Networks powered by quantum entanglement: from a loophole-free Bell test to a quantum Internet

Ronald Hanson
QuTech and Kavli Institute of Nanoscience, Delft University of Technology, The Netherlands

Entanglement – the property that particles can share a single quantum state - is arguably the most counterintuitive yet potentially most powerful element in quantum theory. The non-local features of quantum theory are highlighted by the conflict between entanglement and local causality discovered by John Bell. Decades of Bell inequality tests, culminating in a series of loophole-free tests in 2015, have confirmed the non-locality of nature [1].

Future quantum networks [2] may harness these unique features of entanglement in a range of exciting applications, such as quantum computation and simulation, secure communication, enhanced metrology for astronomy and time-keeping as well as fundamental investigations. To fulfill these promises, a strong worldwide effort is ongoing to gain precise control over the full quantum dynamics of multi-particle nodes and to wire them up using quantum-photonic channels.

Here I will briefly introduce the field of quantum networks as well as diamond-based network nodes. I will then present our most recent work demonstrating the realization of the first multi-node network wired by quantum entanglement, including first primitive network protocols.

References

[1] For a popular account of these experiments, see e.g. Ronald Hanson and Krister Shalm, Scientific American 319, 58-65 (2018).
[2] Quantum internet: A vision for the road ahead, S Wehner, D Elkouss, R Hanson, Science 362 (6412), eaam9288 (2018).