OMC length noise contribution

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We calculate the OMC noise contribution on DARM. While it would be enough to calculate the direct coupling from the OMC control to DARM only, we extend the loop noise calculation from the conventional 5×5 matrix to the 6×6 matrix analysis including the OMC control. Since the mechanical design of the OMC has not been fixed and its displacement noise level is unknown, we simply assume the displacement noise level of 10^{-14} Hz at all the frequencies. The control signal is obtained from the Pound-Drever-Hall method at the reflection port of the OMC using the RF sideband f_1 and the offset carrier light coming from the interferometer. The OMC is the 4-mirror ring cavity in the bow-tie shape. The round-trip length is 1.74 m and the finesse is 770. We assume 10 ppm loss at each mirror. The power on the photo-detector is attenuated to be 100 mW.

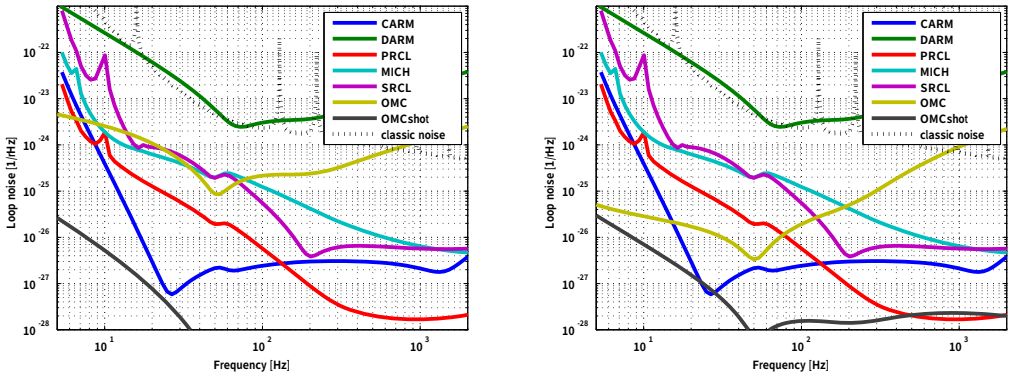

Figure 1: Loop-noise spectra with the OMC control bandwidth of 20 Hz (left) and 200 Hz (right). "OMCshot" shows the shot noise contribution via the direct coupling of the OMC length to DARM (no OMC displacement noise).

Figure 1 shows the results with the OMC control bandwidth of 20 Hz and 200 Hz. The shot noise levels are reasonably low. The noise contributions of shot noise and displacement noise vary according to the control bandwidth. The result tells us the requirement of the displacement noise level of the OMC and thus the material etc.

The PDH could not be used if there were purely the offset carrier light and the phase-modulated sideband coming out from the interferometer as they are in the same quadrature. There are, however, the carrier light in the amplitude quadrature and also the sideband is

not purely phase-modulated due to the detuning of the signal-recycling cavity, so that we can obtain the sufficient amount of the control signal with the PDH method in the case of KAGRA.