New Model of Hydrogen Atom and Its Mathematical Verification

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Abstract

Based on Bohr's model of hydrogen atom, the main purpose of this text is to propose a new hypothesis for the model of hydrogen atom and perform mathematical calculations and verifications using experimental values and physical constants. The new model can not only provide the explanations that the existing theories failed to provide, but also can be used to construct neutrons, atomic nuclei, and individual atoms and molecules by involving only electrons and protons and their interactions. This means we only need to know how single electron and proton interact with each other, then we can establish a full model of hydrogen atom, and then we can establish other atomic nuclei. After all, all matter in the universe is made from hydrogen atoms through nuclear fusion.

Keywords

Hydrogen atoms, orbit, line spectra, electromagnetic interactions

1. Introduction

Based on Bohr's model of hydrogen atom, this text is to propose a new hypothesis for the model of hydrogen atom, and then use the physical quantities such as hydrogen atom spectrum values, electron mass, electron charge, vacuum dielectric constant, Rydberg constant, and speed of light, and apply the proposed model to calculate electron force, traveling distance, kinetic energy, etc., and then calculate the electron velocity and Planck's constant and compare them with the reference values to prove the validity of the model.

2. Deficiencies in Existing Theories Explaining Hydrogen Atoms and Hydrogen Spectra

The existing theories are merely mathematical manipulations, and their underlying physical models are incomplete and deficient, and there are many questions left unanswered. Moreover, some established explanations about the physical mechanism for hydrogen atoms are wrong and confusing. The major defects and deficiencies of the existing theories are listed below:

(1) Failure to explain where the energy levels (ground state, excited state or quantum state) inside the hydrogen atom come from and in what form they exist;
(2) Failure to explain how all the energy levels within the hydrogen atom are distributed around the single proton, what are their positions relative to the nucleus, and what are the relative positions or distance between each energy levels;
(3) Failure to explain whether or not the energy levels exist depending on the existence of electron, that is to say if the only one electron in the hydrogen atom is stripped away, will these energy levels still exist around a single proton;
(4) How is the amount of energy at each energy level distributed inside the hydrogen atom, and what is the difference in the amounts of energy across all energy levels;
(5) Failure to explain how electron transit between energy levels, and whether or not the transition of electron between energy levels is the motion of the electron or other kind of effect or action;
(6) Failure to explain what exactly enable electrons and protons to overcome the electric potential between them and keep them apart in a certain range without colliding toward each other;
(7) Failure to explain how the electron interacts with the photon, namely, when, how and why the electron emit or absorb photons, and how electron can emit photons of different amounts of energy;
(8) Failure to explain why stars containing a large proportion of hydrogen atoms can produce continuous spectra, such as the Sun;
(9) The belief that the motion of electric charge will produce a magnetic moment is completely wrong, and a large number of phenomena show that the moving electric charge does not produce magnetic moment;
(10) Failure to incorporate the Lorentz effect into the model of hydrogen atom and to explain what role the Lorentz effect plays;
(11) Failure to explain how electrons and protons, i.e. hydrogen atoms, can fuse into more complex elements;
Nonetheless, the above questions are answered in the following proposed hypothesis for the model of hydrogen atom.

3. Hypothetical Discussion and Calculation

3.1 Hydrogen Atom Spectrum and Electron Orbit

The Table 1 below shows the wavelength values of some spectral lines of the hydrogen atom [3], including the Lyman series [9], the Balmer series [4], the Paschen series [5], the Brackett series [8], the Pfund series [6] and the Humphreys series [7], arranged from top to bottom according to the wavelength values. The left column lists the reference wavelengths, the middle column lists the calculated wavelengths, and the right column lists the calculated number for the orbits on which the electron moves in the hydrogen atom. According to Rydberg's formula: $\lambda = \frac{n^2}{R}$ [2], where the Rydberg constant R=10967758m^{-1}, and the orbit numbers in the right column are integer values, then the wavelengths obtained from the calculation roughly match with the reference wavelengths, with only two orders of magnitude difference, but this does not affect the following presupposition, because the values in the Table 1 below can well prove that there is a one-to-one coincidence relation between these orbits and the wavelengths.

Reference wavelengths (nm)	Calculated wavelengths	Found orbit number n
	0.0000003647053	2
	0.0000008205870	3
	0.0000014588214	4
	0.0000091176337	10
	0.0000110323368	11
	0.0009117633704	100
91.150	0.9116032647693	3162
91.900	0.9191144625912	3175
92.100	0.9208521923988	3178
92.300	0.9231717184132	3182
92.600	0.9260752288663	3187
93.000	0.9301478023129	3194
93.700	0.9371501449977	3206
94.900	0.9488790689948	3226
97.200	0.9719602675405	3265
102.500	1.0250599074123	3353
121.600	1.2160282894645	3652
364.600	3.6464130590773	6324
383.500	3.8356240172331	6486
388.900	3.8890319243003	6531
397.000	3.9704378050646	6599
410.200	4.1026857084192	6708
434.100	4.3409054065562	6900
486.100	4.8614497147001	7302
656.300	6.5642608999943	8485
820.600	8.2061592715667	9487
866.700	8.6674505400283	9750
875.300	8.7530016617799	9798
886.500	8.8659251052038	9861
901.700	9.0176155418455	9945
923.200	9.2328777677261	10063
954.900	9.5493314130381	10234
1005.200	10.0521911588494	10500
1094.100	10.9422568404591	10955
1282.200	12.8226644862150	11859
1458.000	14.5810398077711	12646
1818.100	18.1833774961118	14122
1875.600	18.7569464060020	14343
1945.100	19.4537889147445	14607
2166.100	21.6627131999083	15414

Gamma rays

X Rays

2279.000	22.7929647061870	15811
2625.900	26.2601382160328	16971
3046.000	30.4640055880153	18279
3281.000	32.8142580279397	18971
3304.000	33.0429764223463	19037
3749.000	37.4914621566231	20278
3819.000	38.1935933487956	20467
3908.000	39.0832489192413	20704
4021.000	40.2125941327298	21001
4052.500	40.5272334601110	21083
4171.000	41.7122005244828	21389
4374.000	43.7450585616495	21904
4664.000	46.6434365163783	22618
4673.000	46.7342186069386	22640
5129.000	51.2949830767601	23719
5905.000	59.0551414427634	25450
6561.000	65.6185091793601	26827
6562.790	65.6331859255100	26830
7476.000	74.7664651244128	28636
7503.000	75.0382479263310	28688
12368.000	123.6894745489460	36832

Table 1: Wavelengths and their Orbit Number

According to the values in the above Table 1, it can be inferred that there are about 60,000 orbits around the proton in the hydrogen atom, and the radius of each orbit is an integer multiple of an interval equidistance, that is $\mathrm{r} = \mathrm{nd}$, wherein r is the orbit radius, n is the orbit number, and d is the equidistance between orbits.

Based on the above inferences, I propose a presupposition of quantized force propagation and its role for electron orbits in hydrogen atom. [15] First, the proton propagates electrostatic force to the surrounding space, and the propagation direction is not only one direction, but all directions from the center of the sphere to the spherical surface, that is, omnidirectional propagation. Meanwhile, this omnidirectionally propagated force decreases with the increase of the propagation distance, that is, the magnitude of the force is inversely proportional to the square of the distance, i.e. $\mathrm{F} = \mathrm{k}\frac{e^2}{R^2}$. Suppose that the propagation of the force is quantized, i.e. in a specific time interval 1t, the force propagates for a distance of 1r, then in the second equal time interval 2t, the force propagates for a distance of 2r, then 3r in 3t, and so on. According to the spherical area formula $S = 4\pi R^2$, further suppose that this omnidirectionally propagated force is a constant value at 0t and 0r (at the center of the sphere), but it is uniformly scattered on a spherical surface of radius nr as it propagates, which explains why the magnitude of the force is inversely proportional to the square of the distance. Specifically, in 1t, this force of a constant value is uniformly scattered on a spherical surface of radius 1r; in 2t, uniformly scattered on a spherical surface of radius 2r, and in 3t, uniformly scattered on a spherical surface of radius 3r, and so on, as shown in the Figure 1 below.

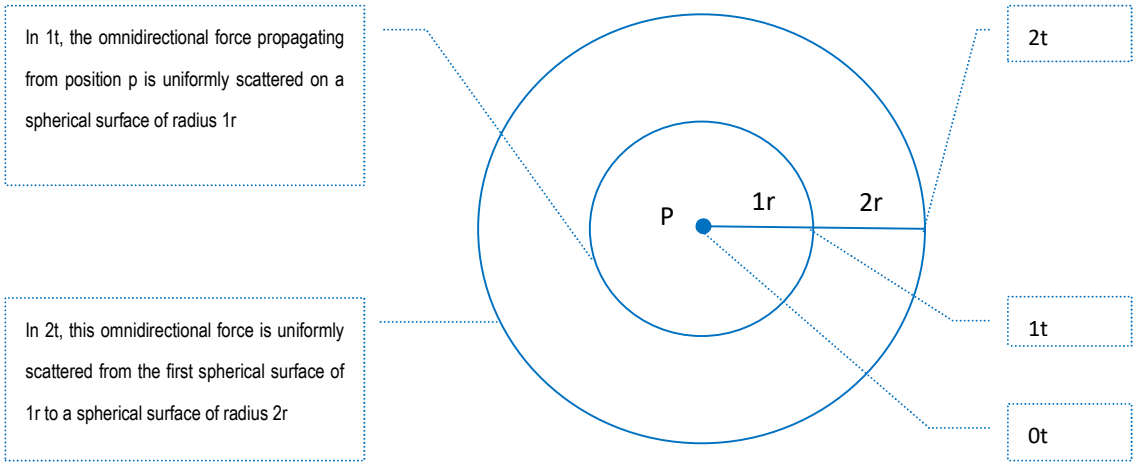

Figure 1: Quantization of force propagation

According to $\mathrm{F} = \mathrm{k}\frac{e^2}{r^2}$ and $\mathrm{S} = 4\pi R^2$, the constant value of this force is $\mathrm{F} = \mathrm{k}\frac{e^2}{r^2}4\pi r^2 = \mathrm{k}\,e^2\,4\pi$, namely the sum of the forces scattered on each spherical surface is constant.

Further suppose that the above-mentioned spherical surface with a radius of nr in nt is the orbit of the electron (namely the so called energy levels in the existing theory) in the hydrogen atom, and some of its orbit numbers are shown in the above Table 1. The electron in the hydrogen atom performs approximate circular motion on the outermost spherical surfaces, and performs tangential motion on the other inter spherical surfaces. [13] Specifically, in these orbits, the electron travels a certain distance in each t and emits one photon outward, and the photon moves in the same direction as the electron and carries a force or energy that equals to the magnitude of the resultant force that causes the electron to move. The lights of all wavelengths in the above Table 1 are the photons emitted when the electron moves in the orbits. In other words, the light is the only unidirectional force with photon as its fundamental unit.

3.2 Hypothesis for electron moving under forces

On the above orbits or spherical surfaces, the electron is attracted by the electrostatic force of the proton. The electrostatic force provides the centripetal force for the electron orbiting the proton. However, in order for the electron to keep a continuous motion around the proton, neither escaping from the proton nor colliding with the proton, a force perpendicular to the centripetal force is required to push the electron to perform tangential motion. Therefore, it is necessary to find a force perpendicular to the electrostatic force in the real world, and this force indeed exists, and it is the Lorentz force. But only one force perpendicular to the centripetal force is not enough to achieve a certain motion of the electron, so further suppose that there is another force perpendicular to both the centripetal force and the Lorentz force, and the magnitude of this force is equal to the Lorentz force. Because the Lorentz force is introduced in the model, a magnetic field must be introduced too, so further suppose that the north and south magnetic charges are located at the positions of the electric charges in the centers of protons and electrons, that is, the magnetic charges and the electric charges are located at the same positions. In this way, the centripetal force for the electron in the hydrogen atom will be the electrostatic force plus the magnetic force. Moreover, further suppose that the

magnitude of electrostatic force is equal to the magnetic force, so the centripetal force is twice the electrostatic force. [14]

According to the above presuppositions, the electron moving in the orbit will receive to four forces, namely the magnetic force, the electrostatic force, and the two mutually perpendicular Lorentz forces. Meanwhile, the nucleus of the hydrogen atom, that is a single proton, also receives the same four forces as the electron does, exactly equal in magnitudes, but in the exact opposite directions. Because the mass difference between proton and electron is large, the following calculations in this text assume that proton is stationary. At last, to perform the calculation, two key numerical values have to be found out first, and that are the equidistance d between the above orbits and the above said time interval. Based on the Bohr model [1], after some calculations and searching, the exact orbit number of the Bohr orbit is found to be 58810. Now, calculate the above said time interval to be $t = \frac{d}{c} = \mathbf{3.001437 \times 10^{-24}}$ and the equidistance d=**8.99808214×10^{-16}.**

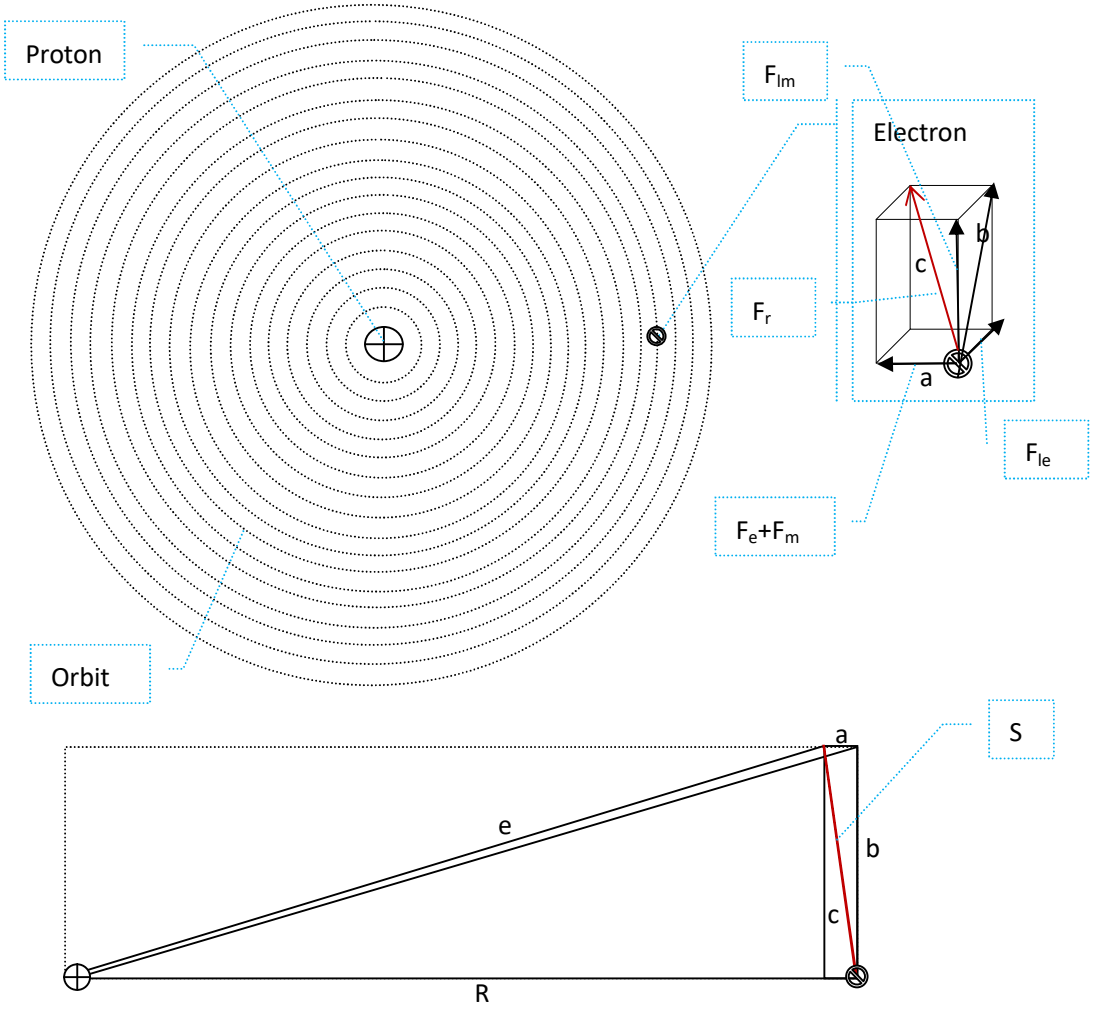

Figure 2: Electron moves under four forces

In the Figure 2 above, R is the radius; a, b, and c are the three sides of a right triangle respectively; The triangle formed by the three sides of [ecR] is an isosceles triangle, wherein e=R; and c is the distance S traveled by the electron under the four forces in one time interval t. $F_e = \frac{e^2}{4\pi\varepsilon}/R^2$ is the electrostatic force,

F_m is the magnetic force, F_{le} is the electric Lorentz force, and F_{lm} is the magnetic Lorentz force, then the resultant force is: $\mathrm{F_r} = \sqrt{(\mathrm{F_e} + \mathrm{F_m})^2 + \mathrm{F_{le}^2} + \mathrm{F_{lm}^2}}$; Suppose F_e equals F_m and F_{le} equals F_{lm}, then $\mathrm{F_r} = \sqrt{4\mathrm{F_e}^2 + 2\mathrm{F_{le}^2}}$.

According to the relationship between the three sides of the right triangle in the above Figure 2, the correspondence between the length of the three sides (travel distance) and the magnitude of the forces, and the relationship between the force and the motion:

$c^2 = a^2 + b^2 \quad | \quad \mathrm{R = e} \quad | \quad e^2 = b^2 + (R - a)^2 \rightarrow c^2 = 2aR \rightarrow \mathrm{F_r} = \sqrt{2(\mathrm{F_e} + \mathrm{F_m})\mathrm{R}} \rightarrow \mathrm{F_r} = \sqrt{4\mathrm{F_e R}}$

$\mathrm{FS = W = E = m}\frac{v^2}{2} = \mathrm{m}\frac{S^2}{2t^2} \rightarrow \mathrm{F} = \frac{\mathrm{mS}}{2t^2} \rightarrow \mathrm{F} = \frac{\mathrm{mR}}{2t^2}$

Obtain $\mathrm{F_r} = \sqrt{4\mathrm{F_e}\frac{\mathrm{mR}}{2t^2}} \rightarrow \mathrm{F_r} = \sqrt{4\frac{\mathrm{e}^2}{4\pi\varepsilon R^2}\frac{\mathrm{mR}}{2t^2}}$

The resultant force F_r calculated according to the above formula does not match, but after inserting a factor value, the following formula is obtained. The values for Bohr model calculated by using the following formula roughly match; wherein 0.35355 is a number I personally inserted, R is the Bohr radius 52917.721067×10^{-15}, $\frac{\mathbf{e^2}}{\mathbf{4\pi\varepsilon}}$ is the electrostatic force emitted by the proton, m is the electron mass 9.10956x10^{-31}, t is the above said time interval 3.00143713×10^{-24};

$$\mathbf{Fr = 0.35355}\sqrt{\mathbf{4}\frac{\mathbf{e^2}}{\mathbf{4\pi\varepsilon R^2}}\frac{\mathbf{mR}}{\mathbf{2t^2}}}$$

The calculation result is: Resultant force F_r= 3.31982984×10^{-1}; After the resultant force is obtained, according to $\mathrm{FS = W = E = m}\frac{v^2}{2} \rightarrow \mathrm{FS} = \frac{\mathrm{m}}{2}\frac{S^2}{t^2} \rightarrow \mathrm{S} = \frac{2\mathrm{F}t^2}{\mathrm{m}}$, wherein the electron mass m=9.10956x10^{-31}, t=3.00143713×10^{-24}, calculate the distance traveled by the electron to be S= 6.5660913362542×10^{-18}, the linear velocity of the electron to be v= 2.1876491350662×10^{6}, the ratio of the speed of light to the linear speed of electrons to be c/v=137.038638;

And then according to $\mathrm{mvR} = \frac{\mathrm{h}}{2\pi}$, the reduced Planck's constant is calculated to be 1.05457192×10^{-34};

According to $\mathrm{E = W = FS}$, the kinetic energy of electron is calculated to be 2.17983059×10^{-18};

However, the above calculations are only valid for the Bohr orbit, because the electron is expected to perform approximately circular motion only in the Bohr orbit. In other orbits, the electron will not perform circular motions, but tangential motions pushed by lateral forces, so that electron will move from the orbits of lower numbers (inner orbits) back to the orbits of higher numbers (outer orbits), and will eventually return to the Bohr orbit and remain stable until an external force pushes the electron again. Moreover, the magnetic force F_m, electric Lorentz force F_{le} and magnetic Lorentz force F_{lm} are completely unknown, the only fact is known that Resultant force F_r has a certain proportional relation with the electrostatic force F_e. Therefore, without knowing the F_m, F_{le} and F_{lm}, the F_r can be obtained if this proportional relation is found. So according to the law of conservation of angular momentum, and after searching, the following formula is found that the

calculation results may provide a good matching:

$$\mathbf{Fr = 0.75303673\frac{e^2m}{4\pi\varepsilon ndt^2}}$$

wherein 0.75303673 is a value that I personally inserted, n is the number of orbit, d is the equidistance d=8.99808214×10^{-16}, $\frac{e^2}{4\pi\varepsilon}$ is the electrostatic force emitted by the proton, m is the electron mass 9.10956x10^{-31}， t is the above said time interval 3.00143713×10^{-24}.

If the number of orbit is chose to be 58810 (Bohr orbit), the resultant force is calculated to be F_r=3.319832165164×10^{-1}; and according to $FS = W = E = m\frac{v^2}{2} \rightarrow FS = \frac{m}{2}\frac{S^2}{t^2} \rightarrow S = \frac{2Ft^2}{m}$, calculate the distance traveled by the electron to be S=6.5660959428532×10^{-18}, the linear velocity of the electron to be v=2.1876506698639×10^{6}, the ratio of the speed of light to the linear speed of electrons to be c/v =137.03854191;

According to $mvR = \frac{h}{2\pi} \rightarrow mvnd = \frac{h}{2\pi}$, the reduced Planck's constant is calculated to be 1.0545726583198×10^{-34};

Alternatively, according to $E = W = FS$, the kinetic energy of the electron E can be obtained by using the above formulas, wherein the F is the resultant force F_r, and S is the distance traveled by the electron; and according to $E = \frac{hc}{\lambda} \rightarrow h = \frac{E\lambda}{c}$, the Planck's constant is calculated to be too large. But after inserting a factor value 346, $h = \frac{E\lambda}{346c}$ the calculation results roughly match. Due to the wordcount limit, only the following wavelengths are chose to calculate Planck's constant:

Wavelength (m)	Orbit number corresponding to the wavelength	Calculated energy of the electron in the orbit	Calculated Planck's constant	Planck's constant reference value
91.15×10^{-9}	3162	7.5405318782885×10^{-16}	6.6261589795884×10^{-34}	6.62607015×10^{-34}
486.1×10^{-9}	7302	1.4139760527728×10^{-16}	6.6262966330729×10^{-34}	
866.7×10^{-9}	9750	7.9307905440007×10^{-17}	6.6265651926184×10^{-34}	
1458×10^{-9}	12646	4.7143232368665×10^{-17}	6.6264370836314×10^{-34}	
4664×10^{-9}	22618	1.4737279222408×10^{-17}	6.6264214176679×10^{-34}	
12368×10^{-9}	36832	5.5574441587792×10^{-18}	6.6264020461232×10^{-34}	

Table 2: Examples of Calculated Planck's constant

4. Model of Hydrogen Atom

4.1 Hypotheses for the Formation and Binding of Nucleons

I believe that protons and electrons are composite particles composed of a centrally located electric charge wrapped by uncharged neutrinos on the outside, and the neutrinos emit gravitational force and give the protons and electrons mass. As shown in the Figure 3 below, a proton and an electron can temporarily form a neutron, while the nucleus is a group of protons and electrons that are bound by the electromagnetic force, rather than the nuclear force. It is based on this presupposition that the equidistance d between the hydrogen

atomic orbits must be greater than the proton radius and lesser than the proton diameter, because the neutron radius is basically the same as the proton, and the average spacing between the nucleus is roughly within the diameter of a proton, so the value range for this equidistance d is 0.85-1.7 femtometers. Thus, it is not very difficult to find out the value within this range and use the Bohr model to test it. [10]

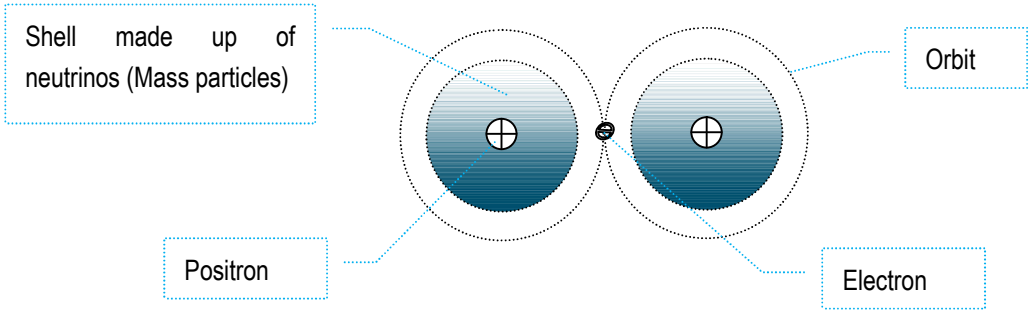

Figure 3: One deuterium nucleus formed by two protons and one electron (pep chain)

4.2 Hypothesis of Electromagnetic Interaction Mechanism of Hydrogen Atom

(1) It is presupposed that the electric charges carried by protons [11] and electrons have always been there since the existence of protons and electrons, and have always been emitting electrostatic force, while the magnetic charges carried by protons and electrons have always been there too, but they are not always activated and emitting magnetic force. If the distance between the positive and negative electric charges reaches a certain critical value, or when they reach a certain orbit, the magnetic charge is activated and starts to emit magnetic force, as shown in the Figure 4 below.

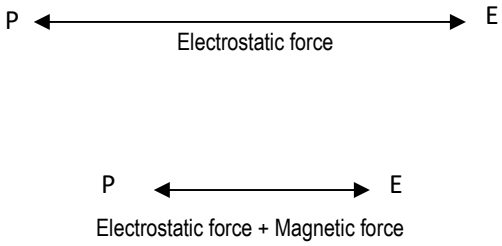

Figure 4: Magnetic charge activated in proton and electron due to their distance narrowing

(2) Because the proton and electron move toward each other, the magnetic charge emits magnetic force when the two reach a certain critical distance or reach a certain orbit of each other. When the electric charge carried by the electron encounters the magnetic force emitted by the opposing proton or when the electric charge carried by the proton encounters the magnetic force emitted by the opposing electron, the electric charge will receive a force in a direction perpendicular to the propagation direction of the magnetic force, and this is the Lorentz Effect. Then, continue to suppose that if the electric charge encounters the magnetic force, it will receive a lateral force (Electric Lorentz force), so when the magnetic charge encounters the electrostatic force, it will also receive a lateral force (Magnetic Lorentz force), and the two lateral forces are equal in magnitude and perpendicular to each other, as shown in the Figure 5 below.

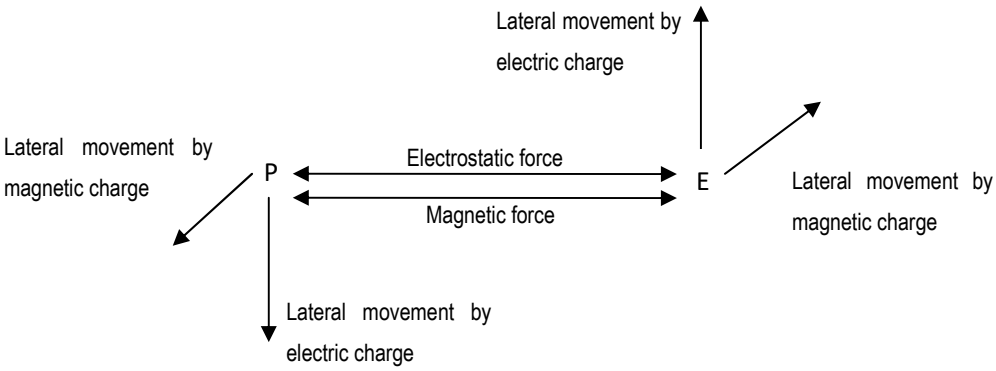

Figure 5: Proton and electron under four forces

(3) If the distance between the proton P and the electron E becomes larger than the critical distance or exceeds a certain orbit, the magnetic charge will be deactivated, and the magnetic force and all lateral forces will also disappear, leaving only the electrostatic force between the proton and the electron, as shown in the Figure 6 below.

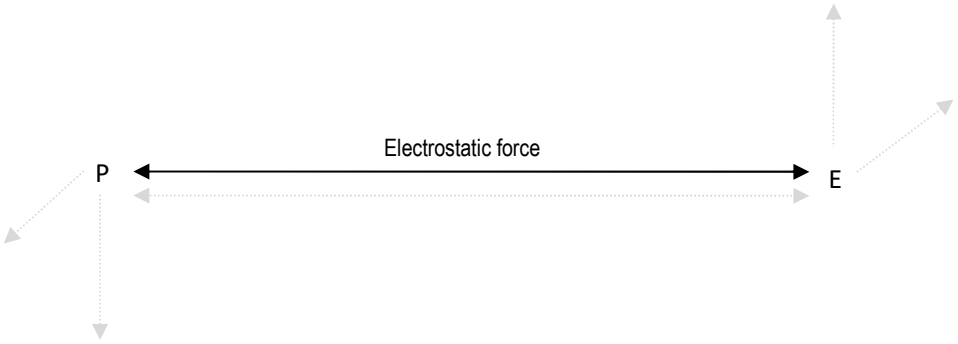

Figure 6: Magnetic charge deactivated in proton and electron due to their distance widening

(4) If an electron and a proton move toward each other due to electrostatic attraction, the magnetic charge is activated at a critical distance, causing the electron and proton to move laterally, and such lateral motion will always prevent the distance between the electron and the proton any further reduced, then the electron and proton will keep moving within a space range without collision into each other, and will always move within this range when there is no external influence, so that a stable hydrogen atom is formed. [12]

(5) According to the calculations above, as compared with the electrostatic force and the magnetic force, the magnitude of Lorentz force is quite large, at least 5 orders of magnitude larger. And as compared with the electrostatic, magnetic, and gravitational forces whose magnitude are inversely proportional to the square of the distance R^2, the magnitude of the Lorentz force may be inversely proportional to the distance R, not the square of the distance R^2.

5. Conclusions

Despite the large number of presuppositions are listed above, the above model can not only provide the explanations that the existing theories failed to provide, but also can be used to construct neutrons, atomic nuclei, and individual atoms and molecules by only involving electrons and protons and their interactions. The interactions between single electron and proton, namely the model of hydrogen atom, is the key to for us the understand everything. Because all the matters in the universe are made from hydrogen atoms through nuclear fusion. If we can use one pair of electron and proton to establish a good model of hydrogen atom, then we can use multiple electrons and protons to establish the models of other nuclei. Therefore, establishing a basic theoretical framework to explain all the interactions between a single electron and a single proton must be the first step toward establishing the ultimate theory of everything.

CRediT authorship contribution statement

Huan Liang wrote the original draft and final version of above paper.

Declaration of Competing Interest

The author did not have any conflict of interest.

Declaration of Funding

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Data Availability Statement

All data, models, and code generated or used during the study appear in the submitted article.

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