Bell correlations in a Bose-Einstein condensate

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In 1964, J. Bell discovered that the parts of a composite quantum system can show correlations that are stronger than any classical theory allows. The existence of these Bell correlations has profound implications for the foundations of physics and at the same time underpins a variety of quantum information technologies that are currently being developed. While Bell correlations have been observed in systems of at most a few (usually two) particles, their role in many-body systems is largely unexplored.

I will present experiments where we detect Bell correlations between the spins of 480 atoms in a Bose-Einstein condensate. We derive a Bell correlation witness from a recent many-particle Bell inequality involving one- and two-body correlation functions only. Our measurement on a spin-squeezed state 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 such as certifiable randomness generation at high rates.