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Quantum Back-Action Evasion for Future Gravitational Wave Detectors

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Quantum noise is a fundamental limitation in gravitational wave detectors, restricting their sensitivity and scientific reach. To overcome this challenge, current detectors rely on frequency-dependent squeezing, implemented using long filter cavities to reduce quantum noise across a broad frequency range. While effective, this approach is difficult to scale, particularly for next-generation interferometer designs that would require additional hundred-meter-scale filter cavities. In this talk, I will present a new method for generating frequency-dependent squeezing using a hybrid quantum network. By coupling an atomic spin ensemble to an entangled light source, our approach enables broadband quantum noise suppression in the acoustic frequency range without the need for large filter cavities. This technique offers a compact and flexible alternative for future gravitational wave detectors and may also find applications in distributed quantum sensing and continuous-variable quantum communication.

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