New tests of quantum mechanics: entanglement, EPR and Bell

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In 2009 we developed a number of novel tests of quantum entanglement, the Einstein-Podolsky-Rosen paradox and the Bell inequality, related to the famous nonlocality of quantum mechanics, leading both to novel scientific tests and potential quantum technologies.

Entanglement transfer between qubits was studied [1], thus demonstrating how entanglement can be treated as a mobile resource which can be communicated from one system to another. The goal of this work, treated in a subsequent paper [2], was to show how entanglement can be treated as a conserved quantity, like energy. Subsequent joint work with Griffith University investigated the relationship between the EPR paradox and a related concept called quantum steering. This work developed practical benchmarks for the demonstration of generalized steering [3].

Next, a high impact letter publication appeared in Physical Review Letters [4] which developed a completely new approach to quantum information with continuous variables. The new feature was the idea of a functional inequality, which introduced the concept of using arbitrary functions of measurements as a novel means of storing or manipulating quantum information. In this case, the payoff is a Bell violation with much greater resistance to loss and decoherence.

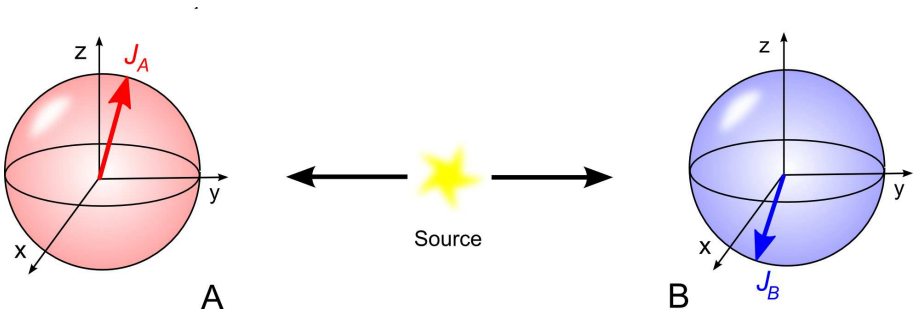

Fig. 1: Diagram of correlated spin tests with Bose-Einstein condensation [5, 6].

It is often important to be able to communicate quantum information using spinor variables. In a joint inter-node study [5], we analysed a general approach to spinor quantum information, in terms of robustness against loss. This was extended to arbitrary spin quantum numbers, which is essential for treating EPR and Bell inequalities in Bose-Einstein condensates. Finally, in a development involving both internode cooperation and several ACQAO partners, we published a major review on the Einstein-Podolsky-Rosen paradox [6]. This is a major review article in the most prestigious and highest impact journal in physics. It represents the first review in the history of the EPR paradox to treat all major experimental and theoretical studies.

References

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