Hydrogen Atom Quantization from Purely Classical Maxwell Electromagnetic Fields

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Abstract

We derive hydrogen-like atomic energy quantization solely from classical Maxwell electromagnetic fields. Modeling energy as a standing wave confined to a toroidal topology imposes discrete geometric and phase coherence constraints. This naturally produces the Rydberg series without reference to charges, particles, mass, quantum postulates, or spacetime curvature. We further propose mass as an emergent property of stable energy flow configurations, and reinterpret momentum-wavelength relations as geometric phenomena arising from classical fields.

1. Introduction

Conventional atomic theory relies on particles, charge, probabilistic wavefunctions, and fundamental quantum axioms. Here, we show these are not necessary. Maxwell's equations in vacuum, deterministic and continuous, admit structured, self-sustaining field configurations. When electromagnetic energy is confined as a standing wave on a toroidal manifold, quantized energy levels emerge naturally from boundary and topological coherence.

This approach does not invoke charges, mass, or collapse. Quantization arises purely from classical field geometry and coherence conditions.

2. Electromagnetic Field Topology

2.1 Maxwell's Equations in Vacuum

In free space, Maxwell's equations reduce to:

- div **E** = 0
- div **B** = 0
- curl **E** = − ∂**B**/∂t
- curl **B** = $\mu_0\varepsilon_0$ ∂**E**/∂t

These admit wave solutions with continuous energy flow. No discrete charges or masses are assumed.

2.2 Toroidal Energy Confinement

We model electromagnetic energy as a self-contained standing wave confined to a torus with two angular directions:

- Toroidal direction with integer winding number n_1
- Poloidal direction with integer winding number n_2

Boundary conditions require wavelengths to fit integer multiples along both loops:

$\lambda_1 = (2\pi R) \div n_1$
$\lambda_2 = (2\pi r) \div n_2$

with R, r the major and minor radii. This imposes discrete allowable modes.

3. Energy Quantization from Geometry

3.1 Fundamental Mode and Energy Scaling

The lowest energy state corresponds to $n_1 = n_2 = 1$, defining a fundamental energy E_0. Higher modes arise from increasing winding numbers, yielding:

$E_{n1,n2} = E_0 \div (n_1 \times n_2)$

Restricting to symmetric modes $n_1 = n_2 = n$ gives:

$E_n = E_0 \div n^2$

which reproduces the hydrogenic Rydberg energy series purely from topological constraints.

3.2 Degeneracy from Directional Flow

Each angular direction admits two independent flow orientations (clockwise and counter-clockwise). This leads to a degeneracy of $2 \times n^2$ states for mode n, consistent with known atomic degeneracies but derived here as a direct consequence of classical field symmetry.

4. Electromagnetic Origin of Mass

Mass is not used to derive the hydrogen atom spectrum. Instead, we propose mass emerges from stable, persistent electromagnetic energy flows.

The toroidal standing wave resists acceleration due to internal momentum circulation, manifesting inertia. Thus, mass arises as an emergent property of energy confinement dynamics governed by Maxwell's equations.

5. Reinterpreting Quantum Mechanics and Momentum-Wavelength Relation

Quantum mechanics is not fundamental but an effective approximation of classical field behavior under geometric constraints. The Schrödinger equation models the evolution of coherent field modes, not particles.

Regarding the momentum-wavelength relation often stated as $p = h \div \lambda$:

- In this framework, **momentum** relates classically to spatial frequency of the standing wave in the moving frame:

$p \propto 1 \div \lambda$

- The constant h is not fundamental but emerges as a **geometric scaling factor**, reflecting the fundamental mode scale of the toroidal configuration.

- Planck's constant thus encodes the energy-per-phase unit of the stable field pattern, arising from the geometry and boundary conditions, rather than from an independent quantum postulate.

6. Additional Remarks on Coherence and Interpretation

- The standing wave must maintain **phase coherence** in both toroidal directions for stability, limiting solutions to discrete allowed modes.
- No discrete charges are needed. Apparent charge effects emerge as interference and interaction patterns of confined energy flows.
- Variations in electromagnetic energy density modulate effective wave velocity, mimicking gravitational effects without spacetime curvature.
- No wavefunction collapse occurs. Measurement corresponds to realignment or phase locking of field modes.
- Time evolution corresponds to phase rotation within the toroidal energy flow, linking energy quantization to internal phase frequency.

7. Conclusion

Classical Maxwell fields confined to a toroidal standing wave topology yield the hydrogen atom spectrum and atomic degeneracies. Quantization emerges from pure geometry and coherence conditions.

Mass and momentum-wavelength relations are reinterpreted as emergent phenomena from stable classical energy configurations, eliminating the need for particles, charge, or quantum axioms.

This approach offers a deterministic, unified foundation for atomic structure within classical field theory.

Reference

1. Maxwell, J.C. *A Treatise on Electricity and Magnetism*, 1873.

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