Experiment makes Schrodinger's cat choose—things can be real, or certain, but not both

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Credit: Dr Mathieu Juan

Experimenting within quantum theory is an extremely complex process, where common intuitions are regularly inverted within shifting reality. Over the years several quantum features and methods of their study have been identified. Now scientists have investigated a new set of assumptions and proposed a novel experiment, to test the consequences of making quantum theory more intuitive.

"While quantum theory is the science behind almost all of our technology, its disconnect with our everyday intuitions is still worrisome

and actively researched," says lead author Associate Professor Daniel Terno.

"How do you find your way in a reality which is shifting, where the opposites are allowed to coexist? Moreover, how do you conduct experiments in it? These are the questions that must be answered when dealing with the floating world of quantum mechanics."

Throughout the development of quantum theory, a set of reasonable ideas has led to strange paradoxes, such as the famous Schrodinger's cat, which is neither dead nor alive.

Another of the most famous (and useful) results of quantum mechanics is that every object can behave as a particle or as a wave, given the right conditions. Associate Professor Terno and colleagues proposed a new experiment in 2011, which was realised by dozens of research groups worldwide. This proposal made complicated experiments much simpler, such as an experiment formerly requiring 40 meters of optical cable now being performed on just a single chip.

Using this wave-particle duality as their starting point, the research team investigated a new and more comprehensible set of assumptions:

1. Every object at any time is really a particle or a wave, but not both (objectivity)
2. If you know enough you can predict everything (determinism)
3. Speed of light is the ultimate limit (locality)

In taking these assumptions and applying them to an experiment, where the measuring device is controlled by a Schrodinger's cat-like state, the research team reached some perplexing paradoxes.

"Only after the cat was found to be dead or alive were we able to tell if

what we did was to look for a particle or for a wave," says Associate Professor Terno. "Then these three innocent-looking ideas result in predictions that would contradict an experiment. The universe simply does not work like that: you can see things to be real, or certain, but not both."

Then the researchers tweaked their initial assumptions, replacing the third assumption with the requirement that how you set your detectors does not affect the system you study before they interact. This tweak lead to another strange result: it is not only that our quantum world is not like that, but such a combination cannot be realized in any universe.

"We can just repeat after Alice: things get curiouser and curiouser."

More information: "Is wave-particle objectivity compatible with determinism and locality?" Radu Ionicioiu, Thomas Jennewein, Robert B. Mann, and Daniel R. Terno, *Nature Communications*, 2014 DOI: 10.1038/ncomm5997

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