Bell correlations in a Bose-Einstein condensate

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The parts of a composite system can share correlations that are stronger than any classical theory allows. These so-called Bell correlations can be confirmed by violating a Bell inequality and represent the most profound departure of quantum from classical physics. We report experiments where we detect Bell correlations between the spins of 480 atoms in a Bose-Einstein condensate [1]. We derive a Bell correlation witness from a recent many-particle Bell inequality [2] involving one- and two-body correlation functions only. Our measurement on a spin-squeezed state [3] exceeds the threshold for Bell correlations by 3.8 standard deviations. Concluding the presence of Bell correlations is unprecedented for an ensemble containing more than a few particles. Our work shows that the strongest possible non-classical correlations are experimentally accessible in many-body systems, and that they can be revealed by collective measurements. This opens new perspectives for using many-body systems in quantum information tasks.

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