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Back-Action Evading Measurement in Gravitational Wave Detectors to Overcome Standard Quantum Limit, Using Negative Radiation Pressure

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We propose a novel scheme how to obtain quantum back action evading measurement on a gravitational wave detector, by introducing negative radiation pressure coupling between the field and the end mirror. The scheme consists of replacing the end mirror with a double-faced one and adding another optical cavity next to it. The measurement is performed by sending a two-mode squeezed vacuum to both cavities and detecting the output through heterodyne detection. Compared to the previously proposed hybrid negative mass spin-optomechanical system in Phys. Rev. Lett. 121, 031101 (2018), we see that our scheme is capable to suppress back action noise by more than nearly two orders of magnitude in the lower frequency region. Overall, the setup has been able to squeeze the output noise below the standard quantum limit, with more efficiency. In addition, the scheme has also proven to be beneficial for reducing eh thermal noise by a significant amount. We confirm our result by a numerical analysis and compared with previous proposals.

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