

Original Paper

An Alternative Approach to the Gravitational Quantization Problem

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Abstract: An alternative path toward resolving the challenge of quantizing gravity is explored. Instead of attempting to quantize gravity, Carlip's suggestion [S. Carlip, *Rep. Progr. Physics* **64**, 885-942 (2001)] that one might change quantum theory to make it consistent with classical general relativity is here briefly explored. The discussion is based on the correspondence principle, which indicates a direction for the change, namely that the changed quantum theory should be non-linear, but does not indicate in detail how the change is to be made. Published results [e.g., A. O. Barut and J. Kraus, *Found. Physics* **13** 189-194 (1983)] demonstrate that inserting nonlinearity into quantum electrodynamics eliminates the oddity that electromagnetism is quantized while gravity remains classical, namely they explain all second quantization effects via a nonlinear matter wave equation that leaves electromagnetism in its classical non-quantized form.

Keywords: correspondence principle, quantum electrodynamics, nonlinear quantum mechanics, classical gravity, Barut

General relativity[1] and quantum field theory[2] are two of the great theories of modern physics. Each has systematically passed experimental tests in its domain of validity. However, several persistent clouds raise questions. It appears odd that the electromagnetic field is quantized, but efforts to quantize gravity have thusfar been unsuccessful. The two theories also appear to be inconsistent with each other. For example, Eppley and Hannah[3] show that a classical gravitational measurement on a quantum system might lead to faster-than-light signal transmission, which (recalling special relativity) would require

reconstruction of our understanding of causality.

It is widely supposed that the clouds will be removed by quantizing gravity. Carlip[4, 5] notes an alternative, namely leaving general relativity in place and changing quantum mechanics. He suggests that the preference for quantum gravity arises because "...most interactions are very successfully described by quantum field theory..." and "...we already know a good deal about how to quantize a classical theory, but almost nothing about how to consistently change quantum theory." Carlip does not propose how quantum theory is to be changed.

This letter proposes an alternative path toward removing one of the clouds. My proposal eliminates the oddity that electromagnetism is quantized, but gravity is not. I propose that a century's failures to quantize gravity arises not from lack of effort but because quantum theory as now constituted is incorrect. What might replace quantum field theory? I begin with the correspondence principle as applied to classical general relativity. A path toward a replacement is identified. A published model that follows the proposed path is noted.

For this proposal, classical general relativity is taken to be correct, gravity not being quantized. In applying the correspondence principle, the important feature of general relativity is taken to be that gravity is nonlinear: The gravitational field created by two masses is not the linear sum of the fields created by the two masses taken separately. From the correspondence principle, I propose: Given that nonlinearity is present macroscopically, it should also be present at the quantum level. What is meant by non-linearity? Quantum mechanics as developed, e.g., by Dirac[6], tells us that if $|A\rangle$ and $|B\rangle$ are states of the system, then each mixed state $|M\rangle$

$$|M\rangle = c_1|A\rangle + c_2|B\rangle \quad (1)$$

is also a state of the system, c_1 and c_2 being complex numbers. In a non-linear system, the mixed state $|M\rangle$ could, but might not, be a state of the system.

To answer an obvious objection: Is it possible to have a nonlinear theory that leads to good approximation to the same results as a simpler theory? As an affirmative example, consider the linearized Poisson-Boltzmann equation for the electrical potential surrounding an ion in a modestly concentrated salt solution. The linearized equation is commonly derived from the nonlinear Poisson-Boltzmann equation, via a truncated power series expansion of exponentials. However, as was shown by Kirkwood[7] and Kirkwood and Poirier[8] much of a century ago, the nonlinear Poisson-Boltzmann equation is simply wrong; it conflates the average potential and the potential of average force. Nonetheless, the correct nonlinear equation for this problem, as obtained by Kirkwood and Poirier, has as its linearized approximation the linearized Poisson-Boltzmann equation. Several different non-linear starting points obtain the same linear approximation.

What is implied by the replacement of linear quantum field theory with a nonlinear theory? Some qualitative features are immediately apparent. In a nonlinear system,

$|M\rangle$ of equation 1 cannot be automatically assumed to be a state of the system. The entire Hilbert-space computational apparatus of quantum mechanics is then eliminated, at least without careful analysis at each invocation. Without making a full analysis here, some objections[9,10] to hidden variable theories may disappear, to the extent that these objections assumed that quantum mechanics has a linear Hilbert-space description. In addition, the standard verbal description of states as 'pure' and 'mixed' becomes a physical distinction. In a two-state linear system, $|A\rangle$ and $|B\rangle$ could be the pure states, in which case $|\pm\rangle = |A\rangle \pm |B\rangle$ are mixed states. However, in linear quantum mechanics, $|\pm\rangle$ may equally be called the pure states, in which case $|A\rangle$ and $|B\rangle$, calculated as $|+\rangle \pm |-\rangle$, are now mixed states. In a nonlinear model, if there are pure states, their linear combinations are not necessarily states at all.

As a first step, Weinberg[11] discusses creating a quantum field with weak nonlinear features. Weinberg begins by creating a generalized framework for considering nonlinear generalizations of quantum mechanics. In his paper, conventional quantum mechanics is assumed to be nearly correct, with nonlinear terms providing weak perturbations to the conventional Hamiltonian. He then notes several experiments involving spectral line broadening or the evolution of a wave function with time that are sensitive to a nonlinear parameter in the system Hamiltonian[12,13]. These experiments may be interpreted to show that the nonlinearity parameters in his nonlinear models are strictly less than 10^{-15} eV, providing a stringent upper limit to the size of this type of small nonlinear modification of orthodox quantum mechanics. Following the development of Weinberg[2], some further implications for quantum field theory appear evident. Symmetries survive, but representations of those symmetries by linear transformations – if possible at all – gain additional constraints or complications. If classical general relativity remains valid, Lorentz and conformal transformations remain available. Renormalization may remain relevant.

On a more challenging level, can a non-linear theory duplicate any of quantum field theory's results? Muthukrishnan, et al.,[14] discuss historical attempts to dispense with second quantization. These attempts failed. However, Barut and collaborators succeeded. They propose a self-energy model based on a non-linear quantum wave equation. Nonlinearity was inserted in the familiar Dirac equation by adding a Coulomb interaction between different regions of an atom's electron cloud. This interaction, being quadratic in the electron wave function, is intrinsically non-linear. Between the Dirac equation and Maxwell's equations, Barut and collaborators advanced by eliminating the internal potential A_μ from their equation for the time evolution of the electron wave function. The resulting model requires that the electromagnetic field remains classical. The model was used to calculate a variety of phenomena that are generally understood to arise from second quantization and vacuum fluctuations in the electromagnetic field. In particular, the results of Barut and collaborators[15] show that their non-linear electrodynamics does not always

require renormalization.

Indeed, Barut and collaborators found no point at which their nonlinear self-energy model with classical electromagnetic field disagrees with orthodox quantum electrodynamics. Their model and conventional quantum electrodynamics consistently predict exactly the same values for physical parameters[15–18]. For example: Barut and Uinal[19] calculated the hydrogen and muonium ground-state hyperfine splittings, the corresponding $n = 1$, $n = 2$ splittings, and the positronium hyperfine splitting and $n = 2$, $n = 1$ transition, and the hydrogen and positronium fine splittings, all through order α^4 (α^5 for terms from the anomalous magnetic moment), finding complete agreement with the standard QED calculations. Barut and Dowling[20] analyze spontaneous emission in cavities, finding that conducting boundaries may inhibit or enhance spontaneous emission, in ways consistent with experiment. Barut and Dowling[21] show how to calculate the Lamb shift and the Casimir-Polder energies for a quantum system near a conducting boundary. For an atom near an infinite conducting plane, they recover the standard QED results, which, however, assumed that the electromagnetic field is quantized. Finally, Barut and Salamin[22] calculated the decay rate $2S_{1/2} \rightarrow 1S_{1/2} + 1\gamma$ for hydrogenlike ions having $Z \in (1, 92)$, finding agreement with conventional quantum electrodynamics calculations. Barut and Dowling[23] consider a two-level atom, comparing their results with results from a neoclassical model treatment. They show that certain odd predictions of the neoclassical model appear to arise from use of the superposition principle in a non-linear system in which the superposition principle does not hold.

The results of Barut and collaborators show that a nonlinear quantum model can explain quantitatively the core spectroscopic properties that support second quantization and orthodox quantum electrodynamics. Evidence forcing a belief in the quantization of the electromagnetic field has therefore been removed. It is then plausible that the electromagnetic field is classical, with quantum effects being statements about the electromagnetic field's sources and not about the electromagnetic field itself. The oddity that gravity is not quantized, while the electromagnetic field is quantized, is removed, namely electromagnetism joins gravity in being classical. It may appear unexpected that two different physical models can lead to the same measurable predictions, but quantum mechanics presents us with a historical example of this phenomenon: When they were first announced, it was by no means obvious that the Heisenberg and Schroedinger quantum theories were even consistent, let alone equivalent.

As to why nonlinear quantum effects at the fundamental level have not already been noticed, *pace* Barut, et al., perhaps we have not asked the right questions. As one possible question: Nonlinear systems can be extremely sensitive to weak perturbations, leading to a possible explanation for the apparent stochastic behavior of quantum processes. One could envision for a complete nonlinear quantum mechanics an equation of motion that included something that mimics a stochastic noise source, thus giving it apparently random

behavior. This notion has traditionally been excluded, because no tested perturbation of any radioisotope has any effect on its decay half-life (K-capture is a special case). To be consistent with experiment, one would need a stochastic noise source that was the same everywhere. Historically, no such noise source was known.

However, nonlinear systems can have great sensitivity to extremely weak perturbations. There is then a possible albeit unlikely general relativistic candidate for the stochastic noise source, namely relict gravitational waves from the primordial cosmic singularity. The amplitude of these waves would be the same everywhere. There are other relicts of the singularity that might be invoked as a stochastic noise source. In particular, there is presumably a cosmological neutrino background whose intensity is very nearly the same everywhere. For this proposal, there is then a possible if highly challenging experimental test, namely that the relative intensity of spectral emission lines from atoms in the vicinity of an intense gravitational wave source, such as those recently observed experimentally[24], might be perturbed.

The approach suggested here would require that quantum field theory[2] be reconstructed almost from the beginning. The correspondence rationale used here proposes *what* might be changed but not *how* the change is to be made. As said by Carlip, "...almost nothing [is known] about how to consistently change quantum theory...". The results of Barut and collaborators have perhaps supplied the needed reconstruction. However, quantum field theory makes many predictions that have been confirmed to very high precision. These predictions would all need to follow from the new theory, or would need to be reinterpreted.

References

1. Charles W. Misner, Kip S. Thorne, John Archibald Wheeler. *Gravitation*. Princeton U.P.: Princeton (2017)
2. Steven Weinberg. *The Quantum Theory of Fields*. Vols. 1-3 Cambridge U.P., Cambridge, U.K. (1995)
3. K. Eppley and E. Hannah. Necessity of Quantizing Gravitational Field. *Foundations of Physics* **7**, 51-68 (1977).
4. S. Carlip. Quantum Gravity: A Progress Report. *Rep. Progr. Physics* **64**, 885-942 (2001), especially page 888.
5. S. Carlip. Is Quantum Gravity Necessary? *Class. Quantum Grav.* **25**, 1-6 (2018).
6. P. A. M. Dirac. *The Principles of Quantum Mechanics* (Fourth Edition). Oxford U.P., Oxford, U.K. (1988).
7. J. G. Kirkwood. On the Theory of Strong Electrolytes. *J. Chem. Phys.* **2**, 767-781 (1934).
8. J. G. Kirkwood and J. C. Poirier. *The Statistical Mechanical Basis of the*

- Debye-Hueckel Theory of Strong Electrolytes. *J. Phys. Chem.* **58**, 591-596 (1954).
9. J. S. Bell. On the Problem of Hidden Variables in Quantum Mechanics. *Rev. Mod. Phys.* **38**, 447-52 (1966).
 10. S. Kochen and E. Specker. The Problem of Hidden Variables in Quantum Mechanics. *J. Math. Mech.* **17**, 59-87 (1967).
 11. S. Weinberg. Testing Quantum Mechanics. *Annals Phys.* **194**, 336-386 (1989).
 12. J. D. Prestage, J. J. Bollinger, Wayne M. Itano, and D. J. Wineland. Limits for Spatial Anisotropy by Use of Nuclear-Spin-Polarized ^9Be . *Phys. Rev. Lett.* **54**, 2387-2380 (1985).
 13. J. J. Bollinger, J. D. Prestage, Wayne M. Itano, and D. J. Wineland. Laser-Cooled-Atomic Frequency Standard. *Phys. Rev. Lett.* **54**, 1000-1003 (1985).
 14. A. Muthukrishnan, M. O. Scully, and M. S. Zubairy. The Concept of the Photon-Revisited. *OPN Trends* **10**, S18-S27 (2003).
 15. I. Acikgoz, A. O. Barut, J. Kraus, and N. Uenal. Self-Field Electrodynamics Without Infinities. A New Calculation of Vacuum Polarization. *Phys. Lett. A* **198**, 126-130 (1995).
 16. A. O. Barut and J. Kraus. Nonperturbative Quantum Electrodynamics: The Lamb Shift. *Found. Phys.* **13**, 189-194 (1983).
 17. A. O. Barut and J. P. Dowling. QED Based on Self-fields: A Relativistic Calculation of $g - 2$. *Zeits. fuer Naturf.* **44A**, 1051-1056 (1989).
 18. A. O. Barut, J. Kraus, Y. Salamin, and N. Uenal. Relativistic Theory of the Lamb Shift in Self-Field Quantum Electrodynamics. **45**, 7740-7745 (1992).
 19. A. O. Barut and N. Uenal, A New Approach to Bound-State Quantum Electrodynamics. II. Spectra of Positronium, Muonium, and Hydrogen. *Physica* **142A**, 488-497 (1987).
 20. A. O. Barut and J. P. Dowling. Quantum Electrodynamics Based on Self-Energy: Spontaneous Emission in Cavities. *Phys. Rev. A* **36**, 649-654 (1987).
 21. A. O. Barut and J. P. Dowling. Quantum Electrodynamics Based on Self-Energy without Second Quantization: The Lamb Shift and Long-Range Casimir-Polder van der Waals Forces near Boundaries. *Phys. Rev. A* **36**, 2550-2556 (1987).
 22. A. O. Barut and Y. I. Salamin. QED Based on Self-Energy: The Relativistic $2S_{1/2} \rightarrow 1S_{1/2} + 1\gamma$ Decay Rates of Hydrogenlike Atoms. *Phys. Rev. A* **43**, 2254-2257 (1991).
 23. A. O. Barut and J. P. Dowling. Self-Field Quantum Electrodynamics: The Two-Level Atom. *Phys. Rev. A* **41**, 2284-2294 (1990).
 24. B. P. Abbott, et al. Properties of the Binary Black Hole Merger GW150914. *Phys. Rev. Lett.* **116**, 241102 (2016).