Quantum reality: what's the fuss all about?

Mike Arnautov (notes)

My defence of QM can be summarised by the American saying “It ain't new and it ain't true and it don't signify” (not the same as “Not true I threw a brick at the constable, and in any case I missed”).

“It ain't new”

1st charge: clashes with a prior, well tested theory (Einstein's GR). Been there before: 19C Newtonian dynamics v. Maxwell's theory of electromagnetism, not obeying Galilean relativity of motion. Michelson-Morley experiment a triumphant confirmation of Maxwell's theory predicting ether to obey Lorenz-Fitzgerald invariance. Einstein's achievement in providing a physical rationale for this new invariance, without an appeal to ether.

2nd charge (generic version): QM is odd. Well, what did we expect? The same rules to apply on all scales? And what makes us think our other theories aren't odd?

Oddly, Einstein's SR thoroughly instrumentalist -- how odd that it supposedly gives a proof of the ontology of block universe! And it has some odd paradoxes – e.g. the twin paradox asymmetry. Surely the two twins, one staying on Earth and one going off to the stars are **both** moving relative to each other, so **both** should age faster than the other one! (No, GR is not required to explain this, but the explanation is counter-intuitive.)

GR also has some odd consequences. E.g. it predicts black holes, but also prevents them from forming, because from the PoV of an external observer time stops at the event horizon boundary. And within the event horizon one space dimension swaps its role with time – is that not mind-boggling enough?

And even Newton… How odd! The most mechanical, deterministic theory had (lurking in the 3-body problem) deterministic chaos within it! Chaos, which is indistinguishable from randomness in the heart of the “clock-work” Newtonian universe!

3rd charge: QM has many versions which cannot be distinguished experimentally. Not true. There is one QM, but many interpretations differing in their ontological assumptions. Only indistinguishable from the perspective of the theory itself. This is also not new – we just never noticed. E.g. absolute space and time were long believed to follow from Newtonian dynamics, but we now know that Gallilean (or neo-Newtonian) space-time will do just as well. Similarly Einstein's original instrumentalist!) version of SR is sharply distinct from the Minkowski's reformulation with its ontological commitments. And recently (2010) the same seems to have transpired about Einstein's GR, which having been reformulated as Shape Dynamics suddenly loses its ontological commitment to relativity of time (a real stunner).

Interpretations are ontological extensions groping towards a successor theory.
Phenomenology under-determines ontology! (Kant not hi-jacked by romantics.)

“It ain't true”

2nd charge revisited: it is matter of educating one's intuition. We tend to lack useful models, which are wrong yet make oddities seem less odd. E.g. in GR there is the famous rubber sheet – completely wrong, but useful. SR – 4D space, profoundly misleading, but useful. Electricity/water analogy ditto. So here are some wrong-but-useful analogies for QM oddities.

Heisenberg's uncertainty: there is a trade-off between establishing a particle's location and its momentum. Often explained as perturbation caused by observing one obscuring the original value of the other. This is actually wrong but intuitively satisfying.

Waves or particles or neither? Depends on the interpretation. (deBroglie-Boehm, spontaneous collapse, idealist versions – all have their incompatible views on the matter) Of these, the pilot wave versions (e.g. Boehm's) are the most intuitively satisfying; computer simulations and even actual fluid dynamics experiments replicate some of the classic experiments (e.g. double slit) by having light particles buffeted by waves.

Superposition – spin up or spin down? Which pound in your bank account actually belongs to the tax-man? What, is QM just a matter of accounting? Well perhaps – e.g. Hawkins radiation suggests so. Virtual particle/antiparticle pairs can form by “borrowing” energy from vacuum and are **guaranteed** to pay back by annihilating again, except on an event horizon boundary. At which point some cosmic accounting mechanism springs into action with the effect of reducing black hole mass, even though it has just absorbed a particle!

Entanglement. Two realities (actual or potential), two sheets of paper – one thrown away. (In Many Worlds both sheets actually persist. NB, **not** the case of a new universe “created” – merely the case of a possible universe not ceasing to exist!). MW ontologically extravagant? It is less so than Newton's infinite space-time, yet we are much more intuitively inclined to accept the possibility of the latter.

“It don't signify”

Does any of this actually matter? Do QM phenomena impinge on macro world of “dry white goods”? No. And yes. No, because of statistics – adequate determinism. Yes, because we can make our macro instruments respond in a deterministic way to nondeterministic QM-level phenomena.

If a lump of radium suddenly stops being radioactive, would we merely say: while very unlikely, it **can** happen just by chance for a while? Or would we seek a reason? Which is the likelier explanation: chance or our lack of understanding of physics? The power of exponentials says the latter is vastly more likely. In ordinary life, we are quite safe simply assuming the properties of matter (emergent from QM) at our scale.