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Thermal Noise in Optical Coatings

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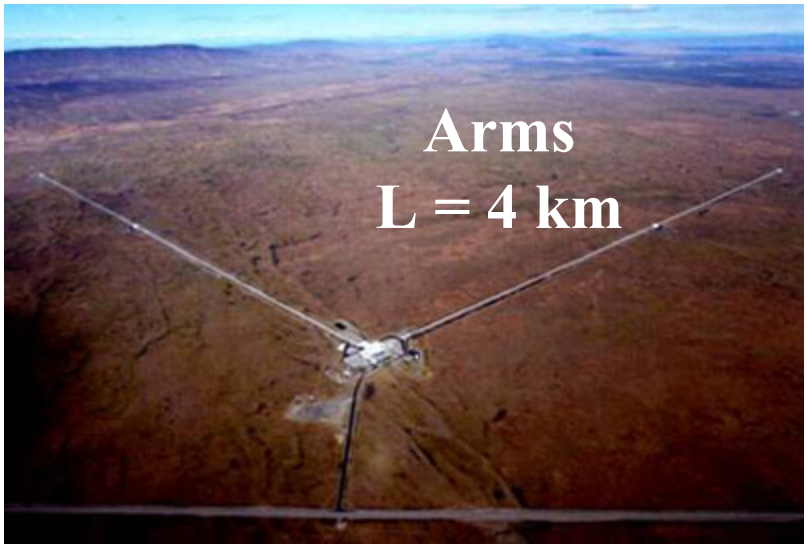

Hanford, WA

Livingston, LA

- **6 cm beam diameter, 34 cm diameter optics.**
- **Black Holes & Neutron Stars inspiral – creates gravity (spacetime) waves.**
- **Arm lengths change in opposition as spacetime wave moves through.**

Coating Thermal Noise - A Unique Problem

Atomic "Brownian" Motion of the Coating Material

ΔL(wave) ~ 1 / 1000 proton diameter

ΔL(noise) ↔ statistical fluctuation ↔ mechanical loss

- Fused silica optics – very low mechanical loss angle φ(substrate) ~ 10^{-8} rad.
- IBS 1064 nm arm cavity mirror coatings are dominant noise source.
- φ(*H* layer material Ta_2O_5) ~ 10^{-4} rad.
- φ(*L* layer material SiO_2) ~ 10^{-5} rad.

Strategies for Reducing Coating Thermal Noise

- Coating Designs minimizing *H* and Total Thickness.
- Finding *H* materials with lower φ.
- Latter is an ongoing research project!

Universities:

- Caltech
- Stanford
- MIT
- Uni. Glasgow
- Embry Riddle
- Hobart & William Smith Colleges
- Uni. Sannio at Benevento

Coating Vendors:

- Laboratoire Des Materiaux Avances (LMA)
- Commonweath Sci. Res. Org. (CSIRO)
- Research Electro Optics (REO)
- Advanced Thin Films (ATF)
- MLD Technologies
- Eclipse Energy Systems, Inc.

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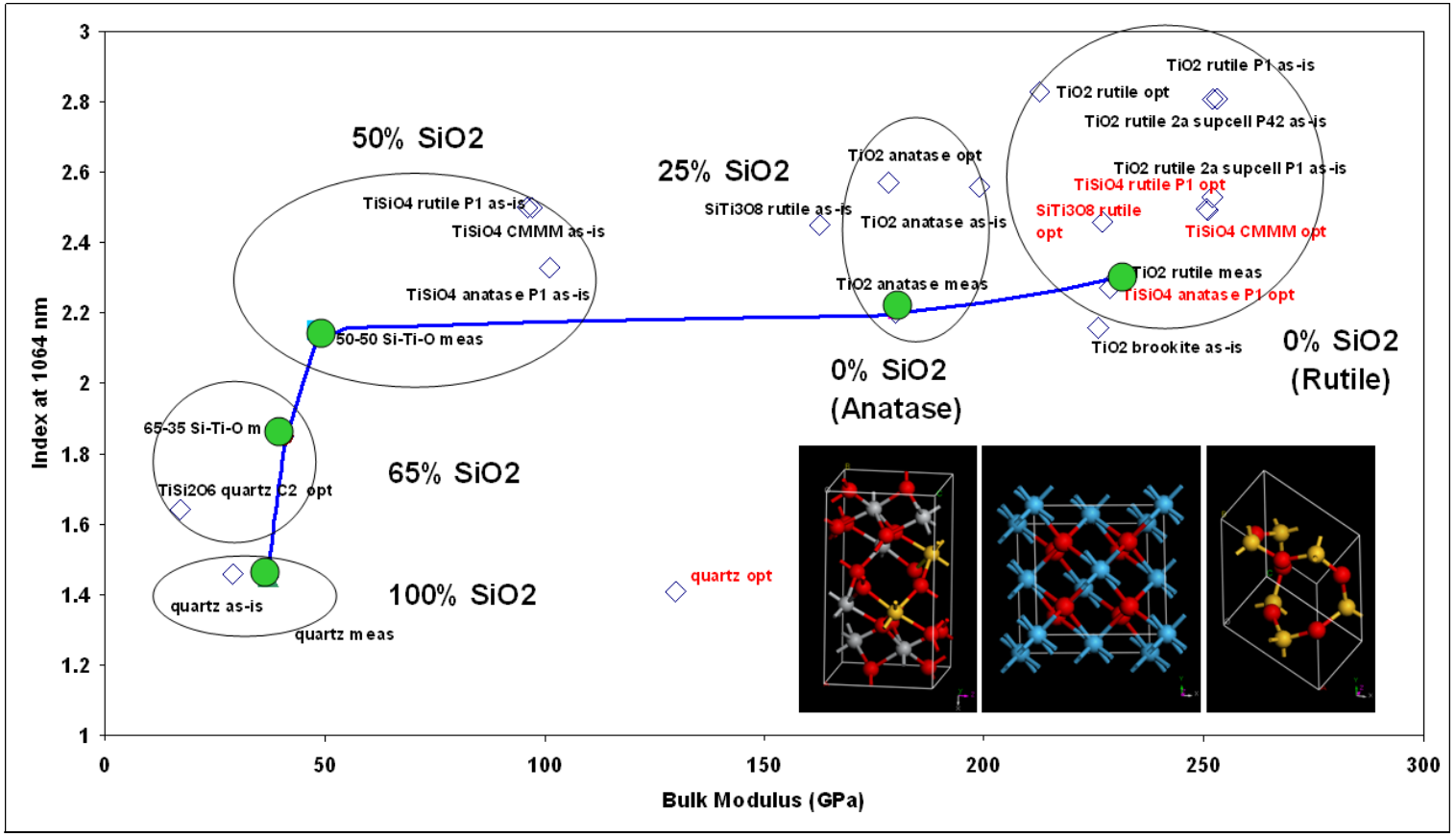
Doping *H* Dielectrics

- Doping TiO_2 into Ta_2O_5
- φ_H reduced by ~ 2.
- Expected range for neutron star inspirals increases by ~ 10%.
- LMA invented this.
- Collaborative effort to understand why this worked.
- Doping SiO_2 into TiO_2 also gave an improvement.

Doping & Prediction of Properties with Quantum Mechanics: Index, Modulus, CTE, Gruneisen



Example - SiO_2 doped TiO_2 (Poster will be on this and other calc's)

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Interested?

- Vendor?
- Researcher – with materials science insights?
- Contact Dr. Gregg Harry at MIT or myself

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Thanks!