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Filter cavity longitudinal control for frequency dependent squeezing

Broadband mitigation of quantum noise in interferometric gravitational-waves detectors can be achieved via frequency dependent squeezing (FDS) of the vacuum field at the dark port of the interferometer. This allows to reduce the vacuum field phase fluctuations at high frequency, where quantum shot noise dominates, and the amplitude fluctuation at low frequency, where the contribution of quantum radiation pressure noise is higher.
Advanced Virgo and Advanced LIGO will implement FDS during the O4 science run, by coupling a frequency-independent squeezed vacuum to an optical filter cavity (FC) with an optical pole in the audio domain. In such scheme, the crossover frequency where amplitude squeezing is converted into phase squeezing depends on the detuning between the FC resonance and the carrier field in the interferometer.
Coarse longitudinal control of the filter cavity can be easily achieved by means of an auxiliary field at the second harmonic of the IR carrier. However, the lock point accuracy is generally limited. An accurate longitudinal control with an IR field is achieved with either a bright, subcarrier field or with the weak RF sidebands used for the coherent control of the squeezing ellipse angle. We propose an alternative solution overcoming some drawbacks of such schemes.

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