RECENT ADVANCES IN POST-QUANTUM PHYSICS

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ABSTRACT: Newton's mechanics in the 17th Century increased the lethality of artillery. Thermodynamics in the 19th led to the steam-powered Industrial Revolution in the UK. Maxwell's unification of electricity, magnetism and light gave us electrical power, the telegraph, radio and television. The discovery of quantum mechanics in the 20th century by Planck, Bohr, Einstein, Schrodinger, Heisenberg led to the creation of the atomic and hydrogen bomb as well as computer chips and the world-wide-web and Silicon Valley's multi-billion dollar corporations. The lesson is that breakthroughs in fundamental physics, both theoretical and experimental have always led to profound technological wealth-creating new industries and will continue to do so. There is now a new revolution brewing in quantum mechanics that can be divided into three periods. The first quantum revolution was from 1900 to about 1975. The second quantum information/computer revolution was from about 1975 to 2015. The early part of this story is told by MIT Professor David Kaiser in his award-winning book how a small group of Berkeley/San Francisco physicists triggered that second revolution. The third quantum revolution is how an extension of quantum mechanics has led to the understanding of consciousness as a natural physical phenomenon that can emerge in many material substrates not only in our carbon-based biochemistry. In particular, this new post-quantum mechanics will lead to naturally conscious artificial intelligence in nano-electronic machines as well as extending human life spans to hundreds of years and more. This development is not far off and is fraught with opportunities and dangers, just like nuclear power and genetic engineering.

KEYWORDS: Quantum mechanics; Rod Sutherland; Retrocausation

QUANTUM MECHANICS AND BEYOND IN A NUTSHELL

Classical physics from Newton to Maxwell emerged from the 17th to the end of the 19th Centuries dealing with the motion of matter under the influence of forces - mainly

electromagnetism. Although Newton thought of gravity as a force, Einstein in 1915 realized that gravity is not a real force in the same way that electromagnetism exerts forces on charged particles. Gravity is, in fact, the curvature of the four-dimensional spacetime continuum induced by large concentrations of matter. This is why astronauts on the space station are weightless, They move on "geodesic" paths free of real forces. This is basically the essence of Einstein's General Theory of Relativity.

Quantum mechanics is not only needed to understand the chemical bond using tiny electrons to make molecules out of atoms, and atomic nuclei out protons and neutrons etc. We also need it to understand the stability and structure of solids, energy generation in stars as well as the long-range coherent phase wave properties of superfluid helium and electrical superconductors at the lowest temperatures near absolute zero. The achievement of high-temperature superconductivity allowing electrical power to flow long distances without any heat dissipation would dramatically change the energy picture as would the development of nuclear fusion - neither goal unfortunately has been achieved after many decades of trying. All of these applications were part of the first quantum revolution still unfinished.

The second quantum information/computation/crytpographic revolution described in David Kaiser's book is about what Einstein called "spooky telepathic action-at-a-distance" given the more neutral name of "entanglement" although some call it "quantum voodoo." Einstein was not comfortable with entanglement because it seemed to contradict his classical physics theory of relativity which requires that no useful signals conveying meaningful messages can be transmitted faster than the speed of light in a good vacuum. However, we now know how to make observed quantum entanglement connecting widely separated particles consistent with Einstein's relativity. In fact, Einstein's mathematics is perfectly consistent with an extension of our notion of time, cause and effect. Our common sense is a psychological illusion in which time only seems in our consciousness to flow from past to present to future. This irreversible "arrow of time" (aka Second Law of Thermodynamics) is seen in the tragic fact that we age and die, eggs do not unscramble themselves, etc. However, quantum entanglement, which is beginning to play the crucial role in practical command-control-communication technology, is becoming increasingly important to Google, Apple, Microsoft et-al in their Artificial Intelligence Big Data business, is telling us that time also flows in reverse from future to present. In fact, all quantum entanglement phenomena in the present come from back-from-the-future "destiny" partial causes in addition to the familiar classical historical past partial causes of those same present effects. In other words what happens to the world now not only depends on our past history, but also on our future destiny!

Finally, we have the third or "post-quantum revolution" that explains not only how

our own human consciousness emerges out of the two-way action-reaction between classical matter particle and fields with their respective back-from-the-future destiny and from-the-past history quantum information "thought" mental wave fields, but all possible forms of consciousness including conscious artificial intelligence machines from Intel, Microsoft, Apple et-al at the billionth of a meter "nano-electronic" level. Our history mental field is the seat of our memories of things past. Our destiny mental field is the source of our intuition, of our creative ability to imagine, wonder and discover.

A COMMENT ON HTTPS://WWW.QUANTAMAGAZINE.ORG/20170223-BOOTSTRAP-GEOMETRY-THEORY-SPACE/#RESPOND

Chew's bootstrap was of a logical nature. It may be connected with Igor Novikov's temporal bootstrap of "globally self-consistent loops in time." Novikov was mainly thinking about time travel to the past through traversable wormholes in a classical way. Kip Thorne & students then did some calculations with quantum Feynman histories that seemed to agree with Novikov's idea. David Deutsch and Seth Lloyd considered slightly different models of quantum computation between a pair of entangled qubits, one going back in time through a CTC traversable wormhole. We also have ER = EPR connecting AdS ER wormholes in the interior bulk with EPR CFT correlations on the cosmological horizon boundary in Susskind's "The World is a Hologram" idea. In fact we have both past and future cosmological horizons, which take us to Yakir Aharonov's locally retrocausal "weak measurements" underlying von Neumann's strong measurements. Huw Price of Trinity College Cambridge has clarified the meaning of entanglement and the violation Bell's locality inequality in terms of a more fundamental timelike locally real retrocausality of future causes of past effects as the only explanation of all kinds of entanglement that is consistent with Einstein's relativity. Price re-introduced the old idea of Costa de Beauregard's "zig-zag" implicit in both Yakir Aharonov's "destiny" and "history" quantum waves similar, though not identical, to John Cramer's "confirmation" and "offer" waves in the Transactional Interpretation. Finally, in 2015 Australian physicist Rod Sutherland has taken these ideas in an action-principle Lagrangian mathematics of a fully relativistic Bohm pilot-wave/hidden variable particle model in which Aharonov's "weak measurements" are clearly represented a locally retrocausal "zig-zag" manner that allows us to dispense with higher dimensional configuration space. This is a considerable simplification conceptually and computationally. Indeed, Sutherland has done some preliminary work on quantum gravity from this new POV. Even more important Sutherland has taken some first steps toward a Post-Quantum-Mechanics PQM which is to QM as Einstein's GR is to his SR. In both cases the key is the action-reaction organizing

principle (not to be confused with the more specific Newton's 3rd Law from translational symmetry of the dynamical action). In relativity, the action-reaction is between the space-time continuum and matter-energy. In PQM, which requires the Bohm 1952 picture, the action-reaction is between the pilot waves and matter-energy. PQM is basically a non-statistical nonlinear theory in which messages encoded in an entanglement pattern can be locally decoded without a key. This corresponds to traversable ER bulk wormholes from signaling EPR entanglements on their horizon boundaries obeying Novikov's globally self-consistent loops in time. Thus we are back to Geoff Chew's "bootstrap" at least in spirit. The QM bootstrap posited a unitary S-Matrix. The PQM bootstrap is non-unitary corresponding perhaps to pumped open dissipative structures held far from thermodynamic equilibrium, but with macroscopic (ODLRO) long range quantum phase coherence (e.g. laser analogy). The QM limit of PQM involves setting the action-reaction to zero and ad_hoc introduction of the Born rule for squaring amplitudes etc and then integrating the future away. This hides all retrocausal effects and yields the vN collapse picture of strong measurements with linear unitary retarded time evolution of closed systems between the measurements.

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"Jack Sarfatti has been exploring a generalisation of David Bohm's[4] ontological interpretation of quantum mechanics, extended so a particle is not just guided by the quantum potential, but, in turn, through backactivity, modifies the quantum potential field. Backactivity introduces nonlinearity into the evolution of the wave function, much like the bidirectional nonlinear interaction of spacetime and matter-energy in general relativity.
The effects of backactivity are negligible in interactions at the atomic scale; divergences from the predictions of conventional quantum mechanics would be manifest only in systems where quantum coherence occurs at the mesoscopic and

macroscopic scale. Sarfatti suggests that this post-quantum backactivity may be involved in various phenomena as follows:

Postulates

i. Life in general, and consciousness in particular, depends upon a backactivity-mediated feedback loop operating on macroscopic quantum structures in the cell. Roger Penrose[15] and Stuart Hameroff have suggested the microtubule as the site of this quantum system, but it may be elsewhere.

Life, through homeostasis, maintains the far-from-equilibrium quantum machinery necessary for its own existence. Rocks aren't alive because they have no structures which prevent thermal decoherence of the wave function. There is, then, an élan vital, and it consists of backactivity operating in macromolecular quantum systems assembled within the cell.

ii. Backactivity is the missing puzzle-piece needed to unify quantum mechanics and general relativity. Linear quantum mechanics operating in a background spacetime cannot possibly describe the effects of spacetime curvature due to mass-energy or curvature acting on itself. Macroscopic quantum systems employing backactivity may produce strong spacetime curvature or interactions with the zero-point vacuum energy not predicted by orthodox quantum mechanics or general relativity. Per item (1) above, a "macroscopic quantum system employing backactivity" is, necessarily, alive.

iii. Development of a comprehensive and consistent post-quantum theory incorporating backactivity may, then, permit development of technologies impossible without such effects, for example:

Communication across spacelike-separated intervals.

Faster-than-light travel with an Alcubierre-like "warp drive"[1] without the need for exotic, negative energy, matter.

Access to the zero-point energy of the vacuum.

If Haisch, Rueda, and Puthoff's suggestion[11] that interaction with the zero-point energy is the source of inertia (as opposed to the Mach/Einstein view that it is caused by the dragging of inertial frames by distant galaxies), then technologies employing backactivity might be able to modify inertia.

I don't know whether these suggestions are correct—nobody does at present, but there's nothing in any of them which seems inaccessible to experiment in the relatively near future. Let's assume calculations are done, predictions are made, experiments are performed, and the experimenters win the Nobel prize, shafting the theorists once again—that backactivity is shown to exist and indeed both accounts for life and permits the unification of quantum mechanics and general relativity." John Walker https://ricochet.com/archives/saturday-night-science-flying-saucers-explained/

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"Why retrocausality — and why free will?

The 'classic' motivation for retrocausal models in QM stems from Bell's Theorem, and the nonlocality it seems to entail. Nonlocality is often felt to be counterintuitive in itself, and the source of an unresolved tension between quantum theory and special relativity. As Bell himself described the implications of his famous result: "[I]t's a deep dilemma, and the resolution of it will not be trivial ... [T]he cheapest resolution is something like going back to relativity as it was before Einstein, when people like Lorentz and Poincaré thought that there was an aether — a preferred frame of reference — but that our measuring instruments were distorted by motion in such a way that we could not detect motion through the aether."

As Bell was well aware, the dilemma can be avoided if the properties of quantum systems are allowed to depend on what happens to them in the future, as well as in the past. Like most researchers interested in these issues, however, Bell felt that the cure would be worse than the disease — he thought that this kind of "retrocausality" would conflict with free will, and with assumptions fundamental to the practice of science. (He said that when he tried to think about retrocausality, he "lapsed into fatalism".)

If this objection to retrocausality in QM is well-founded, it raises interesting issues about the nature and origins of this "free will", that turns out to play such a surprising role in the foundations of physics. If the objection is not well-founded, then it is high time it is moved aside, so that the retrocausal approach can be given the attention it otherwise seems to deserve.

Moreover, there are other motivations for exploring retrocausal models in QM, some the focus of considerable current research. Examples include:

The proposed retrocausal explanation of the results of 'weak measurements' by

Aharonov, Vaidman and others.

The relevance of retrocausality to the issue of the viability of an 'epistemic' interpretation of the quantum state, especially in the light of recent results such as the PBR Theorem.

Recent work throwing new light on the relation between retrocausality in QM, on the one hand, and time-symmetry and other symmetries, on the other.

For these reasons, too, there is a pressing need for a better understanding of notions of free will and causality, and of their relevance to the retrocausal approach to the quantum world. This conference brought together many of the leading writers and researchers on these topics, to discuss these issues."

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