance between the proton and the

Mediterranean Journal of Basic and Applied Sciences (MJBAS)
Volume 6, Issue 3, Pages 01-34, July-September 2022

neutron increases by a few fm, the strong force of interaction between the mass clouds will decrease, which is in fact part of the properties of the strong nuclear force: the nuclear force has a strong interaction at short range distances. For shorter distances, the strong force decreases rapidly and for longer distances, around a few fm, the strong force decreases as well. It is explained too due to the binding between the nucleons: shorter distances: the nucleons are already bound and the strong force decreases; longer distances: the binding is not enough to reach the nucleons and the strong force decreases.

Ionized Helium Atom

The Helium Atom has two electrons orbiting the nucleus which has two protons and two neutrons. The electronic configuration of the Helium Atom is: $1s^2$. On other hand, if an electron is removed from the Helium atom, the Helium ion He^+ is formed. Helium ionized with one electron is like the hydrogen atom except for Z=2 (due to the two protons). The electronic configuration of the Ionized Helium Atom is: $1s^1$. Therefore, the most probable radius in the ground state with shell or quantum level 1s is:

$r = \frac{n^2 a_o}{Z}$ (a_o: Bohr radius=5.3 $*10^{-11}$ m) n=1 Z=2

r=0.0265 nm

And the energy is: $E = \frac{-13.6z^2}{n^2}$ n=1 Z=2

E=54.4 eV

$$(E)(r)= \left(\frac{-z^2e^4m_o}{8\varepsilon_o{}^2h^2n^2}\right)\left(\frac{n^2h^2\varepsilon_o}{\pi m_o Ze^2}\right)$$

$$=\frac{-Ze^2}{8\pi\varepsilon_o} \quad Z=2$$

(E)(r)=2*0.7194 eV-nm

E(eV)=2*0.7194/r (nm) r=0.0265 nm E=54.4 eV

In this form, the only two protons in this nucleus affect these values: r_{max} and E, while the neutrons have no effect on the electron [6]. Since the mass cloud of the two protons of the helium ion compared to that of the hydrogen atom which has one proton is larger, the electron in this shell or quantum level 1s is more strongly bound: 54.4 eV (He^+)>13.6 eV (H).

Helium Nucleons

The Helium nucleus or α particle with a radius of r=1.9 fm has two protons and two neutrons [1],[6]. In the interaction between the mass clouds of these nucleons, the energy emitted ($E=mc^2$) in the bond of the Helium nucleons is 28.3 MeV.

Nucleons

Consider a heavy nucleus that has many nucleons: protons and neutrons. The mass clouds of nucleons within the nucleus interact with each other without any effect on the proton charge. For a heavy nucleus, the average value of the binding energy of each nucleon is about 8 MeV.

Particle bonds between Particle and Antiparticle

When one particle is the antiparticle of the other particle, the masses of the particles and antiparticles are equal and oppositely charged. In the interaction of these two particles, there is a total loss of mass (mass plus mass cloud) of both particles, which is converted to electromagnetic energy ($E=mc^2$).

A particle and an antiparticle are the same particles in terms of their properties including their masses except for their electrical charges. Thus, if the particles have an electrical charge, one particle has a positive charge and the other particle has a negative charge. The most frequently found particle in nature is called a particle. However, for a pair of particles that do not have an electrical charge, one particle is arbitrarily called a particle and the other particle an antiparticle [1],[6].

Besides, if a particle and its antiparticle are close to each other, the mass cloud of one of the particles interacts with the mass cloud of the other particle. In this interaction, the total mass (mass plus mass cloud) of the particle and the antiparticle is converted into electromagnetic radiation emitted in the form of electromagnetic rays or photons.

Electron and Positron

The electron has a negative electrical charge with mass m and its antiparticle called positron has a positive electrical charge with mass m´ where m=m´. In the interaction of the electron with the positron, the total mass (mass plus mass cloud) of the electron and positron is converted into electromagnetic energy, and two gamma rays or photons with an energy of 0.511 MeV each one is produced. Two photons are needed to hold the conservation of momentum [1],[6].

$e^- + e^+ \rightarrow \gamma_1 + \gamma_2$

$E_{\gamma 1} + E_{\gamma 2} = 2mc^2$ where m is the electron rest mass $m=0.511\ MeV/c^2$

Proton and Antiproton

The interaction of the proton (p^+) with the antiproton (p^-) can be achieved experimentally in accelerators or particle colliders installed for example at CERN, DESY, SLAC, Fermilab [1],[6]. The proton has a positive electrical charge with mass m and its antiparticle called antiproton has a negative electrical charge with mass m´ where m=m´. If the proton and antiproton interact, the total mass (mass plus mass cloud) of the proton and antiproton is converted into electromagnetic energy, and two gamma rays or photons with an energy of 938.28 MeV each one is produced. Two photons are needed to hold conservation of momentum.

$P^- + P^+ \rightarrow \gamma_1 + \gamma_2$

$E_{\gamma 1} + E_{\gamma 2} = 2mc^2$ where m is the proton rest mass $m=938.28\ MeV/c^2$

Muon and antimuon

The muon has a negative electrical charge with mass m and its antiparticle called antimuon has a positive electrical charge with mass m´ where m=m´. If the muon and antimuon interact, the total mass (mass plus mass cloud) of the muon and antimuon is converted into electromagnetic energy, and two gamma rays or photons with an energy of 105.6 MeV each one are produced [1],[6]. Two photons are needed to hold conservation of momentum.

$\mu^- + \mu^+ \rightarrow \gamma_1 + \gamma_2$

$E_{\gamma 1} + E_{\gamma 2} = 2mc^2$ where m is the muon rest mass $m = 105.6\ MeV/c^2$

Neutral Pion and neutral antipion

The masses of the neutral pion and the neutral antipion are equal and without electrical charge. If the neutral pion and neutral antipion interact, the total mass (mass plus mass cloud) of the neutral pion and neutral antipion is converted into electromagnetic energy, and two gamma rays or photons with an energy of 134.97 MeV each one is produced. Two photons are needed to hold conservation of momentum. Between these two particles: neutral pion and neutral antipion, the selection of particle and antiparticle are arbitrary [1],[6].

$\pi^o + \bar{\pi}^o \rightarrow \gamma_1 + \gamma_2$

$E_{\gamma 1} + E_{\gamma 2} = 2mc^2$ where m is the neutral pion rest mass $m = 134.97\ MeV/c^2$

5. Bound of Diatomic Molecules

It is possible to analyze the center of mass (CM) as follows:

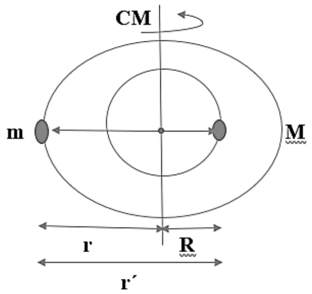


Fig.10. Center of mass for diatomic molecules

$mr = MR \quad R = (m/M)r \quad r' = r + R \quad r' = r + (m/M)r$

$r' = \frac{M+m}{M} r \quad r = \frac{M}{M+m} r'$

$$m\frac{v^2}{r} = \frac{kZe^2}{r'^2}$$

$$v^2 = r\frac{kZe^2}{mr'^2} = \frac{M}{M+m} r' \frac{kZe^2}{mr'^2} = \frac{kZe^2}{2m_o r'} \qquad M = m = m_o$$

$$v = \sqrt{k\frac{Ze^2}{2m_o r'}}$$

$$m_{RDM} = \frac{mM}{m+M} \quad \text{(reduced mass of the Diatomic Molecule)}$$

Hydrogen Molecule H_2

Firstly, we consider the Hydrogen molecule H_2 which is formed due to the bond of two Hydrogen Atoms H where each Hydrogen Atom H consists of one proton and one electron. The electronic configuration of the Hydrogen Atom $1s^1$. Nowadays, this bond of the Hydrogen molecule H_2 is explained by the mean of the covalent bond. In the hydrogen molecule H_2, the electrons in the shell 1s circulate between the two hydrogen atoms. Therefore, the two electrons are shared by the two Hydrogen Atoms H. The two electrons can be shared if the spins are in opposite direction. Besides, the electrons of both atoms remain in the zone between them longer than in any other zone, which produces an attractive force of the protons towards this zone which explains the covalent bond. These types of forces are the forces that form homonuclear diatomic molecules, such as the Hydrogen molecule, in which for this reason both electrons remain attached to the two protons of both atoms [1], [4], [5], [7].

Nevertheless, this covalent bond can be explained using the mass symmetry: mass and cloud mass. If the two atoms of Hydrogen H are close to each other, the mass cloud of the proton of one atom of H interacts with the mass cloud of the electron of the same atom and with the mass cloud of the electron of the other atom because the electrons are shared by the two Hydrogen atoms. The same occurs for the proton of the other Hydrogen atom. In this interaction, the loss of the mass clouds that interact will be converted into electromagnetic energy according to Einstein's equation: $E=mc^2$ and the variant mass formula discovered by myself [1].

The bond energy that corresponds to the electromagnetic energy emitted when the bond occurs is calculated with the variant mass formula developed by myself as follows:

The mass of Hydrogen Atom H is: $m_o=1.673534*10^{-27}$ kg.

The reduced mass of the Hydrogen Molecule is:

$m_{RH2}=\frac{m_o\,m_o}{m_o+m_o}=\frac{m_o}{2}$ where m_o is the mass of the Hydrogen Atom

The internuclear distance is: r´=0.74 A (1 A=10^{-10} m).

$v=\sqrt{k\frac{Ze^2}{2m_o r'}}$ $k=\frac{1}{4\pi\epsilon_o}=9*10^9\ Nm^2/C^2$ Z=1 $e=1.602*10^{-19}$ C

v=30537.65179 m/s

$m=m_o e^{-(\frac{v^2}{2c^2})}$ where c is the light velocity $c=3*10^8$ m/s

$\Delta mc^2=m_oc^2-(m_oe^{-(\frac{v^2}{2c^2})})c^2$

$\Delta mc^2=4.87$ eV

If it is used the formula of E versus r (Bohr approach), it is obtained the same results:

$(E)(r)=(\frac{-z^2e^4m_o}{8\varepsilon_o{}^2h^2n^2})\ (\frac{n^2h^2\varepsilon_o}{\pi m_oZe^2})$

$=\frac{-Ze^2}{8\pi\varepsilon_o}$ Z=1

(E)(r)=0.7194 eV-nm

E(eV)=0.7194/r (nm)

E(eV)=0.7194/r(nm) where r is double of the internuclear distance: r=2r´

Mediterranean Journal of Basic and Applied Sciences (MJBAS)
Volume 6, Issue 3, Pages 01-34, July-September 2022

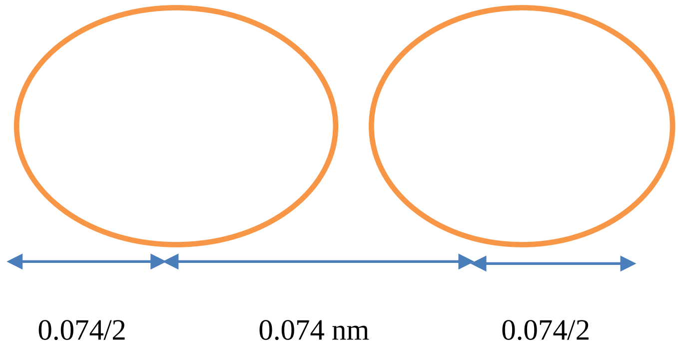


Fig.11. Diatomic Molecule and the maximum distance for the shared electron: 2r´ (Hydrogen Molecule)

Then, the distance r is: 2*0.074 nm

E(eV)=0.7194/(2*0.074) eV

E=4.86 eV

The experimental value for the bond energy for the Hydrogen molecule H_2 is 4.72 eV. This bond energy of the Hydrogen molecule H_2 is lower than the bond energy between the electron and the proton in the Hydrogen Atom: 4.72 eV<13.6 eV. It is because of the electrostatic force of repulsion of the two shared electrons in the Hydrogen molecule H_2. Also, the internuclear distance between the two Hydrogen Atoms (0.74 A) is greater than the distance between the electron (in the shell 1s) and proton in the Hydrogen Atom (0.53 A): 0.74 A>0.53 A [1], [4], [5], [7].

Ionized Hydrogen Molecule H_2^+

The Ionized Hydrogen molecule H_2^+ is formed due to the bond of two Hydrogen Atoms H but with one electron expelled from the H_2 molecule. Nowadays, this bond of the Ionized Hydrogen molecule H_2^+ is explained by the mean of the covalent bond. In the Ionized hydrogen molecule H_2^+, the electron in the shell 1s circulates between the two hydrogen atoms. Therefore, the electron is shared by the two Hydrogen Atoms H. Besides, the electron of both Hydrogen atoms remains in the zone between them longer than in any other zone, which produces an attractive force of the protons towards this zone which explains the covalent bond. Therefore, the electron remains attached to the two protons of both atoms due this reason [1], [4], [5], [7].

Nevertheless, this covalent bond can be explained utilizing the mass symmetry: mass and cloud mass. If the two atoms of Hydrogen H are close to each other, the mass cloud of the proton of one atom of H interacts with the mass cloud of the electron shared by the two Hydrogen atoms. The same occurs for the proton of the other Hydrogen atom. In this interaction, the loss of the mass clouds that interact will be converted into electromagnetic energy according to Einstein's equation: $E=mc^2$ and the variant mass formula discovered by myself [1].

The bond energy that corresponds to the electromagnetic energy emitted when the bond occurs is calculated with the variant mass formula developed by myself as follows:

The mass of Hydrogen Atom H is: $m_o=1.67353 *10^{-27}$ kg.

The internuclear distance is: r´=1.06 A (1 A=10^{-10} m).

$v = \sqrt{k\frac{Ze^2}{2m_o r'}}$ $k=\frac{1}{4\pi\epsilon_o}=9*10^9$ Nm^2/C^2 Z=1 $e=1.6*10^{-19}$ C

v=25515.17586 m/s

$m = m_o e^{-(\frac{v^2}{2c^2})}$ where c is the light velocity $c=3*10^8$ m/s

$\Delta mc^2= m_oc^2-(m_o e^{-(\frac{v^2}{2c^2})})c^2$

Δmc^2=3.40 eV

If it is used the formula of E versus r (Bohr approach), it is obtained the same results:

$(E)(r)= (\frac{-z^2e^4m_o}{8\varepsilon_o{}^2h^2n^2})\ (\frac{n^2h^2\varepsilon_o}{\pi m_oZe^2})$

$=\frac{-Ze^2}{8\pi\varepsilon_o}$ Z=1

(E)(r)=0.7194 eV-nm

E(eV)=0.7194/r (nm)

E(eV)=0.7194/r(nm) where r is double of the internuclear distance:

r=2r´

The figure is the same as the previous figure of the diatomic molecule and the maximum distance for the shared electron for the Hydrogen Molecule.

Then, the distance r is: 2*0.106 nm

E(eV)=0.7194/(2*0.106) eV

E=3.39 eV.

The experimental value for the bond energy for the Ionized Hydrogen molecule H_2^+ is 2.65 eV. The bound energy for H_2 is not double the bound energy for H_2^+, because the repulsion between the electrons of the H_2 which decreases the bound from 5.3 eV to 4.72 eV and the distance is 0.74 A instead of 0.53 A which is the internuclear distance of H_2^+ divided by 2: 1.06 A / 2 [1], [4], [5], [7].

Therefore, the molecule of H_2 is more stable than the molecule of ionized hydrogen H_2^+. The bound energy for the H_2^+ is less intense than for H_2: 2.65 eV<4.72 eV. Besides, the internuclear distance of the Ionized Hydrogen Molecule H_2^+ (1.06 A) is greater than the internuclear distance of the Hydrogen Molecule H_2 (0.74 A): 1.06 A>0.74 A.

Oxygen Molecule O_2

The electronic configuration of the oxygen atom O is: $1s^2$ $2s^2$ $2p^4$. The oxygen atom consists of 2 electrons in the first level n=1 and 6 electrons in the second level n=2. The Oxygen molecule O_2 is formed by the covalent bond of two Oxygen Atoms O where each Oxygen Atom O consists of eight protons, eight neutrons, and eight electrons: 2

electrons in the first level and 6 electrons in the second level. Besides, two electrons of the second level are shared by each oxygen atom O. Then, there are four electrons shared totally to form the covalent bond [1], [4], [5], [7].

Nowadays, this bond of the Oxygen Molecule O_2 is explained by means of the covalent bond. In the Oxygen Molecule, four electrons of the second level circulate between both oxygen atoms. Besides, the four shared electrons remain in the zone between them longer than in any other zone, which produces an attractive force of the protons towards this zone which explains the covalent bond. Therefore, the four electrons remain attached to the protons of both atoms due this reason [1], [4], [5], [7].

Nevertheless, this covalent bond can be explained by means of the mass symmetry: mass and cloud mass. If the two atoms of Oxygen O are close to each other, the mass cloud of the protons of one atom of O interacts with the mass cloud of the electrons of the same atom and with the electrons of the other atom because the electrons are shared by the two Oxygen atoms. The same occurs for the protons of the other Oxygen atom. In this interaction, the loss of the mass clouds that interact will be converted into electromagnetic energy according to Einstein's equation: $E=mc^2$ and the variant mass formula discovered by myself [1].

The bond energy that corresponds to the electromagnetic energy emitted when the bond occurs is calculated with the variant mass formula developed by myself as follows:

The mass of Oxygen Atom O is: $m_o=2.65 *10^{-26}$ kg.

The internuclear distance is: r=1.21 A (1 A=10^{-10} m).

$v=\sqrt{k\frac{Ze^2}{2m_o r}}$ $k=\frac{1}{4\pi\epsilon_o}=9*10^9\ Nm^2/C^2$ Z=2 $e=1.6*10^{-19}$ C

v=8487.27 m/s

$m=m_o e^{-(\frac{v^2}{2c^2})}$ where c is the light velocity $c=3*10^8$ m/s

$\Delta mc^2= m_o c^2-(m_o e^{-(\frac{v^2}{2c^2})})c^2$

$\Delta mc^2=5.96$ eV

If it is used the formula of E versus r (Bohr approach), it is obtained the same results:

$(E)(r)= (\frac{-z^2e^4m_o}{8\varepsilon_o{}^2h^2n^2})\ (\frac{n^2h^2\varepsilon_o}{\pi m_o Ze^2})$

$=\frac{-Ze^2}{8\pi\varepsilon_o}$ Z=2

(E)(r)=2*0.7194 eV-nm

E(eV)=(2*0.7194)/r (nm)

E(eV)=(2*0.7194)/r(nm) where r is double of the internuclear distance: r=2r´

Mediterranean Journal of Basic and Applied Sciences (MJBAS)
Volume 6, Issue 3, Pages 01-34, July-September 2022

The figure is the same as the previous figure of the diatomic molecule and the maximum distance for the shared electron for the Hydrogen Molecule.

Then, the distance r is: 2*0.121 nm

E(eV)=(2*0.7194)/(2*0.121) eV E=5.95 eV

La energía de enlace experimental del O_2 es de 5.08 eV. It is possible to calculate the rotation frequency w for the O_2:

$L=Iw\approx\frac{h}{2\pi}$ $w\approx\frac{h}{2\pi I}$ $h=6.63*10^{-34}$ J-s (Planck constant)

The mass of Oxygen Atom O is: $m_o=2.65*10^{-26}$ kg.

The internuclear distance is: r=1.21 A (1 A=10^{-10} m).

$I=2m_o(r/2)^2=1.94*10^{-46}$ kg m^2

$w=5.43*10^{11}$ Rad/s

It is in accordance with the experimental measurements for the rotation frequency [1]. The experimental value of the angular velocity of the oxygen molecule is in the order of 10^{11} Rad/s. The rotation frequency is lower than the vibration frequency which is in the order of 10^{13} Hz.

The kinetic energy of rotation of the oxygen molecule is:

$K=\frac{1}{2}Iw^2$ $I=1.94*10^{-46}$ $w=5.43*10^{11}$ Rad/s

$K=2.86*10^{-23}$ J K=0.000179 eV

The kinetic energy of translation of the oxygen molecule is of the order of $6*10^{-21}$ J.

6. Quark Symmetry & Quark Confinement

6.1. Introduction

Quark confinement means that no matter how hard it is tried, it is not possible to get a single quark or antiquark from the hadrons. However, this does not mean that they are inaccessible. In the same way that Rutherford indirectly experimented with the atom, the experiments indirectly show evidence of quarks being inside hadrons as in protons (two up quarks and one down quark) and neutrons (two down quarks and one up quark). Thus, this is demonstrated with the high-energy electron accelerators to probe the proton (SLAC) and at CERN with the neutrino beam and also by using high-energy protons for these purposes. The particle deflected through large angles indicates that the proton has an internal structure made up of quarks. Besides, the combined data from the seven Heavy Ion experiments at CERN have given a clear picture of a new state of matter (quark plasma and gluons within hadrons). Furthermore, this experimental result verifies an important prediction of the present theory of the fundamental strong forces between quarks: the quark confinement [11], [12].

Therefore, particle accelerator experiments indirectly show evidence for the existence of quarks that have charge, mass (and even color). Evidence for quarks comes from three main experimental methods: hadron spectroscopy,

Mediterranean Journal of Basic and Applied Sciences (MJBAS)
Volume 6, Issue 3, Pages 01-34, July-September 2022

lepton scattering, and jet production. Protons are hadrons made up of gluons and three quarks: up, up, and down. Neutrons are hadrons made up of gluons and three quarks: down, down and up. Then, quarks and gluons are the fundamental constituents of matter [11], [12].

At the evolving stage, the entire universe was in a peculiar state of plasma of quarks with gluons at very high temperatures. Afterward, the temperature dropped, and the plasma cooled and produced the protons and neutrons of today's galaxies [11], [12].

The quarks are as follows: up (u: charge: 2/3), down (d: charge: -1/3), strange (s: charge: -1/3), charmed (c: charge: 2/3), bottom (b: charge: -1/3), top (t: charge: 2/3). All quarks have spin 1/2 (fermions). The quark and the antiquark have the same mass, but they have opposite electric charges and if a quark has a strangeness (+1), the antiquark has a strangeness (-1) [11], [12].

There are three families of particles:

(1) Family of leptons: which are fundamental particles and do not have quarks as constituents. These particles are e^-, μ^-, τ^-, which each have their own neutrino: v_e, v_μ y v_τ. For these particles, their antiparticles are e^+, μ^+, τ^+, and their antineutrinos are $\overline{v_e}$, $\overline{v_\mu}$, $\bar{v}_\tau$.

(2) Family of mesons: They have two quarks as constituents; one is quark and one is antiquark. The spins of some mesons are zero and of other mesons are one. The strangeness for some mesons are:

strangeness=+1: $k^o(d\bar{s})$, $k^+(u\bar{s})$

strangeness= -1: $k^-(s\bar{u})$, $\overline{k^o}$ $(s\bar{d})$

strangeness=0 : $\pi^-(d\bar{u})$, η' $(s\bar{s})$, η $(d\bar{d})$, π^o $(u\bar{u})$, $\pi^+(u\bar{d})$

(3) Baryon family: They are composed of three quarks and antibaryons are composed of three antiquarks. Examples of baryons are the proton (uud) and the neutron (ddu). The spin of the baryon is half-integer 1/2 or 3/2 and spins up to 11/2 have been observed.

Therefore, the baryon family has three quarks in the particle plasma, the meson family has two quarks, but the lepton family has no quarks [11], [12].

6.2. Quark Symmetry and Interaction between Quarks

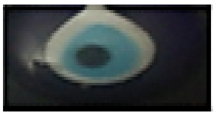
As it was mentioned before, there are pieces of evidence that hadrons are made of quarks. Because quarks have mass and charge (and even color), then, it is concluded that quarks also have mass symmetry established by the mass duality (The Yin Yang): mass and mass cloud. The charge of the quark is concentrated in its mass nucleus with an uncharged mass cloud around its nucleus. The mass cloud allows the confinement or the respective binding between quarks. Furthermore, the mass of a quark cannot interact with the mass cloud of the same quark, and vice versa [12].

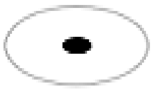
Gluons are the force carriers in the strong interactions as the nuclear interactions. Thus, gluons are the intermediary forces between the quarks. Then, the exchange force between the mass clouds of interacting quarks is mediated by

Mediterranean Journal of Basic and Applied Sciences (MJBAS)
Volume 6, Issue 3, Pages 01-34, July-September 2022

gluons. The force of interaction between the mass clouds of interacting quarks is very strong and at a distance of about one fm. For shorter distances, the strong force decreases rapidly and for longer distances, around a few fm, the strong force decreases as well. Also, it is explained due to the binding between the quarks (shorter distances: the quarks are already bound and the strong force decreases; longer distances: the binding is not enough to reach the quarks and the strong force decreases) [12].

The interaction diagram between two quarks is represented in the same form as the diagram of the mass symmetry for the other particles with mass (The Yin Yang: mass and mass cloud). The interaction diagram between three quarks can be represented with the same approach and using the additional property that quarks have colors:





Quark Symmetry Interaction between two quarks Interaction among three quarks

Quark structure in mesons Quark structure in Baryons

Fig.12. Quark with the mass symmetry (mass and mass cloud), Quark structure in baryons and mesons (leptón has not any quark) & Interaction diagram between two quarks and among three quarks where each quark is composed of mass (where it is deposited the charge) and mass cloud (which allows the binding and the confinement!!): The Yin Yang and using the additional property that quarks have colors

6.3. Quark and Gluon interaction with their colors

All quarks are fermions (spin of 1/2) and thus, the quarks must not violate the Pauli exclusion principle. Now consider the particle Δ^{++}(uuu), which has three similar quarks, and their spins are bidirectional. Then, its spin is 3/2 (other examples are Δ^{-}(ddd) and Ω^{-}(sss)) [11], [12].

The standard model, which is very successful, assigns a new feature called color. The colors are red (r), green (g), and blue (b) and their anticolors are ($\bar{r}$), ($\bar{g}$) y ($\bar{b}$). Any quark: u, d, s, c, b, t, and any antiquark can exist in three different colored states, for example; Δ^{-}(dr,dg,db) and Ω^{-}(sr,sg,sb).

The quark construction for some baryons is as follows: proton (udu): $u_r d_g u_b$, neutron (dud): $d_r u_g d_b$, Σ^{+}(usu): $u_r s_g u_b$, Σ^{o}(uds): $u_r d_g s_b$, Σ^{-}(dsd): $d_r s_g d_b$, Δ^{++}(uuu): $u_r u_g u_b$, Δ^{-}(ddd): $d_r d_g d_b$, Ω^{-}(sss): $s_r s_g s_b$.

Now, let's consider some simple examples for exchanging the gluon via Feynman diagrams. Normally, the color of the quark is changed at the vertex of the gluon and the color difference is carried by the gluon. The gluon carries

Mediterranean Journal of Basic and Applied Sciences (MJBAS)
Volume 6, Issue 3, Pages 01-34, July-September 2022

one color unit and one anticolor unit [11], [12]. The figure below shows the gluon interaction between two quarks. In this figure, the exchange force per gluon is as follows: the exchange gluon at the upper left is intermediate between (u_r) side m to (d_g) side n, which is shown by $r\bar{g}$ (mn), and conversely from (d_g) side n to (u_r) side m, which is shown by $g\bar{r}$ (nm) [11]. [12].

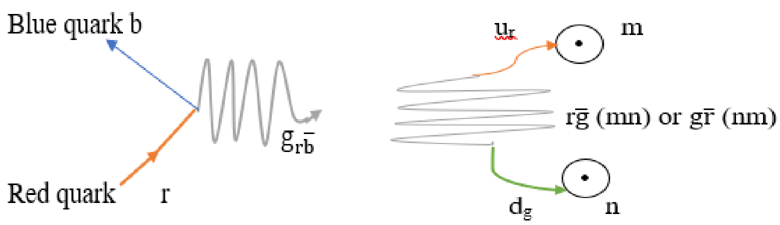


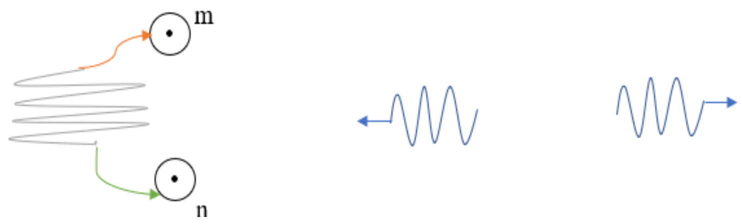
Fig.13. Change of quark color by gluon (at the vertex of the gluon) and Gluon interaction between two quarks

Furthermore, high-energy electron-positron annihilation can also produce muons and antimouns, which in turn produce hadrons. The ratio of the number of hadron events to the number of muon events gives a measure of "colors" of quarks: $e^+ + e^- \rightarrow u + \bar{u} \rightarrow$ hadrons [11], [12].

6.4. Interactions between quarks: Electromagnetic, Weak, and Strong

Electromagnetic Interaction: $\pi^o \rightarrow \gamma + \gamma$

The π^o is made up of quarks ($u\bar{u}$) or ($d\bar{d}$). The intermediary forces between the mass clouds of the two quarks are the gluons. Thus, π^o decays into two gamma rays. The half-life of this decay is 10^{-17} sec [11], [12].



Before decay After decay

Fig.14. Electromagnetic Interaction

Weak Interaction: neutron decay: $n \rightarrow p + e^- + v_e$

The following diagram is a Feynman diagram with a sequence from bottom to top.

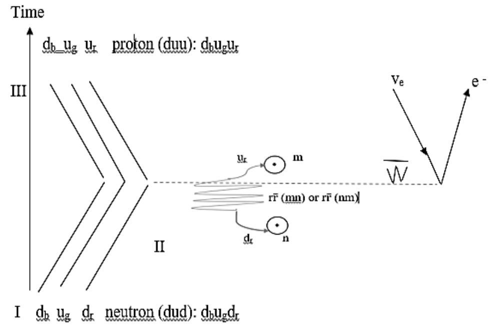


Fig.15. Neutron decay (weak interaction) and the Feynman diagram

The decay steps are as follows:

I) Neutron (($d_b u_g d_r$)) before the beginning of the decay.

II) Quark (d_r) vertex: Neutron decay: The electric charge of the (d) quark (-1/3) changes to the charge of the (u) quark (+2/3) in the Feynman diagram plus the $\overline{W}$ boson : $d_r \rightarrow u_r + \overline{W}$ & $\overline{W} \rightarrow e^- + v_e$

(-1/3) (e)-> (+2/3) (e) – (e) Charge Conservation

Furthermore, the difference in mass energy between the sides of the (d) quark in the neutron and the (u) quark in the proton is offset by the binding energy of the quarks in these two baryons and also by the decay energy β. Thus, quark (d) changes to quark (u). The half-life of neutron decay is 15 minutes [11], [12].

III) The proton is produced.

Strong Interaction: Gluons are the force carriers in the strong interactions as the nuclear interactions: proton and neutron interactions. The protons and neutrons are held tightly together and bound in the nucleus by the gluons. Furthermore, the exchange of pions occurs in the strong interaction between protons and neutrons in the nucleus. Also, in the short-range interaction between nucleon and nucleon, there is a residual color mediating force. The gluon generates a color change between the quarks and they are the exchange particles of the color force between the quarks (just as photons are the exchange particles between two charged particles in the electromagnetic force). The hadron is composed of quarks, a dynamic cloud of gluons, and virtual pairs of quark-antiquarks in equilibrium [11], [12].

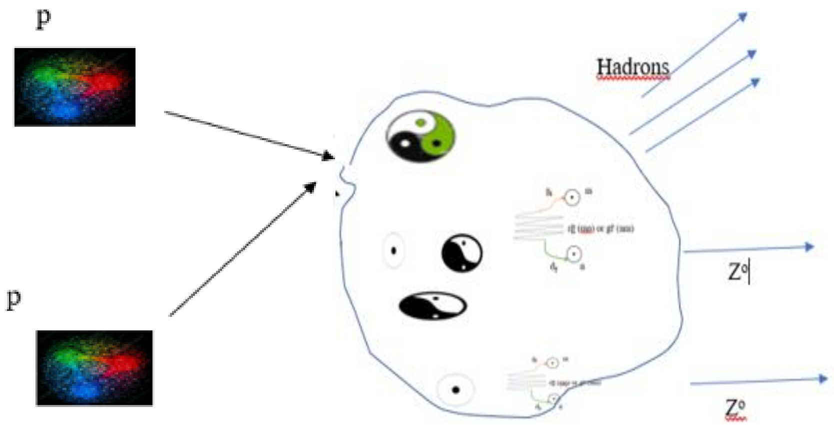
Quark-gluon plasma exists at an extremely high temperature of about 2.5×10^{12} Kelvin, and its density is too high. Free quarks and gluons, which are the building blocks of matter, are believed to have existed a few microseconds after the "Big Bang". According to the theory, the universe was initially very hot and made up of free quark, antiquark, and gluon gases. This gas is called quark-gluon plasma (QGP). It is needed to be able to recreate and study the quark-gluon plasma in the laboratory. Nevertheless, instead of “Bing Bang” it should be called “Micro Bang” [11], [12].

The following example considers the head-on collision of two protons with extremely high energy. For a short time, the temperature and pressure will rise in the collision area, the distance between the quarks decreases by about 0.1 fm, and the quarks are released with this high energy. Many new pions, new quarks, and antiquarks will be produced. For the sake of momentum existence, the distance between quarks will increase and they will cool to a distance of about one fm and there will be interaction between quarks and antiquarks. Consequently, interactions between these quarks cause hadrons to form [11], [12].

Experiments at CERN's super proton synchrotron first attempted to create QGPs in the last century and may have been partially successful, and such experiments are still being performed today at Brookhaven National Laboratory with the Relativistic Heavy Ion Collider. Head-on collisions between two high-energy protons (construction quark of the proton is uud), can produce several hadrons, whose constituents are quarks and very massive particles such as Z^o boson [11], [12].

$p + p \rightarrow \text{hadrons} + 2Z^o$

Mediterranean Journal of Basic and Applied Sciences (MJBAS)
Volume 6, Issue 3, Pages 01-34, July-September 2022



Soup of quarks and gluons

Fig.16. Proton-proton head-on collision with hadron productions

6.5. Nuclear Physics Questions answered easily with mass symmetry: mass and mass cloud: The Yin Yang

No Single Quark Particle

The strong interaction between the mass clouds of quarks produces the binding of the quarks through mediating particles called gluons. Then, the mass cloud interaction between quarks is the one that produces the binding of the quarks, and thus, there cannot be a single quark in a particle, because it has nowhere to bond or adhere.

Quark Confinement

Quark Confinement means that it is impossible even with a high-energy accelerator to separate a quark from its particle. By hypothesis, there are very strong interactions between the mass clouds of quarks and thus, so far not a single quark could be separated from the particle. Nevertheless, the quark and its antiquark can be produced by a reaction like: $e^{+} + e^{-} \rightarrow q + \bar{q}$

Origin of Nuclear Force and Quark Energy

In Nuclear Physics, the strong nuclear force and the binding energy between the nucleons in the nucleus are generally mentioned without giving any details of what the origin of this force is. Thus, by relating this question to the interaction between mass clouds between quarks due to the mass duality of quarks: mass, and mass cloud, it is very simple and obvious to explain the origin of the nuclear force and nuclear binding energy.

The forces between two quarks in the nucleon are mediated by the exchange of gluons. These forces have very strong interaction and have a short range (1fm). On the other hand, the binding energy of the nucleons in the nucleus is about 8 MeV, which is much less than the binding energy between the quarks in a particle.

Gluons are mainly exchanged between two quarks in a nucleon. Some small fractions of the gluons in a nucleon, instead of exchanging between two quarks in a nucleon, can exchange between two quarks, which are in the neighborhood of a nucleon with another nucleon. In this case, these two nucleons come together. Considering a simple example, the deuteron which has one proton and one neutron with the exchange of some fractions of a number of gluons between the quark of the proton, and the quark of the neutron, this causes its binding energy to be

2.225 MeV. For heavy nuclei, the same thing happens to neighboring nucleons, and so the heavy nucleus is formed.

In this way, the nuclear binding energy originates from the binding energy of the mass cloud of the quarks, and instead of the term "Nuclear Energy", should be used as "Quark Energy" [11], [12]. On other hand, there are particles with two quarks (mesons), particles with three quarks (baryons) and then, it is very probable to find particles with more than three quarks (quaternions).

7. Conclusions

Since in nature there is symmetry, there should also be symmetry in physics since physics describes the phenomena of nature. In Physics, there is symmetry between the forces and their interactions: electric charges, electric dipoles, magnetic poles, magnetic bars (rods or compass), spins of electrons at the atom, and spins of the nucleons in the nucleus. Then, the particle mass must also have this symmetry: mass duality. For convenience and due to later explanations, I call this mass symmetry or mass duality as follows: mass and mass cloud.

If two particles are close to each other, the mass cloud of one of them interacts with the mass cloud of the other particle. In this interaction, the loss of the mass clouds of the two particles will be converted into electromagnetic energy according to Einstein's equation: $E=mc^2$ and the variant mass formula discovered and developed by myself. Furthermore, as mentioned in the postulates, the mass m and the mass cloud m* of the same particle have the same value: m*=m. Besides, the mass of a particle cannot interact with the mass cloud of the same particle, neither partially nor totally. However, the interaction occurs between the mass cloud of one particle and the mass cloud of another particle, either partially or totally. If the interaction is between particle and antiparticle, there is a conversion of the total mass (mass and cloud mass) in electromagnetic energy or photons.

For the proton, part of the mass of the uncharged proton is distributed in the orbital or mass cloud around the nucleus mass that contains the positive charge. For the electron, part of the mass of the uncharged electron is distributed in the orbital or mass cloud around the nucleus mass that contains the negative charge.

For example, in the formation of the hydrogen atom, a part of the mass cloud of the proton interacts with the mass cloud of the electron, and the total mass-energy lost in this interaction is transformed into electromagnetic energy or photons according to Einstein's equation: $E=mc^2$ and the variant mass formula discovered and developed by myself. Then, the two particles join together due to this mass cloud interaction and the electrostatic force between the two particles. Then, it is right this mass symmetry: mass and mass cloud, since the electron and the proton in the interaction of the mass cloud lose mass but do not lose electric charge.

In this mass symmetry, the mass cloud is located in the respective orbitals which represent the possible locations or places of the particle determined probabilistically by the respective Schröndiger equation. The mathematical solution of the Schrödinger equation for the hydrogen atom with Coulomb potential energy is obtained for the quantum numbers n, l, ml for different quantum energy levels or energy shells. The figures of the variation of the electron probability density P(r) versus r for these shells in which the electron and proton are bound together in the hydrogen atom are shown at the research article. In addition to the probability of finding electrons in these shells, the bond is produced by the distribution of the mass cloud of the proton. Thus, the mass cloud of the proton interacts with the mass cloud of the electron, resulting in the bonding of the two particles.

Also, the mass symmetry is demonstrated for the Hydrogen Atom, Ionized Helium Atom, Helium Nucleus, Muonic Atom, and Deuteron. The extrapolation of the figure of the energy of the shells or energy levels (E) versus (r) for the hydrogen atom is used for the muonic atom where the muon is in the shell or energy level instead of the electron. The interaction of the mass cloud of the muon and the proton produces the bond between the two particles. The coordinates of r and E coincide with the extrapolation of the curve of E versus r.

In the interaction between the particle and its antiparticle, the conversion of energies of the total mass (mass and mass cloud) of the particle and antiparticle into electromagnetic energy takes place. The mass symmetry is demonstrated for the Electron, Positron, Proton and Antiproton, Muon and Antimuon, Neutral Pion and Neutral Antipion.

In addition, the mass symmetry is demonstrated for Diatomic Molecules as the Hydrogen molecule H_2, Ionized Hydrogen molecule H_2^{+}, and the Oxygen Molecule O_2. The results of the application of the variant mass formula in obtaining the binding energy largely agree with the experimental results.

The main function of the mass cloud is the binding energy. The mass cloud interaction generates binding energy between the electrons and the nucleus in the atom through the protons and between the nucleons in the nucleus: protons with protons, neutrons with neutrons, and protons with neutrons. The nuclear force between two nucleons is characterized by being strong and short-range. These properties of the nuclear force between nucleons are explained by the interactions of the mass clouds between the nucleons.

Besides, there is also the same mass symmetry for the mass of quarks: mass and mass cloud. There are strong interactions between the mass clouds of quarks. Thus, some of the properties of the quark can be justified:

[1] In the particle families, baryons have three quarks, mesons have two quarks, and leptons have no quarks. The reason that leptons do not have any quarks is that the binding energy between the mass clouds of quarks causes the interaction between two and three quarks and therefore an individual quark cannot bind or adhere to the particle.

[2] Since the binding energy between the mass cloud of the quarks inside the particle is very strong, separating a quark from the hadrons is not possible at present. This shows that quarks are confined within hadrons and this is also another justification for the properties of quarks: quark confinement.

[3] A quark in a nucleon that is in the nucleus is expected to have effects on the quark in the nucleons that are around that nucleon through the mass cloud interaction. Thus, this is the exchange of a small fraction of the number of gluons between these two quarks of two different nucleons that causes these two nucleons to join. The binding energy is about +8MeV, which is much less than the binding energy between two quarks in a nucleon. Consequently, nuclear energy originates from the strong interaction between the mass cloud of the quarks.

These properties of quarks were explained and proved simply by considering that quarks have mass duality: mass and mass cloud. Therefore, quarks cannot be considered as particles without composite construction and quarks are not elementary particles. On other hand, there are particles with two quarks (mesons), particles with three quarks (baryons) and then, it is very probable to find particles with more than three quarks (quaternions).

Therefore, this scientific research presents evidence of the existence of mass symmetry: mass and mass cloud based on Einstein's equation and in the Variant Mass formula for the Electron in the atom discovered and demonstrated by myself where theoretical and experimental results are detailed.

Declarations

Source of Funding

This research did not receive any grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing Interests Statement

The author declares no competing financial, professional, or personal interests.

Consent for publication

The author declares that he/she consented to the publication of this research work.

Availability of data and material

The author is willing to share the data and material according to relevant needs.

References

[1] Giovanni Alcocer. (2020). The Fundament of the Mass: The Variant Mass of Electron at Atom. Meditteranean Journal of Basic and Applied Sciences, 4(4): 18-113.

[2] Giovanni Alcocer. (2020). Variant Mass for an accelerated charged Particle. Asian Journal of Basic Science & Research, 2(3): 43-59.

[3] Giovanni Alcocer. (2020). The fundament of the Mass and Effects of the Gravitation on a Particle and Light in the Mass, Time, Distance, Velocity, Frequency, Wavelength: Variant Mass for a Particle which emits Gravitational Energy for a Particle Orbiting a large Planet or Sun for a Binary Star and Variant Frequency for the Light Passing Close a Gravitational Field from a Massive Object (Sun), Mediterranean Journal of Basic and Applied Sciences, 4(3): 42-69.

[4] Giovanni Alcocer. (2021). X-Rays Fluorescence & Compton Experiment, Variant Mass of the Electron at the Atom & Variant Mass for an Accelerated Charged Particle (Maxwell Radiation). Meditteranean Journal of Basic and Applied Sciences, 5(3): 48-123.

[5] Giovanni Alcocer. (2021). X-Rays and Electron Diffraction & Interference and Diffraction for the electron by using the Fourier Approach and Wave Properties, The Variant Mass of the Electron at the Atom & The Variant Mass for an Accelerated Charged Particle (Maxwell Radiation). Meditteranean Journal of Basic and Applied Sciences, 5(4): 51-119.

[6] Rasoul Javahery, Existence of Negative Mass Based on Einstein´s Equation E=mc2, University of Tehran, The General Science Journal.

[7] Jorge Sanchez Sanchez. (1980). Física Molecular y Estado Sólido, Editorial Limusa, México.

[8] Serway, Física. (1993). Mc Graw Hill, México.

[9] Paul Tipler, Física Moderna. (1969). Ediciones URMO, USA.

[10] Daniele Sasso. (2010). On the Physical Structure of Radiant Energy: Waves and Corpuscles.

[11] Rasoul Javahery, Simple Explanations of Quark Properties, University of Tehran, The General Science Journal.

[12] Giovanni Alcocer. (2022). Mass Symmetry. Meditteranean Journal of Basic and Applied Sciences, 6(1): 75-101.