

Calculating the energy of electron in H-atom using modified SUSY physics

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Abstract: In this paper considering the authors previously proposed SUSY concept - ‘fermion and boson mass ratio is close to 2.26’ and considering the electroweak neutral boson, an attempt is made to understand the total energy of revolving electron in the Hydrogen atom. Thus in this paper authors succeeded in extending the basic applications of SUSY and Electroweak theory to atomic level. With further research and analysis, the hidden secrets of electroweak unification can be understood very easily.

Keywords: SUSY, Z boson, Hydrogen atom, Revolving electron’s total energy.

1. INTRODUCTION

In the earlier published papers the authors proposed that, any fermion and its corresponding boson mass ratio is close to 2.26 but not unity [1-7]. In this paper an attempt is made to understand the total energy of revolving electron in Hydrogen atom with the help of SUSY and neutral electroweak boson. In this new proposal it is noticed that, bosonic form of the electron, bosonic form of the proton and neutral weak boson play a crucial role. The two interesting things are - revolving electron’s total is a function of geometric mean mass of proton and electron and is independent of the reduced Planck’s constant. But in order to understand the discrete nature of Hydrogen spectrum it seems to be a must to consider the concept - “maximum number of electrons in a shell = $2n^2$ where $n = 1,2,3,..$ ”.

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Seshavatharam, U.V.S. **2. HISTORY OF SUPERSYMMETRY**

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In particle physics, supersymmetry (often abbreviated SUSY) is a proposed symmetry of nature [8-11] relating two basic classes of elementary particles: bosons, which have an integer-valued spin, and fermions, which have a half-integer spin. Each particle from one group is associated with a particle from the other, called its superpartner, whose spin differs by a half-integer. In a theory with unbroken supersymmetry each pair of superpartners shares the same mass and internal quantum numbers besides spin, but since no superpartners have been observed yet, supersymmetry must be a spontaneously broken symmetry. A supersymmetry relating mesons and baryons was first proposed, in the context of hadronic physics, by Hironari Miyazawa in 1966. This supersymmetry did not involve space-time, that is it concerned internal symmetry, and was badly broken. His work was largely ignored at the time. J. L. Gervais and B. Sakita (in 1971), Yu. A. Golfand and E. P. Likhtman (also in 1971), and D.V. Volkov and V.P. Akulov (in 1972), independently rediscovered supersymmetry in the context of quantum field theory, a radically new type of symmetry of space-time and fundamental fields, which establishes a relationship between elementary particles of different quantum nature, bosons and fermions, and unifies space-time and internal symmetries of the microscopic world. Supersymmetry with a consistent Lie-algebraic graded structure on which the Gervais-Sakita rediscovery was based directly first arose in 1971 in the context of an early version of string theory by Pierre Ramond, John H. Schwarz and André Neveu. Finally, J. Wess and B. Zumino (in 1974) identified the characteristic renormalization features of four dimensional supersymmetric field theories, which singled them out as remarkable QFTs, and they and Abdus Salam [12] and their fellow researchers introduced early particle physics applications. The mathematical structure of supersymmetry (Graded Lie superalgebras) has subsequently been applied successfully to other areas of physics, in a variety of fields, ranging from nuclear physics, critical phenomena, quantum mechanics to statistical physics. It remains a vital part of many proposed theories of physics. The first realistic supersymmetric version of the Standard Model was proposed in 1981 by Howard Geogi and Savas Dimopoulos and is called the Minimal Supersymmetric Standard Model or MSSM for short. It was proposed to solve the hierarchy problem and predicts superpartners with masses between 100 GeV and 1 TeV. Supersymmetry is also motivated by solutions to several theoretical problems, for generally providing many desirable mathematical properties and for ensuring sensible behavior at high energies. Supersymmetric quantum field theory is often much easier to analyze, as many more problems become exactly solvable. When supersymmetry is imposed as a localsymmetry, Einstein's theory of general relativity is included

automatically, and the result is said to be a theory of supergravity. It is also a feature of a candidate of a theory of everything, superstring theory.

3. CURRENT STATUS OF SUSY

The Large Hadron Collider at CERN is currently producing the world's highest energy collisions and offers the best chance at discovering superparticles for the foreseeable future. As of September 2012, no meaningful signs of the superpartners have been observed. The failure of the Large Hadron Collider to find evidence for supersymmetry has led some physicists to suggest that the theory should be abandoned. Experiments with the Large Hadron Collider yielded an extremely rare particle decay event, casting doubt on the scientific theory of supersymmetry. Supersymmetry differs notably from currently known symmetries in that its corresponding conserved charge (via Noether's theorem) is a fermion called a supercharge and carrying spin-1/2, as opposed to a scalar (spin-0) or vector (spin-1). A supersymmetry may also be interpreted as new fermionic (anticommuting) dimensions of spacetime, superpartners of the usual bosonic spacetime coordinates, and in this formulation the theory is said to live in superspace.

Currently there is only indirect evidence for the existence of supersymmetry, primarily in the form of evidence for gauge coupling unification. A central motivation for supersymmetry close to the TeV energy scale is the resolution of the hierarchy problem of the Standard Model. Without the extra supersymmetric particles, the Higgs boson mass is subject to quantum corrections which are so large as to naturally drive it close to the Planck mass barring its fine tuning to an extraordinarily tiny value. In the supersymmetric theory, on the other hand, these quantum corrections are canceled by those from the corresponding superpartners above the supersymmetry breaking scale, which becomes the new characteristic natural scale for the Higgs mass. Other attractive features of TeV-scale supersymmetry are the fact that it often provides a candidate dark matter particle at a mass scale consistent with thermal relic abundance calculations, provides a natural mechanism for electroweak symmetry breaking and allows for the precise high-energy unification of the weak, the strong and electromagnetic interactions. Therefore, scenarios where supersymmetric partners appear with masses not much greater than 1 TeV are considered the most well-motivated by theorists. These scenarios would imply that experimental traces of the superpartners should begin to emerge in high-energy collisions at the LHC relatively soon. As of 2012, no meaningful signs of the superpartners have been observed, which is beginning to significantly constrain the most popular incarnations of supersymmetry [13].

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In particle physics, the weak interaction is the mechanism responsible for the weak force or weak nuclear force, one of the four fundamental interactions of nature, alongside the strong interaction, electromagnetism, and gravitation [14]. The theory of the weak interaction is sometimes called quantum flavordynamics (QFD), in analogy with the terms QCD and QED, but in practice the term is rarely used because the weak force is best understood in terms of electro-weak theory (EWT). In the Standard Model of particle physics the weak interaction is caused by the emission or absorption of Wand Z bosons [15,16]. All known fermions interact through the weak interaction. Fermions are particles one of whose properties, spin, is a half-integer. A fermion can be an elementary particle, such as the electron; or it can be a composite particle, such as the proton. W and Z bosons are much heavier than protons or neutrons and this heaviness means that the weak force has a very short range. The force is termed ‘weak’ because its field strength over a given distance is typically several orders of magnitude less than that of the strong nuclear force and electromagnetism. The weak interaction is responsible for the existence and structure of atomic nuclei, and is responsible for both the radioactive decay and nuclear fusion of subatomic particles. Most fermions will decay by a weak interaction over time. Important examples include beta decay, and the production of deuterium and then helium from hydrogen that powers the sun’s thermonuclear process. Such decay also makes radiocarbon dating possible, as carbon-14 decays through the weak interaction to nitrogen-14. It can also create radio luminescence, commonly used in tritium illumination, and in the related field of betavoltaics. Quarks, which make up composite particles like neutrons and protons, come in six “flavours” - up, down, strange, charm, top and bottom – which give those composite particles their properties. The weak interaction is unique in that it allows for quarks to swap their flavour for another. For example, during beta minus decay, a down quark decays into a up quark, converting a neutron to a proton. In addition, the weak interaction is the only fundamental interaction that breaks parity-symmetry, and similarly, the only one to break CP-symmetry.

5. MODIFIED SUPER SYMMETRY

In modified Super symmetry, the authors already proposed and established that [1-7],

1. Fermion and its corresponding boson mass ratio is close to 2.2627 but not unity.

$$\frac{m_f}{m_b} \cong \Psi \cong 2.2627 \quad (1)$$

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Here, m_f represents the mass of fermion and m_b represents its corresponding mass of boson and Ψ is the proposed empirical SUSY ratio to be estimated with a suitable theory [1,2] or to be fitted from particle mass data [17]. This idea can be applied to leptons, quarks and nucleons.

2. All the observed mesons are SUSY bosons only [3].
3. Presently believed charged electroweak boson is nothing but the top quark boson [1,2, 17].
4. There exists a charged Higgs fermion of rest mass m_{xf} and its corresponding charged Higgs boson mass is [1,2,7]

$$m_{xb} \cong \frac{m_{xf}}{\Psi} \quad (2)$$

5. Charged Higgs boson pair generates the observed [17] electroweak neutral boson, (m_z). Based on this idea, Charged Higgs boson rest energy can be expressed as $m_{xb}c^2 \cong \frac{m_zc^2}{2} \cong 45594$ MeV and its corresponding Higgs fermion rest energy can be expressed as $m_{xf}c^2 \cong \Psi m_{xb}c^2 \cong \Psi \left(\frac{m_zc^2}{2} \right) \cong 103150$ MeV .
6. Charged Higgs boson and the presently believed charged electroweak boson jointly generates a neutral boson of rest energy 126 GeV [1,2,17,18].

In particle physics authors explained the various applications of this modified SUSY in the published papers [1-7]. In the following section an attempt is made to estimate or fit the total energy of electron in Hydrogen atom.

6. TO UNDERSTAND THE TOTAL ENERGY OF ELECTRON IN HYDROGEN ATOM

It is noticed that, neutral electroweak boson plays an interesting role in estimating the total energy of electron. It can be understood in the following way. Let E_p , E_k and E_T represent the revolving electron's, potential, kinetic and total energies respectively in any orbit or shell [19,20] . If m_p , m_e and m_z represent the rest masses of proton, electron and neutral weak boson respectively, it is noticed that,

$$E_p \cong - \left(\frac{(\sqrt{m_p m_e} / \Psi)}{m_z} \right) \frac{m_e c^2}{2n^2} \quad (3)$$

Seshavatharam, U.V.S. Accuracy point of view, here LHS is equal to 27.2114 eV and RHS is equal to Lakshminarayana, S. 27.118 eV and error is 0.34%. Here in this relation please note the following 5 points.

A) $\Psi \cong 2.26237$ is the proposed empirical super symmetric fermion and boson mass ratio [10,11] .

B) In the ratio $\left(\frac{\sqrt{m_p m_e} / \Psi}{m_z} \right)$, $\frac{\sqrt{m_p m_e}}{\Psi} \cong \sqrt{\left(\frac{m_p}{\Psi} \right) \left(\frac{m_e}{\Psi} \right)} \cong m_e$ can be considered as the geometric mean mass of the bosonic form of the proton $\left(\frac{m_p}{\Psi} \right)$ and the bosonic form of the electron $\left(\frac{m_e}{\Psi} \right)$. So far authors could find many evidences for the independent existence of $\left(\frac{m_p}{\Psi} \right)$ but could not find the evidence for the independent existence for $\left(\frac{m_e}{\Psi} \right)$. It is for further study. If one is willing to replace the electron mass by the Muon mass [17], automatically charged pion mass can be fitted as $\frac{\sqrt{m_p m_\mu}}{\Psi} \cong 139.2$ MeV . This is one best evidence for the proposed new Susy concepts. In reference [1] authors proposed that strange quark boson rest energy is 67.4 MeV. Strange quark boson pair generates the observed neutral pion of rest energy 135 MeV.

C) $\left(\frac{m_p}{\Psi} \right) \cong 415$ MeV boson plays a crucial role in understanding the presently believed strange mesons and light vector mesons. It's first excited state is $(2)^{\frac{1}{4}} . 415 \cong 493$ MeV and can be compared with the charged strange K meson. It couples with up boson of rest energy 1.94 MeV and generates a neutral ground state meson with 417 MeV. First excited state of 417 MeV is $(2)^{\frac{1}{4}} . 417 \cong 496$ MeV and can be compared with the neutral K meson [1]. 415 MeV pair generates a neutral meson of rest energy 830 MeV. Its first excited state is $(2)^{\frac{1}{4}} . 830 \cong 987$ MeV. 415 MeV couples with up quark meson [1,2] of rest energy 368 MeV and generates 783 light meson. Similarly it couples with down quark meson of rest energy 475 MeV and generates 890 light meson.

D) Please be noted that $\frac{\sqrt{m_p m_e} c^2}{\Psi} \cong m_e c^2 \cong 9.68$ MeV can be considered as the ground state of the charged Pion and can be called as the EPION [3]. Here

one may ask the fundamental questions -1) So far why could not we see the boson 9.68 MeV. 2) What is the significance of the proposed 9.68 MeV boson in nuclear physics? Here authors emphasize the fact that, 9.68 MeV can be considered as the ground state nuclear force carrier and plays a crucial role in binding the nucleons. Based on this proposal semi empirical mass formula energy coefficients can be fitted very easily. For detailed information please see section (8).

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- E) At $n = 1, 2, 3, \dots$ ($2n^2$) represents the total number of electrons in any principle quantum number or quantum shell. Please be noted that, in Hydrogen atom, only one electron may be existing but from 'atomic nature' point of view, ($2n^2$) may be given some role in this relation. From modern theory of Hydrogen atom, maximum number of electrons that can be accommodated in any principal quantum shell are ($2n^2$) where $n=1, 2, 3$. This proposal can be reinterpreted as follows: In Hydrogen atom, in n principal quantum shell, electron can exist in ($2n^2$) different states.

By any reason, if kinetic energy is equal to half the magnitude of potential energy, then

$$E_K \cong \left(\frac{(\sqrt{m_p m_e} / \Psi)}{m_z} \right) \frac{m_e c^2}{4n^2} \quad (4)$$

Now total energy of electron in any principle quantum shell can be expressed as

$$E_T \cong E_p + E_K \cong - \left(\frac{(\sqrt{m_p m_e} / \Psi)}{m_z} \right) \frac{m_e c^2}{4n^2} \quad (5)$$

Now based on the jumping nature of electron, in Hydrogen atom, emitted photon's energy can be expressed as

$$E_{\text{photon}} \cong \left(\frac{(\sqrt{m_p m_e} / \Psi)}{m_z} \right) \frac{m_e c^2}{4} \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \quad (6)$$

where $n_2 > n_1$. In all these relations one very interesting thing is that, rest mass of proton and rest mass of electron jointly play a crucial role in estimating the revolving electron total energy. Another interesting thing is that in all these relations accuracy mainly depends upon the SUSY number (Ψ). If one is willing to think in this direction, (Ψ) can also be fitted accurately from these relations also. If so its value will be close to 2.254.

7. BOHR RADII IN HYDROGEN ATOM

Now from above expressions, in Hydrogen atom, Bohr radii can be expressed as

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$$a_n \cong (2n^2) \left(\frac{m_z}{(\sqrt{m_p m_e} / \Psi)} \right) \frac{e^2}{4\pi\epsilon_0 m_e c^2} \quad (7)$$

This is a very interesting expression and is very simple to understand and to easy to analyze. From this relation, electron's revolving velocity in any orbit or shell can be expressed as

$$v_n \cong \frac{1}{\sqrt{2n^2}} \sqrt{\frac{(\sqrt{m_p m_e} / \Psi)}{m_z}} \cdot c \quad (8)$$

Angular momentum of electron in any orbit or shell can be expressed as

$$m_e v_n a_n \cong \sqrt{2n^2} \sqrt{\frac{m_z}{(\sqrt{m_p m_e} / \Psi)}} \cdot \frac{e^2}{4\pi\epsilon_0 c} \quad (9)$$

At $n = 1$ the fine structure ratio can be expressed as

$$\alpha \cong \frac{1}{\sqrt{2}} \sqrt{\frac{(\sqrt{m_p m_e} / \Psi)}{m_z}} \cong \sqrt{\frac{(\sqrt{m_p m_e} / \Psi)}{2m_z}} \quad (10)$$

8. TO FIT AND CO-RELATE THE SEMI EMPIRICAL MASS FORMULA ENERGY COEFFICIENTS WITH THE PROPOSED 9.68 MEV PROTON-ELECTRON SUSY BOSON

In nuclear physics, the semi-empirical mass formula is used to approximate the mass and various other properties of an atomic nucleus. As the name suggests, it is based partly on theory and partly on empirical measurements [21-23]. The theory is based on the liquid drop model proposed by George Gamow, which can account for most of the terms in the formula and gives rough estimates for the values of the coefficients. It was first formulated in 1935 by German physicist Carl Friedrich von Weizsacker, and although refinements have been made to the coefficients over the years, the structure of the formula remains the same today. It gives a good approximation for atomic masses and several other effects, but does not explain the appearance of magic numbers. In modern nuclear physics the corresponding semi empirical relation can be expressed as follows.

$$B = a_v A - a_s A^{2/3} - a_c \frac{Z(Z-1)}{A^{1/3}} - a_a \frac{(A-2Z)^2}{A} \pm \frac{a_p}{\sqrt{A}} \quad (11)$$

Here a_v = volume energy coefficient, a_s is the surface energy coefficient, a_c is the coulomb energy coefficient, a_a is the asymmetry energy coefficient and a_p is the pairing energy coefficient.

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Let
$$\frac{m_n - m_p}{m_e} \cong \ln(4\pi) \cong k \quad (12)$$

Here, m_n , m_p , and m_e represent the rest masses of neutron, proton and electron respectively. This is a discovery and is an accurate relation. Let

$$\Psi \cong \frac{\sqrt{m_p m_\mu}}{m_\pi^\pm} \cong 2.256 \quad (13)$$

where $m_\mu \cong 105.66 \text{ MeV} / c^2$ is the rest mass of muon and $m_\pi^\pm \cong 139.57 \text{ MeV} / c^2$ is the charged pion rest mass. Let

$$E_x \cong m_{\nu} c^2 \cong \frac{\sqrt{m_p m_e}}{\Psi} c^2 \cong \sqrt{\frac{m_e}{m_\mu}} \cdot m_\pi^\pm c^2 \cong 9.7 \text{ MeV} \quad (14)$$

It can be considered as the ground state nuclear force carrier. With this energy unit SEMF energy coefficients can be fitted in the following semi empirical approach.

a) The coulombic energy coefficient can be expressed in the following way.

$$a_c \cong e^{-k} E_x \cong 0.772 \text{ MeV} \quad (15)$$

b) The asymmetry energy coefficient can be expressed in the following way.

$$\frac{a_a + a_c}{E_x} \cong k \rightarrow a_a \cong k E_x - a_c \cong (k - e^{-k}) E_x \cong 23.78 \text{ MeV} \cong 23.8 \text{ MeV} \quad (16)$$

c) The pairing energy coefficient can be expressed as

$$a_p \cong \frac{1}{2} a_a \cong 11.89 \text{ MeV} \cong 11.9 \text{ MeV} \quad (17)$$

d) The surface energy coefficient can be expressed as

$$a_s \cong \frac{a_a + a_p}{2} + 2a_c \cong 19.38 \text{ MeV} \cong 2E_x \cong 19.4 \text{ MeV} \quad (18)$$

e) The volume energy coefficient can be expressed as

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$$a_v \cong \frac{a_a + a_p}{2} - 2a_c \cong 16.29 \text{ MeV} \cong 16.3 \text{ MeV} \quad (19)$$

Thus

$$(a_s, a_v) \cong \frac{a_a + a_p}{2} \pm 2a_c \quad (20)$$

$$a_v + a_s \cong a_p + a_a \cong 3a_p \quad (21)$$

For light and heavy atoms (including super heavy stable isotopes), proton-nucleon stability relation can be expressed as

$$A_s \cong 2Z + (e^{-k}Z)^2 \cong 2Z + \left(Z \cdot \frac{a_c}{E_x} \right)^2 \cong 2Z + \left(\frac{Z}{4\pi} \right)^2 \quad (22)$$

Table-1: To fit the stable mass numbers of Z

S.No	Z	A_s
1	21	44.80
2	29	63.33
3	37	82.67
4	47	108.0
5	53	123.79
6	60	142.80
7	69	168.15
8	79	197.52
9	83	209.62
10	92	237.60
11	100	263.33
12	112	303.43

where A_s can be considered as the stable mass number of Z and

$$A_s - 2Z \cong (e^{-k}Z)^2 \cong \left(\frac{Z}{4\pi} \right)^2 \quad (23)$$

Table-2: Existing and proposed SEMF binding energy coefficients.

Existing energy coefficients	$a_v \cong 15.78$ MeV	$a_v \cong 18.34$ MeV	$a_c \cong 0.71$ MeV	$a_a \cong 23.21$ MeV	$a_p \cong 12.0$ MeV
Proposed energy coefficients	$a_v \cong 16.3$ MeV	$a_v \cong 19.4$ MeV	$a_c \cong 0.772$ MeV	$a_a \cong 23.8$ MeV	$a_p \cong 11.9$ MeV

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Table-3: To fit SEMF binding energy.

Z	A	$(BE)_{cal}$ in MeV	$(BE)_{meas}$ in MeV
26	56	492.5	492.254
28	62	546.9	545.259
34	84	728.1	727.341
50	118	1006.8	1004.950
60	142	1182.6	1185.145
79	197	1553.0	1559.40
82	208	1623.2	1636.44
92	238	1799.8	1801.693

Please see table-1 for fitting the proton number and its corresponding stable mass number.

Please see table-2 for the comparison of the semi empirical mass formula energy coefficients.

Please see table-3 for the obtained semi empirical mass formula based nuclear binding energy.

9. DISCUSSION AND CONCLUSIONS

It is very interesting to that, the above given expressions are very simple to understand and very simple to implement. In physics history it is already well established that, electroweak bosons play a crucial role in neutron - proton decay. Now it is also very clear that, the electroweak neutral boson plays a crucial role in understanding the presently believed electromagnetic interaction that connects proton and the electron. Thus in this paper authors made a successful attempt to extend the basic applications of SUSY and Electroweak theory to atomic level. One very interesting thing is that, all the proposed expressions are independent of the famous reduced Planck's constant. In this

Seshavatharam, U.V.S. regard with further research and analysis, other hidden secrets of electroweak
 Lakshminarayana, S. unification can be understood [24,25] easily. Now the fundamental question to
 be answered is – How to extend these relations to other atoms where $Z > 1$?
 Authors are working in this new direction and will be discussed in near future.
 If one is willing to the consider the concepts (Zm_p) and (Zm_e) , with reference to
 the relation (3), where $Z > 1$, potential energy of one electron can be expressed
 as follows.

$$E_p \cong - \left(\frac{\left(\sqrt{(Zm_p)(Zm_e)} / \Psi \right)}{m_z} \right) \frac{Zm_e c^2}{2n^2} \cong -Z^2 \left(\frac{\left(\sqrt{m_p m_e} / \Psi \right)}{m_z} \right) \frac{m_e c^2}{2n^2} \quad (24)$$

Similarly with reference to the relation (5), where $Z > 1$, total energy of
 one electron can be expressed as follows.

$$E_T \cong - \left(\frac{\left(\sqrt{(Zm_p)(Zm_e)} / \Psi \right)}{m_z} \right) \frac{Zm_e c^2}{4n^2} \cong -Z^2 \left(\frac{\left(\sqrt{m_p m_e} / \Psi \right)}{m_z} \right) \frac{m_e c^2}{4n^2} \quad (25)$$

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