ISSN: 2350-0743

International Journal of Recent Advances in Multidisciplinary Research

Vol. 11, Issue 10, pp. 10329-10331, October, 2024

RESEARCH ARTICLE

THE HYDROGEN BOND

***Richard Lewis**

Alumnus, Cambridge University, Cambridge, England

ARTICLE INFO

Article History
Received 20th July, 2024
Received in revised form
16th August, 2024
Accepted 27th September, 2024
Published online 30th October, 2024

Keywords:

Hydrogen Bond.

****Corresponding author: Richard Lewis***

ABSTRACT

The nature of the hydrogen bond is studied in the context of the Spacetime Wave Theory. The usual description of a covalent bond is: a chemical bond that involves the sharing of electron pairs between atoms. These electron pairs are known as shared pairs or bonding pairs, and the stable balance of attractive and repulsive forces between atoms, when they share electrons is known as covalent bonding [1]. This picture of the hydrogen bond is challenged by suggesting that rather than overlapping in the space between the nuclei, the electrons position themselves to occupy an approximately hemispherical region on the remote side of the nucleus from the other atom.

Citation: Richard Lewis. 2024. "The Hydrogen Bond.*", International Journal of Recent Advances in Multidisciplinary Research,* 11, (10), 10329-10331.

INTRODUCTION

The picture below shows the hydrogen atom in position after the bond has been established: The reason why such a chemical bond can form with hydrogen and not helium is that the electron has the freedom to occupy one half of the electron shell and can therefore move to the remote side of the nucleus as shown in the diagram. In the case of the helium atom the first shell is full and there is no freedom of movement. When two hydrogen atoms approach each other from a distance, the electrons and the protons begin to interact. However, the electrostatic forces are such that the near sides of the electron waves are closer and therefore feel the strongest repulsive effect. This pushes the wave path of the electron to the remote side of the nucleus. Once this has happened, resolving along the line between the nuclei we have a slight offset between the positive charge of the proton and the negative charge of the electron so that there will be an energy point where the repulsive effect between the atoms takes over and this will be the stable distance between the hydrogen atoms in the covalent bond. Experimental measurements show this distance to be around 7.4×10^{-11} m [2].

Calculating the hydrogen electron radius: This calculation is based on the analysis of the hydrogen atom presented in the paper on the Unification of Physics.

In the context of the Spacetime Wave theory the entire mass of the electron is in wave energy given by $E = hf$ where f is the frequency of the electron wave and h is the Planck constant.
For the hydrogen atom the energy E_n associated with the nth energy level is given by:

$$E_n = E_T - E_{gs}/n^2$$

Where E_T is the total energy of the electron calculated from its mass and E_{gs} is the ground state energy. The value of n is a positive integer corresponding to the energy levels. This formula is derived empirically taking into account the Balmer formula for the wavelength of the emitted light when a hydrogen electron changes energy level.

Balmer [3]: $\lambda = b[m^2/(m^2 - n^2)]$

The path length of the wave for energy level n is denoted by s_n and the frequency and wavelength are denoted by f_n and λ_n respectively. X_n is the number of wavelengths in the loop so that $s_n = \lambda_n X_n$

The path of the electron wave should be thought of as encircling the nucleus many times before closing the loop. The number of wavelengths in the entire path loop X_n must be a positive integer.

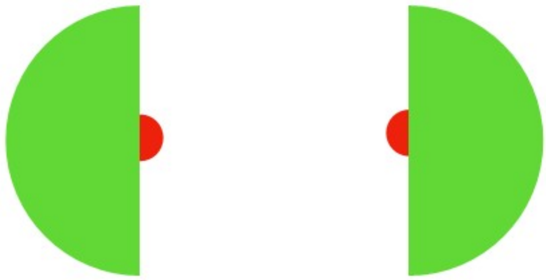

Figure 1: Hydrogen Molecule

Using: $E_n = hc/\lambda_n = X_n\, hc/s_n$ we get the result that $X_n = s_n(E_T - E_{gs}/n^2)/hc$

The condition that X_n is an integer for all values of n means that s_n must take the form:

$s_n = s_1 n^2$

Therefore: $X_n = s_1(E_T n^2 - E_{gs})/hc$

The condition that X_n is an integer for all values of n means that s_1E_T/hc is a positive integer and s_1E_{gs}/hc is a positive integer.

Let us assign an integer value K to s_1E_{gs}/hc

E_T / E_{gs} is a known value:

Using the value of E_T as 0.510998 MeV = 510998 eV [4] we have $E_T / E_{gs} = 37565$

Using the value 37565, our formula the number of wavelengths in the loop is:

$X_n = K (37565\, n^2 – 1)$

For reasons explained later there are good reasons to suppose that the formula for the number of wavelengths in the loop should be $X_n = 37636\, n^2 – 1$

This can be factorised into (194n + 1) (194n - 1)

We then take the number of wavelengths in a single pass around the nucleus to be:

(194n + 1) /2 and the number of passes to be 2(194n - 1)

Then for the case n = 1 we have a radius of the electron path given by $2\pi\, r = 97.5\, \lambda_1$

The wavelength of hydrogen in the lowest energy level can be derived from:

$E_1 = E_T - E_{gs} = 510998 - 13.6 = 510984$ eV

Then using E = hf and c = fλ we get $\lambda_1 = 2.42637932 \times 10^{-12}$ m
The radius calculated in this way is 3.76516×10^{-11} m

In the terminology of the Spacetime Wave theory this would be called the effective radius which is the radius at which there is equal wave energy on both sides of the wave path.

This radius value compares with the Bohr radius 5.29×10^{-11} using the Bohr model. Actually measuring the extent of the electron of the hydrogen atom is a difficult problem because the electron does not have a precise boundary and the charge radius of the orbital shell is not so precise as the charge radius of the proton.

However, it does seem to be possible to measure the internuclear distance between the hydrogen atoms at around 7.4×10^{-11} m and it is interesting to note that this value is quite close to two radii as calculated above.
So the nuclei are approximately positioned in such a way that the spheres defined by the effective radius are touching.

The position of the electron wave: The electron wave should be thought of as a chain of positive and negative charges in each wavelength with the negative charge being slightly greater than the positive charge. Then when an electron wave wraps around the hydrogen nucleus, the alignment of the loop in successive passes will be such that it is aligned positive to negative and negative to positive charge so that the loop is displaced by half of one wavelength. This is why it is proposed that the equation $X_n = 37636\, n^2 – 1$ should be factorised so that there the number of wavelengths in each encirclement of the nucleus is (194n + 1)/2 which corresponds to the value 97n + 1/2. Then we make the hypothesis that the number of encirclements needs to bring the position of the wave to the original starting point and since each encirclement moves the wave position on by half a wavelength then it will take 2(194n - 1) encirclements to return to the start point. For this hypothesis to be valid it is necessary to take K=1 and adjust the electron energy equation to $E_n = E_T + \Delta E - E_{gs}/n^2$ where ΔE is an energy adjustment of the order of 0.18% to the value of E_T to change the constant in the equation from 37565 to 37636.

The idea that the possible energy states of an orbital electron are limited by this alignment process provides an explanation for the quantisation of the electron and in turn the quantisation of the light emitted by the electron. The closure hypothesis is also valid under the assumption of 97n - 1/2 wavelengths in each pass around the nucleus with a total of 2(194n + 1) passes. The analysis does suggest that the radius associated with each energy level of the hydrogen atom is approximately proportional to n.

The nature of electric charge: The nature of electric charge in the context of the Spacetime Wave theory is described in more detail in the paper on the Unification of Physics [5]. In summary the cause of the electric charge is a time variation in synchronisation with the space variation of the spacetime wave. The wave in space has the effect of compression and expansion of space as the wave passes at the speed of light and the time variation means that there is a net expansion or compression of space. The net charge of the electron is considered to be allocated equally to each wavelength but each wavelength comprises a positive charge followed by a slightly greater negative charge so that the net charge of the electron is negative. This picture of the cause of electric charge then gives us the understanding that the underlying cause of the electric charge of the electron or proton is a net compression or expansion of space. One can think of the electrostatic force as being delivered by space curvature of the medium of space in a similar way to the gravitational force is being delivered by spacetime curvature.

A note on the electron shell model: Since we have shown a mechanism by which the alignment of the electron wave places constraints on the number of wavelengths in the loop, this leads to the idea that an orbital electron occupies a certain surface area of the electron shell. In the first shell the surface area constraint allows up to two electrons. When the first shell is full the electron in the second shell must find a stable orbital position outside shell 1.

The greater surface area of shell 2 means that the surface area constraint for each electron allows up to 8 electrons in shell 2. The advantage of this surface area approach over the use of quantum numbers [6] is that for the heavier elements further down the periodic table the filling of shells is not in strict order of shell but will depend on the lowest energy position when the next electron is added.

Appendix 1 Balance of forces in the hydrogen bond: There must be a balance of forces in the hydrogen bond so that the atoms find a stable position which is the lowest energy position. Referring to the diagram above it is apparent that there will be a net electrostatic force of repulsion due to the proton - proton repulsion and the electron - electron repulsion. This force of repulsion will increase as the atomic nuclei get closer together. What is the force of attraction? As the hydrogen atoms approach each other with the possibility of bonding, the electrons are forced into an orbital path which encircles the line between the two nuclei. This would have the effect of creating a magnetic dipole at each hydrogen atom acting along the line between the two nuclei. The electrons have to adopt one of two possible spin orientations around the line joining the two nuclei. This will form magnetic dipoles at each atom oriented N-S or S-N.If the spin orientation were N-S : S-N (or S - N : N - S) i.e. opposite orientation then there would be a force of repulsion and there would be no bond and the atoms would move further apart. If the orientation were N-S : N-S (or S - N : S - N) i.e. the same orientation then there would be a force of attraction which would bring the atoms closer together. From this it can be seen that the balance of forces in the bond between two hydrogen atoms is between a magnetic force of attraction and an electrostatic force of repulsion.

Appendix 2 Electron binding energy

In the derivation of the formula for the number of wavelengths in the electron loop it was necessary to make an energy adjustment ΔE to the electron energy in order to bring the formula for the number of wavelengths to a perfect square.

$E_n = E_T + \Delta E - E_{gs}/n^2$

The adjustment was chosen to find the closest result namely (194n + 1) (194n - 1) which corresponds to $X_n = 37636\, n^2 – 1$ However, we should consider the possibility that ΔE is a form of binding energy. We know that when a proton binds to a neutron there is a mass deficit which corresponds to the binding energy for the proton and the neutron. Perhaps there is a similar form of binding energy between an electron and a proton so that the mass E_T of a free electron has to be revised downwards when it is bound as an orbital electron. In this case we would expect ΔE to be negative and we should adjust the formula for the number of wavelengths to become (192n + 1) (192n - 1) which corresponds to $X_n = 36864\, n^2 – 1$. This would put the value of ΔE as around 9535.7 eV in the negative direction and this represents around 1.9 % of the mass of the free electron.

$E_1 = E_T + \Delta E - E_{gs} = 510998 - 9535.7 - 13.6 = 501449$ eV
Then using $E = hf$ and $c = f\lambda$ we get $\lambda_1 = 2.47252 \times 10^{-12}$ m
The radius calculated in this way is 3.7974×10^{-11} m

Precise measurements will be needed to determine experimentally which formula for X_n(192 or 194) is correct and whether it is plus or minus half a wavelength to calculate the radius.

REFERENCES

1. Whitten, Kenneth W.; Gailey, Kenneth D.; Davis, Raymond E. (1992). "7-3 Formation of covalent bonds". *General Chemistry* (4th ed.). Saunders College Publishing. p. 264. ISBN 0-03-072373-6.
2. Roger L. DeKock; Harry B. Gray; Harry B. Gray (1989). Chemical structure and bonding. University Science Books. p. 199. ISBN 978-0-935702-61-3. Archived from the original on 31 March 2021. Retrieved 27 October 2020.
3. Nave, C. R. (2006). "Hydrogen Spectrum". *Hyper Physics*. Georgia State University. Retrieved March 1, 2008
4. "2022 CODATA Value: electron mass energy equivalent in MeV". *The NIST Reference on Constants, Units, and Uncertainty*. NIST. May 2024. Retrieved 2024-05-18.
5. Lewis, Richard D. The Unification of Physics. November 2020DOI: 10.6084/m9.figshare.21776954Conference: 4th International Conference on Recent Advances in PhysicsAt: Dubai, UAE
6. Whittaker, Edmund T. (1989). A history of the theories of aether & electricity. 2: The modern theories, 1900 - 1926 (Repr ed.). New York: Dover Publ. ISBN 978-0-486-26126-3.

****