The fallacy of Feynman's and related arguments on the stability of the hydrogen atom according to quantum mechanics

R. L. MILLS,

BlackLight Power, 493 Old Trenton Road, Cranbury, NJ 08512, USA
rmills@blacklightpower.com

ABSTRACT. Recently published data showing that the Rydberg series extends to lower states in a catalytic plasma reaction [R. L. Mills, P. Ray, "Extreme Ultraviolet Spectroscopy of Helium-Hydrogen Plasma," J. Phys. D, Applied Physics, Vol. 36, (2003), pp. 1535–1542] has implication for the theoretical basis of the stability of the hydrogen atom. The hydrogen atom is the only real problem for which the Schrödinger equation can be solved without approximations; however, it only provides three quantum numbers—not four, and inescapable disagreements between observation and predictions arise from the later postulated Dirac equation as well as the Schrödinger equation. Furthermore, unlike physical laws such as Maxwell's equations, it is always disconcerting to those that study quantum mechanics (QM) that the particle-wave equation and the intrinsic Heisenberg Uncertainty Principle (HUP) must be accepted without any underlying physical basis for fundamental observables such as the stability of the hydrogen atom in the first place. In this instance, a circular argument regarding definitions for parameters in the wave equation solutions and the Rydberg series of spectral lines replaces a first-principles-based prediction of those lines. It is shown that the quantum theories of Bohr, Schrödinger, and Dirac provide no intrinsic stability of the hydrogen atom based on physics. An old argument from Feynman based on the HUP is shown to be internally inconsistent and fatally flawed. This argument and some more recent ones further brings to light the many inconsistencies and shortcomings of QM and the intrinsic HUP that have not been reconciled from the days of their inception. The issue of stability to radiation needs to be resolved, and the solution may eliminate of some of the mysteries and intrinsic problems of QM.

RÉSUMÉ. Les données récemment publiés démontrant que les séries Rydberg s'étendent aux états inférieurs lors de la réaction catalytiques de plas-

ma [R. L. Mills, P. Ray, "Extreme Ultraviolet Spectroscopy of Helium-Hydrogen Plasma," J. Phys. D, Applied Physics, Vol. 36, (2003), pp. 1535–1542] comportent des implications pour le fondement théorique de la stabilité de l'atome d'hydrogène. L'atome d'hydrogène est le seul vrai problème pour lequel l'équation de Schrödinger peut être résout sans approximations ; Toutefois, il n'offre que trois chiffres quantiques et non quatre, et les divergences inévitables entre l'observation et les prédictions surviennent de l'équation ultérieure postulée de Dirac ainsi que de l'équation de Schrödinger. En plus, contraire aux lois physiques telles que l'équation de Maxwell, il est toujours contrariant aux étudiants de la mécanique quantique (MQ) que l'équation d'ondes de particules et le Principe d'incertitude de Heisenberg (PIH) doivent être acceptés sans fondement intrinsèque physique pour les observables fondamentaux tel que, pour commencer, la stabilité de l'atome d'hydrogène. Dans cette instance, un argument circulaire concernant les définitions des paramètres des solutions de l'équation d'ondes et des séries de Rydberg de raies spectrales remplace une prédiction basée sur premiers principes de ces raies. Il est démontré que les théories quantiques de Bohr, Schrödinger et de Dirac n'offrent aucune stabilité intrinsèque de l'atome d'hydrogène basée sur la physique. Un vieil argument de Feynman basé sur le PIH est internement révélé comme étant incohérent et défectueux. Cet argument ainsi qu'un nombre d'arguments plus récents révèlent de nombreuses irrégularités et faiblesses de la MQ et du PIH intrinsèque qui n'ont jamais été réconciliées depuis leur création. La question de stabilité à la radiation doit être résolue, et la solution pourrait éliminer quelques mystères et problèmes intrinsèques de la MQ.

1   Introduction

J. R. Rydberg showed that all of the spectral lines of atomic hydrogen were given by a completely empirical relationship:

$$\bar{v} = R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2} \right) \tag{1}$$

where $R = 109{,}677 \text{ cm}^{-1}$, $n_f = 1,2,3,...$, $n_i = 2,3,4,...$ and $n_i > n_f$. Bohr, Schrödinger, and Heisenberg each developed a theory for atomic hydrogen that gave the energy levels in agreement with Rydberg's equation.

$$E_n = -\frac{e^2}{n^2 8\pi\varepsilon_o a_H} = -\frac{13.598 \text{ eV}}{n^2} \tag{2a}$$

$$n = 1,2,3,... \tag{2b}$$

Novel emission lines were recently reported [1–6] with energies of $q \cdot 13.6$ eV where $q = 1,2,3,4,6,7,8,9,11$ or these discrete energies less 21.2 eV corresponding to inelastic scattering of these photons by helium atoms due to excitation of $\text{He}\,(1s^2)$ to $\text{He}\,(1s^1 2p^1)$. These lines matched $\text{H}(1/p)$, fractional Rydberg states of atomic hydrogen, formed by a resonant nonradiative energy transfer to He^+. That is

$$n = \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, ..., \frac{1}{p}; \quad p \text{ is an integer } \leq 137 \tag{2c}$$

replaces the well known parameter $n = 1,2,3,...$ in the Rydberg equation for hydrogen excited states. Thus, the long held view that the hydrogen atom has an "ground" state of 13.6 eV is challenged. These results have major implications for the theoretical basis of the stability of the hydrogen atom. Besides a nonphysical circular argument regarding definitions for parameters in the Schrödinger equation solutions to give Eqs. (2a) and (2b) [7–14, 15 Chp 38] and the Rydberg series of spectral lines themselves, the standard theoretical explanation for the stability from Feynman [16] is based on the Heisenberg Uncertainty Principle (HUP). Upon further scrutiny, Feynman's argument is found to be internally inconsistent and fatally flawed, and brings to light the many inconsistencies and shortcomings of QM and the intrinsic HUP that have not been resolved from the days of their inception. Unfortunately these issues are largely ignored by the physics community.

As shown in Sec. II, Feynman incorrectly relies on using the HUP to determine the angular momentum and consequently the kinetic energy of an electron bound by the Coulomb field of a proton. This attempt to explain the stability of the hydrogen atom is necessitated by the fact that there is no physical basis for the stability of the hydrogen atom from the Bohr, Schrodinger, or Dirac theories [7–14, 15 Chp 35][(1)]. The argument is simply a mathematical manipulation to get the Bohr force balance equation. The Bohr theory is well known to be wrong since it is in disagreement with or fails at predictions for many experimental observations such as the hydrogen spectrum in a magnetic field, the spectrum of helium, and the nature of the chemical bond. Feynman is incorrect in his treatment of the HUP as a physical principle separate from the postulated SE since it arises purely mathematically from the SE. Feynman incorrectly uses the HUP to determine the momentum of the bound electron. Error in the momentum and

position is not the same as the momentum and position as incorrectly asserted by Feynman. Furthermore, the angular momentum of the electron from the SE is zero, not $\hbar$ as incorrectly asserted by Feynman (even ignoring the factor of 2 error using the correct Eq. (3) for the HUP). These inescapable facts invalidate the argument. A further failing is that according to the SE, the electron must go closer to the nucleus than the Bohr radius. The opposite is claimed by Feynman. In fact, the electron must exist in the nucleus since the wave function is a maximum there. Feynman is also incorrect about the HUP being a physical law that can not be avoided. An experimental method that avoids the HUP has been found, and the long held and taught view that the HUP is the physical basis of the wave-particle duality nature of the electron has been experimentally disproved [7, 8, 15 Foreword and Chp. 37, 15].

Since the SE does not predict stability with respect to radiation of the accelerating point-charge electron[(2)], Feynman [16] proposed that conventional theory only permits integer states of hydrogen starting at $n = 1$ based on the Uncertainty Principle given by

$$\Delta x \Delta p \geq \frac{\hbar}{2} \tag{3}$$

In QM, the HUP is presented as a separate law of nature. Feynman claims that no one has found a way around it.

Specifically:

Feynman states [16], "It is impossible to design an apparatus to determine which hole the electron passes through, that will not at the same time disturb the electrons enough to destroy the interference pattern. If an apparatus is capable of determining which hole the electron goes through, it *cannot* be so delicate that it does not disturb the pattern in an essential way. No one has ever found (or even thought of) a away around the uncertainty principle. *So we must assume that it describes a basic characteristic of nature*."

Feynman's position has recently been over turned. Durr et al. [19] have found a way around the HUP, and the Uncertainty Principle was demonstrated experimentally to fail in a test of its long touted basis of the wave particle duality [8]. According to Gerhard Rempe [22], who lead the Durr et al. experimental team, "*The Heisenberg uncertainty principle has nothing to do with wave-particle duality*." Durr et al. report [19], "We show that the

back action onto the atomic momentum implied by Heisenberg's position-momentum uncertainty relation cannot explain the loss of interference." However, the experimental results of Durr et al. of the diffraction pattern of ^{85}Rb atoms scattering from standing light waves where the internal states were manipulated by microwaves are predicted classically [15 Foreword and Chp 37]. Other data with far-fetched interpretations based on the HUP such the existence of the same ^{9}Be^{+} ion in two places at once, supercurrents flowing in opposite directions at once, and spooky actions at a distance are also explained by first principle laws which demonstrate that the HUP is not a physical principle [15 Foreword and Chp 37]. Rather it is a misinterpretation of applying the Schwartz Inequality to the wavefunction interpreted as a probability wave [23]. The mathematical result shows that the electron can have a continuum of momenta and positions in the $n=1$ state with a continuum of energies simultaneously which can not be physical. This result is independent of error introduced by measurement.

The Heisenberg Uncertainty Principle is wrongly interpreted as: the uncertainty in the measured momentum times the uncertainty in the measured position must be no less than $\hbar$ as given by Eq. (3). The Heisenberg Uncertainty Principle (HUP) is the mathematical expression for the statistical error in the variables of the wavefunction such as those assigned to the position and momentum of the electron. Since the wave function is interpreted as the probability of the position of the electron which puts it everywhere at once with an infinite number of positions and energies simultaneously including ones with negative kinetic energy, the Heisenberg Uncertainty Principle merely reveals that this model is not a valid physical description of the electron[3]. It is interpreted as a separate physical principle regarding measurement which it is not, and is often equated with the rise-time-band width relationship of classical physics [24] and touted as the basis of the spectral line-width versus life-time relationship of excited states. The latter follows from conservation of energy, the former gives a relationship for the errors in the variables of a probability wave model [8, 15 Chp 2]. The correct basis is the physics of the rise-time-band width relationship rather than an interpretation of measurement uncertainty from pure mathematics as discussed previously [15 Chp 2]. The HUP is not valid from first principle considerations and leads to nonsensical consequences and predictions inconsistent with experimental observations as discussed previously [8, 15 Foreword and Chp 37] and *infra*.

2   Scrutiny of Feynman's Stability Argument Based on the HUP

Since the SE offers no foundation for the stability of isolated atomic hydrogen, Feynman attempted to find a basis for the definition of the "ground state" in the Heisenberg Uncertainty Principle [16]. Feynman based his derivation on the determination of the momentum as $p \approx h / a$ from the HUP wherein he argues, "We need not trust our answer to within factors like 2, π, etc. We have not even defined a very precisely." The kinetic energy follows classically from the momentum, and the electrostatic energy is given classically to give the total energy as

$$E = h^2 / 2ma^2 - e^2 / a \qquad (4)$$

Feynman determined the minimum energy in order to solve for the radius of the hydrogen atom.

$$dE / da = -h^2 / ma^3 + e^2 / a^2 = 0 \qquad (5)$$

The result is exactly the Bohr radius.
The uncertainty principle [23] is

$$\sigma_x \sigma_p \geq \frac{\hbar}{2} \qquad (6)$$

where σ_x and σ_p are given by

$$\sigma_x^2 = \int \psi^* \left(\hat{X} - \rangle x \langle \right)^2 \psi \, dx \qquad (7)$$

$$\sigma_p^2 = \int \psi^* \left(\hat{P} - \rangle p \langle \right)^2 \psi \, dx \qquad (8)$$

The definition of the momentum operator in a *one dimensional* system is [23]

$$\hat{P}_x = -i\hbar \frac{d}{dx} \qquad (9)$$

and the position operator is

$$\hat{X} = x \qquad \left(\text{multiply by x}\right) \qquad (10)$$

Based on the HUP, Feynman's derivation of the Bohr radius is flawed on the basis of at least eight points:

1.) The HUP gives a lower limit to the product of **the *uncertainty* in the momentum and the *uncertainty* in the position—not the product of the momentum and the position**. The momentum or position could be arbitrarily larger or smaller than its uncertainty. For example, QM textbooks express the movement of the electron, and the HUP is an expression of the statistical aspects of this movement. McQuarrie [25], gives the electron speed in the $n = 1$ state of hydrogen as 2.18764×10^6 m/sec. Remarkably, the uncertainty in the electron speed according to the HUP is 1.4×10^7 m/sec [26] which is an order of magnitude larger than the speed. The short comings of the theory are obvious given that the constant parameters of the hydrogen atom are known to 10 figure accuracy.

2.) Eq. (3) follows from the Schrodinger equation, not the Bohr theory. In the time independent Schrödinger equation, the kinetic energy of rotation K_{rot} is given by [20]

$$K_{rot} = \frac{\ell(\ell+1)\hbar^2}{2mr^2} \qquad (11)$$

where

$$L = \sqrt{\ell(\ell+1)\hbar^2} \qquad (12)$$

is the value of the electron angular momentum L for the state $Y_{lm}(\theta,\phi)^{(4)}$. For the $n = 1$ state, $\ell = 0$; thus, **the angular momentum according to the Schrödinger equation is exactly zero—not $\hbar$**. Furthermore, the kinetic energy of rotation K_{rot} is also **zero**. As a consequence, it is internally inconsistent for Feynman to accept the HUP which arises from the Schrodinger equation on the one hand and that the electron obeys the classical Coulomb law and is bound in an inverse squared Coulomb field on the other. Rather than a kinetic energy of $\dfrac{\hbar^2}{2mr^2}$ which is added to the Coulomb energy of $-\dfrac{e^2}{r}$ to get the total energy, exactly zero should be added to the Coulomb energy. This is an inescapable nonsensical result which arises

from the SE directly, and it can not be saved by incorrectly assigning the angular momentum as $\hbar$ from the uncertainty relationship. Furthermore, the result that $L = K_{rot}$ = **exactly zero violates the HUP making the argument further internally inconsistent.** In addition, applying Eq. (3) to spherical harmonic solutions for Ψ with an exact momentum and energy for a given ℓ in Eqs. (11) and (12), respectively, requires that $\Delta\theta \to \infty$ since

$\Delta L = 0$ in the relationship $\Delta L \Delta \theta \geq \dfrac{\hbar}{2}$. The result $\Delta\theta \to \infty$ is nonsensical.

Postulating a linear combination of spherical harmonics is not consistent with a single momentum state and will not save the HUP since the linear combination is not an eigenfunction. Rather it is a wavefunction of a set that is not orthonormal (i.e. it violates QM postulates by not yielding the Kroenecker delta).

3.) It is also ironic that Feynman's position is that the HUP which is inherent in the SE does not permit the electron radius to be less than $a_0 = 5 \times 10^{-11}$ m. A valid theory can not permit the electron to "spiral into the nucleus." However, an inescapable fact of QM is that the wave function solution of the SE requires that **the electron is in the nucleus** [8]. This is clearly claimed in the literature as discussed by Karplus to explain the spin-nuclear coupling called Fermi contact interaction for example [27]. In fact, the probability density function Ψ^2 has a maximum at the nucleus for the $n = 1$ state, and the nucleus has a finite volume. Griffiths gives the time average that the electron is in the nucleus [28]. This situation corresponds to infinite energy using Feynman's correct assertion that the Coulomb potential must apply to the interaction of the electron and the nucleus.

4.) Feynman's derivation of the Bohr radius is flawed since Eq. (2.11) of Feynman (Eq. (5)) is nothing more than the Bohr force balance equation given by McQuarrie [29] and also derived by Mills [7]. Thus, this approach fails at explaining the stability of the 13.6 eV state beyond an arbitrary definition wherein "We need not trust our answer to within factors like 2, π, etc. [16]."

5.) Feynman's derivation of the Bohr radius is internally inconsistent since the kinetic and electrostatic energies were derived **classically**; whereas, QM and the HUP are not consistent with classical mechanics.

6.) Feynman's derivation of the Bohr radius is internally inconsistent since the **HUP requires uncertainty** in the position and momentum. Yet, Eqs. (2.10-2.11) of Feynman (Eqs. (4-5)) can be solved to give an **exact** rather than a most probable electron position, momentum, and energy.

7.) The faulty logic is compounded by the fact that the HUP is founded on the definition of the momentum operator given by Eq. (9) and the position operator given by Eq. (10). Thus, the HUP is based on the postulated SE and its associated postulates and descriptions of particles as probability waves. **It is not based on physics—rather it is based purely on mathematics** [23]. In fact, it is nonsensical in many physical tests such as scattering of electrons from neutral atoms, confining electrons to atoms, confining electrons to atoms in excited states wherein a photon causing a transition carries $\hbar$ of angular momentum, and the cosmological consequences of the HUP as described previously [8, 15 Chp. 1, Appendix II]. Also, it is disproved experimentally that it provides a basis for the wave-particle duality nature of light and particles [19]; even though, the opposite is widely touted [8, 15 Foreword and Chp 37].

8.) The consideration of the HUP as the basis of the band-width versus life-time of excited states discussed *supra.* arises from the mathematical ability to write the HUP in the form:

$$\Delta E \Delta t \geq \frac{\hbar}{2} \tag{13}$$

Feynman argues that the uncertainty in a measurement is equivalent to the measurement. Applying the HUP as argued by Feynman to the lifetime of fundamental particles such as the electron and proton gives a lifetime for their decay of 6.4×10^{-22} s and 3.5×10^{-25} s, respectively. Since the proton and electron are stable, the HUP according to Feynman is experimentally disproved. The proton and electron are predicted to be stable as discussed previously [15 Chps. 27, 29, and 30].

In addition, the HUP is experimentally disproved since it predicts nonlocality, noncausality, spooky actions at a distance, and perpetual motion [8]. The HUP is further experimentally disproved since it predicts an essentially infinite cosmological constant [8, 15 Chp. 1, Appendix II], zero-point vibration, and uncertainty in spacetime at the Planck scale.

Specifically:

The Rutherford experiment demonstrated that even atoms are comprised of essentially empty space [30]. Zero-point field fluctuations, virtual particles, and states of negative energy and mass invoked to describe the vacuum are nonsensical and have no basis in reality since they have never been observed experimentally and would correspond to an essentially infinite cosmological constant throughout the entire universe including regions of no mass. As given by Waldrop [31], "What makes this problem into something more than metaphysics is that the cosmological constant is observationally zero to a very high degree of accuracy. And yet, ordinary quantum field theory predicts that it ought to be enormous, about 120 orders of magnitude larger than the best observational limit. Moreover, this prediction is almost inescapable because it is a straightforward application of the uncertainty principle, which in this case states that every quantum field contains a certain, irreducible amount of energy even in empty space. Electrons, photons, quarks--the quantum field of every particle contributes. And that energy is exactly equivalent to the kind of pressure described by the cosmological constant. The cosmological constant has accordingly been an embarrassment and a frustration to every physicist who has ever grappled with it."

HUP is disproved by additional observations that contradict inalienable predictions. For example, like the similar nonsensical prediction of zero-point energy of the vacuum, the inescapably-predicted zero-point vibration (ZOV) has never been directly measured. ZOV violates the second law of thermodynamics, and it is in conflict with direct experimental results such as the formation of solid hydrogen and Bose-Einstein condensates of molecules as discussed previously [11]. Furthermore, Lieu and Hillman [32] and Ragazzoni et al. [33] have recently shown using the Hubble space telescope that the infinities in the quantum singularity which became the universe with the big bang can not be reconciled by invoking uncertainty on the Planck-time scale. Time is continuous rather than quantized, the QM-based concepts of the graviton, the big bang, and uncertainty principle are experimentally disproved. Thus, the basis of the stability of matter is not provided by the Heisenberg Uncertainty Principle based on its invalidity as a physical principle as well as its improper application as a mathematical principle. It is surprising that the community is not concerned that quantum mechanics does not even address this most fundamental issue.

   Lieb [34] also addresses the fact that the Schrödinger equation has been accepted for over a half of a century without addressing the stability of matter. Lieb also shows that the Feynman argument is "wrong" due to an inappropriate application of the Heisenberg Uncertainty Principle and admonishes the misrepresentation in textbooks. By considering a wavefunction comprised of two components at two radii such that the electron can not have both sharply defined momentum and position in accordance with the Uncertainty Principle, Lieb shows that the radius can be arbitrarily small including zero such that the energy is negative infinity. This result is obviously not predictive of stability. However, Lieb claims that the stability problem is now resolved with his work. But, the proclamation is hollow in that is not based on physical laws and is not even internally consistent with quantum mechanics. According to Lieb, "Atoms are stable because of an uncertainty principle." After showing that the Heisenberg Uncertainty Principle can not be used to establish stability, Lieb proceeds to use a different postulated uncertainty principle in the form of an inequality. When the wave function and the corresponding energy are solved, it is found that a lower bound in the energy arises. However, the wave function is not a solution of the Schrödinger equation. During the minimizing, Ψ is not square integrable, and the wave equation for Ψ is not even a differential equation. Thus, the argument is invalid.

   Furthermore, the approach by Feynman and Lieb are physically baseless. Attempts to prove that a system has a kinetic energy that exceeds some lower bound such that the total energy is not negative infinity is not based on physics since it ignores radiation-loss terms. More recently, Bugliaro at al. [35] have attempted to use QED to prove the stability of matter with N nonrelativistic electrons and K static nuclei of nuclear charge $\le Ze$ that can interact with photons. Here, the problem is "rigged" since the radiation field is defined to be quantized, an ultraviolet cutoff is arbitrarily imposed, Maxwell's equations are not obeyed due to the defined properties of the polarizations, and creation and annihilation operators including the limitation of the couplings of photons to electrons via Pauli operators only. Furthermore, the proof has nothing to do with the solutions of the actual atomic energy levels. Even then, stability is only found for a nuclear charge $Z \le 6$. Thus, it is evident that neither the Schrödinger equation, variants thereof, or QED provide a general, self consistent, rigorous, and physical basis for the stability of matter.

3   Further Issues with QM

Quantum mechanics has remained mysterious to all who have encountered it. Starting with Bohr and progressing into the present, the departure from intuitive, physical reality has widened. The connection between quantum mechanics and reality is more than just a "philosophical" issue. It reveals that quantum mechanics is not a correct or complete theory of the physical world and that inescapable internal inconsistencies and incongruities with physical observation arise when attempts are made to treat it as a physical as opposed to a purely mathematical "tool." Some of these issues are discussed in a review by Laloë [36].

The hydrogen atom is the only real problem for which the Schrödinger equation can be solved without approximations; however, it only provides three quantum numbers—not four, and inescapable disagreements between observation and predictions arise from the later postulated Dirac equation as well as the Schrödinger equation [7, 8, 12–14, 15 Foreword and Chp 37]. Furthermore, unlike physical laws such as Maxwell's equations, it is always disconcerting to those that study quantum mechanics that both must be accepted without any underlying physical basis for fundamental observables such as the stability of the hydrogen atom in the first place. In this instance, a circular argument regarding definitions for parameters in the wave equation solutions and the Rydberg series of spectral lines replaces a first-principles-based prediction of those lines [7, 8, 13, 15 Foreword and Chp 37]. Nevertheless, the application of the Schrödinger equation to real problems has provided useful approximations for physicists and chemists. Schrödinger interpreted $e\Psi^*(x)\Psi(x)$ as the charge-density or the amount of charge between x and $x + dx$ (Ψ^* is the complex conjugate of Ψ). Presumably, then, he pictured the electron to be spread over large regions of space. Three years after Schrödinger's interpretation, Max Born, who was working with scattering theory, found that this interpretation led to inconsistencies and he replaced the Schrödinger interpretation with the probability of finding the electron between x and $x + dx$ as

$$\int \Psi(x)\Psi^*(x)dx \tag{14}$$

Born's interpretation is generally accepted. Nonetheless, interpretation of the wave function is a never-ending source of confusion and conflict. Many scientists have solved this problem by conveniently adopting the

Schrödinger interpretation for some problems and the Born interpretation for others. This duality allows the electron to be everywhere at one time—yet have no volume. Alternatively, the electron can be viewed as a discrete particle that moves here and there (from $r = 0$ to $r = \infty$), and $\Psi\Psi^*$ gives the time average of this motion. Despite its successes, after decades of futility, quantum mechanics and the intrinsic Heisenberg Uncertainty Principle have not yielded a unified theory, are still purely mathematical, and have yet to be shown to be based in reality [8]. Both are based on circular arguments that the electron is a point with no volume with a vague probability wave requiring that the electron have multiple positions and energies including negative and infinite energies simultaneously. It may be time to revisit the 75 year old notion that fundamental particles such as the electron are one or zero dimensional and obey different physical laws than objects comprised of fundamental particles and the even more disturbing view that fundamental particles don't obey physical laws—rather they obey mathematics devoid of physical laws. Perhaps mathematics does not determine physics. It only models physics.

The Schrödinger equation was originally postulated in 1926 as having a solution of the one electron atom. It gives the principal energy levels of the hydrogen atom as eigenvalues of eigenfunction solutions of the Laguerre differential equation. But, as the principal quantum number $n \gg 1$, the eigenfunctions become nonsensical. Despite its wide acceptance, on deeper inspection, the Schrödinger equation solution is plagued with many failings as well as difficulties in terms of a physical interpretation that have caused it to remain controversial since its inception. Only the one electron atom may be solved without approximations, but it fails to predict electron spin and leads to models with nonsensical consequences such as negative energy states of the vacuum, infinities, and negative kinetic energy. In addition to many predictions, which simply do not agree with observations, the Schrödinger equation and succeeding extensions predict noncausality, nonlocality, spooky actions at a distance or quantum telepathy, perpetual motion, and many internal inconsistencies where contradicting statements have to be taken true simultaneously [7–8, 15 Foreword and Chp 37].

It was reported previously [8] that the behavior of free electrons in superfluid helium has again forced the issue of the meaning of the wavefunction. Electrons form bubbles in superfluid helium which reveal that the electron is real and that a physical interpretation of the wavefunction is necessary. Furthermore, when irradiated with light of energy of about a 0.5 to several electron volts [37], the electrons carry current at different rates as if they exist with different sizes. It has been proposed that the behavior of free

electrons in superfluid helium can be explained in terms of the electron breaking into pieces at superfluid helium temperatures [37]. Yet, the electron has proven to be indivisible even under particle accelerator collisions at 90 GeV (LEPII). The nature of the wavefunction need to be addressed. It is time for the physical rather than the mathematical nature of the wavefunction to be determined.

From the time of its inception, quantum mechanics has been controversial because its foundations are in conflict with physical laws and are internally inconsistent. Interpretations of quantum mechanics such as hidden variables, multiple worlds, consistency rules, and spontaneous collapse have been put forward in an attempt to base the theory in reality. Unfortunately many theoreticians ignore the requirement that the wave function must be real and physical in order for it to be considered a valid description of reality. For example, regarding this issue Fuchs and Peres believe [38] "Contrary to those desires, quantum theory does *not* describe physical reality. What it does is provide an algorithm for computing *probabilities* for macroscopic events ('detector ticks') that are the consequences of our experimental interventions. This strict definition of the scope of quantum theory is the only interpretation ever needed, whether by experimenters or theorists."

With Penning traps, it is possible to measure transitions including those with hyperfine levels of electrons of single ions. This case can be experimentally distinguished from statistics over equivalent transitions in many ions. Whether many or one, the transition energies are always identical within the resonant line width. So, *probabilities* have no place in describing atomic energy levels. Moreover, quantum theory is incompatible with probability theory since it is based on underlying unknown, but determined outcomes as discussed previously [8].

The Copenhagen interpretation provides another meaning of quantum mechanics. It asserts that what we observe is all we can know; any speculation about what an electron, photon, atom, or other atomic-sized entity is really is or what it is doing when we are not looking is just that— speculation. The postulate of quantum measurement asserts that the process of measuring an observable forces it into a state of reality. In other words, reality is irrelevant until a measurement is made. In the case of electrons in helium, the fallacy with this position is that the "ticks" (migration times of electron bubbles) reveal that the electron is real before a measurement is made. Furthermore, experiments on transitions on single ions such as Ba^+ in a Penning trap under continuous observation demonstrate that the postulate of quantum measurement of quantum mechanics is experimentally disproved as discussed previously [8, 39]. These issues and other such flawed

philosophies and interpretations of experiments that arise from quantum mechanics were discussed previously [7, 8, 14, 15 Foreword and Chp 37].

Quantum mechanics gives correlations with experimental data. It does not explain the mechanism for the observed data. But, it should not be surprising that it gives good correlations given that the constraints of internal consistency and conformance to physical laws are removed for a wave equation with an infinite number of solutions wherein the solutions may be formulated as an infinite series of eigenfunctions with variable parameters. There are no physical constraints on the parameters. They may even correspond to unobservables such as virtual particles, hyperdimensions, effective nuclear charge, polarization of the vacuum, worm holes, spooky action at a distance, infinities, parallel universes, faster than light travel, etc. If you invoke the constraints of internal consistency and conformance to physical laws, quantum mechanics has never successfully solved a physical problem.

Throughout the history of quantum theory; wherever there was an advance to a new application, it was necessary to repeat a trial-and -error experimentation to find which method of calculation gave the right answers. Often the textbooks present only the successful procedure as if it followed from first principles; and do not mention the actual method by which it was found. In electromagnetic theory based on Maxwell's equations, one deduces the computational algorithm from the general principles. In quantum theory, the logic is just the opposite. One chooses the principle (e.g. phenomenological Hamiltonians) to fit the empirically successful algorithm. For example, we know that it required a great deal of art and tact over decades of effort to get correct predictions out of Quantum Electrodynamics (QED). For the right experimental numbers to emerge, one must do the calculation (i.e. subtract off the infinities) in one particular way and not in some other way that appears in principle equally valid. There is a corollary, noted by Kallen: from an inconsistent theory, any result may be derived.

Reanalysis of old experiments and many new experiments including electrons in superfluid helium challenge the Schrödinger equation predictions. Many noted physicists rejected quantum mechanics. Feynman also attempted to use first principles including Maxwell's Equations to discover new physics to replace quantum mechanics [40]. Other great physicists of the 20th century searched. "Einstein [...] insisted [...] that a more detailed, wholly deterministic theory must underlie the vagaries of quantum mechanics" [41]. He felt that scientists were misinterpreting the data. These issues and the results of many experiments such as the wave-particle duality, the Lamb shift, fine structure, hyperfine structure of the hydrogen atom, positronium, and muonium, spin and anomalous magnetic moment of the elec-

tron, transition and decay lifetimes, excited-states energies, nature of the chemical bond, de Broglie wavelength, as well as experiments invoking interpretations of spooky action at a distance such as the Aspect experiment, entanglement, and double-slit-type experiments are shown to be absolutely predictable and physical in the context of a theory of classical quantum mechanics (CQM) derived from first principles [7–14, 15 Foreword and Chp 37].

4   A Recent Novel Maxwellian Approach to Stability

To provide physical insight into atomic problems and starting with the same essential physics as Bohr of e^- moving in the Coulombic field of the proton and the wave equation as modified by Schrodinger, a classical approach has been put forward which yields a model which is remarkably accurate and provides insight into physics on the atomic level [8–15]. The proverbial view deeply seated in the wave-particle duality notion that there is no large-scale physical counterpart to the nature of the electron may not be correct. Physical laws and intuition may be restored when dealing with the wave equation and quantum mechanical problems. Specifically, a theory of classical quantum mechanics (CQM) is derived from first principles that successfully applies physical laws on all scales. Using Maxwell's equations, the classical wave equation is solved with the constraint that a bound electron cannot radiate energy. Although an accelerated *point* particle radiates, an *extended distribution* modeled as a superposition of accelerating charges does not have to radiate [21, 42, 43]   Rather than use the postulated Schrödinger boundary condition: $\Psi \rightarrow 0$ as $r \rightarrow \infty$, the condition for nonradiation by an ensemble of moving point charges that comprises a current density function is

> *For non-radiative states, the current-density function must NOT possess spacetime Fourier components that are synchronous with waves traveling at the speed of light.*

By further application of Maxwell's equations to electromagnetic and gravitational fields at particle production, the Schwarzschild metric (SM) is derived from the classical wave equation which modifies general relativity to include conservation of spacetime in addition to momentum and matter/energy. The result gives a natural relationship between Maxwell's equations, special relativity, and general relativity. CQM holds over a scale of spacetime of 85 orders of magnitude—it gives remarkably accurate predic-

tions from the scale of the quarks to that of the cosmos [8–15]. A review is given by Landvogt [44].

5   Conclusion

The classical theory derived from Maxwell's equations with the constraint that the $n = 1$ state is nonradiative leads to the prediction of stable atomic and molecular hydrogen states below the traditional $n = 1$ state that match recently reported atomic and molecular emissions [1-6] and spectroscopic and analytical data on lower-energy molecular hydrogen isolated at liquid-nitrogen temperature [5, 6].   The experimentally confirmed existence of atomic hydrogen electronic states below the 13.6 eV level has major implications regarding the correctness of quantum mechanics.   Quantum mechanical theory is not derived from first principles and relies on faith in the infallibility of the Schrödinger equation since it can not be directly experimentally confirmed. The faith in this premise is based on the exact solution of the hydrogen atom; however, even this has been shown to have major problems which are well known [7–14, 15 Chp. 35, Foreword, and Chp 37]. More complicated problems in quantum mechanics rely on finding combinations of wavefunctions from an infinite selection that reproduce the desired data as eigenvalue solutions of the Schrödinger equation. Thus, the existence of hydrogen energy levels below the "ground state," a state that is an absolute quantum mechanical definition which can not be supported by Feynman's argument, calls into question the fundamental postulate of quantum mechanics and thus questions the validity of the fundamental relationship $H\Psi = E\Psi$ [5].   The issue of stability to radiation may be resolved by applying Maxwell's equations to an extended distribution, and the solution appears to eliminate of some of the mysteries and intrinsic problems of QM [8–15].

References

[1] Mills, R. L., Ray, P., J. Phys. D, Appl. Phys., **36**, 1535–1542, (2003).

[2] Mills, R. L., Ray, P., Dhandapani, B., Nansteel, M., Chen, X., He, J., J. Mol. Struct., **643**(1–3), 43–54, (2002).

[3] Mills, R. L., Ray, P., Int. J. Hydrogen Energy, **27**, 301–322, (2002).

[4] Mills, R. L., Ray, P., Dong, J., Nansteel, M., Dhandapani, B., He, J., Vib. Spectrosc., **31**, 195–213, (2003).

[5] Mills, R. L., Chen, X., Ray, P., He, J., Dhandapani, B., Thermochim. Acta, **406**/1-2, 35–53, (2003).

[6]   Mills, R. L., Lu, Y., He, J., Nansteel, M., Ray, P., Chen, X., Voigt, A., Dhandapani, B., "Spectral Identification of New States of Hydrogen," submitted, http://www.blacklightpower.com/pdf/technical/EGunNMR%200326 04.pdf.

[7]   Mills, R. L., Int. J. of Hydrogen Energy, **25**, 1171–1183, (2000).

[8]   Mills, R. L., Int. J. Hydrogen Energy, **26**, 1059–1096, (2001).

[9]   Mills, R. L., "Classical Quantum Mechanics," in press, http://www.blacklightpower.com/pdf/technical/Theory102804Web.pdf.

[10] Mills, R. L., Int. J. Hydrogen Energy, **27**, 565–590, (2002).

[11] Mills, R. L., "The Nature of the Chemical Bond Revisited and an Alternative Maxwellian Approach," in press; posted at
http://www.blacklightpower.com/pdf/technical/Hydro102804Web.pdf.

[12] Mills, R. L., "Exact Classical Quantum Mechanical Solutions for One- Through Twenty-Electron Atoms," submitted; posted at
http://www.blacklightpower.com/pdf/technical/1-20e102804.pdf

[13] Mills, R. L., "Exact Classical Quantum Mechanical Solution for Atomic Helium Which Predicts Conjugate Parameters from a Unique Solution for the First Time," submitted; posted at
http://www.blacklightpower.com/pdf/technical/Helium102804.pdf

[14] Mills, R. L., "Maxwell's Equations and QED: Which is Fact and Which is Fiction," submitted; posted at
http://www.blacklightpower.com/pdf/technical/MaxwellianEquationsandQED1 02804.pdf.

[15] Mills, R. L., *The Grand Unified Theory of Classical Quantum Mechanics*, September 2001 Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by Amazon.com; January 2005 Edition posted at
http://www.blacklightpower.com/bookdownload.shtml.

[16] Feynman, R. P., Leighton, R. B., Sands, M., *The Feynman Lectures on Physics, Vol. III, Quantum Mechanics*, Addison-Wesley Publishing Company, (1965) Reading, MA, pp. 1-9 and 2-6.

[17] Pearle, P., Found. Phys., **7**(11/12), 931–945, (1977).

[18] Weisskopf, V. F., Rev. Mod. Phys., **21**, 305–315 (1949).

[19] Durr, S., Nonn, T., Rempe, G., Nature, **395**(6697), 33–37, (1998).

[20] Margenau, H., Murphy, G. M., *The Mathematics of Chemistry and Physics*, D. Van Nostrand Company, Inc., New York, (1956), Second Edition, pp. 363–367.

[21] Haus, H. A. Am. J. Phys., **54**, 1126–1129, (1986).

[22] Weiss, P., Science News, **154**(10), 149, (1998).

[23] McQuarrie, D. A., *Quantum Chemistry*, University Science Books, Mill Valley, CA, (1983), pp. 135–140.

[24] Siebert, W. McC. , *Circuits, Signals, and Systems*, The MIT Press, Cambridge, Massachusetts, (1986), pp. 488–502.

[25] McQuarrie, D. A., *Quantum Chemistry*, University Science Books, Mill Valley, CA, (1983), back cover.

[26] McQuarrie, D. A., *Quantum Chemistry*, University Science Books, Mill Valley, CA, (1983), p. 38.

[27] Karplus, M., Porter, R. N., *Atoms and Molecules an Introduction for Students of Physical Chemistry*, The Benjamin/Cummings Publishing Company, Menlo Park, California, (1970), p. 567.

[28] Griffiths, D. J., *Introduction to Quantum Mechanics*, Prentice-Hall, (1995), Prob. 4.14.

[29] McQuarrie, D. A., *Quantum Chemistry*, University Science Books, Mill Valley, CA, (1983), pp. 22–26.

[30] Beiser, A., *Concepts of Modern Physics*, Fourth Edition, McGraw-Hill Book Company, New York, (1978), pp. 119–122.

[31] Waldrop, M. M., Science, **242**, 1248–1250, (1988).

[32] Lieu, R., Hillman, L. W., Astrophys. J., **585**(2), L77–L80 (2003).

[33] Ragazzoni, R., Turatto, M., Gaessler, W., Astrophys. J., **587**(1), L1-L4, (2003).

[34] Lieb, E. H., Rev. Mod. Phys., **48**(4), 553–569, (1976).

[35] Bugliaro, L., Fröhlich, J., Graf, G. M., Phys. Rev. Lett., **77**, 3494–3497, (1996).

[36] Laloë, F., Am. J. Phys. **69**(6), 655–701, (2001).

[37] Maris, H. J., J. Low Temp. Phys., **120**, 173 (2000).

[38] Fuchs, C. A., Peres, A., Phys. Today, **53**(3), 70, (2000).

[39] Peil, S., Gabrielse, G., Phys. Rev. Lett., **83**, 1287–1290, (1999).

[40] Dyson, F., Am. J. Phys., **58**, 209–211, (1990).

[41] Horgan, J., Sci. Am., **267**(1), 94, (1992).

[42] Abbott, T. A., Griffiths, D. J., Am. J. Phys., **153**, 1203–1211, (1985).

[43] Goedecke, G., Phys. Rev **135B**, 281, (1964).

[44] GLandvogt, G., Int. J. Hydrogen Energy, **28**, 1155, (2003).

Notes

[1] Bohr just postulated orbits stable to radiation with the further postulate that the bound electron of the hydrogen atom does not obey Maxwell's equations—rather it obeys different physics. Schrödinger and Dirac both used the Coulomb potential, and Dirac used the vector potential of Maxwell's equations. But, both ignored electrodynamics and the corresponding radiative consequences. Dirac originally attempted to solve the bound electron physically with stability with respect to radiation according to Maxwell's equations with the further constraints that it was relativistically invariant and gave rise to electron spin [17]. He was unsuccessful and resorted to the current mathematical-probability-wave model that has many problems [7, 8, 12–14, 15 Foreword and Chp. 37].

In quantum mechanics, the spin angular momentum of the electron is called the "intrinsic angular momentum" since no physical interpretation exists. (Currents corresponding to the observed magnetic field of the electron can not exist in one dimension of four dimensional spacetime where Ampere's law and the intrinsic special relativity determine the corresponding unique current.) The Schrödinger equation is not Lorentzian invariant in violation of special relativity. It failed to predict the results of the Stern-Gerlach experiment which indicated the need for an additional quantum number. Quantum electrodynamics was proposed by Dirac in 1926 to provide a generalization of quantum mechanics for high energies in conformity with the theory of special relativity and to provide a consistent treatment of the interaction of matter with radiation. It is fatally flawed. From Weisskopf [18], "Dirac's quantum electrodynamics gave a more consistent derivation of the results of the correspondence principle, but it also brought about a number of new and serious difficulties." Quantum electrodynamics; (1) **Does not explain nonradiation of bound electrons**; (2) contains an internal inconsistency with special relativity regarding the classical electron radius—the electron mass corresponding to its electric energy is infinite (The Schrödinger equation fails to predict the classical electron radius); (3) it admits solutions of negative rest mass and negative kinetic energy; (4) the interaction of the electron with the predicted zero-point field fluctuations leads to infinite kinetic energy and infinite electron mass; (5) Dirac used the unacceptable states of negative mass for the description of the vacuum; yet, infinities still arise. Dirac's equation which was postulated to explain spin relies on the unfounded notions of negative energy states of the vacuum, virtual particles, and gamma factors.

Dirac's postulated relativistic wave equation also leads to the inescapable results that it gives rise to the Klein Paradox and a cosmological constant that is at least 120 orders of magnitude larger than the best observational limit as discussed previously [7, 8, 15 Chp 1 and Appendix II]. The negative mass states further create an absolute "ether"-like frame in violation of special relativity which was disproved by the Michelson-Morley experiment.

(2) As shown in "Schrödinger States Below n=1" section of Mills [8], the definition of the "ground state" is mathematically purely arbitrary. The SE permits a continuum of solutions which **must be defined to be integers** starting with n=1 as shown the "Schrödinger Theory of the Hydrogen Atom" section of Mills, [8]. In fact, an equally valid solution of the Schrödinger equation gives electronic states corresponding the fractional quantum numbers n=1/integer as shown in "Schrödinger States Below *n* =1" section of Mills [8]. Transitions to these states require a resonant nonradiative energy transfer of an integer times the Hartree, and the resultant instability results in further energy release as characteristic radiation until the next stable state corresponding to a principal quantum number of 1/integer is reached [1–6].

The circular argument between the experimental observation that the hydrogen atom does not spontaneously emit light once it has achieved an energy level of 13.6 eV and the choice of parameters in the SE to give the Rydberg series starting at *n* =1 is required since QM theory does not say why an atom radiates. It is taught in textbooks that atomic hydrogen cannot go below the ground state, but no reason based on physics is given. Quantum states of QM refer to energy levels of probability waves. From these, emission and absorption of radiation is inferred. But QM doesn't explain why it is emitted or absorbed or why certain states are stable. For example, the Schrödinger equation (SE) was **postulated** in 1926. It does not explain the stability of the hydrogen atom. To say that the atom obeys the SE is nonsensical. Consider the hydrogen atom without regard to the mathematical formula called the SE. Mathematics does not determine physics. It only models physics. The SE is not based on directly testable physical laws such as Maxwell's equations. It only gives correlations, and is in fact inconsistent with physical laws. As a historical note:

> [My father] said, "I understand that they say that light is emitted from an atom when it goes from one state to another, from an excited state to a state of lower energy."
> I said, "That's right."
> "And light is kind of a particle, a photon, I think they call it."
> "Yes."
> "So if the photon comes out of the atom when it goes from the excited to the lower state, the photon must have been in the atom in the excited state."
> I said, "Well no."
> He said, "Well, how do you look at it so you can think of a particle photon coming out without it having been there in the excited state?"
> I thought a few minutes, and I said, "I'm sorry; I don't know. I can't explain it to you."
> -Richard P. Feynman, *The Physics Teacher* (September 1969).

According to the generally accepted Born interpretation of the meaning of the wavefunction, the probability of finding the electron between r, θ, ϕ and $r + dr, \theta + d\theta, \phi + d\phi$ is given by

$$\int \Psi(r,\theta,\phi)\Psi*(r,\theta,\phi)drd\theta d\phi$$

The electron is viewed as a discrete particle that moves here and there (from $r = 0$ to $r = \infty$), and $\Psi\Psi*$ gives the time average of this motion. The Schrödinger equation possesses terms corresponding to the electron radial and angular kinetic energy which sum with the potential energy to give the total energy. These are necessary conditions for an electron bound by a central field [20]. Herman Haus derived a test of radiation based on Maxwell's equations [21]. Applying Haus's theorem to the point particle that must have radial kinetic energy demonstrates that the Schrödinger solution for the $n = 1$ state of hydrogen is radiative; thus, it violates Maxwell's equations. Since none is observed for the $n = 1$ state, QM is inconsistent with observation. The derivation is shown in the "Schrödinger Wave Functions in Violation of Maxwell's Equations" section of Mills [15 Chp. 35] and previously discussed in "The Postulated Schrödinger Equation Does Not Explain the Stability of the Hydrogen Atom" section of Mills [8].

[3] Ref. [8] discusses the inconsistencies between the probability distribution interpretation of the wavefunction and probability theory which is based on an underlying unknown but deterministic physics, as well as the inappropriateness of the consideration of a many-body probability distribution for a single electron.

[4] At page 365 Margenau and Murphy [20] state

" but with the term $\dfrac{\ell(\ell+1)\hbar^2}{2mr^2}$ added to the normal potential energy. What is the meaning of that term? In classical mechanics, the energy of a particle moving in three dimensions differs from that of a one-dimensional particle by the kinetic energy of rotation, $\dfrac{1}{2}mr^2\omega^2$. This is precisely the quantity $\dfrac{\ell(\ell+1)\hbar^2}{2mr^2}$, for we have seen that $\ell(\ell+1)\hbar^2$ is the *certain* value of the square of the angular momentum for the state Y_ℓ, in classical language $\left(mr^2\omega^2\right)^2$ which is divided by $2mr^2$, gives exactly the kinetic energy of rotation."

[5] Perhaps Einstein was right that "God does not play dice with the universe" meaning that reality is not created by the observer from a formless sea of probability waves;