

LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY
- LIGO -
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The updated Advanced LIGO design curve		
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This is an internal working
note of the LIGO project.

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1 Overview

This document describes the updated projection of the Advanced LIGO design curve, based on recent measurements on coating samples that provide more accurate estimates of coating thermal noise (see [P1700448](#)).

The Advanced LIGO curve is based on a GWINC model¹ that includes estimates for the main fundamental noises of the interferometer, in particular: seismic noise, thermal noise and quantum noise. The comoving range values reported in the tables and in the plots are calculated with the GWINC int73 function that includes cosmological effects, as documented in [T1500491](#).

For a description of the February 2018 changes to GWINC incorporating the recent coating thermal noise parameters, see section 3.

2 Updated Advanced LIGO design curve

Figure 1 shows an updated Advanced LIGO noise curve.

With respect to the original estimates in [P1400177](#), the main differences are:

- coating thermal noise has been updated to reflect [P1700448](#), see full details in section 3;
- the transmission of the SRM installed after O2 is 0.325 (original value in previous design: 0.2).

¹GWINC svn revision 2894. GWINC can be downloaded from the [MIT svn](#).

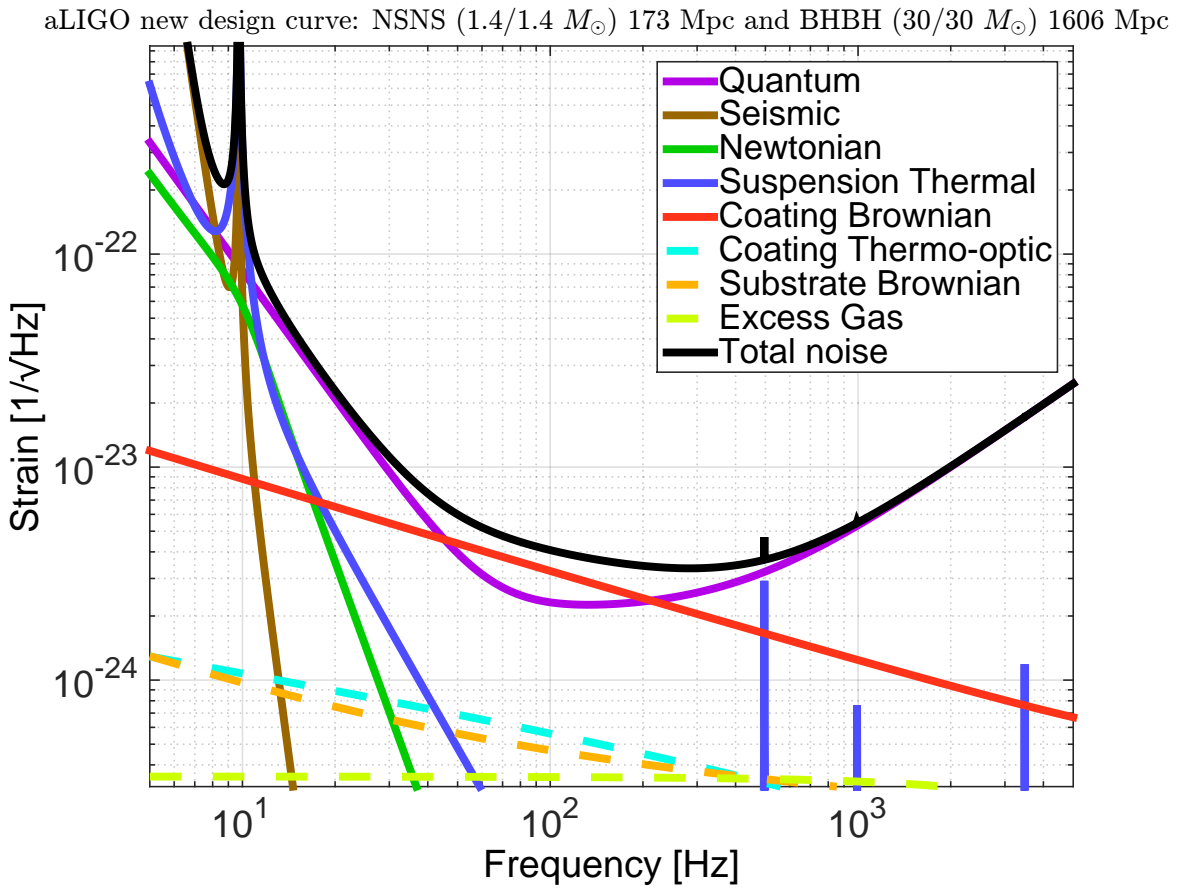


Figure 1: Updated estimate of the Advanced LIGO design curve.

3 GWINC model update

The core GWINC code was upgraded to allow for coating materials with frequency dependent loss angles. This appears in the `IFOModel` structure as a new fields under `Materials.Coating` named `Philown_slope` and `Phihighn_slope`. The coating loss angle for each material is then given by

$$\phi(f) = \phi_{100} \times \left(\frac{f}{100\text{Hz}} \right)^{\text{slope}} \quad (1)$$

where ϕ_{100} is the value at 100 Hz given in `Philown` or `Phihighn`. The values for the coating loss angle slopes are estimated from P1700448 and G1600641 to be 0.1 for tantala and 0.4 for silica. (The value for IBS silica is poorly constrained, but seems to reside between 0.3 and 0.5 and is clearly between the nominal 0.8 for fused silica and 0. This value is also of very little importance in current coatings since silica losses are sub-dominant.)

The overall loss values for both tantala and silica have also been updated again based on P1700448 and G1600641. The new values are `Philown` = 0.5×10^{-4} and `Phihighn` = 3.6×10^{-4} . (The previous values were `Philown` = 0.4×10^{-4} and `Phihighn` = 2.4×10^{-4} .)

The full list of GWINC parameters is shown in table 1.

Table 1: Gwinc parameters for the updated aLIGO design sensitivity.

Gwinc Parameter	Value	Comment
ifo.Materials.Coating.Phihighn	3.6×10^{-4}	tantala mechanical loss
ifo.Materials.Coating.Philown	5×10^{-5}	silica mechanical loss
ifo.Laser.Power	125	full power
ifo.Optics.Loss	37.5e-6	75ppm round trip loss in arm cavities
ifo.Optics.BSloss	0.5e-3	based on O2 model
ifo.Optics.PhotoDetectorEfficiency	0.9	
ifo.Optics.SRM.Transmittance	0.325	New SRM transmission
ifo.Optics.SRM.Tunephase	0	SRM tuning
ifo.Optics.Quadrature.dc	$90 \times \pi / 180$	Readout phase
Gwinc Output	Value	Comment
Finesse	446	
Power Recycling Factor	43	
Arm power	750 kW	
Power on beam splitter	5.35 kW	
BNS range	173 Mpc	(comoving)
BBH range (30/30)	1.61 Gpc	(comoving, $z = 0.4$)