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QUANTUM-ASSISTED INTERFEROMETRY IN SPACE: REAL-TIME COHERENCE IN SPACE TELESCOPE ARRAYS WITH SHARED QUANTUM STATES

Abstract

Distributing a constellation of telescopes across a vast region of space enables high-resolution imaging, but this comes at a price. When a new, hit-or-miss signal is detected, high resolutions can only be achieved if multiple elements of the system are configured in a jointly coherent state (e.g., pointing in the same direction, keeping time and relative position exactly, scanning the same frequency band).

Over large distances, the inevitable communication delay among telescopes in the array would preclude achieving a fully coherent state in real time for each new event, except with very small probability. A partially coherent state is simpler to achieve, if the array is provided with many elements or each element scans a wider field, but there are clear efficiency bounds.

For realistic missions, involving a small number of narrow-field telescopes, we show that the efficiency of real-time imaging can be significantly improved if different nodes are not only in classical communication, but also able to generate and share entangled quantum states.

Our examples are based on entanglement-assisted information theory and non-local games, two branches of quantum information that flourished in the last decade. We use both new settings and classic ones, that we adapt for concrete scenarios. We also discuss technical viability and how, in some configurations, the system could generate and distribute useful classes of entangled states in a purely optical (memory-less) implementation.