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Double Surface Characteristics of Water, Hydrogen Sulphide and Hydrogen Selenide

Janez Špringer*

Cankarjevacesta 2, 9250 GornjaRadgona, Slovenia, EU

Corresponding Author:** ***Janez Špringer, *Cankarjeva cesta 2, 9250 Gornja Radgona, Slovenia, EU*

Abstract: *Double surface characteristics of water molecule, hydrogen sulphide molecule and hydrogen selenide molecule on double surface are presented.*

Keywords: *subtle bond, water, oxygen, hydrogen, hydrogen sulphide, sulphur, hydrogen selenide, selenium, exact and half-exact geometry*

1. Introduction

In the previous paper the unstable subtle bond between hydrogen and oxygen atom in formic acid molecule was presented.[1] In this paper we will pay attention to the stable subtle bond between unequal atoms of the same molecule on the example of atoms which make up water, hydrogen sulphide and hydrogen selenide molecule. The needed data are taken from reference [2] toput them in the key formula, which relate the length on the elliptic surface $n$and the length on the average elliptic-hyperbolic surface $s(n)$as follows [3]:

$$s(n) = n\left(2 - \frac{1}{\sqrt{1+\frac{\pi^2}{n^2}}}\right). \quad (1)$$

2. The Water Molecule

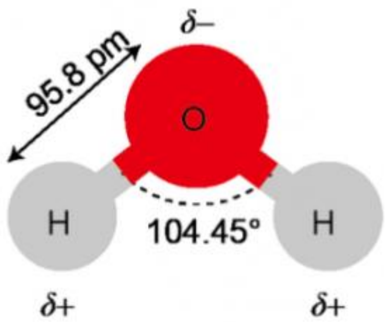

Figure1. *The water molecule*

2.1. The Exact Distance between Hydrogen Atoms H in Water Molecule H₂O

The distance $d_{HH\ in\ H2O}^{measured}$ between hydrogen atoms H in water molecule$H_2O$is $151.44\,pm$ [2] which expressed in Compton wavelengths of the electron equals $d_{HH\ in\ H2O}^{measured} = 62.416\,\lambda_e$. The π-times longer orbit length of$s_{HH\ in\ H2O}^{measured} = 196.085\,\lambda_e$ is close to the geometrically stable orbit lengthof $s(196\,\lambda_e) = 196.025\,\lambda_e$.(1) And the doubled value $2s_{HH\ in\ H2O}^{measured} = 392.170\,\lambda_e$ is close to the geometrically stable orbit lengthof$s(392\,\lambda_e) = 392.013\,\lambda_e$.(1)We can propose that the number of stable bonding orbit n in this case should be $n_{HH\ in\ H2O}^{proposed} = 196$.If sothe stable distance between hydrogen atoms Hin water molecule$H_2O$is of exact value $d_{HH\ in\ H2O}^{exact} = 151.39\,pm$.

2.2. The Exact Distance between Oxygen Atom O and Hydrogen Atom H in Water Molecule H₂O

The distance$d_{OH\ in\ H2O}^{measured}$ between oxygen atom $O$and hydrogen atom H in water molecule$H_2O$is $95.78\,pm$ [2] which expressed in Compton wavelengths of the electron equals $d_{OH\ in\ H2O}^{measured} =$

$39.476\ \lambda_e$. The π-times longer orbit length of $s_{OH\ in\ H2O}^{measured} = 124.016\,\lambda_e$ is close to the geometrically stable orbit length of $s(124\,\lambda_e) = 124.040\,\lambda_e$.(1)And the doubled value $2s_{OH\ in\ H2O}^{measured} = 248.032\,\lambda_e$ is close to the geometrically stable orbit lengthof$s(248\,\lambda_e) = 248.020\,\lambda_e$.(1) We can propose that the number of stable bonding orbit n in this case should be $n_{OH\ in\ H2O}^{proposed} = 124$.If sothe stable distance between oxygen atom $O$and hydrogen atom H in water molecule$H_2O$is of exact value$d_{OH\ in\ H2O}^{exact} = 95.80\ pm$.

2.3. The Exact Angleφ_{HOH}in Water Molecule H_2O

With the help of the exact distance between hydrogen atoms $d_{\boldsymbol{HH}\ in\ H2O}^{exact} = 151.39\ pm$and the exact distance between oxygen and hydrogen atom $d_{\boldsymbol{OH}\ in\ H2O}^{exact} = 95.80\ pm$we canusing the cosine rule calculate the exact value of angle $\varphi_{HOH\ in\ H2O}^{exact}$ in the water moleculeH_2O**:**

$$cos\varphi_{HOH\ in\ H2O}^{exact} = 1 - \frac{1}{2}\left(\frac{HH}{OH}\right)^2 = 1 - \frac{1}{2}\left(\frac{151.39}{95.80}\right)^2 = -0.24863. \qquad (2a)$$

And

$$\varphi_{HOH\ in\ H2O}^{exact} = 104.40°. \qquad (2b)$$

Here, the exact value of angel is rounded to two decimal places.

3. The Hydrogen Sulphide Molecule

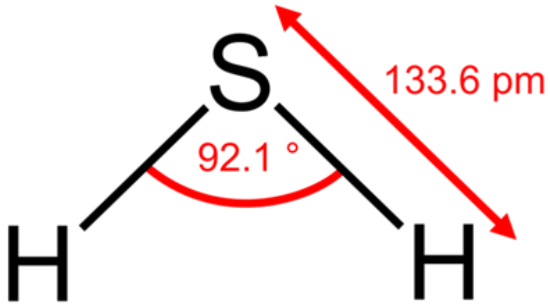

Figure2. *The hydrogen sulphide molecule*

3.1. The Exact Distance between Hydrogen Atoms in Hydrogen Sulphide Molecule H_2S

The distance$d_{HH\ in\ H2S}^{measured}$ between hydrogen atoms H in hydrogen sulphide molecule$H_2S$is $192.33\ pm$ [2] which expressed in Compton wavelengths of the electron equals $d_{HH\ in\ H2S}^{measured} = 79.269\,\lambda_e$. The π-times longer orbit length of$s_{HH\ in\ H2S}^{measur\ ed} = 249.029\,\lambda_e$ is close to the geometrically stable orbit lengthof$s(249\,\lambda_e) = 249.020\,\lambda_e$.(1)And the doubled value $2s_{HH\ in\ H2S}^{measured} = 498.058\,\lambda_e$ is close to the geometrically stable orbit lengthof$s(498\,\lambda_e) = 498.010\,\lambda_e$. (1)We can propose that the number of stable bonding orbit n inthis case should be $n_{HH\ in\ H2S}^{proposed} = 249$.If sothe stable distance between hydrogen atoms$H$in hydrogen sulphide molecule$H_2S$is of exact value$d_{HH\ in\ H2S}^{exact} = 192.32\ pm$.

3.2. The Exact Distance between Sulphur Atom S and Hydrogen Atom H in Hydrogen Sulphide Molecule H_2S

The distance $d_{SH\ in\ H2S}^{measured}$ between sulphur atom $S$and hydrogen atom H in hydrogen sulphide $H_2S$is $133.56\ pm$[2] which expressed in Compton wavelengths of the electron equals $d_{SH\ in\ H2S}^{measured} = 55.047\ \lambda_e$. The π-times longer orbit length of$s_{SH\ in\ H2S}^{measured} = 172.934\,\lambda_e$ is close to the geometrically stable orbit lengthof$s(173\,\lambda_e) = 173.029\,\lambda_e$.(1)And the doubled value $2s_{SH\ in\ H2S}^{measured} = 345.868\,\lambda_e$ is close to the geometrically stable orbit length of $s(346\,\lambda_e) = 346.014\,\lambda_e$. (1)We can propose that the number of stable bonding orbit n in this case should be $n_{SH\ in\ H2S}^{proposed} = 173$.If sothe stable distance between sulphur atom $S$and hydrogen atom H in hydrogen sulphide molecule$H_2S$is of exact value$d_{SH\ in\ H2S}^{exact} = 133.63\ pm$.

3.3. The Exact Angleφ_{HSH}in Hydrogen Sulphide Molecule H_2S

With the help of the exact distance between hydrogen atoms $d_{\boldsymbol{HH}\ in\ H2S}^{exact} = 192.32\ pm$ and the exact distance between sulphur atom and hydrogen atom $d_{\boldsymbol{SH}\ in\ H2S}^{exact} = 133.63\ pm$ we can using the cosine rule calculate the exact value of angle $\varphi_{HSH\ in\ H2S}^{exact}$in the hydrogen sulphide molecule **H_2S:**

$$cos\varphi_{HSH\ in\ H2S}^{exact} = 1 - \frac{1}{2}\left(\frac{HH}{SH}\right)^2 = 1 - \frac{1}{2}\left(\frac{192.32}{133.63}\right)^2 = -0{,}03565. \quad (3a)$$

And

$$\varphi_{\boldsymbol{HSH}\ in\ H2S}^{exact} = 92.04°. \quad (3b)$$

Here, the exact value of angel is rounded to two decimal places.

4. The Hydrogen Selenide Molecule

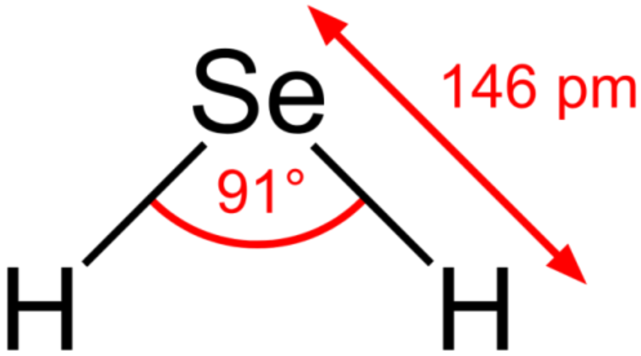

Figure3. *Hydrogen selenide molecule*

4.1. The Half-exact Distance between Hydrogen Atoms in Hydrogen Selenide Molecule H_2Se

The distance $d_{HH\ in\ H2Se}^{measured}$between hydrogen atoms H in hydrogen selenide H_2Semolecule is $208.09\,pm$ [2] which expressed in Compton wavelengths of the electronequals$d_{HH\ in\ H2Se}^{measured} = 85.764\,\lambda_e$. The π-times longer orbit length of$s_{HH\ in\ H2Se}^{measur\ ed} = 269.435\,\lambda_e$ is far from geometrically stable orbit length of $s(269\,\lambda_e) = 269.018\,\lambda_e$. And the doubled value $2s_{HH\ in\ H2Se}^{measured} = 538.870\,\lambda_e$ is close to the geometrically unstable orbit lengthof$s(538.50\,\lambda_e) = 538.501\,\lambda_e$. We can propose that the stable subtle HH bonding orbit in this case is not present so the exact distance between HH atoms in the hydrogen selenide molecule H_2Secannot be proposed and the value of measured distance$d_{HH\ in\ H2Se}^{measured} = 208.09\,pm$ stays unchanged.

4.2. The Exact Distance between Selenium Atom Se and Hydrogen Atom H in Hydrogen Selenide Molecule H_2Se

The distance $d_{SeH\ in\ H2Se}^{measured}$between selenium atom $Se$and hydrogen atom H in hydrogen selenide molecule $H_2Se$is $146.00\,pm$ [2] which expressed in Compton wavelengths of the electron equals $d_{SeH\ in\ H2Se}^{measured} = 60.174\ \lambda_e$. The π-times longer orbit length of$s_{SeH\ in\ H2Se}^{measure\ d} = 189.041\,\lambda_e$ is close to the geometrically stable orbit lengthof$s(189\,\lambda_e) = 189.026\,\lambda_e$. (1) And the doubled value $2s_{SeH\ in\ H2Se}^{measured} = 378.082\,\lambda_e$ is close to the geometrically stable orbit length of $s(378\,\lambda_e) = 378.013\,\lambda_e$. (1)We can propose that the number of stable bonding orbit n in this case should be $n_{Se\ in\ H2Se}^{proposed} = 189$.If sothe stable distance between selenium atom $Se$and hydrogen atom H in hydrogen selenide molecule$H_2Se$is of exact value $d_{SeH\ in\ H2Se}^{exact} = 145.99\,pm$.

4.3. The Half-Exact Angle$\boldsymbol{\varphi_{HSeH}}$in Hydrogen Selenide Molecule H_2Se

With the help of the measured distance between hydrogen atoms $d_{\boldsymbol{HH}\ in\ H2Se}^{exact} = 208.09\,pm$ and the proposed exact distance between selenium and hydrogen atom $d_{\boldsymbol{SeH}\ in\ H2Se}^{exact} = 145.99\,pm$ we can using the cosine rule calculate the half-exact value of angle $\varphi_{HSeH\ in\ H2Se}^{half-exact}$ in the hydrogen selenide molecule **H_2Se:**

$$cos\varphi_{HSeH\ in\ H2Se}^{half-exact} = 1 - \frac{1}{2}\left(\frac{HH}{SeH}\right)^2 = 1 - \frac{1}{2}\left(\frac{208.09}{145.99}\right)^2 = -0{,}01584. \quad (4a)$$

And

$$\varphi_{\boldsymbol{HSeH}\ in\ H2Se}^{half-exact} = 90.91°. \quad (4b)$$

Here, the half-exact value of angel is rounded to two decimal places.

5. Results

The given results bring values of distances HH and HX as well as angles HXH

5.1. The Distances HH

The distances HH between hydrogen atoms H in water molecule H_2O, in hydrogen sulphide molecule H_2S and in hydrogen selenide molecule H_2Se are collected in Table 1.

Table1. *The distances HH between hydrogen atomsH in hydride molecules H_2X where X = O, S or Se*

H_2X	Distance HH (measured)	Distance HH (measured)	Orbit HH (measured)	n	orbit s(n)	Distance HH (proposed)
H_2O	$\mathbf{151.44\ pm}$	$62.416\ \lambda_e$	$196.085\ \lambda_e$	196	$196.025\lambda_e$	$\mathbf{151.39\ pm}$
H_2S	$\mathbf{192.33\ pm}$	$79.269\ \lambda_e$	$249.029\ \lambda_e$	249	$249.020\ \lambda_e$	$\mathbf{192.32\ pm}$
H_2Se	$\mathbf{208.09\ pm}$	$85.764\ \lambda_e$	$269.435\ \lambda_e$	269	$269.018\ \lambda_e$	/

A subtle bond between hydrogen atoms H can be noticed in water molecule H_2O as well asin hydrogen sulphide molecule H_2S, but seems to be absent in hydrogen selenide molecule H_2Se.

5.2. The distancesXH

The distances between hydrogen atom H and non-hydrogen atom X in water molecule H_2O, hydrogen sulphide molecule H_2S and hydrogen selenide molecule$H_2Se$are collected in Table 2.

Table2. *The distances XH between hydrogen atom H and non-hydrogen atom X in hydride molecules H_2X where X = O, S or Se*

H_2X	Distance XH (measured)	Distance XH (measured)	Orbit XH (measured)	n	orbit s(n)	Distance XH (proposed)
H_2O	$\mathbf{95.78\ pm}$	$39.476\ \lambda_e$	$124.016\ \lambda_e$	124	$124.040\ \lambda_e$	$\mathbf{95.80\ pm}$
H_2S	$\mathbf{133.56\ pm}$	$55.047\ \lambda_e$	$172.934\ \lambda_e$	173	$173.029\ \lambda_e$	$\mathbf{133.63\ pm}$
H_2Se	$\mathbf{146.00\ pm}$	$60.174\ \lambda_e$	$189.041\ \lambda_e$	189	$189.026\ \lambda_e$	$\mathbf{145.99\ pm}$

A subtle bond between a hydrogen atom H and a non-hydrogen atom X can be noticed in all three hydrides: water moleculeH_2O, hydrogen sulphide moleculeH_2S, and hydrogen selenide moleculeH_2Se.

5.3. The angles HXH

Proposed exact angle values between atoms in watermolecule $H_2O$and hydrogen sulphide molecule H_2S as well as half-exact angle value in hydrogen selenide molecule H_2Se are collected in Table3.

Table3. *Proposed angle values in hydride molecules H_2X where X = O, S or Se (oxygen, sulphur or selenium)*

H_2X	Angle φ_{HXH}	Status
H_2O	*104.40°*	exact
H_2S	*92.04°*	exact
H_2Se	*90.91°*	half-exact

An exact angle value can be proposed in water moleculeH_2O as well asin hydrogen sulphide moleculeH_2S, and a half-exact one in hydrogen selenide moleculeH_2Se.The valuesin Table 3 are rounded to two decimal places.

6. INTERESTING COINCIDENCE

H_2Se molecule, which is larger than H_2S molecule and does not form intramolecular subtle bond between hydrogen atoms (see section 4.1.), as H_2S does (see section 3.1.),may contribute to the stronger intermolecular bonds of H_2Se molecules compared to H_2S molecules, and as a result, H_2Se exhibits a higher boiling point than H_2S does.

7. CONCLUSION

Hydrides from the sixth group of elements have interesting double surfacecharacteristics

DEDICATION

To Socrates and his quote[4]

Figure4. *Wisdom begins in wonder*

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