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Evaluation of fusion sensor arrays for Newtonian noise mitigation in ET

Newtonian noise (NN) induced by seismic density fluctuations limits the sensitivity of current and future gravitational-wave detectors. In particular, it poses a significant challenge to achieving the low-frequency benchmark sensitivity of the upcoming third-generation detector Einstein Telescope (ET). Several mitigation strategies for NN in ET have been proposed, all of which rely on arrays of seismometers that measure the seismic noise floor and estimate the NN at the test masses. With the rise of distributed acoustic sensing (DAS) in geology and geophysics, a new type of seismic sensor has become available. As a distributed fiber sensor, DAS is easy to deploy, offers dense spatial coverage, and reduces the cost per sensor, making it a promising candidate for NN mitigation.

In this work, we investigate the potential of fusion sensor arrays composed of both displacement-measuring seismometers and strain-measuring DAS sensors for coherent cancellation of Newtonian noise for ET. We estimate the NN at a single test mass to enable direct comparison with previous results. We first analyze the interplay between strain and displacement sensors in these arrays and assess the stability of the resulting cancellation solutions against the sensor positions. Our results show that fusion sensor arrays can match or exceed the performance of traditional seismometer-only arrays in certain configurations. We further evaluate fusion arrays under varying P- and S-wave compositions, as well as for an array located in the vicinity of the ET infrastructure only. Our findings demonstrate that fusion sensor arrays represent a promising approach for NN mitigation in ET.

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