Atomic clock networks as exotic field telescopes for multi-messenger astronomy

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Abstract

Multi-messenger astronomy, the coordinated observation of different classes of signals originating from the same astrophysical event, provides a wealth of information about astrophysical processes. So far, multi-messenger astronomy has correlated signals from known fundamental forces and standard model particles like electromagnetic radiation, neutrinos and gravitational waves (GW). Many of the open questions of modern physics suggest the existence of exotic fields with light quanta (masses $<<$ 1 eV). Quantum sensor networks could be used to search for astrophysical signals predicted by beyond-standard-model theories which address these questions. Here, we show that networks of precision quantum sensors that by design are shielded from or are insensitive to conventional standard-model physics signals can be a powerful tool for multi-messenger astronomy. We consider the case where high-energy astrophysical events produce intense bursts of exotic low-mass fields (ELFs), and we propose a novel model for the potential detection of an ELF signal based on general assumptions. We estimate ELF signal amplitudes, delays, rates, and distances of GW sources to which global networks of atomic magnetometers and atomic clocks could be sensitive. We find that such precision quantum sensor networks can function as ELF telescopes to detect signals from sources generating ELF bursts of sufficient intensity. Details in Nature Astronomy **5**, 150 (2021)

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