Quantum physics says goodbye to reality – Physics World

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Some physicists are uncomfortable with the idea that all individual quantum events are innately random. This is why many have proposed more complete theories, which suggest that events are at least partially governed by extra "hidden variables". Now physicists from Austria claim to have performed an experiment that rules out a broad class of hidden-variables theories that focus on realism -- giving the uneasy consequence that reality does not exist when we are not observing it (*Nature* **446** 871).

Some 40 years ago the physicist John Bell predicted that many hidden-variables theories would be ruled out if a certain experimental inequality were violated – known as “Bell’s inequality”. In his thought experiment, a source fires entangled pairs of linearly-polarized photons in opposite directions towards two polarizers, which can be changed in orientation. Quantum mechanics says that there should be a high correlation between results at the polarizers because the photons instantaneously “decide” together which polarization to assume at the moment of measurement, even though they are separated in space. Hidden variables, however, says that such instantaneous decisions are not necessary, because the same strong correlation could be achieved if the photons were somehow informed of the orientation of the polarizers beforehand.

Bell’s trick, therefore, was to decide how to orient the polarizers only after the photons have left the source. If hidden variables did exist, they would be unable to know the orientation, and so the results would only be correlated half of the time. On the other hand, if quantum mechanics was right, the results would be much more correlated – in other words, Bell’s inequality would be violated.

Many realizations of the thought experiment have indeed verified the violation of Bell’s inequality. These have ruled out all hidden-variables theories based on joint assumptions of realism, meaning that reality exists when we are not observing it; and locality, meaning that separated events cannot influence one another instantaneously. But a violation of Bell’s inequality does not tell specifically which assumption – realism, locality or both – is discordant with quantum mechanics.

Markus Aspelmeyer, Anton Zeilinger and colleagues from the University of Vienna, however, have now shown that realism is more of a problem than locality in the quantum world. They devised an experiment that violates a different inequality proposed by physicist Anthony Leggett in 2003 that relies only on realism, and relaxes the reliance on locality. To do this, rather than taking measurements along just one plane of polarization, the Austrian team took measurements in additional, perpendicular planes to check for elliptical polarization.

They found that, just as in the realizations of Bell’s thought experiment, Leggett’s inequality is violated – thus stressing the quantum-mechanical assertion that reality does not exist when we’re not observing it. “Our study shows that ‘just’ giving up the concept of locality would not be enough to obtain a more complete description of quantum mechanics,” Aspelmeyer told

Physics Web. “You would also have to give up certain intuitive features of realism.”

However, Alain Aspect, a physicist who performed the first Bell-type experiment in the 1980s, thinks the team’s philosophical conclusions are subjective. “There are other types of non-local models that are not addressed by either Leggett’s inequalities or the experiment,” he said. “But I rather share the view that such debates, and accompanying experiments such as those by [the Austrian team], allow us to look deeper into the mysteries of quantum mechanics.”