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Gap Energy in Hydrogen and Helium

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Abstract: *The thesis that the atom and the electron must be aligned has been upgraded with the help of the gap energy on the example of Hydrogen and Helium atom*

Keywords: *Atom-electron alignment, orbit distribution, gap energy*

1. INTRODUCTION

The purpose of this article is on the example of Hydrogen and Helium isotopes to upgrade the thesis that the atom and the electron must be aligned [1], [2].

2. THE BOHR-LIKE OBIT

The original Bohr-like orbit length $s_{Bohr-like}$ and the corresponding kinetic energy of the electron are related to the effective nuclear charge which covers the nuclear charge as well as the shielding effect committed by the neighbouring electrons.

a) The original Bohr-like orbit length $s_{Bohr-like}$ expressed in the Compton wavelengths of the electron is in inverse proportion to the effective nuclear charge $Z_{effective}$:

$$s_{Bohr-like}\ x\ Z_{effective} = \alpha^{-1} = 137.035\ 999\ 084. \tag{1}$$

Where α^{-1} denotes the inverse fine structure constant.

b) And the original Bohr-like orbit kinetic energy of the electron is proportional to the effective nuclear charge $Z_{effective}$:

$$\frac{Wk_{Bohr-like}}{Z_{effective}} = Ry = 13.605\ 693\ 122\ 994\ eV. \tag{2}$$

Where Ry denotes Rydberg constant.

Bohr orbit in Hydrogen atom can be considered as Bohr-like orbit with the unit value of the effective nuclear charge:

$$Z_{effective}^{Hydrogen} = 1. \tag{3}$$

Otherwise the effective nuclear charge of Bohr-like atoms surpasses the unit value. The first one is that of Helium:

$$Z_{effective}^{Helium} = \frac{27}{16} = 1{,}6875. \tag{4}$$

3. THE BOHR-LIKE OBIT DISTRIBUTION

The Bohr-like orbit can be distributed around the original orbit. So the electron in the ground state of any atom circulates around the nucleus on one of the distributed orbits according to the restrictions of the double surface geometry [2]:

$$s(n) = n\left(2 - \frac{1}{\sqrt{1+\frac{\pi^2}{n^2}}}\right), \qquad 1 \le n \in \mathbb{N} \le 2n_{original}. \tag{5}$$

Possessing the same total energy but the different kinetic energy[2]:

$$W_k(n) = Z_{effective}.Ry\left(2\frac{s(n_{original})}{s(n)} - 1\right) = Z_{effective}.Ry\left(2\frac{n_{original}(2-\frac{1}{\sqrt{1+\frac{\pi^2}{(n_{original})^2}}})}{n(2-\frac{1}{\sqrt{1+\frac{\pi^2}{n^2}}})} - 1\right),$$

$$1 \le n \in \mathbb{N} \le 2n_{original}. \qquad (6)$$

Taking the next form for Hydrogen atom:

$$Wk(n) = Ry\left(2\frac{s(81)}{s(n)} - 1\right) = Ry\left(2\frac{137(2-\frac{1}{\sqrt{1+\frac{\pi^2}{(137)^2}}})}{n(2-\frac{1}{\sqrt{1+\frac{\pi^2}{n^2}}})} - 1\right),\ 1 \le n \in \mathbb{N} \le 272. \qquad (7)$$

And the next form for Helium atom:

$$Wk(n) = \frac{27}{16}Ry\left(2\frac{s(81)}{s(n)} - 1\right) = \frac{27}{16}Ry\left(2\frac{81(2-\frac{1}{\sqrt{1+\frac{\pi^2}{(81)^2}}})}{n(2-\frac{1}{\sqrt{1+\frac{\pi^2}{n^2}}})} - 1\right),\ 1 \le n \in \mathbb{N} \le 162. \qquad (8)$$

The distributed Bohr-like orbit lengths with the corresponding kinetic energy of the electron (distribution energy) are thus quantized and limited.

4. THE ATOM-ELECTRON ALIGNMENT

The atom-electron alignment assumes the laying of an atom as a wave within an electron as a wave as follows[2]:

$$\frac{\lambda_{electron}}{\lambda_{atom}}\frac{s(1)}{s(n)} = \frac{m_{atom}}{m_{electron}}\frac{s(1)}{s(n)} = 1. \quad n \in \mathbb{N}. \qquad (9)$$

Here λ and m denotes Compton wavelength and mass, respectively, and $R = s(n)$ is the modified atom-electron ratio respecting the double-surface geometry[2]:

$$R = s(n) = \frac{m_{atom}}{m_{electron}}\ s(1) = \frac{m_{atom}}{m_{electron}}\ x\ 1{,}696\ 685\ 529. \qquad (10)$$

The atom-electron alignment is achieved by the appropriate kinetic energy of the electron:

$$m_{electron} = m_{electron}^{rest} + \frac{W_k}{c^2}. \qquad (11)$$

So it holds

$$R_{aligned} = s(n) = \frac{m_{atom}}{m_{electron}^{rest} + \frac{W_k}{c^2}}\ s(1) = \frac{m_{atom}}{m_{electron}^{rest} + \frac{W_k}{c^2}}\ 1{,}696\ 685\ 529. \qquad (12)$$

And

$$R_{unaligned} = s(n \notin \mathbb{N}) = \frac{m_{whole}}{m_{electron}^{rest}}\ s(1) = \frac{m_{whole}}{m_{electron}^{rest}}\ 1{,}696\ 685\ 529. \qquad (13)$$

Then

$$W_k = \left(\frac{R_{unaligned}}{R_{aligned}} - 1\right)m_{electron}^{rest}c^2. \qquad (14)$$

The kinetic energy of the electron enabling the atom-electron alignment $W_k^{aligned}$ is unique with little chance of being completely equal to one of the distribution energies. So the electron cannot be distributed in the atom and aligned by the atom at the same time. Let us propose that the exit from the conundrum is the gap energy as the smallest difference between the two concerned energies.

5. THE GAP ENERGY

The gap energy is the smallest difference between the kinetic energy of the electron enabling the alignment of the electron by the atom, denoted $W_k^{alignment}$, and the kinetic energy of the electron enabling the particular distribution of the electron in the atom, denoted $W_k^{distribution}$:

$$W_{gap} = W_k^{alignment} - W_k^{distribution}. \tag{15}$$

Sufficiently accurate values of the mass [3],[4] of an electron and an atom are required to obtain non-random values of the gap energy. Such data are used in Table1 for the calculation of the gap energy of three isotopes of Hydrogen (protium H-1, deuterium H-2 and tritium H-3) and two isotopes of Helium (He-3 and He-4). So the results may differ from that given in previous articles [1], [2].

Table1. *The gap energy in the Hydrogen and Helium*

	m_{atom} (in Daltons)	$R_{aligned}$	$Wk_{aligned}$ (in eV)	$Wk_{distribution}$ (in eV)	W_{gap} (in eV)
				On the 149th orbit: 11,41518804	-0,1480
H-1 (protium)	1,007825032241	s(3117)=3117,00158…	11,26722887		
				On the 150th orbit: 11,24845552	0,0188
				On the 87th orbit: 29,22778360	-0,4182
H-2 (deuterium)	2,014101778114	s(6229)=6229,00079…	28,80955118		
				On the 88th orbit: 28,74166186	0,0679
				On the138th orbit: 13,40861162	-0,0784
H-3 (tritium)	3,016049281985	s(9328)=9328,00052…	13,33024237		
				On the 139th orbit: 13,21436364	0,1159
				On the 113th orbit: 9,967947046	-0,0194
He-3	3,016029322645	s(9328)=9328,00052…	9,948511208		
				On the 114th orbit: 9,679328839	0,2692
				On the 83th orbit: 21,85472017	-0,1753
He-4	4,00260325413	s(12379)=12379,00039…	21,67940387		
				On the 84th orbit: 21,32196490	0,3574
$m_{electron}^{rest} = 0{,}00054857990907\ Da$					

The alignment energy lies between two distribution energies so two gap energies are available for each electron, i.e. one negative as well as the other positive. Negative gap energy means that the electron has to transmit this kinetic energy to the potential energy to become aligned by the atom. Positive gap energy means that the electron has to receive this kinetic energy from the potential energy to become aligned by the atom. For instance in the protium H-1 the electron on the 149th and

150th distributed orbit can become aligned with the help of the gap energy $W_{gap} = -0.1458$ eV and $W_{gap} = 0.0188\, eV$, respectively. The first energy should be transmitted so it has negative sign. And the second energy should be received so it has positive sign. For the most abundant isotope He-4 the gap energy is $W_{gap} = -0.1753$ eV and $W_{gap} = 0.3574\, eV$, respectively.

6. CONCLUSION

The gap energy is a part of total energy of the electron in the atom. Until it is measured, the thesis of part and whole remains on the threshold of physics.

DEDICATION

This fragment is dedicated to pilgrimage town of Sveta Trojica v Slovenskih goricah

Figure1. *The Holy Trinity in Slovenske gorice*

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