Death by experiment for local realism

A fundamental scientific assumption called local realism conflicts with certain predictions of quantum mechanics. Those predictions have now been verified, with none of the loopholes that have compromised earlier tests. SEE LETTER P.682

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The world is made up of real stuff, existing in space and changing only through local interactions — this localrealism hypothesis is about the most intuitive scientific postulate imaginable. But quantum mechanics implies that it is false, as has been known for more than 50 years¹. However, brilliantly successful though quantum mechanics has been, it is still only a theory, and no definitive experiment has disproved the localrealism hypothesis — until now. On page 682 of this issue, Hensen *et al.*² report the first violation of a constraint called a Bell inequality, under conditions that prevent alternative explanations of the experimental data. Their findings therefore rigorously reject local realism, for the first time.

Bell inequalities are named after John Bell, the physicist who discovered in 1964 that the predictions of quantum mechanics are incompatible with the local-realism hypothesis¹. There are many different ways to make this hypothesis precise³, but Hensen and colleagues' exposition basically follows Bell's original formulation, which states it as the conjunction of two other hypotheses: realism (which Bell called predetermination), essentially meaning that measurements reveal preexisting physical properties of the world; and locality, roughly meaning that any change



Figure 1 | **Violation of a three-party Bell inequality.** A Bell inequality is a mathematical relationship regarding the statistics of measurement outcomes obtained by two or more parties. Under certain physical conditions relating to the timing of events, a violation of a Bell inequality proves that local realism — a hypothesis satisfied in all of science except quantum mechanics — is false. Hensen *et al.*² have violated a Bell inequality in such a way that the requisite physical conditions were satisfied for the first time, using the scheme shown in this cartoon. **a**, At separate locations, Alice and Bob create entangled states of an electron and a photon, then send the photons to Juanita's laboratory. **b**, Alice and Bob randomly choose a setting for measurements of their respective electrons. **c**, They obtain their measurement outcomes, and Juanita performs a joint measurement of the photons. Alice's and Bob's outcomes are purely random unless Juanita gets a rare successful outcome (as shown here) that indicates entanglement between Alice's and Bob's electrons. By collating the results over many runs, Hensen *et al.* showed that a Bell inequality had been violated by a statistically significant amount.



50 Years Ago

It may not be generally realized that work is in progress on the colossal project of constructing a 40-in. diameter, 300 miles long, Trans-Alpine oil pipeline to convey oil from the Adriatic to the heart of Germany ... Among the many practical problems concerned with such a project, apart from tunnelling and mechanical excavation in the high Alps, are the necessity to dredge the harbour at Trieste so that it can eventually accommodate oil tankers of 160,000 dead weight tons; setting storage tanks there on piles because available land is a rocky hill site; construction of several thousand feet of piers in the Adriatic ... Involved also in the scheme is the building of five separate pumping stations, each equipped with two 4,000-horsepower electric centrifugal pumps required to lift hundreds of thousands of tons of oil from sea-level to one of the highest points of Felber Tauern. From Nature 30 October 1965

100 Years Ago

'Distances at which sounds of heavy gun-firing are heard' - Referring to the correspondence on this subject, I have been collecting information as to places at which the sound of the firing in Belgium has been heard in this country ... Here, at a distance of about 125 miles from Ypres (taking that town for convenience, as a known centre) I have heard firing quite unmistakably since the beginning of the war — often all day, and for many days in succession, and frequently at night too. So far as I have been able to ascertain, the greatest distance from Ypres at which the firing has been heard unmistakably is about 140 miles ... Observations seem to show that the direction of the wind has less to do with the transmission of the sound than certain atmospheric conditions. From Nature 28 October 1915