Very-long-baseline optical interferometry

Description

In conventional astronomy the ability to resolve stellar objects is limited by the size of the telescope through the Rayleigh criterion, and imaging more distant or smaller objects therefore requires larger telescopes. A method for overcoming this is using several spatially separated but connected telescopes to mimic the size of a larger telescope. This technique is called long-distance, or very-long-baseline interferometry, because the signals in the individual telescopes are not detected directly but are instead made to interfere. It is the phase information between the signals in the different telescopes that allows for the increased resolving power.

For radio telescopes it is possible to directly resolve the phase of the incoming signal, and this can be compared to a known reference, given by for example an atomic clock. This allows for telescopes to be separated by arbitrarily large distances, since the signals are synthetically interfered after the fact.

In the optical domain this approach is not easily adopted, because direct detection of the optical phase it not possible, and phase-measurement techniques such as heterodyne interferometry are poorly suited to low-intensity stellar signals. Instead, one needs to directly interfere the photons by connecting the telescopes with optical fibre, and additional loss introduced by the fibres limits the separation of the telescopes, and therefore also their collective resolution.

Quantum networks offers a way of overcoming this distance limitations by measuring the phase non-locally. Instead of sending the photons from the telescopes through fibre, one instead distributes entangled photons to these telescopes.

The stellar photons are stored in quantum memories at the telescopes, and using shared entanglement between the telescopes the phase between the memory qubits can be inferred. This shared entanglement can be distributed over arbitrarily long distances using quantum repeater protocols, thereby transferring the photon loss from the stellar photons containing the signal of interest to a resource that can be prepared off-line.

Quantum advantage

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