LCGT with 10-dB squeezing

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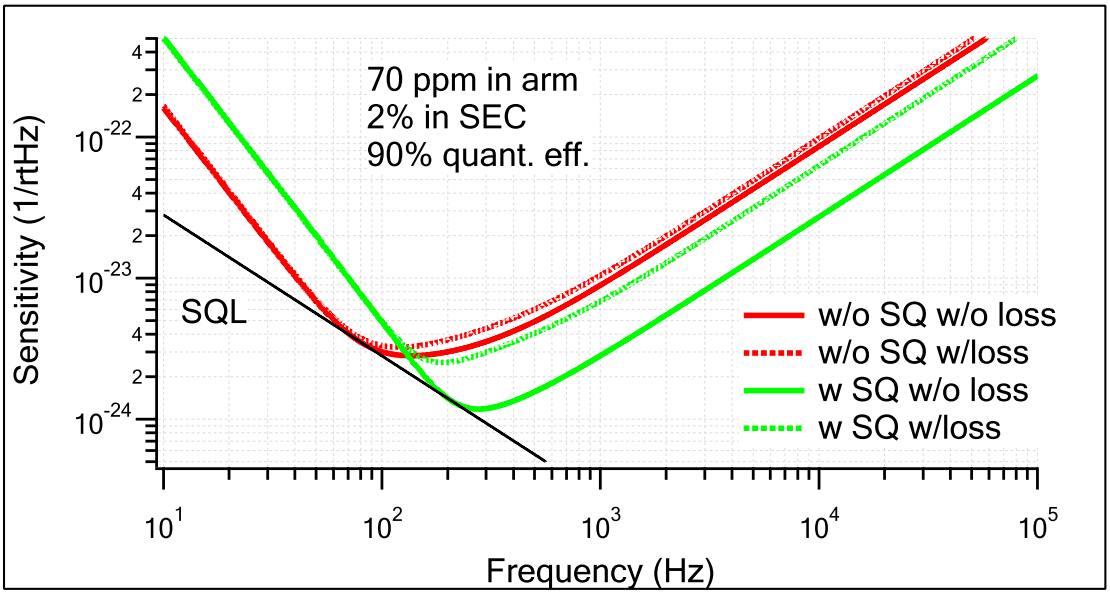
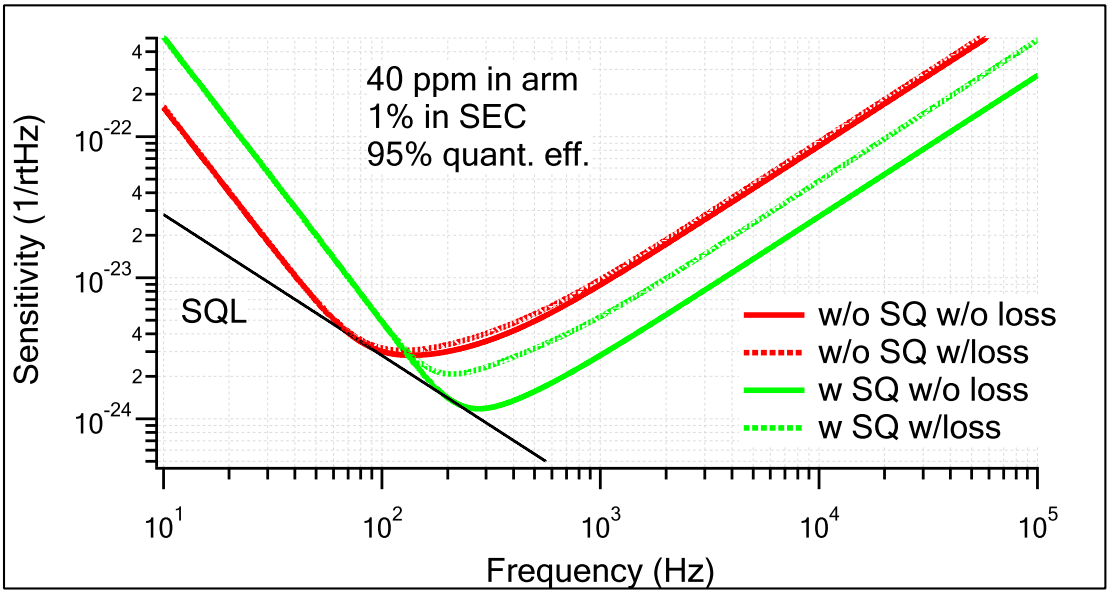


Figure 1: Sensitivity curves with and without squeezing. Optical losses are 70 ppm/roundtrip in the arms, 2 % in the SEC, and 10 % at the PD.

Injection of squeezed vacuum can improve LCGT's sensitivity at high frequencies, but we should be careful about optical losses. Since the finesse of the arm cavities of LCGT is quite high, the influence of the optical losses is more significant than, for example, enhanced LIGO. See Fig. 1. Here we assume 70 ppm losses per roundtrip in each arm, which is equivalent to 3 % loss per arm, 2 % loss in the SEC, and 10 % loss at the photo-detection. The 10-dB squeezing could reduce shot noise by a factor of $\sqrt{10}$ in the strain sensitivity without optical losses, but the improvement is actually only by a factor of ~ 1.5 with losses.

Figure 2 shows the curves with less optical losses. Here we assume 40 ppm losses per roundtrip in each arm, 1 % in the SEC, and 5 % at the photo detection. The absorption in the sapphire substrate would be around 20 ppm/cm. If the thickness of the ITM and the BS is 15 cm, the absorption alone imposes 0.8 % loss in the SEM. These numbers would be already quite challenging.



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Besides, here we assume pure squeezing. An actual squeezer has its own optical losses and the anti-squeezing factor is larger than the squeezing factor. Thus radiation pressure noise would be larger than what is shown in the above graphs.

Squeezing would be more effective if we could reduce the finesse and increase the power, but the laser power of LCGT is limited by the cooling ability of the cryogenic system and we cannot increase the incident power. Taking into account all the facts shown here and also how large the classical noise level is, the optimal squeezing factor can be chosen, which will not be as high as 10 dB.