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High-rate, high-fidelity entanglement of qubits across an elementary quantum network

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We demonstrate remote entanglement of trapped-ion qubits via a quantum-optical fibre link with fidelity and rate approaching those of local (intra-trap) operations. Two $^{88}Sr^{+}$ qubits are entangled via the polarization degree of freedom of two 422nm photons, which are coupled by high-numerical-aperture lenses into single-mode optical fibres and interfere on a beamsplitter. A novel geometry allows high-efficiency photon collection while maintaining unit fidelity for ion-photon entanglement. We generate heralded Bell pairs with fidelity 94% at an average rate 182 per second (success probability 0.022%). Heralded entanglement of remote qubits with fidelity above 90% has not previously been reported for any physical systems with better than sub-Hz rates. The combination of high rate and high fidelity can enable a variety of networking applications, such as device-independent quantum key distribution and entanglement distillation at practical speeds.