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A Rebuttal of Wave-Particle Duality by Augmented Newtonian Dynamics (AND)

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Abstract: ***Augmented Newtonian Dynamics (AND) is a modified framework for understanding the behavior of particles within classical mechanics, extending traditional Newtonian dynamics by incorporating interactions that arise from the quantum vacuum. In this theory, the vacuum is not an empty void but a dynamic medium that influences particle motion through transient fluctuations. These fluctuations, although imperceptible at macroscopic scales, result in brief yet significant interactions that modify the trajectories and stability of particles. At the core of AND is the idea that particles, while orbiting the nucleus, continuously engage in short-lived, localized interactions with the vacuum. These interactions exert forces on the particles that are strong enough to influence their motion yet occur over such brief time scales that they do not violate macroscopic conservation laws of energy and momentum. This subtle yet persistent interaction with the vacuum provides a stabilizing effect on the motion of particles, preventing phenomena such as the collapse of orbital systems or rapid energy dissipation, which would otherwise be expected in classical mechanics. By integrating these vacuum-based forces into the classical framework, Augmented Newtonian Dynamics offers a new perspective on particle motion, one that accounts for stability in systems where classical mechanics would traditionally predict instability. The theory posits that these interactions, while small in their instantaneous effects, accumulate over time to produce stable, self-correcting dynamics for particles in various systems, leading to observable phenomena that diverge from traditional Newtonian predictions without invoking additional classical forces.***

Keywords: wave-particle duality, virtual particles, Schrodinger equation, wave- functions, quantum mechanics, quantum electrodynamics, quantum

1. Introduction

In science, the process of understanding the world around us typically starts with observations—things we notice or measure in nature. From these observations, scientists form hypotheses, which are tentative explanations or predictions that can be tested through further experiments or observations. These hypotheses are used to build theories—comprehensive frameworks that explain and predict phenomena based on a large body of evidence. It is often the case that when a phenomenon, like light or electricity, is observed and hypotheses are formed based on those observations, the prevailing justification for officially adopting the hypothesis can usually be summed up as, "It works!" Sometimes, in a process of justification additional theories are built upon the original theory. Often, multiple theories are proposed to explain the same phenomenon, as new information comes to light, with each new theory generally expanding upon the previous one. However, at times the whole ontology upon which a theory is based might be false, in such a case a revision of the original observations and hypotheses is needed. One such theory might be the wave-particle duality of quantum mechanics.

Wave-particle duality:
At the turn of the Nineteenth Century as the nature of the atom and its properties became more apparent, a paradox presented itself. In classical physics, the electron was envisioned as a charged particle orbiting around the nucleus (like a planet orbiting the Sun), it therefore experiences a centripetal force due to the attractive Coulomb force between the electron and the nucleus. This could be seen as a stable orbit, just like the motion of a planet. However, classical electrodynamics (Maxwell's equations) predict that accelerating charges radiate energy: According to Maxwell's laws of electromagnetism, any charged particle that is accelerating will emit electromagnetic radiation. In the case of the electron in orbit around the nucleus, the electron is constantly accelerating due to its circular motion. This means that as the electron moves in its orbit, it would continuously emit radiation (photons). The emitted radiation would carry energy away from the electron. As the electron radiates energy, its kinetic energy decreases, and it loses angular momentum. This means that over time, the electron would spiral inward, slowly losing energy and gradually falling closer to the nucleus.

The time **t** for an electron to spiral into the nucleus due to energy loss through electromagnetic radiation is given by an integral based formula that correctly models the time scale for the electron to spiral into the nucleus

$$t = \int_0^t dt' = \int_{r_0}^0 -\frac{12c^3\pi^2\epsilon_0^2 m^2 r^2}{Ze^4} dr = \frac{4c^3\pi^2\epsilon_0^2 m^2 r_0^3}{Ze^4} \quad (1)$$

Where:
c is the speed of light,
ϵ_0 is the vacuum permittivity,
m is the mass of the electron,
r_0 is the initial orbit radius,
Z is the atomic number (for hydrogen, Z = 1),
e is the charge of the electron.

Step-by-Step:
Known Constants: the constants required for the calculation ARE:
Initial Orbit Radius (r_0): For a hydrogen atom, the initial radius r_0 is the Bohr radius: $r_0 = 5.29 \times 10^{-11}$ m
Speed of light c = 3.0 x 10^8 m/s,
Vacuum permittivity $\epsilon_0 = 8.85\times 10^{-12}$ C^2 N.m^2,
Electron mass m=9.11× 10^{-31} kg,
Electron charge e = 1.602×10^{-19} C,
Z = 1 for hydrogen.

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Substituting the values:

$$t = \frac{4(3.0 \times 10^{8})^{3}(3.1416)^{2}(8.85 \times 10^{-12})^{2}(9.11 \times 10^{-31})^{2}(5.29 \times 10^{-11})^{3}}{1 \times (1.602 \times 10^{-19})^{4}}$$

$$= \quad t \approx 10^{-11} \text{ seconds} \qquad (2)$$

As can be imagined this result that an atom could only exist for only 10^{-11} s if a classical interpretation were used, represented as large a shock to physicists as had Max Planck's discovery of the quantisation of energy, or Rutherford's splitting of the atom. This was a huge issue and had to be addressed by Quantum mechanics if it was to be accepted as the new paradigm in physics.

The Concept

Wave-particle duality refers to the idea that particles, like electrons or photons, can exhibit both wave-like and particle-like behavior depending on the experimental conditions. This was a central idea in the development of quantum mechanics. In some experiments (like interference or diffraction), particles like electrons or light can behave like waves, showing patterns that are typically associated with waves, such as constructive and destructive interference.

In other experiments (like the photoelectric effect), these same particles can behave like discrete particles, interacting with matter in a way that is more typical of a particle.

Wave-particle duality was, in many ways, a hypothesis based on experimental observations that could not be reconciled with classical physics. The experiments suggested that particles did not fit neatly into a classical framework, and quantum mechanics emerged to explain these discrepancies. However, wave-particle duality was indeed a tentative hypothesis initially because: There wasn't a single experiment that demonstrated that a particle could simultaneously be both a wave and a particle. Instead, it was a working model to explain experimental data that couldn't be explained otherwise. Classical physics, especially Newtonian mechanics and Maxwell's electromagnetism, had no place for this duality. The idea that something could be both a particle (discrete, localized) and a wave (spread out, continuous) seemed to contradict everything understood about the nature of matter. The duality wasn't fully understood. The quantum mechanical description, where particles are described by a wave function (as in Schrödinger's equation), provided a mathematical model that worked to predict outcomes. But it didn't offer an intuitive or "real-world" explanation of how particles could exhibit these two seemingly incompatible behaviors.

The idea that an entity could simultaneously exhibit localized and spread-out behavior was mind-boggling. It was the ultimate contradiction in classical physics: "How can something be both a localized object and a wave that spreads over space?"

Quantum mechanics whole-heartedly adopted the principle of wave-particle duality despite the seemingly inconsistent evidence for its existence. One of the questions that are posed in this paper is, was quantum mechanics right in adopting the wave-particle duality?

The Lamb shift

In 1947, Willis Lamb and Robert Retherford performed an experiment that revealed a small but significant energy shift between two energy levels of the hydrogen atom that had previously been thought to be degenerate (i.e., having the same energy). These two levels, both part of the hydrogen atom's 2s and 2p states, should have been the same energy in the classical Bohr model, but Lamb and Retherford observed a slight difference in their energies—this shift was later named the Lamb shift.

The magnitude of the Lamb shift was small, but its implications were profound, as it suggested that there were quantum corrections to the energy levels that classical theories couldn't explain. The shift was on the order of 0.00004 eV, which was too small to be accounted for by the known theory of atomic physics at the time. The Lamb shift posed a challenge to physicists because it seemed to imply that the Bohr model and earlier quantum mechanics (based on the Schrödinger equation) were incomplete. A new theory had to account for the difference between the two states. Hans Bethe, a key figure in the development of quantum electrodynamics, was the first to provide a theoretical explanation for the Lamb shift in 1947. He used perturbation theory and considered the effects of virtual photons—the idea that the electromagnetic field around the electron is not simply a smooth, static background, but rather fluctuates due to the creation and annihilation of virtual particle-antiparticle pairs. These fluctuations lead to a small but measurable correction to the energy levels of the electron, resulting in the Lamb shift. This was one of the first successful applications of quantum electrodynamics (QED) to atomic physics.

Julian Schwinger, who was working independently on quantum electrodynamics, also contributed significantly to understanding the Lamb shift. Schwinger used a different approach, known as quantum field theory, to describe the interaction between electrons and the electromagnetic field. His formulation provided a more rigorous framework for understanding the vacuum fluctuations and the correction to the electron's energy levels. Schwinger's work helped clarify the role of self-interaction of the electron with its own electromagnetic field, which was critical in explaining the Lamb shift and other phenomena in QED. Schwinger's contributions were foundational to the development of QED and were later recognized with a Nobel Prize in 1965. Good morning! Julius Schwinger's work on the self-interaction of the electron is an important aspect of quantum electrodynamics (QED). His approach involves treating the interaction of an electron with its own electromagnetic field, leading to the phenomenon known as *electron self-energy*. This is a quantum effect in which an electron interacts with the field it generates, leading to corrections to the electron's mass and its behavior.

Here's a brief mathematical description:

In QED, the interaction of the electron with the electromagnetic field is described by the Lagrangian density, which for a free electron and electromagnetic field is:

$$\mathcal{L} = \bar{\psi}(i\gamma^{\mu}\partial_{\mu} - m)\psi - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} \qquad (3)$$

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where:
ψ is the Dirac spinor describing the electron,
γ^μ are the gamma matrices,
m is the electron mass,
$F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu$ is the electromagnetic field strength tensor,
Aμ is the four-potential of the electromagnetic field.

The self-interaction arises when the electron interacts with its own electromagnetic field, which is expressed as a loop diagram in Feynman diagrams. The self-energy correction to the electron propagator is given by:

$$\Sigma(p) = \int \frac{d^4k}{(2\pi)^4} \frac{-ie^2\gamma^\mu \frac{1}{\not{k}-\not{p}+m}\gamma^\nu}{k^2-m^2+i\epsilon} D_{\mu\nu}(k) \quad (4)$$

where:
Σ(p) is the self-energy operator (a function of the electron's momentum pp),
Dμν(k) is the photon propagator (in momentum space),
γ^μ are the gamma matrices,
$\not{k}$ and $\not{p}$ are the Dirac operators acting on the momentum of the photon and the electron, respectively,
k is the loop momentum of the photon, and
e is the electron charge.

The electron self-energy leads to a correction to the electron's mass and wavefunction, which requires renormalization. This involves subtracting the infinities that arise in loop integrals (such as those from the self-energy correction). The renormalized electron propagator is then modified as:

$$S(p) = \frac{i}{\not{p} - m - \Sigma(p)} \quad (5)$$

where Σ(p) is the self-energy correction, and the renormalization procedure ensures that physical predictions (such as observable quantities) remain finite and well-defined.

Augmented Newtonian Dynamics on Wave-particle duality

Augmented Newtonian Dynamics offers a complete rebuttal to the concept of wave particle duality. The reason for denial of wave-particle duality is as follows: Wave-particle duality was initially adopted by quantum mechanics to explain why the electron did not undergo radiative instability and fall into the nucleus as a result of expending all its energy. However, with the discovery of the Lamb Shift and the Quantum Electron Dynamics (QED) theory that the electron within the atom was constantly emitting and absorbing 'virtual photons' in a process of self-interaction, meant that the electron could be self- stabilizing itself in its orbit around the nucleus. This theory that the electron is self-stabilising its energy around the nucleus by constantly emitting and absorbing 'virtual photons' so that it does not radiate away its energy and fall into the nucleus, is the perfect classical explanation as to why the electron does not spiral into the nucleus. Augmented Newtonian Dynamics (AND) is a modified framework for understanding the behavior of particles within classical mechanics, extending traditional Newtonian dynamics by incorporating ideas from quantum mechanics into its own theory. According to quantum mechanics, the vacuum is not an empty void but a dynamic medium that influences particle motion through transient fluctuations. These fluctuations, although imperceptible at macroscopic scales, result in brief yet significant interactions that modify the trajectories and stability of particles. At the core of AND is the idea that particles, while orbiting the nucleus, continuously engage in short-lived, localized interactions with the vacuum. These interactions exert forces on the particles that are strong enough to influence their motion yet occur over such brief time scales that they do not violate macroscopic conservation laws of energy and momentum. This subtle yet persistent interaction with the vacuum provides a stabilizing effect on the motion of particles, preventing phenomena such as the collapse of orbital systems or rapid energy dissipation, which would otherwise be expected in classical mechanics. By integrating these vacuum-based forces into the classical framework, Augmented Newtonian Dynamics offers a new perspective on particle motion, one that accounts for stability in systems where classical mechanics would traditionally predict instability. The theory posits that these interactions, while small in their instantaneous effects, accumulate over time to produce stable, self-correcting dynamics for particles in various systems, leading to observable phenomena that diverge from traditional Newtonian predictions without invoking additional classical forces.

One of the chief formulations introduced by Augmented Newtonian Dynamics is to eschew the idea of wave-functions and wave-particle duality and to treat the electron as a solid particle orbiting the nucleus rather than as a sometimes wave, sometimes particle as envisioned by quantum mechanics. The supposition by quantum mechanics for the bound electron to be treated as an electron cloud or wave-function is denied. The AND model incorporates the idea of real photon interactions with short durations that don't disrupt macroscopic conservation laws.

Mathematical Description of Lamb shift according to AND:

The energy of the real photon exchanged during the self-interaction of the electron:

$$E_{\text{photon}} = hf \quad (6)$$

where f is the frequency of the photon. However, these interactions happen over an extremely short time scale, τ, and their effect on energy and momentum conservation is negligible on longer time scales.

Time-Scale Effect: The time scale τ over which these photon exchanges occur is extremely short, and as such, the total energy change due to these photon exchanges is small compared to the electron's macroscopic motion. Mathematically, we can express this as:

$$\Delta E_{\text{photon}} = \frac{hf}{\tau} \quad (7)$$

Since τ is tiny, the energy change ΔE_{photon} becomes very small, so the impact on overall energy or momentum conservation is negligible. This is the key feature of the theory: real photons are involved, but their interaction time is so brief that their effect on long-term dynamics is essentially invisible.

Effective Stabilization via Photon Exchange: The stabilization of the electron's orbit can be modeled as a result of a dynamic equilibrium between the Coulomb force and the short-lived photon exchange. The electron's orbit remains stable due to this process, which adjusts the electron's motion to counteract the classical tendency to spiral inward. We can write an effective potential incorporating both the Coulomb attraction and the photon-induced correction:

$$V_{\text{eff}}(r) = -\frac{ke^2}{r} + \Delta E_{\text{photon}} \quad (8)$$

where ΔE_{photon} represents the stabilizing effect of the short-lived virtual photons that possess the energy of a real photon. The equilibrium between these forces ensures that the electron doesn't spiral into the nucleus.

No Violation of Conservation Laws: The short interaction time of the photons means that the electron's total energy and momentum do not change in a measurable way over macroscopic timescales. This can be expressed as:

$\Delta E_{\text{photon}} \ll E_{\text{classical}}$ and $\Delta p_{\text{photon}} \ll p_{\text{classical}}$ (9)

where $E_{\text{classical}}$ is the classical kinetic energy of the electron and $p_{\text{classical}}$ is its classical momentum. Because the interaction time τ is so small, the real photon exchanges have negligible effects on the total energy and momentum of the system when considered over longer times.

The explanation of how a self-interaction by a bound electron, in a process wherein the bound electron emits and re-absorbs a 'virtual' photon in a time period of 10^{-15} seconds can involve sufficient energy for the electron to self-stabilise its orbit around the nucleus may be explained through the use of the Heisenberg Uncertainty Principle as it applies to energy and time:

$$\Delta T \Delta E \geq \frac{\hbar}{2} \quad (10)$$

The Heisenberg uncertainty principle in physics, as it relates the uncertainty in energy (ΔE) and the uncertainty in time (ΔT):

$\Delta T \cdot \Delta E \geq \frac{h}{2}$

Here:

ΔT is the uncertainty in time.

ΔE is the uncertainty in energy.

h is Planck's constant, which is approximately 6.626×10^{-34} J.

Given:

$\Delta T = 10^{-15}$ s

$h = 6.626 \times 10^{-34}$ J

To calculate the minimum uncertainty in energy (ΔE) given this uncertainty in time.

Step-by-Step Calculation:

1) Rearrange the uncertainty principle equation to solve for ΔE

$$\Delta E \geq \frac{h}{2\Delta T} \quad (11)$$

Plug in the given values for h and ΔT:

$$\Delta E \geq \frac{6.626\times10^{-34}}{2\times10^{-15}} \quad (12)$$

2) Perform the calculation:

Answer:

The uncertainty in energy is:

$$\Delta E \geq \frac{6.626\times10^{-34}}{2\times10^{-15}} = 3.313 \times 10^{-19}\ \text{J} \quad (13)$$

The energy of 3 x 313 x 10^{-19} J or 2.0 eV over a time period of 10^{-15} s, is more than sufficient for the electron to stabilise its orbit around the nucleus. It is estimated that in a hydrogen atom, an electron orbits the nucleus at a rate of about 6.55×10^{15} times per second, which is a good fit.

The key here is that while virtual particles themselves are not directly observable, their consequences on real physical systems can be measured. The Lamb shift is a small energy shift in the energy levels of the hydrogen atom. The interaction between the electron and the fluctuating electromagnetic field (represented by virtual photons) modifies the energy difference between the 2s and 2p states. This shift doesn't directly involve the detection of virtual photons, but instead it is the consequence of their influence on the electron's energy levels. While virtual particles fluctuate rapidly on very short time scales (such as 10^{-15} seconds), their overall effect on the electron's state is averaged out over longer timescales. The measurement of the Lamb shift is not about detecting the short-lived virtual photons themselves, but rather about measuring the long-term effect they have on the atom's energy levels. In this way, virtual particles can be thought of as contributing to the overall statistical behavior of the system, and it is this statistical effect (the Lamb shift) that we measure in experiments. The energy scale of the virtual interaction (on the order of 3.313 x 10^{-19} J) reflects the magnitude of the quantum correction to the energy levels. While these interactions occur over short timescales (on the order of 10^{-15} s), the energy shift due to these interactions accumulates over the longer timescale of the atomic system's evolution. In practical terms, what we measure experimentally is the small shift in the hydrogen atom's energy levels, which results from the virtual photon exchange. This shift is what we refer to as the Lamb shift and is observable through precision spectroscopic techniques.

2. Conclusion

Wave-particle duality has long been a central tenet of quantum mechanics, explaining phenomena like the stability of electron orbits and the discrete energy levels observed in atoms. The theory arose in response to the failure of classical physics to explain certain atomic behaviors, such as the stability of electrons within atoms. In classical mechanics, electrons would spiral into the nucleus due to the electromagnetic attraction between them, radiating energy until they were eventually absorbed into the nucleus. The introduction of wave-particle duality, along with the concept of the electron's wave function, was thought to help resolve this paradox by suggesting that particles like electrons could exhibit both wave-like and particle-like behavior.

However, if wave-particle duality were found to be false, it would necessitate a dramatic overhaul of our understanding of atomic physics. The Schrödinger equation, central to quantum mechanics, describes how the quantum state of a system evolves over time. It operates in multiple dimensions, accounting not only for spatial coordinates but also for additional degrees of freedom such as momentum, spin, and potential energy. In the case of the electron in an atom, the wave function derived from the Schrödinger equation provides a probabilistic description of the electron's position and energy. If wave-particle duality were discarded, the need for such a multi-dimensional equation would vanish, as the electron's behavior could instead be described by classical mechanics, where the concepts of position, velocity, and momentum would suffice to determine its state without the need for a probabilistic wave function. Concepts such as the electron wave function and the idea of the electron "cloud" would need to be eliminated. Instead of describing electron behavior in terms of probabilistic wave functions, the electron's energy states would have to be explained using classical physics principles such as mass, momentum, and velocity. Quantum jumps, which are currently understood as discrete transitions between different energy states due to quantum behavior, might instead be seen as direct interaction where an electron that absorbed an electron might reflect off the nucleus like a billiard ball following the laws of classical physics where, angle of reflection equals angle of incidence, solving the 'reflection' problem that fascinated quantum mechanics for years without any successful resolution. Transitions are governed purely by classical mechanics, akin to changes in velocity or momentum in a more classical sense.

This shift would require a complete revision of atomic spectroscopy, as the emission and absorption spectra of atoms are presently understood through the lens of quantum mechanics. Spectral lines, which arise from the transitions between different energy levels, would need to be reinterpreted under a classical framework. The discrete energy levels associated with atomic transitions might no longer be seen as quantum states but as arising out of classical interactions between particles and forces at the atomic scale. In essence, without wave-particle duality, the entire framework of quantum mechanics as we know it would have to be discarded in favor of classical principles, leading to a fundamentally different understanding of subatomic interactions and atomic structure.

It is noted in this paper that the observations made throughout its study of the physical nature of matter, the observations made by quantum mechanics have been incredibly accurate, in fact it is safe to say that if the insights provided by quantum mechanics into matter had not been so accurate and meaningful, it would have been all but impossible to put forward an alternate theory challenging quantum mechanics. At every level Augmented Newtonian Dynamics has found that both theories QM and AND share the facts borne out by observations made by quantum mechanics, only the final interpretation of the facts arising from these observations differs. In this manner the author Augmented Newtonian Dynamics plans to write a series of paper explaining everything from electricity to the profound mystery of gravity.

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