Three Long-Standing Misunderstandings in Quantum mechanics

This note is not about how we do physics; only how we think about physics, which, come to think of it, does have an effect on how we do it.

I,II. Reality does not obligingly take on odd characteristics of incomplete models of Reality.

I. Quantum jumps and wave function collapse. The celebrated hydrogen models of Bohr 1913, Sommerfeld 1916, Heisenberg and Schrodinger 1925, and Dirac 1928 all exhibit infinitely many noninteracting stationary states with very similar sets of energy levels. Real atoms radiate and absorb electromagnetic radiation in very long electromagnetic wave trains captured spectrographically and corresponding remarkably well[1] energetically to differences between energies in the models. One cannot escape the inference that real atoms possess interacting, very long-lived dynamic states carrying very nearly[1] the energies of the models' noninteracting stationary states.

We don't have to look far to understand the discrepancy. The models all lack the electromagnetic radiation field responsible for interaction in real atoms! They carry only the static Coulomb e/r potential, so solutions exist only when nothing is happening! Quantum jumps (Bohr 1924) and wave function discontinuity/collapse (Heisenberg 1927) refer to the lapses in the models when anything happens!

The lapses would become still mysteriously rapid transitions in a consistent hydrogen model carrying electromagnetic radiation interaction.[2] Meanwhile it's clear that the present incomplete models imply nothing whatsoever regarding consciousness or any other aspect of Reality, as had been widely supposed. Nothing here of interest to philosophers of science or the public at large.

II. Uncertainty. Solutions of the Schrodinger hydrogen model are linear combinations of its stationary states with complex coefficients of constant magnitude. In 1926 Born suggested interpreting these magnitudes, squared and normalized, as the probabilities of finding the atom <u>in</u> the respective stationary states. Real atoms have at most one stationary state[3]: they settle into dynamic equilibrium with the surrounding radiation field. The stationary states, complex coefficients, and probabilities are artifacts of the radiationless model only, with absolutely no implied uncertainty regarding Reality. Einstein was right after all: God doesn't play dice with the universe. Once again, this time regarding quantum uncertainty, nothing here to concern philosophers of science or the public at large.

III. "There is no Arrow of Time in an isentropic system" sounds deep, but it's just a tautology.

III. Spooky action at a distance ; Quantum Entanglement. In 1935 Einstein called violation of cause-and-effect in quantum mechanical systems "spooky action at a distance" and Schrodinger called it "Quantum Entanglement" in agreement. Cause-and-effect; "before" and "after", do not hold in <u>any</u> fundamental physical model: all fundamental models are essentially time-symmetric. They are also deterministic, so the state at any given time determines the state at any other time. No superluminal communication is involved: information is a global property of time-symmetric deterministic systems.

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[1] Only an infinitely long electromagnetic wave train or infinitely long-lived state could define an exact energy.
[2] If Dirac couldn't make that work, maybe nobody can!
[3] the ground state, ignoring disturbance by a weak external field.

We take cause-and-effect for granted in our universe, but we experience cause-and-effect only because of the enormous difference between our past and future. If we reverse the directions of all the particles and fields in our universe almost everything tracks back to a Big Bang ~9 to 14 billion years ago. Not much is coming at us from boundaries, if any, or our future. Virtually the entire history of the universe is encoded in its overall present positions and momenta. If we reverse the momenta just in our brains, the boundaries are wide open, so the path back becomes a little sketchy right away, and in less than 100 years back it's gone. Our brains carry significant information about the past and nothing to speak of about the future.

In 1927 Arthur Eddington called the direction from our past toward our future the Arrow of Time, and in 1928 he identified it with increasing entropy (see Appendix). A system has the Arrow whenever its entropy is changing and none while it's truly constant. "spooky action at a distance" is simply true isentropy (constant entropy). it's neither "Entanglement" nor fundamentally "Quantum". It's a defining property of time-symmetric deterministic systems. In our universe, isolating a system over a significant period from our surrounding Arrow[4] is a considerable achievement, but the correlations observed are not spooky. Isolation involves not entanglement but, if you like, disentanglement from the Arrow. There is again nothing here to excite philosophers of science. The paradoxes vanish once the Arrow of Time and more particularly the absence of the Arrow in isentropic systems are taken into account.

Over the last century many prominent physicists must have noticed the spread of misunderstandings such as those just addressed. Why weren't these things straightened out long ago? People may have repeatedly pointed these things out over the years only to find their observations lost in the vast mass of material published over that period. These are neither subtle nor contentious points! Someone with clout in the physics community could do us all a great service by clearing the air of these up to 100 year old misunderstandings.

Appendix. The Arrow of Time leading to Eddington 1927-1928:

1. Carnot 1824; Clausius 1850-1857: The 2nd Law of thermodynamics. The flow of heat from hotter to cooler regions defines the Arrow of Time. Our Sun: 6000K→Earth: 300K→ Outer Space: 2.7K.

More generally, including systems with no heat flow:
2. Clausius 1864; Gibbs 1884-1901: Entropy≈log(hypervolume in phase space)[5]. Increasing entropy defines a system's Arrow of Time. Constant entropy (isentropy) supplies no Arrow. Disentanglement is isentropy in isolation from our surrounding Arrow: the increasing entropy (volume) of our universe at large.

The myriad Arrows defined by instances of 1 and 2 have never been observed to disagree.

[4] That's where, as a practical matter, quantum mechanics comes in. It's far easier to isolate a subatomic particle from the surrounding Arrow of Time than the Great Pyramid of Khufu.
[5] Really the limit as the number of degrees becomes infinite. Boltzmann's entropy as a measure of disorder, his microstates per macrostate, and his H Theorem are all red herrings; false and misleading. After Clausius, it's all Gibbs. Another widespread misunderstanding; another story.