University of Sannio Coating Work for KAGRA

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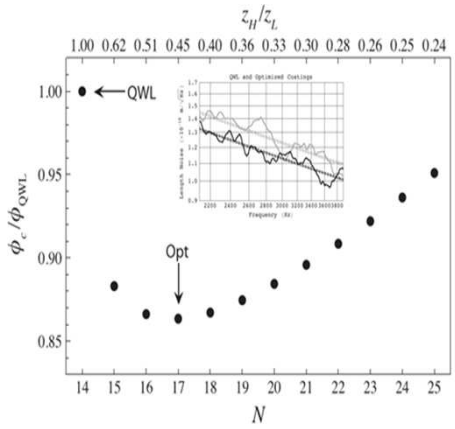
Coating Thickness Optimization

Our group introduced the idea of coating thickness optimization , which can be used to design HR coatings with minimum Brownian (and thermooptic) noise for prescribed (mono- or dichroic) transmittance(s) **[ArXiv:1406.3237]**.

Prototype optimized coatings were manufactured by LMA. Their measured thermal noise (TNI) was $\sim 18\%$ lower compared to the std . $(\lambda/4)$ design with the same transmittance (entailing an event-rate boost $\sim 35\%$) **[PRD - 81 (2010) 122001]**. Coating thickness optimization is part of the AdLIGO baseline design.

A custom version of our thickness-optimized coating design codes (written in MATHEMATICA) is being developed for KAGRA (core MOU work).



KAGRA

Seeking the Holy Grail for Cryogenic Coatings

Excess loss (cryo - peak) observed **[CQG 25 (2008) 055005]** in 1st - choice GW - IFO coating materials (SiO_2, Ta_2O_5) – yet process dependent (Yamamoto).

No cryo-peak in HfO_2 **[LIGO-G080314]** - but HfO2 crystallizes upon (needed) anneal-Ing, resulting into unacceptable optical scattering losses.

SiO_2 doping of HfO_2 (~20%) prevents thermally induced crystallization, without spoil-ing good cryo behaviour of pure HfO_2 **[LIGO G1400275]**.

Silica doping stabilizes also TiO_2 against thermally-induced crystallization **[Chao et al., Appl. Opt. 40 (2002) 2177]**. Recent measurements from Glasgow indicate that *α*-TiO2 is also cryo-peak free **[I. Martin, GWADW '14]**.

Silica doped Hafnia and Silica doped Titania could be first choice materials for KAGRA (and other cryo IFOs), with *high* dielectric constrast @1064nm [$n_{TiO_2} = 2.32$, and $n_{HfO_2} = 1.58$] , and *low* mechanical losses at $T \sim 10K$.

nm-layered Composites

Our group introduced the idea of using nm-layered glassy-oxide composites [LIGO G-1100586] as an alternative to co-sputtered (doped) glassy oxide mixtures **[collaboration with S. Chao's Group at NTHU, Taiwan, ROC]**.

nm-layered TiO_2/SiO_2 **[LIGO-P1400122]** and HfO_2/Al_2O_3 **[Liu et al, Appl. Surf. Sci. 252, 6206 (2006)]** composites have been annealed to high temperatures with *no* evidence of TiO2 crystallization .

nm-layered composites are *easier to model*, and could be *less noisy* (at the same optical density level) compared to doped (cosputtered) mixtures **[LIGO-G1301061]**.

Optical (scattering) and cryogenic properties of nm-layered composites should be investigated [INFN AdCOAT research program, 2014-2016].`

We are moving the first step toward incorporating the mixture(s) (co-sputtered or nm-layered) composition(s) in our coating optimization code.