University of Twente, Enschede
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Plenary Lecture – Physica Lecture

Speaker: Ronald Hanson (QuTech and Kavli Institute of Nanoscience, Delft University of Technology)
Title: Towards a Quantum Internet: status, progress and challenges

Abstract:

Towards a Quantum Internet: status, progress and challenges

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 blind quantum computation, 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.

After briefly looking back at an exciting decade in quantum science, I will introduce the field of quantum networks and discuss the current status and challenges. I will discuss our latest work on the realization of a multi-node network in the lab including first protocols and teleportation [3,4], on increasing the distance between nodes to metropolitan scales [5], on development of next-generation devices with improved quantum spin-photon interfaces, and on the development of a quantum network control stack [6].

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).

[3] Realization of a multi-node quantum network of remote solid-state qubits, M. Pompili, S.L.N. Hermans, S. Baier et al., Science 372, 259-264 (2021).

[4] Qubit teleportation between non-neighboring nodes in a quantum network, S.L.N. Hermans, M. Pompili et al., to appear in Nature, arXiv:2110.11373 (2021).

[5] Telecom-band quantum interference of frequency-converted photons from remote detuned NV centers, A. Stolk, K.L. van der Enden et al., arXiv:2202.00036 (2022).

[6] Experimental demonstration of entanglement delivery using a quantum network stack, M. Pompili, C. Delle Donne et al., arXiv:2111.11332 (2021).