ISSN: 3068-2789

Review Article

Journal of All Physics Research and Applications

The Renascence of Bohr's Hydrogen Atom Model, its Application on Helium, and the Bridge to Thermodynamics

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ABSTRACT

The present article takes up various issues that are interlinked by their contents and thus form a coherent whole. They refer to already published papers of the author. Common to them all is their alternative approach to orthodox precepts. First, a planar atom model with well-defined electron trajectories is introduced, leaning on Bohr's Hydrogen atom model and questioning the conventional quantum mechanical model with probabilities of presence, instead applying the spin-orbit coupling of the electron. Second, this model was empirically proved by computation of the bond-length in the H_2-molecule, comparing it with XRD-values. Third, this model was applied to the Helium atom, regarding the Pauli-principle which concerns the electron-spins. Fourth, this atom model was applied in order to explain the thermal radiative behaviour of Helium which has been discovered by the author, bridging quantum-mechanics with thermodynamics. The key concept for his behaviour consists in an eccentric asymmetric harmonic oscillator for Helium which can be excited by thermal radiation as well as by momentum transfer due to the thermal motion of the atoms, and vice versa.

Keywords: Spin-Orbit-Coupling, Standing Electron Wave, Molecular Model of H_2, Atom Model of He, Kinetic Gas Theory, Thermal Radiation and Absorption, Eccentric Asymmetric Harmonic Oscillator, Bridge Quantum Mechanics – Thermodynamics, Modulo Rule.

Received: July 13, 2026;
Accepted: July 20, 2026;
Published: July 27, 2026

Introduction

From time to time the attempt was made to vindicate the classical atom model of Niels Bohr, implying two-dimensional, well-defined electron trajectories, which was replaced by the model of Heisenberg, Schrödinger, Dirac and others in the 1920s (here named »orthodox model«), implying three-dimensional electron orbitals with electronic probabilities of presence. Thereby (as in example), the fact is neglected, that Bohr's model only explains the discrete spectre of insulated Hydrogen atoms (which only exist at very low pressures) by computing the energy differences between the excited electron orbits, correlating them via Einstein's formula for the photoelectric effect, whereas the orthodox orbital model is first at all suited to principally explain the different electron shells, the Aufbau-principle of the periodic system, and the orientation of chemical bonds [1]. Both models are not even able to completely explain the Helium atom [2].

By the alternative atom model, proposed by the author and based on Bohr's approach, not only the bond-length in the H_2-molecule, but also the well-defined electron trajectory in the Helium atom could be computed. Whereas the bond length in the H_2-molecule could be empirically proved by XRD measurement results, delivering the evidence for the model, in the case of the Helium atom the empirical proof was much more difficult since it does not undergo chemical bonds. Hereto, the author's study of the behaviour of gases in the presence of thermal radiation could be adduced, allowing the bridge between thermodynamics and quantum mechanics by assuming a rotating eccentric asymmetric harmonic oscillator for the electrons which is able to absorb thermal radiation energy.

Citation: Thomas Allmendinger (2026) The Renascence of Bohr's Hydrogen Atom Model, its Application on Helium, and the Bridge to Thermodynamics. J All Phy Res Appli 2: 1-9.

These three aspects – H_2-molecule, Helium atom model and its behaviour within thermal radiation – will be subsequently discussed in separate chapters. But at first, it will be demonstrated that and why both models cannot be simultaneously valid.

The Questionability of the Orthodox Atom Model and the Alternative Model

Niels Bohr's publication in 1913, describing the Hydrogen atom not as a rigid body but as a composite of a relatively heavy, positively charged nucleus and a relatively light, negatively charged electron, circling the nucleus, represented a considerable mile-stone in physics [3]. It resembles the planet-model around the sun. However, the attractive force is not induced by gravitation (which can be neglected here) but by the Coulomb force, while the repulsive force, being in equilibrium with the attractive force, is due to centrifugation, thus depending on the mass and on the velocity of the electron. A further significant difference consists in the fact that only definite rotation distances are possible, which corresponds to definite electronic energies. The empiric evidence for this behaviour was given by the discrete electromagnetic spectrum of Hydrogen which had been observed by J.J. Balmer already in 1885, finding special mathematic regularities [4]. Based on Einstein's *photoelectric effect ($E = h \cdot v$)*, published in 1905, Bohr could formally explain these spectral regularities, assuming correspondence between the (metastable) energy levels of the excited electron and the absorbed or emitted light, introducing a quantum number. Thereby, it should be realized that the relevant spectra were taken at very low pressures which enabled the existence of atomic Hydrogen, while at normal pressure solely H_2-molecules occur.

The respective computation can be found in physical textbooks. Here, solely the most distinctive results are presented, whereby n means a quantum number (which corresponds to the shell-number x or y). In order to avoid confusion with the frequency v, the abbreviation u is used for the electronic velocity. Moreover, common abbreviations and values are used for e = elementary charge, ε_0 = permittivity constant, m_{el} = electron mass, h = Planck's constant.

radius: $r_n = r_1 \cdot n^2$ where by $r_1 = \frac{\varepsilon_0 \cdot h^2}{\pi \cdot m_{el} \cdot e^2} = 0.5299 \cdot 10^{-10}$ m (Bohr-radius)

velocity: $u_n = u_1/n$ where by $u_1 = \frac{e^2}{2\,\varepsilon_0 \cdot h} = 2.1877 \cdot 10^6$ ms^{-1}

angular velocity of the electron: $\omega_{el,n} = u_n/r_n$; rotation frequency of the electron: $\nu_{el,n} = \omega_{el,n}/2\pi$

Thereby it is remarkable, that v_{light} becomes $n/2 \cdot v_{electron}$.

light frequency: $v_{light} = R_\infty \cdot (1/(n_x^2 - n_y^2))$, Rydberg constant $R_\infty = m_{el} \cdot e^4/8\,\varepsilon_0^2 \cdot h^2) = 3.2899 \cdot s^{-1}$

Combining the first two expressions, the angular momentum L_n can be determined, yielding $|L_n| = m_{el} \cdot u_n \cdot r_n = m_{el} \cdot u_1 \cdot r_1 \cdot n = n \cdot h/2\pi = n \cdot \hbar$

There by, it has to be noticed that the unit of the angular momentum is Js (i.e. energy by time), thus it is identical equal with the one of Planck's quantum h, which originally was conceived as a *quantum of actio*n, i.e. as the product of work and time, too. However, such a term does not exist elsewhere in physics, particularly not as a conservation law. As a consequence, h (respectively $\hbar = h/2\pi$) rather expresses an *angular momentum*, implicating a conservation law. But it was not explicable at that time why such a planar ground state exists, avoiding the fall of the electron onto the nucleus which would be the case if it behaved like a Hertz-oscillator.

A further progress was made by the hypothesis of Louis de Broglie, established 1924 in his thesis, assuming a *wavy nature of the electron*. Indeed, this phenomenon could later be empirically verified by observing diffraction of electron beams at thin metal foils [5]. Philosophers spoke of a »wave-particle-duality«. However, the origin of this behaviour was not obvious. That is also the case for the usual de Broglie formulation which solely describes the behaviour mathematically, using the electron momentum p_{el}:

$p_{el} = m_{el} \cdot u_{el} = h/\lambda_{el} \rightarrow \lambda_{el} \cdot p_{el} = h$

where by λ_{el} = wave-length of the electron

Thereby, it has to be regarded that the momentum p_{el} is a vector. As a consequence, the Planck-constant h must be a vector, too, whose absolute value is known. Moreover, in the H-atom model of Bohr the ground state and the excited states correspond to *standing waves* differing in their angular momenta, since they are running through closed circles.

Based on this relation, Werner Heisenberg propagated the so-called *uncertainty principle*. According to that, it is impossible to simultaneously determine the location and the momentum of a particle (electron). It is mathematically expressed by the relation $\Delta x \cdot \Delta p \geq h$

If for x the wavelength λ_{el} is inserted, the analogy to the de-Broglie-relation becomes evident. But in contrast to that, this relation actually represents an inequality – which seems strange in the quantum-mechanical world where very exact values occur.

Moreover, this formulation seems to implicate a further aspect, namely the exclusion of a planar constellation and the implication of a three-dimensional motion, which came off in view of the three-dimensional multi-electron systems being relevant for the »Aufbau-Principle« of the periodic system of elements, as well as for the directed chemical bonds in molecules. However, *in an insulated two-particle system like the one of the H-atom, a three-dimensional electron motion is fundamentally impossible since thereto an external force or impetus would be needed which had to be perpendicular to the rotation plane.*

In order to accomplish computations fulfilling Heisenberg's uncertainty principle, i.e. in order to compute it, Erwin Schrödinger contributed the differential equation, which is named after him, enabling the computation of the probabilities of electron presence in the so-called orbitals. Its operator »Hamiltonian«, acting on a state function and delivering Eigen-values, comprises the following expression for the kinetic

energy. It uses the electronic momentum $\boldsymbol{p}_{el}$ and is given by a Laplace-operator as follows:

$$E_{kin,el} = \frac{\boldsymbol{p_{el}}^2}{2m_{el}} = -\frac{\hbar^2}{2m_{el}}\left(\frac{\partial^2}{\partial x^2} + \frac{\partial^2}{\partial y^2} + \frac{\partial^2}{\partial z^2}\right)$$

The sore point of this approach consists in the fact that the angular momentum, which appears in the Bohr model as a vector aligned in one direction, is split within the 1s-orbital into three components, according to the Cartesian coordinate system, and resulting in a three-dimensional constellation shown in Figure 1. But this is not possible because of the above-mentioned reason: Obviously, the angular momentum implies a singular vector, which – otherwise than a simple velocity vector – cannot be composed by three partial vectors when no external impact exists. If at all, the respective Laplace-operator should exhibit solely two components, not three.

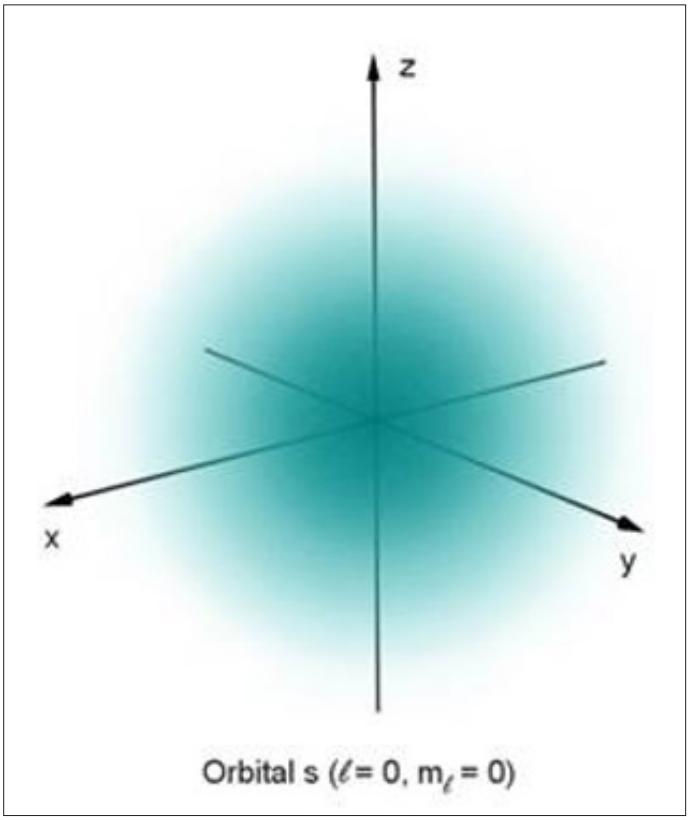

Figure 1: 1s-orbital, according to https://de.wikipedia.org/wiki/Atomorbital#/media/Datei:Orbital_s1.png

But such a complicate computational method as Schrödinger's is not needed; the simple application of physical laws is sufficient, using polar coordinates instead of Cartesian ones. Rather, this mathematically intricate method may have played a part in disregarding the planar character of the electron orbit. Besides, it pretended to have found a novel natural law in the form of the uncertainty principle. But if the so-called 1s-orbital would exist, the electron movement would have lost its character, implying an angular momentum. It cannot simultaneously be true when the planar, empirically verified Bohr model is true. Nevertheless, it became generally accepted, displacing the Bohr model in the quantum mechanical theory.

In fact, this so-called uncertainty principle does not represent a novel natural law. Rather, it delivers a mathematical but inadmissible remodelling of the de Broglie-relation, respectively of the quantized electronic angular momentum at the Hydrogen atom. Instead, a special phenomenon could deliver the explanation which had been discovered by Uhlenbeck and Goudsmith in 1925/26, namely the *electron spin,* implying an invariant *magnetic moment of the electron* [6,7]. It was postulated due to the multiplet-character of electron spectra taken in the presence of magnetic fields. Within the H-atom, it induces a *spin-orbit coupling* which explains that the electron cannot fall onto the nucleus. In other words: The electron spin represents *a perpetuum mobile* which is liable for the existence of atoms. Thus, the here used H-model intrinsically comprises the angular momentum ħ in the ground state.

Indeed, the spin-phenomenon was noticed when it became public. But it was implemented in the already existing three-dimensional quantum mechanical theory (especially by Dirac and by Pauli), instead of extending Bohr's planar approach.

The Application of the Planar H-Atom-Model on the H_2-Molecule

In the initial author's concept for a modified H-atom-model, at the ground state a planar orbit was assumed, due to the spin-orbit coupling. However, for the excited electron states he was still influenced by the orthodox three-dimensional atom model, assuming an additional orthogonal harmonic oscillator within a standing wave [8]. Thereby, the fact was disregarded that a closed planar rotation already represents a standing wave, thereby sparing such an additional condition. Anyway, in order to compute the bond-length in the H_2-molecule solely the ground states of the two atoms are relevant, where the angular momentum of each Hydrogen atom must be $u_{rot} \cdot r_{rot} \cdot m_{el} = h/2\pi = \hbar$. Indeed, in such a constellation could be presented (Figure 2), yielding a potential-well (Figure 3), and being verified by empiric XRD-data [9]. Similar results had been obtained by Heitler using the orthodox method [10]. Therefore, the evidence for the correctness of this planar model was actually furnished.

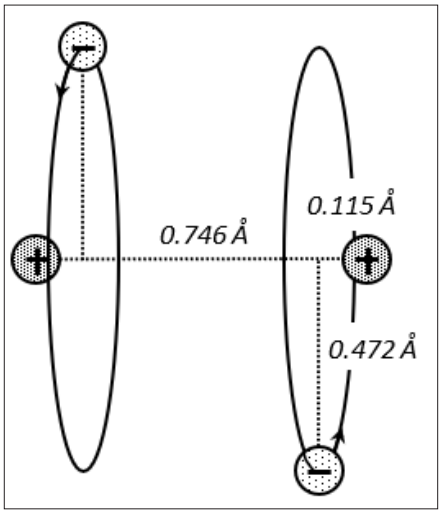

Figure 2: Model of the H_2-molecule with well-defined electron orbits, according to [9]

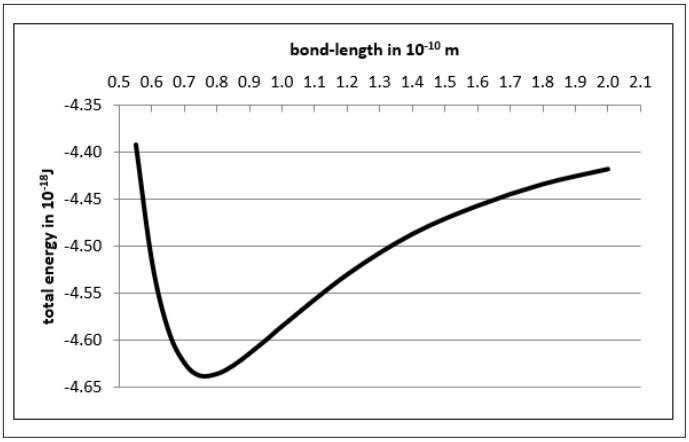

Figure 3: Total energy as a function of the bond-length at the intra-nuclear antipodal array of the H_2-molecule, according to [9]

The Analogous Atom Model for Helium

Analogously, a two-dimensional atom model for the noble gas Helium in its ground state may be deduced. Its nuclear charge is 2+ which implicates two electrons rotating along well-defined trajectories or orbits. Just as in the orthodox model, both electrons are preferably located in the same shell, letting suppose that they move synchronically in diametrically opposite directions. But if the Pauli-principle is considered, excluding that two electrons are located in the same orbit, such a constellation appears to be forbidden.

Initially, several three-dimensional models were developed, too, first a model consisting of two orthogonal electron rotations, and second a model consisting of a rotation and an orthogonal harmonic oscillation, but which finally had to be abandoned [11-13]. Rather, a planar orthogonal combination of two equal (imaginary) orthogonal electron rotations proved to be adequate, such as schematically depicted in Figure 4 and according to [14]. Therein, the resulting radius R of the electrons amounts to $\sqrt{2} \cdot r$ (r = separate imaginary radius). Or in other words: The resulting angular momentum of the electrons is not twice the angular momentum of the imaginary ones (amounting to ħ); instead, there is a factor $\sqrt{2}$, implying that

$$u_{rot,0} \cdot R_0 \cdot m_{el} = \sqrt{2} \cdot h/2\pi = \sqrt{2} \cdot \hbar \qquad (1)$$

The values of the parameters for this model in the ground state are:

$R_0 = 0.5644 \times 10^{-10}$ m $\qquad u_{rot,0} = 2.901 \times 10^{6}$ ms^{-1}

$\omega_0 = 5.14 \times 10^{16}$ s^{-1}

where by $u_{rot,0}$ = rotation velocity in the ground state, and ω_0 = angular velocity

Thus, the Pauli-principle is fulfilled, even though both electrons are located in the same orbit.

However, empirical evidence for this model cannot be easily delivered as it is possible for Hydrogen, because the Helium atom and the Hydrogen atom are distinguished in two principal respects: The two-electronic Helium represents a noble gas which occurs at normal conditions in the form of single atoms being incapable of undergoing chemical reactions, while Hydrogen normally occurs in the form of H_2-molecules whose bond lengths can be validated by XRD-data, as demonstrated in the previous chapter, referring to [9]. Thus, for Helium such simple evidence is not feasible. But as will be pointed out in the next chapter, verification could be made by applying thermal radiation effects and regarding thermodynamic aspects.

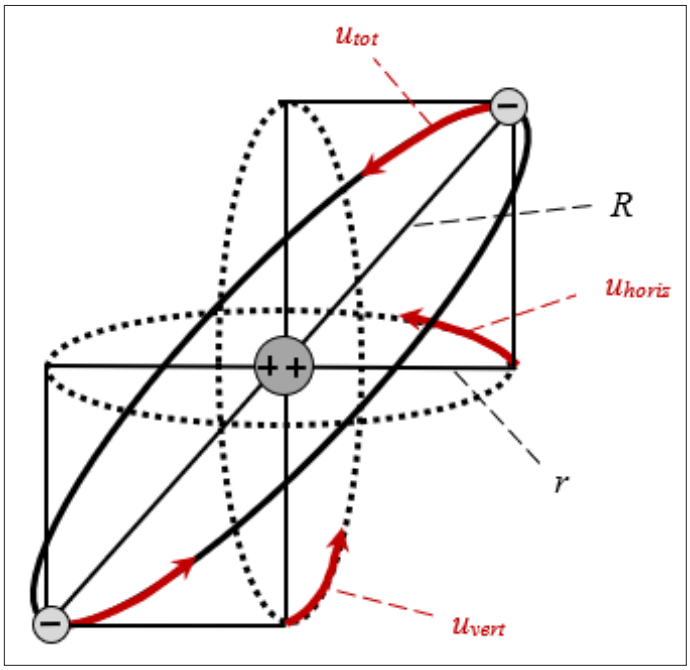

Figure 4: 2D-model of Helium composed by two imaginary orthogonal orbits of the electrons, according to [14]

The Thermal Radiative Behaviour of Helium

The fact that Helium can adsorb and emit thermal radiation, combined with warming-up and cooling-down, was incidentally discovered by the author with measurements carried out on air and on CO_2 [15]. These measurements had originally been provided in order to verify the atmospheric temperature increase due to the CO_2-concentration increase which is assumed as the origin of climate change. But surprisingly, aside from the fact that the CO_2-concentration is very low, air did not only behave like pure CO_2; moreover, every gas turned out to be active, even noble gases such as Helium. Thus, the results for Helium could be adduced for a quantum mechanical interpretation, which was delivered in subsequent publications, and which will be summarized later. But first, the used apparatus and the results as well as their evaluation in terms of the kinetic gas theory, being described in, will be briefly resumed [15].

The measurements were carried out in one-meter-long tubes, applying as radiation sources sunlight, on the one hand, and IR-spots, on the other hand. In order to avoid or minimize interference in the walls of the measuring tube, due to the relatively low heat capacity of gases, a material with low heat capacity and low heat conductivity was used, namely Styrofoam. Additional improvements were gradually made by thin aluminium foils mirroring the heat radiation. The gas was enclosed by thin plastic foils at both ends of the tube, and the

temperatures were measured by thermometers at three positions, see Figures 5 and 6.

Figure 5: Solar tube, according to [15]

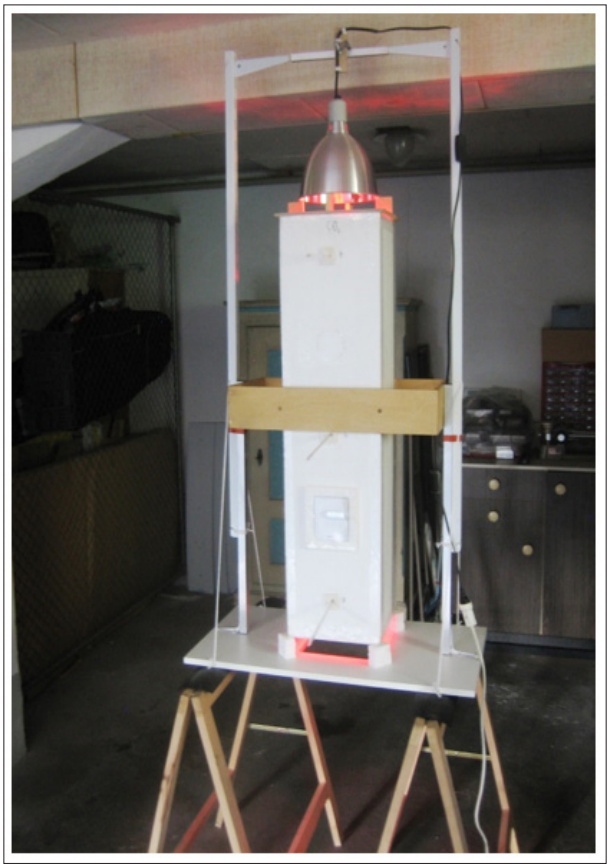

Figure 6: Heat radiation tube, according to [15]

The advantage of the first method is that the sunlight intensity along the tube remains constant. However, the portion of thermal radiation is relatively low. Moreover, its intensity is not constant but depends on the daytime, the time of year and the sea level of the measuring station. Therefore, the measurements were always made in summer at midday.

The advantage of the second method, using artificial light, is that the light intensity is constant. However, it decreases along the tube without being absorbed since the intensity of light sent by a point source depends on the distance. Moreover, it is difficult to estimate the original intensity and the wave length dispersion, based on indications of the producer and on the approximate computations according to Planck's formula. By comparing the solar spectrum with the spectrum of the IR-spot, approximate values for the effective wavelength were obtained, being lower than 2 µm. To scale: the limit to the visible red light is at 0.76 µm. As subsequent but less reliable measurements using a hot plate yielded, larger wavelengths seem to be possible, too [16]. The here relevant measurements with Helium were made by means of the second method.

The essential result of these measurements consisted in the observation that any gas is warmed-up when it is thermally irradiated, but solely up to a limiting temperature where the thermal absorption intensity of the gas is equal to its emission intensity. The comparison of the noble gases Argon, Neon and Helium yielded that the limiting temperatures depend on the gas type, cf. Figures 7 and 8.

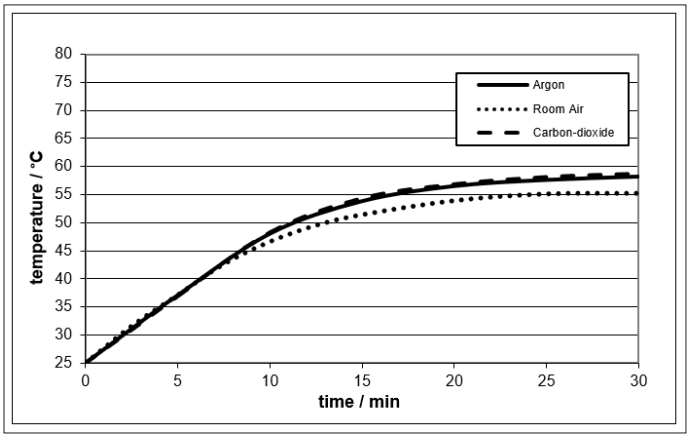

Figure 7: Average warming-up rates for different gases, measured with the heat radiation tube method A, 150W IR-spot, medium thermometer position) (Figure 25 in [15])

Those differences could be explained by the kinetic gas theory which presumes proportionality between the kinetic energy of the gas particles and the absolute temperature.

In order to explain this radiative behaviour, proportionality was assumed between the collision wattage of the atoms and the radiation wattage. As a theoretical result of this approach, proportionality between radiation wattage and gas pressure was predicted, but it could not be exactly computed. However, empirical evidence was furnished for atmospheric air in a subsequent publication where measurements at different altitudes

– implying different atmospheric pressures and temperatures – were made [17]. Similar results for air, Carbon-dioxide and Argon were published later on by Seim and Olsen [18].

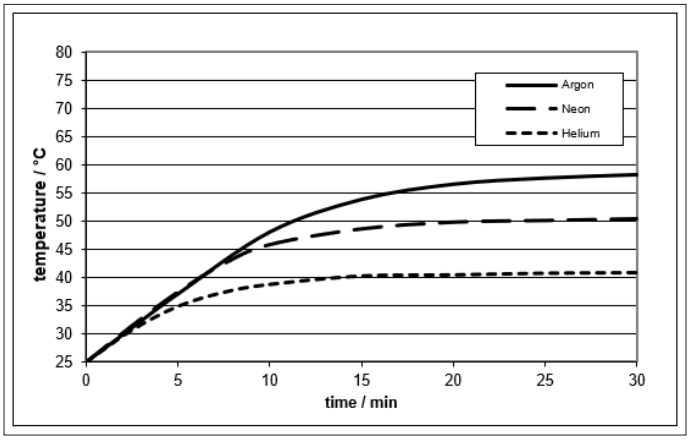

Figure 8: Average warming-up rates for different gases, measured by the heat radiation tube (method A, 150W IR-spot, medium thermometer position) (Figure 26 in [15])

A quantum mechanical explication and a computation of the expected wave lengths was tentatively given already in, assuming that there is a connection between the thermal radiation and the oscillation of the electronic shell [15]. However, the respective computation turned out to be erroneous, while at that time no model was available. So, a comprehensive treatise was needed, based on the actual atom model of Helium [14,19]. Moreover, recently a revision and improved version was published which will subsequently be outlined [20].

The Quantum Mechanical Description of the Excited State of Helium

As scheduled in Figure 9, the thermal radiation emitted by a spot (or by another light source) can be absorbed by atoms which undergo an electronic excitation (excited state) being able either to emit thermal radiation or to increase the heat content. Conversely, the kinetic heat of the gas can lead to this excited state. In contrast to the electronic excitation which happens in the case of Hydrogen (where excited states with multiple angular momenta are reached), requiring UV-light, this excitation takes place within the ground state, involving IR-light.

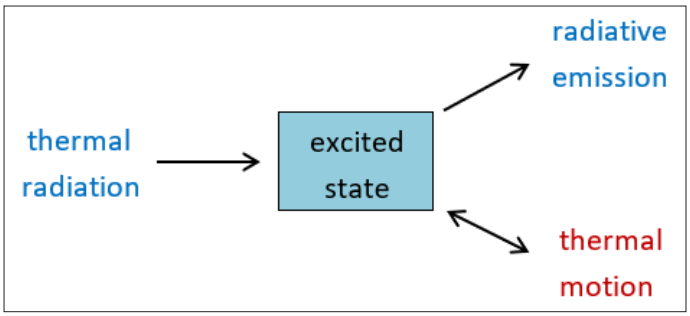

Figure 9: Schema of the energetic relations at the atom, according to [19] and [20]

As a consequence, an electronically excited, metastable state of the atom must exist which implies an energetic elevation. It is characterized by an electronic oscillation of the electronic shell which obeys quantum mechanical criteria, and which is able to explain the transfer of the oscillation energy to kinetic motion as well as the electromagnetic radiation.

This oscillation can be modelled – as described in – by means of a rotating eccentric asymmetric harmonic oscillator of the electrons, using the planar atom model of Helium [19,20,14]. It comprises two different electron velocities, the rotating and the oscillating one which is perpendicular to the rotating one. As in the case of a normal harmonic oscillator, the oscillating velocity u_{osc} is time-dependent and varies between the outer and the inner turning point, while the rotating velocity u_{rot} is more or less constant since the extinction ΔR is relatively small compared to the rotation radius R. However, the angular velocity ω_{osc} which determines the oscillating velocity u_{osc} is more or less constant. The electron course with its extreme positions is scheduled in Figure 10, expressing a standing wave:

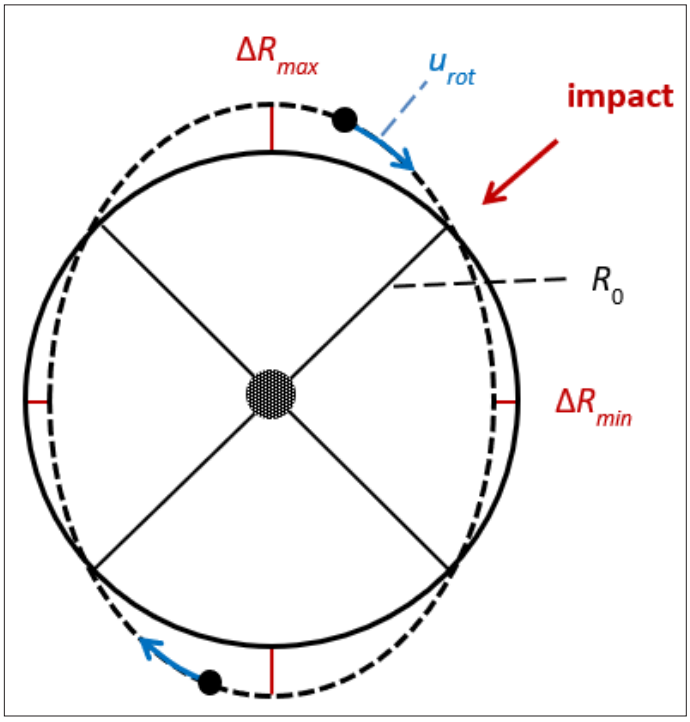

Figure 10: Orbit of the electrons as a result of a collision or a thermal-radiative excitation (= dotted curve; red lines: maximal and minimal positions of the electrons) according to [19] and [20]

The asymmetry of this special oscillator is due to the fact that the centrifugal force depends in another degree on the distance than the Coulomb force does. The extinctions as functions of the oscillation angle $\varphi = \varphi_{osc} = \omega_{osc} \cdot t$ can be expressed as follows (Figure 11):

$$\Delta R = A \cdot sin\varphi + B \cdot (sin\varphi)^2 \quad (2)$$

ΔR = extinction (distance deflection, amplitude)

$$A = (\Delta R_{max} + \Delta R_{min})/2$$
$$B = (\Delta R_{max} - \Delta R_{min})/2$$

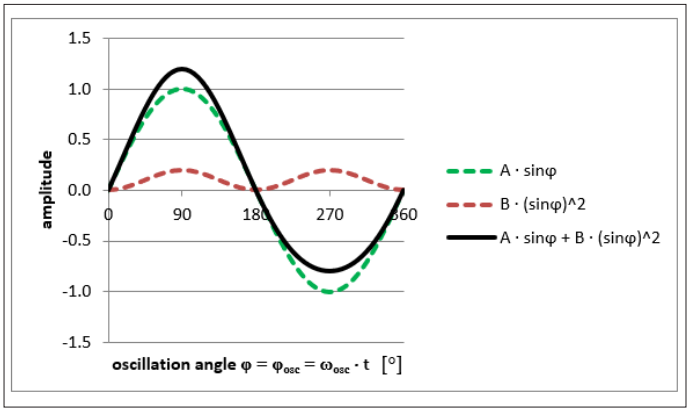

Figure 11: Linear depiction of a standing wave by an asymmetric harmonic oscillator, according to [19] and [20]

In this case, ΔR_{max} corresponds to ΔR_{out}, and ΔR_{min} to ΔR_{in}.

As for any harmonic oscillator, the total energy of an asymmetric harmonic oscillator is given by the kinetic energy of the oscillating electrons at the zero-point, i.e. at the point where the distance deflection as well as the potential energy is zero. And since two diametrically running electrons are implied, its double amount must be used.

The oscillation velocity u_{osc} results from the mathematical derivation of the distance deflection on ΔR and becomes a function of time, expressed as followed:

$$u_{osc} = \Delta\dot{R} = A \cdot \omega_{osc} \cdot \cos(\omega_{osc} t) + 2B \cdot \omega_{osc} \cdot \cos(\omega_{osc} t) \cdot \sin(\omega_{osc} t) \quad (3)$$

This yields at the zero-point where ωosc · t = 0 the kinetic or total energy:

$$E_{osc} = m_{el} \cdot (u_{osc,max})^2 = m_{el} \cdot A^2 \cdot (\omega_{osc})^2 \quad (4)$$

But whereas ω_{osc} is given as a multiple of ω_0 (preferably 2), the amplitude A, E_{osc}, ΔR_{out} and ΔR_{min} are not readily known. As described in, they can be computed by determining the extreme distances $R_{out} = R_0 + \Delta R_{out}$ and $R_{in} = R_0 - \Delta R_{in}$ [20]. That is feasible by equating the energies which are needed in order to achieve the excited state, whereby the energy of the outer electron position must be alike the inner energy of the inner electron position. Relevant are the total energies, i.e. the sums of the potential and the kinetic energies. Using the energetic relations which are valid in this model, and taking ΔR_{out} and ΔR_{in} as unknown variables, it was possible to determine the two ΔR-values by nested intervals, yielding ΔR_{out} = 0.045 x 10^{-10} m and ΔR_{in} = 0.0387 x 10^{-10} m, corresponding to $\boldsymbol{E_{tot}}$ **= 0.0416 x 10^{-18} J**.

Besides, the amplitude A could be computed, yielding the value 0.04185 x 10^{-10} m. This enabled to compute E_{osc}, assuming $\omega_{osc} = \omega_{rot}$ = 5.14 x 10^{16} s^{-1}, and becoming **0.0421 x 10^{-18} J**. The application of that ω_{osc}-value (instead of $2\omega_{rot}$) seems striking, but it is indicated in view of the good accordance of those two energy values which ideally should be equal. In particular, the bridge between electron oscillation and thermal motion – thus between quantum mechanics and thermodynamics –, could be established and improved in [20].

The Bridge Between Electronic Oscillation and Thermal Motion

The key idea for bridging electronic oscillation and thermal motion consists in the application of the *theorem of conservation of the momentum* ***P*** to the collision process, whereby $u_{osc,max}$ means the electron velocity at the point where t = 0, and w the atom or particle velocity due to thermal motion, as described in [19,20]. Thereby, the momentum ***P*** of the atom as a whole is equated with the momentum of the electrons within the atom:

$$P_{electron} = 2m_{el} \cdot u_{osc,max} = \bar{P}_{atom} = m_{He} \cdot \Delta\bar{w}_{He}$$

$$\rightarrow u_{osc,max} = m_{He}/2m_{el} \cdot \Delta\bar{w}_{He} \quad (5)$$

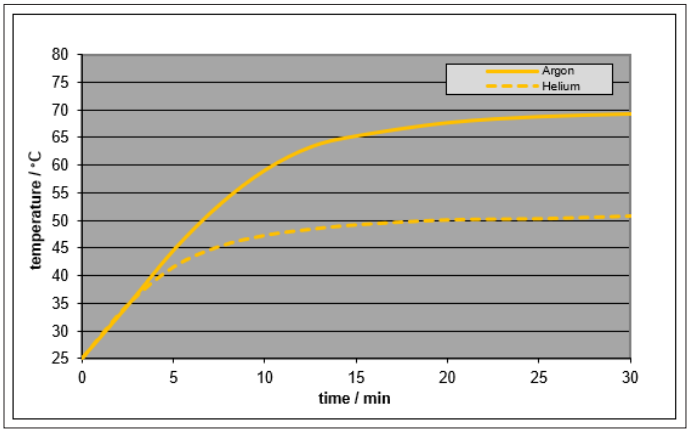

Figure 12: Comparison of Argon and Helium (method B2, 150 W, medium pos.) (Figure 27 in [15])

As empirical data source, the results depicted in Figure 12 were used, implying $T_{lim,He}$ = 524K and T_{amb} = 298K. Therefore, Δ_{wHe} becomes 59 ms^{-1}, yielding $\boldsymbol{u_{osc,max}}$ **= 0.216 x 10^6 m^{-1}**.

For comparison: The value for $u_{osc,max}$, quantum-mechanically computed as described above, becomes $A \cdot \omega_{osc}$ = **0.215 x 10^6 ms^{-1}**. Therefore, the accordance of the two values (namely the computed and the empirically determined one) is excellent, too.

Finally, the connection between the oscillation energy and the thermal radiation energy had to be checked, possibly using Einstein's photoelectric effect.

The Connection of the Oscillation Energy with the Thermal Radiation Energy

So far, accordance between the oscillation energy of the electrons and the kinetic motion energy of the atoms had been found, yielding 0.0416 x 10^{-18} J and 0.0421 x 10^{-18} J. But the final objective of this consideration was to find a connection between these energies and the thermal radiation energy, determined by its frequency or wave length. Hitherto, Einstein's photoelectric effect, given by the formula $E = h \cdot \nu$ (ν = radiation frequency), seemed relevant.

The problem is that the effective wave length, indicated in, was not exactly known but solely estimated, preferably assuming λ = 1.9 µm [15]. If the average energy value 0.042 Js is taken, together with h = 6.6261 x 10^{-34} Js, the frequency 0.0063 x 10^{16} s^{-1} is obtained. And since $\nu \cdot \lambda = c = 3 \cdot 10^8$ ms^{-1} (light velocity), the

wave length λ becomes 4.76 µm. This value is more than twice the empirical one. How can this be explained?

An obvious explanation is that the empirical value of the wave length is actually larger than estimated. This could be confirmed by the fact that air (which behaves like Argon) is warmed-up already in the presence of low-temperature radiators, as described in [16].

However, an alternative explanation is thinkable: Considering that E_{osc} depends on $(\omega_{osc})^2$, and assuming that the angular velocity ω_{osc} should be at least $\sqrt{78} = 8.8$ times smaller, which would result in a corresponding reduction of the oscillation frequency. This seems not to be readily possible since the condition must be fulfilled that the sine-values as well as the cosine-values of the oscillation angle – thus of the product angular velocity and time – must be equal at any 45°-step (where an inversion of the course occurs). That is not the case for any arbitrary factor.

But a solution is possible by applying the so-called *modulo-rule*, delivering the quotient 9 as the lowest possible value, and yielding the following value for

$$\omega_{osc,part} = \omega_{rot}/9 = 0.571 \times 10^{16}\ s^{-1} \quad (6)$$

Using Equation (6) with $A = 0.04185 \times 10^{-20}$ m, this yields the value $E_{osc,part} = 5.2 \times 10^{-22}$ J which is very close to the empirical value of 5.4×10^{-22} J. It means that the oscillation period of the electron becomes nine times smaller than the rotation period, i.e. the oscillation becomes slower than the rotation. This is visualised in Figure 13 (which has not been published so far):

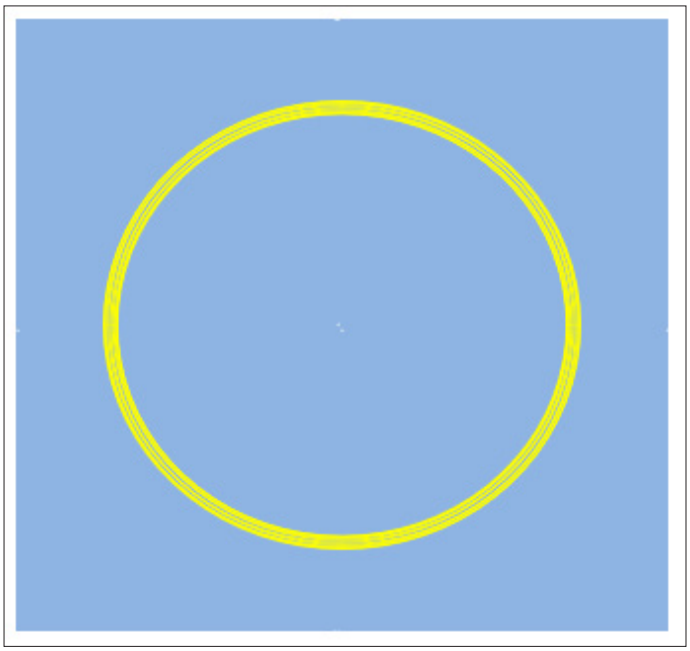

Figure 13: Probabilities of electron presence in a thermally excited Helium atom (modulo-quotient 9)

Since further modulo-quotients are possible – namely the integral multiple of 9 –, this also means that a variety of wave lengths come into question, i.e. those with the wave lengths 0.33, 0.66, 0.99, 1.32, 1.65, 1.98, 2.31, 2.64, 2.97 µm etc. Thereby, those with a wave length larger than 0.76 µm are in the IR-range. Indeed, *it seems plausible that several wave lengths exist together, implicating a continuous-like spectrum, instead of a discrete one.* This would also explain why it is so difficult to identify the wavelength which is effective for the thermal radiation and adsorption.

Conclusions

The here presented results confirm the validity of a planar atom model for Hydrogen according to Bohr's model first by applying it on the H_2-molecule and empirically validating it by XRD data. Thereby, the ground state of Hydrogen exhibits the electronic angular momentum $\hbar = h/2\pi$. In order to explain its stability, the *electron-spin* must be taken into account, inducing a spin-orbit coupling. Thus, it appears like a *perpetuum mobile*. Moreover, an appropriate planar atom model for Helium was developed. Unlike in the case of Hydrogen where the angular momentum is $\hbar$, here the Pauli-principle implies the electronic angular momentum $\sqrt{2} \cdot \hbar$. Empiric validation is more difficult for Helium than for Hydrogen since it does not enable chemical bonds. Furthermore, interactions occur between the single atoms due to thermal collisions. They could be explained by the *kinetic gas theory*, which connects the kinetic energy of the particles with the absolute temperature of the gas. The collisions induce electronic excitation being describable by an *eccentric asymmetric harmonic oscillator*, capable of emitting thermal radiation. Conversely, thermal radiation can induce electronic excitation, while the electronically excited atoms can induce thermal movement of the atoms. This principally explains the recently discovered thermal radiative behaviour of gases by the interaction between the electronic oscillation and the kinetic motion of the atoms, as well as between the electronic oscillation frequency and the thermal radiation frequency. But in particular, a high degree of accordance could be found between the numerical and the empirical values, thereby bridging quantum mechanics and thermodynamics. A crucial point was the fact that the electronic oscillation frequency is lower than the rotation frequency which could be resolved by applying *modulo rule*. Since it predicts several possible frequencies (or wave lengths), it seems plausible that several wave lengths exist simultaneously, inducing a continuous-like spectrum, instead of a discrete one.

Thereby it has to be realized that quantum mechanics obeys strict regularities, while thermodynamics obeys the laws of probability, concerning transversal motions and rotations of atoms (or molecules) around themselves. Therefore, from the observers view, the Helium atom appears to be three-dimensional, while intrinsically it is two-dimensional. In fact, the considered constellation represents a special case for Helium, but it is characteristic and in principle applicable for larger atoms. However, the mathematical modelling of atoms with higher electronic shells appears to be very difficult or even impossible.

This principle seems even applicable to molecules and thus to gases like nitrogen and oxygen, potentially explaining the Raleigh-scattering and the fact, that the sky is blue. But at least it theoretically confirms the thesis that climate change is not due to »greenhouse gases« such as CO_2, but to the anthropogenic surface darkening of the Earth.

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