

RESEARCH ARTICLE

On the Zugzwang and the Delayed Quantum Zwischenzug in Quantum Mechanics

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Abstract

The birth of quantum mechanics in 1925-1926 may be described metaphorically as a scientific zugzwang (being forced to make a move on the chessboard): the old classical language could not longer explain atomic phenomena, yet every move into a new theory required the sacrifice of familiar concepts such as trajectory, visualization, determinism, and simple locality. Heisenberg's matrix mechanics, Schrödinger's wave mechanics, Born's probability interpretation, and Bohr's complementarity were powerful responses to this crisis. However, the many interpretations of quantum mechanics suggest that the mathematical formalism was accepted before a single agreed physical picture was found. This article proposes the metaphor of the delayed quantum zwischenzug (instead of playing the expected move, a new unexpected move changes the situation of the chessboard): a hidden, unexpected "in-between move" by Nature that may later reopen the interpretive game. Nicholson in 1912 proposed a transverse oscillation of the electron while orbiting around the proton. J.J. Thomson in 1913 postulated unknown attractive and repulsive forces inside of the atom. Quantum chromodynamics in 1964 discovered the composition of protons as three quarks with charges (+2/3e; -1/3e; +2/3e). We propose one delayed quantum zwischenzug, where that composite proton rotates with the light speed c and radiates the Planck action intensity $h/4\pi$ with the speed $v = \alpha c$ (α is the Sommerfeld fine structure constant). The orbiting electron oscillates at the distance a_0 (the Bohr radius) on the stable orbit. The Coulomb law is expressed through both attractive and repulsive forces as it was anticipated by J.J. Thomson in 1913. The orbiting electron can absorb and release a photon with mass m_γ . The electron screening by photons modifies the effective electrical charge of that orbiting electron as $-1 e/n^2$. This screening effect influences both attractive and repulsive forces inside of that hydrogen between orbiting electron and the rotating composite proton. This delayed quantum zwischenzug can newly interpret the known mathematical formulae, e.g. the Rydberg energy. The article concludes that the "delayed quantum zwischenzug" is a useful physical picture that preserves quantum predictions while restoring some visualization of events in the inner architecture of the hydrogen.

Keywords: Attractive and Repulsive Forces Inside of Atom, Delayed Quantum Zwischenzug, Planck Action Intensity [Js steradian^{-1}], Zugzwang in Quantum Mechanics.

1. Introduction

In chess, **zugzwang** is a position in which player would prefer not to move, because every legal move worsens the position. In quantum physics around 1925-1926, the founders of quantum mechanics found themselves in

an analogous intellectual condition. Classical physics had achieved magnificent victories, but inside of the atom its language became increasingly inadequate. The Copenhagen generation was forced to move from pictorial mechanics to symbolic mechanics,

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e.g. [1]-[10]. The move saved the game empirically, but sacrificed classical transparency. We propose a metaphor: **Nature placed the founders of quantum mechanics in zugzwang, and the future may still contain Nature’s delayed quantum zwischenzug.**

The word **zwischenzug** in chess means an unexpected intermediate move, often inserted before the expected continuation. It changes the logic of position. In quantum mechanics, the delayed quantum zwischenzug would be a future hidden conceptual move: a surprising deeper structure that changes how we interpret the quantum board. **Nature as the Great Chess Master** could arrange the chessboard around the years 1925-1926 in such a way that all classical concepts were dissolved. The founders had to accept a formalism that worked extraordinarily well, even though its meaning remained disputed.

The delayed quantum zwischenzug is a hidden intermediate move by Nature, not visible from the Copenhagen position, by which a deeper physical structure may later be revealed beneath the abstract quantum formalism.

2. An Attempt to Visualize the Motion of a Free Composite Proton

The founders of the old quantum theory: Haas [11], Nicholson [12], Bohr [13] in their hydrogen models limited themselves to the circular orbit of a negatively charged electron in the electrostatic field of an **equal positive charge uniformly distributed over a sphere**

of finite radius. In order to stabilize that orbital path of electron Nicholson proposed some transverse oscillations of that orbiting electron, Bohr proposed his famous model of hydrogen with stationary orbits, e.g. [14]-[24].

J.J. Thomson [25] anticipated a combined radial attractive force with a radial repulsive force inside of that atom. J.J. Thomson [25] in his very inspirational paper proposed: „It is possible that the force exerted by a single atomic charge may not spread out uniformly in all directions, but be concentrated along certain lines or cones.“ J.J. Thomson [25] in 1913 stated: „We shall not, however, at this stage enter into any consideration as to the origin of this force; we shall simply postulate its existence.“ This J.J. Thomson inspiration leads us to the definition of the Planck action intensity $h/4\pi$ with dimension [Js steradian⁻¹]. Moreover, we have now an information about the composition of protons that might be useful for such model with cooperating attractive and repulsive forces acting between the proton and the electron in the hydrogen atom.

A proton is a stable subatomic particle with mass m_p and a positive electric charge $+1 e$. In the modern Standard Model of particle physics, protons are known to be composite particles of two up quarks of charge $+2/3 e$ each, and one down quark of charge $-1/3 e$, e.g. [26]-[28]. Stávek [29], [30] modeled this composite proton as two quarks with mass $m_p/2$ and charge $+2/3 e$ rotating around the quark with mass m_c and charge $-1/3 e$. This model is given by Fig. 1.

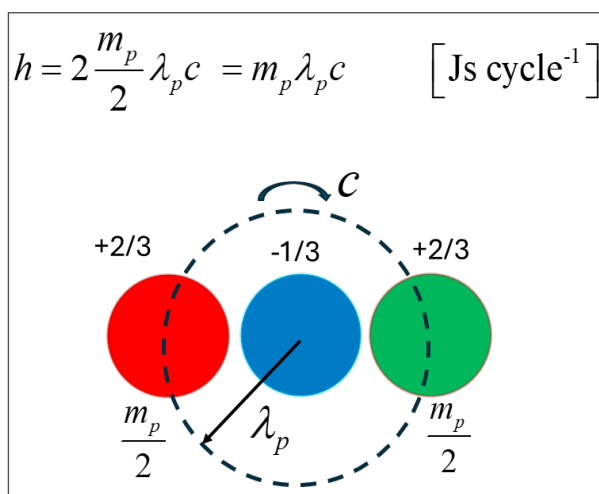


Figure 1. The free rotating composite proton with the radius $\lambda_p = 1,32 \text{ fm}$ (the Compton wavelength), the quark charge radius of the red and green quarks is about $r = 0,84 \text{ fm}$ (proton radius puzzle).

The rotation of this composite circular proton creates the total Planck action intensity $h/4\pi$ [Js sr⁻¹] composed from two contributions of red and green quarks $h/8\pi$.

The total action intensity guides red and green quarks on their circular path around the blue quark with the charge $-1/3 e$. This possible scenario is given by Fig. 2.

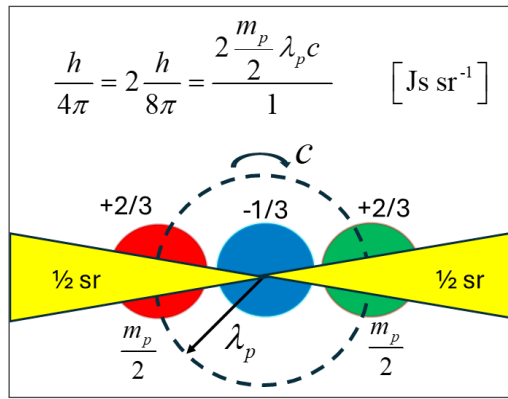


Figure 2. The free rotating composite proton with red, green and blue quarks radiating the Planck action intensity $h/4\pi$.

3. An Attempt to Visualize the Motion of a Composite Proton and Orbiting Electron in the Hydrogen Atom

The rotating composite proton inside of the hydrogen

atom radiates the Planck action intensity $h/4\pi$ [Js steradian⁻¹] with the speed $v = \alpha c$. The orbiting electron oscillates under the influence of both attractive and repulsive forces between the orbits with Bohr radius a_0 and the radius $\sqrt{2} a_0$. This situation is shown in Fig. 3.

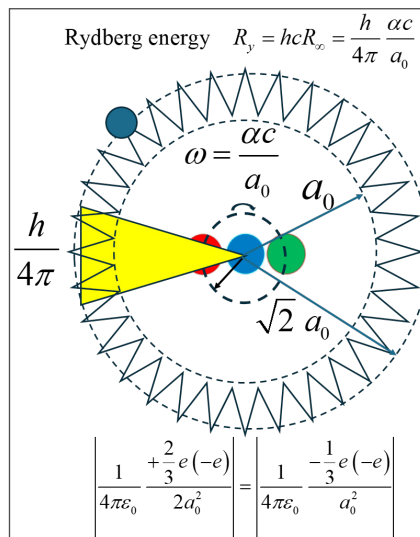


Figure 3. The rotating composite proton and orbiting electron under the influence of attractive and repulsive forces inspired by the J.J. Thomson paper [25]. The visualization of the Rydberg energy formula.

Fig. 4 depicts the detail of the electron oscillation between the Bohr radius a_0 and the radius $\sqrt{2} a_0$ around

the rotating composite proton. The orbiting electron makes $1/\alpha$ cycles around the rotating composite proton.

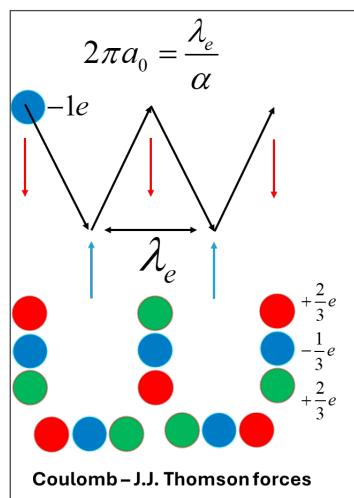


Figure 4. The rotating composite proton and orbiting electron under the influence of attractive and repulsive forces inspired by the J.J. Thomson paper [25]. The electron oscillates between the Bohr radius a_0 and the radius $\sqrt{2} a_0$. The electron is orbiting with the speed $v = \alpha c$ (the Sommerfeld speed [31]) synchronized with the radiating Planck action intensity from the rotating composite proton with the speed c .

4. Electron Shielding by Photons in the Hydrogen Atom

The shielding effect influences the attraction or repulsion between the electron and the proton in the hydrogen atom. The adsorption of photons on the surface of electrons and their desorption modifies the orbital radius of that electron – “the quantum jumps”.

Table I. The electron shielding by the photon mass in the visible spectrum – the Balmer series.

Transition of n	3 → 2	4 → 2	5 → 2	6 → 2
Name	H-α	H-β	H-γ	H-δ
Wavelength (nm)	656.279	486.135	434.0472	410.1734
Mass (10 ⁻³⁶ kg)	3.36	4.55	5.09	5.39
Energy difference (eV)	1.89	2.55	2.86	3.03
Color	Red	Cyan	Blue	Violet

Fig. 5 depicts adsorbed visible photons on the surface of electron. The more massive photon increases the

It is experimentally very well known that only photons with certain mass can be adsorbed or desorbed on/ from the surface of that electron.

Table I surveys four visible photons from the Balmer series that can be seen in the spectrum of that hydrogen atom.

shielding effect and the distance of orbiting electron from the central composite proton.

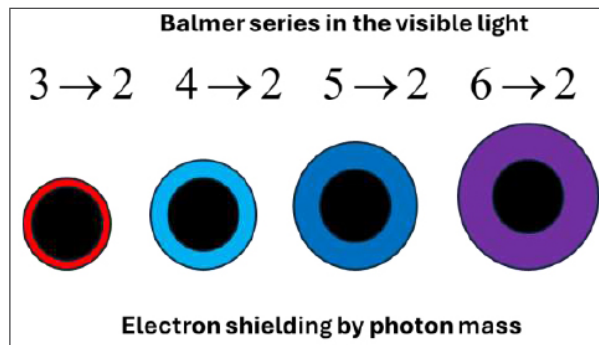


Figure 5. The adsorbed photon mass on the surface of the electron – the electron shielding. The effective electron charge decreases as $-1/n2$ and therefore the orbital radius grows

The famous Bohr model predicts the wavelengths of hydrogen atomic transitions: Eqs. 2 - 4:

$$\frac{1}{\lambda} = R_y \frac{1}{hc} \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \tag{2}$$

$$\frac{hc}{\lambda} = h\nu = m_f c^2 = hc R_\infty \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \tag{3}$$

$$m_f c^2 = \frac{h}{4\pi} \frac{\alpha c}{a_0} \left(\frac{1}{n_1^2} - \frac{1}{n_2^2} \right) \tag{4}$$

where R_y is the Rydberg unit of energy, R_∞ is the Rydberg constant, n_1 and n_2 are two different positive integers, λ is the wavelength of the emitted or absorbed light, m_f is the mass of that photon. The Planck action intensity $h/4\pi$ rotates with the angular speed $\alpha c/a_0$.

Eq. 4 combines the Planck action intensity with the angular orbital speed change of that electron. This is an example of the visualization of events in the inner architecture of atom.

5. Conclusion

The founders of quantum mechanics were placed in a historical **zugzwang**. Classical physics could not remain unchanged, but the new mathematical language demanded profound conceptual sacrifices. The Copenhagen school stabilized the new theory, but it did not end the interpretive game.

Nature still poses a hidden move – **the delayed quantum zwischenzug** as a valuable metaphor for the future of quantum foundations. The delayed quantum zwischenzug is Nature’s hidden intermediate move: a future quantum discovery that may restore a deeper physical intelligibility beneath quantum mechanics, revealing that the board was larger than Copenhagen had imagined.

The immortal zugzwang game is a chess game between Friedrich Sämisch and Aron Nimzowitsch, played in **Copenhagen** in March 1923. It gained its name because the final position is sometimes considered a rare instance of zugzwang occurring in the middlegame [32].

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Conflict of Interest

The author declares that there is no conflict of interest.

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