Why Gravity is Non-Quantum

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Abstract

The comprehensive analysis of Niels Bohr shows that the classical world is a necessary additional independent conceptual structure not derivable from quantum mechanics. The results of measurement must always be expressed classically. Furthermore, neither linear "decoherence", nor any other unitary linear models/interpretations can ever result in the observed *nonlinear* classical physics. As we will see, the invariant objective classical events constituting the dynamically non-linear spacetime of general relativity *is* this classical structure. Hence, *classical* gravitation is required to make the abstract and purely formal, perfectly linear, quantum mechanical eternal coexistence of many mutually incompatible possibilities into the concrete reality of the observed nonlinear world. It also means that "Quantum Gravity" is a pseudo-problem, a mirage, "Quantum Spacetime" an oxymoron.

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Let us start by stating the obvious: There is no such thing as "Quantum Gravity" - there is *no* (consistent) theory [1] and there are *no* experiments. As a recent telling example, "phenomenology" is mentioned only *once* (in 707 pages, on p. 321) in [1], and then only to dismiss it. So "Quantum Gravity" presently is not physics. And in this article I explain why it never will be.

As much as everybody today likes to talk about "quantum entanglement", "quantum superposition" and, in the field presently under scrutiny, "quantum spacetime", there is no denying that when *we* actually observe nature, the observations are always real objective *non-quantum* outcomes. If you really think about it, everything "quantum" is actually just *indirectly inferred* from objective classical observations. For example is a "picture of an atom", *e.g.* using an electron microscope, just a classical picture on a screen or a printed page. Even deceptively "quantum theoretical" beasts such as individual Eigenvalues, Expectation values (averages), etc, are in reality perfectly objective *classical* entities and only come about after "measurement", *i.e.* observation of real happenings = events in spacetime; which itself *consists* of invariant, *i.e.* objective observer-independent, events. An event per definition is something that actually occurs, and in quantum mechanics things that actually occur are *classical* results of "measurement".

Niels Bohr [2] always emphasized that a classical framework of concepts is independently needed[1] to connect purely formal quantum mechanics with observable facts, as observers and their measuring devices by necessity are classically real. "The primary unanalyzable reality of ordinary experience", as Bohr phrased it, is a necessary additional assumption not derivable from quantum mechanics[2]. Bohr clearly understood[3] that no amount of linear

[1]A multitude of alternative "resolutions" of the quantum measurement problem have been proposed over the years, without succeeding.

[2]Even apart from the fundamental and eternal persistence of unitary linear quantum superpositions in the absence of measurement, the "correspondence principle" is for example not true in general (neither for $\hbar \to 0$, nor for large quantum numbers $n \to \infty$) but only for regular/"orderly" classical systems. Just because the quantum dynamics is exactly linear it can never, by itself, produce a nonlinear classical world, and would hence preclude irregular/"unorderly" classical deterministic chaos, in contradiction to what is actually seen.

[3]The phrase "entanglement" ("verschränkung") of linear quantum systems was coined already in 1935 by Schrödinger in his (in)famous "cat-paper" [3] motivated directly by its appearance in the "EPR-paradox"-paper [4] as "the state of the combined system". "Decoherence" posits that if one subsystem is the entire "unknown" quantum environment

quantum "decoherence" [6] (dynamical unitary quantum phase randomization), neither internal nor environmental, can ever explain the disappearance of coexisting quantum possibilities [7], [8] if everything, including measuring instruments and observers, are quantum entities. This is demonstrated very transparently in *e.g.* [9]. No matter how large a linear system becomes it cannot magically turn nonlinear all by itself. In the purely linear quantum dynamics the superpositions persist *indefinitely*, obeying unitary evolution. And through an infinite-regress of ever larger superpositions of subsystems, the "von Neumann-chain" [5], this inexorably leads to the conclusion that in a linear quantum model *nothing ever can be measured* [10] (linear entanglement and decoherence does not alter this fact of no actual outcomes one bit). Wigner [11], and also von Neumann himself [5], argues that the nonlinear collapse of the quantum unitary evolution, finally allowing definite outcomes to be realized, happens when the consciousness of the observer (somehow) terminates the von Neumann-chain of ever larger linear superpositions. However, where and how does consciousness first enter in the hierarchy of life: human/cat/cockroach/amoeba/.../God? The problem is then just replaced by an even trickier one.

Bohr also said "there is no quantum world", just an abstract quantum formalism to connect empirical experiences in our *real* world - the only one. In Bohr's analysis, quantum mechanics is but a symbolic mathematical algorithm effectuating this correlation. Interestingly, Einstein, in the very first paragraph of [4], similarly states: "Any serious consideration of a physical theory must take into account the distinction between the objective reality, which is independent of any theory, and the physical concepts with which the theory operates". As John Wheeler asserts: "No elementary quantum phe-

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it should induce *random* quantum phases in the resulting superposed linear addition of quantum amplitudes. But whenever one looks closely at claims that randomization by itself collapses the wavefunction, one always finds that the collapse - the conceptual "measurement" transition from quantum to classical ignorance (*i.e.* *no* outcome at all vs. single objective outcome but possibly unknown to *us*) - has to be put in *"by hand"* as decoherence is nothing but standard quantum mechanics, and *no* unitary treatment can explain why only *one* independent outcome is observed $\sum_{n=1}^{\infty} \psi_n(x_2)\phi_n(x_1) \xrightarrow{\text{“meas”}} \psi_k(x_2)\phi_k(x_1)$; *which* single k that results is taken to be *random* in *principle*. Furthermore, *probabilities* (the simply *postulated* "Born rule"), *i.e.* all *uncertainty*, only appear *after* "measurement" is complete, *before* "measurement" the dynamics is in terms of eternally present and exactly deterministic superposed quantum amplitudes. This is evident mathematically *e.g.* already from the German original edition of [5] from 1932, and was understood by Bohr on physical grounds regarding "measurement" even long before that.

nomenon is a phenomenon until it is a registered (observed) phenomenon" [12]. If it were otherwise, how could you even submit your "quantum" results to a scientific journal, such as this one?

Furthermore, John Bell [13] showed that all measurements can be boiled down to *positions*; the position of instrument pointers, ink on a computer output, etc. But positions in space at given times are *events* - which constitute the spacetime of classical relativity. As Wheeler states "Happily, nature provides its own way to localize a point in spacetime, as Einstein was the first to emphasize. Characterize the point by what happens there! Give a point in spacetime the name *"event"*." [14] - events thus truly are the invariant fundamental "atoms" of reality, the same for all observers, the continuous differentiable manifold of which build up and constitute the totality of spacetime. Relativity is a classical theory in which events, and their relationships given in terms of invariant spacetime intervals, are indispensable. Events are primary, the fundamental concept of real *observed* nature. "*Quantum* Spacetime"? "*Quantum* Gravity"? There is no such thing! The geodesics in curved spacetime *are* gravity, and they too consist of classical *events*.

Several authors, *e.g.* [15], have linked gravity to the dynamical mechanism that turn mere subjective quantum mechanical "tendencies for possibilities" into cold, hard, classical facts - events[4]. This is possible as general relativity is a truly nonlinear theory. (If gravity was quantum, *i.e.* linear, we would be back to square one.) The three other known fundamental interactions, Quantum ElectroDynamics, Quantum FlavorDynamics ("the weak force") and Quantum ChromoDynamics, are all purely *quantum* mechanical and as such powerless to classically *realize* their mere quantum potentialities and hence, by themselves, cannot result in a classical world. For example is a "quark quantum field" never detected, instead there are various objective signals in a detector classically observed. Even though at the outset QFD and QCD are nonlinear (non-abelian), quantization[5] linearizes them.

An additional, quite separate, *modern* reason for an independent classi-

[4]Also, note Bohr himself: "...all measurements thus concern bodies *sufficiently heavy*" [2].

[5]For example by inserting their "classical" action in the Feynman functional path-integral - "summing", *i.e.* functionally integrating, over all field histories - which is just a fancy description of linear quantum superposition of amplitudes. The same conclusion is reached by canonical quantization, as it "lives" in a *linear* (Hilbert/Fock) vector space. In fact, *linearity* is *always* a trait of quantum mechanics, as its very starting point is the *linear* superposition principle.

cal structure is that our "normal" world in general is nonlinear, more often than not even chaotic, whereas quantum mechanics is not [16] as only nonlinear equations can support chaos[6]. So, where, then, does the nonlinearity of classical physics, necessary for chaotic dynamics, come from? Unless we want to introduce entirely new *ad hoc* principles, it must come from gravity as the other three known interactions are *exactly* linear due to their *quantum* formulation without any intrinsic "measurement" mechanism. Indeed, in general relativity, the equation of motion - the "geodesic equation" - is a direct consequence of Einstein's gravitational field equations (not so in Newtonian gravity *linear* in the gravitational potential) and can be *highly* nonlinear, just as required.

And as if all this were not enough, the very origin of quantization is *bound states*[7]. Even in quantum mechanics a *free* particle can have *any* of a continuum of *non*-quantized energies - but in general relativity "test-particles" float *freely* along geodesics, *a priori* disqualifying any quantization of it.

All said and done, this leads us to conclude that gravity should not, and cannot, be quantized, as it would rob us of the classical world in terms of events so absolutely crucial for making sense of quantum mechanics itself - and also crucial for making observations in the first place - not to mention functioning as a social human being! Classical events are indispensable for the scientific endeavor, and as relativity *is* this spacetime of events it should not be quantized. Deterministic chaos can, and demonstrably does, exist in classical physics as it is a theory of *events* which is *nonlinear* - the necessary criterion for chaos. Quantum-mechanically, chaos (*e.g.* extreme/exponential sensitivity to initial conditions) *cannot* exist, as quantum mechanics is a *linear* theory about quantum amplitudes[8]. Through gravitation we can thus

[6]The misnomer "Quantum Chaos" actually only concerns how the (non-chaotic) quantum system is affected if its *classical analog* is chaotic. We are here concerned with exactly the opposite question: How can fundamental theory give rise to chaos in our "normal" classical world of everyday phenomena *at all*? It evidently cannot come from quantum theory alone.

[7]Discrete bound states in atoms, for example, give quantized photons. And the very historical *origin* of quantum mechanics and $\hbar$ in the first place - Planck's resolution of the "black body" cavity radiation - is due to that the bound quantum harmonic oscillator can take on only energies in "packets", *i.e. quanta*, $\hbar\omega$.

[8]To obtain N bits of information regarding its future dynamics a chaotic system requires $\sim N$ bits of input information, a linear system only $\sim logN$, independently further validating and strengthening Bohr's physical insight that the classical world is indepen-

understand why events occur at all. Relativity is a theory of actualities, real occurrences, including our very perceptions, in real four-dimensional spacetime. Quantum mechanics, on the other hand, is a theory of mere tendencies for coexisting, mutually incompatible, possibilities in an abstract, generally infinite-dimensional, linear Hilbert space we never have any actual contact with.

To summarize: Spacetime *consists* of real classical objective *events* - *actual* phenomena/occurances and provides the independent classical conceptual framework[9] of Bohr, necessary to make sense of quantum mechanics. This is why gravity should not, and cannot, be "quantized".

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dently needed; reached long before the concept of deterministic chaos was known. A direct mathematical consequence of discrete (quantized) energy-levels is that quantum time-evolution contains only *periodic* motions with definite frequencies - quite the opposite of chaos. Hence there is no chaos in quantum mechanics, only regularity, compare footnote 2.

[9]This also means that the Planck-scale has no physical meaning. When $\hbar \to 0$, appropriate as the spacetime of general relativity is merely a "book-keeping" of all realized classical events, the Planck-length/mass/energy/time/temperature all go to zero.

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