Thermal noise from optical coatings

Syracuse University Experimental Relativity Group
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LIGO-G000070-00-D
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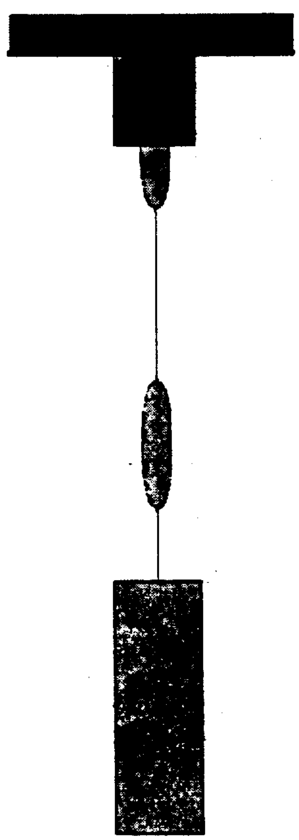
Experimental Results on Loss from Coatings

The effects of optical coatings on thermal noise have been examined with a resonant Q experiment using fused silica slides.



Slide 4 in X 1 in X 0.1 in
No flatness specification
80-50 polish

Coated with Ta_2O_5/SiO_2 in LIGO run at REO on both sides

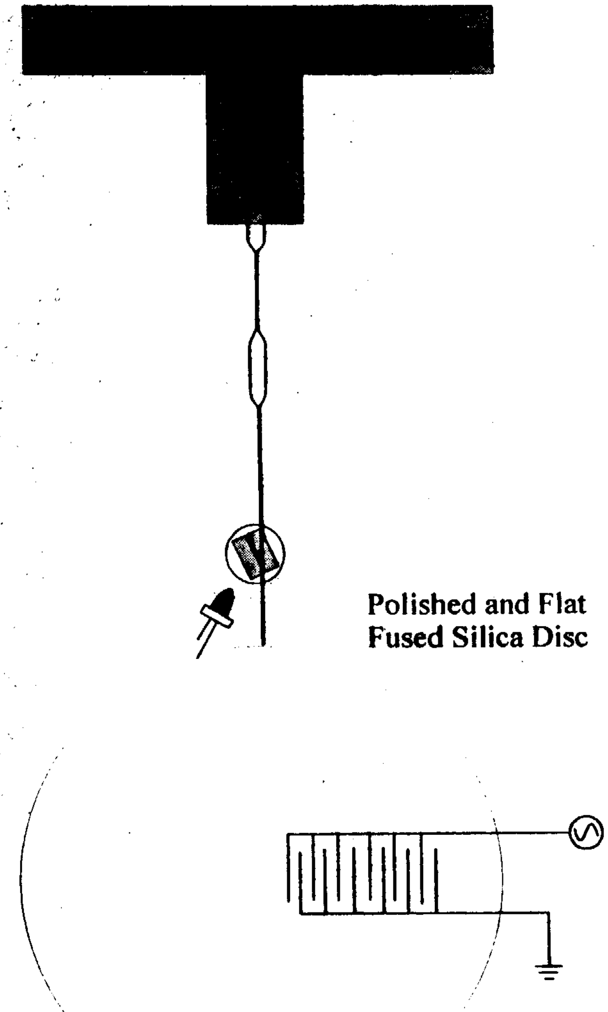
Results from slide experiment

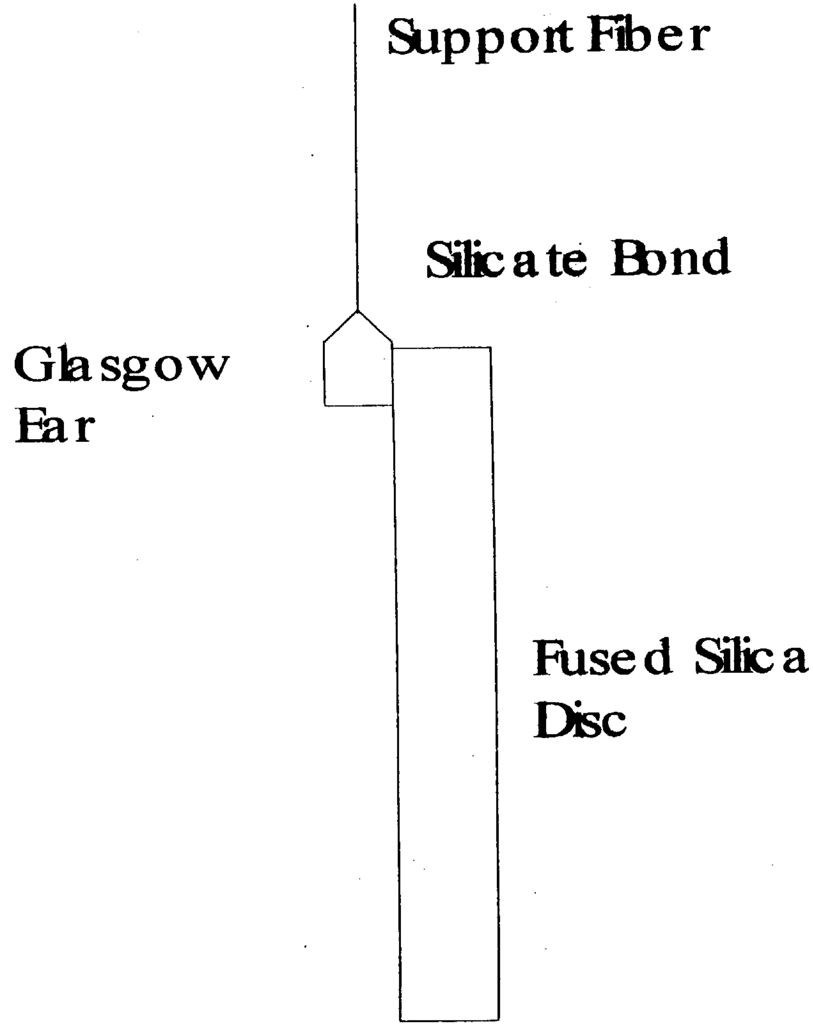
- Best $Q_{uncoated} = 4.9 \times 10^6$
- Best $Q_{coated} = 1.6 \times 10^5$
- Corresponds to a 3.2 cm dissipation depth, of comparable size to mirror thickness
- Similar results coming from Glasgow (see G. Cagnoli's talk at Aspen 2000)

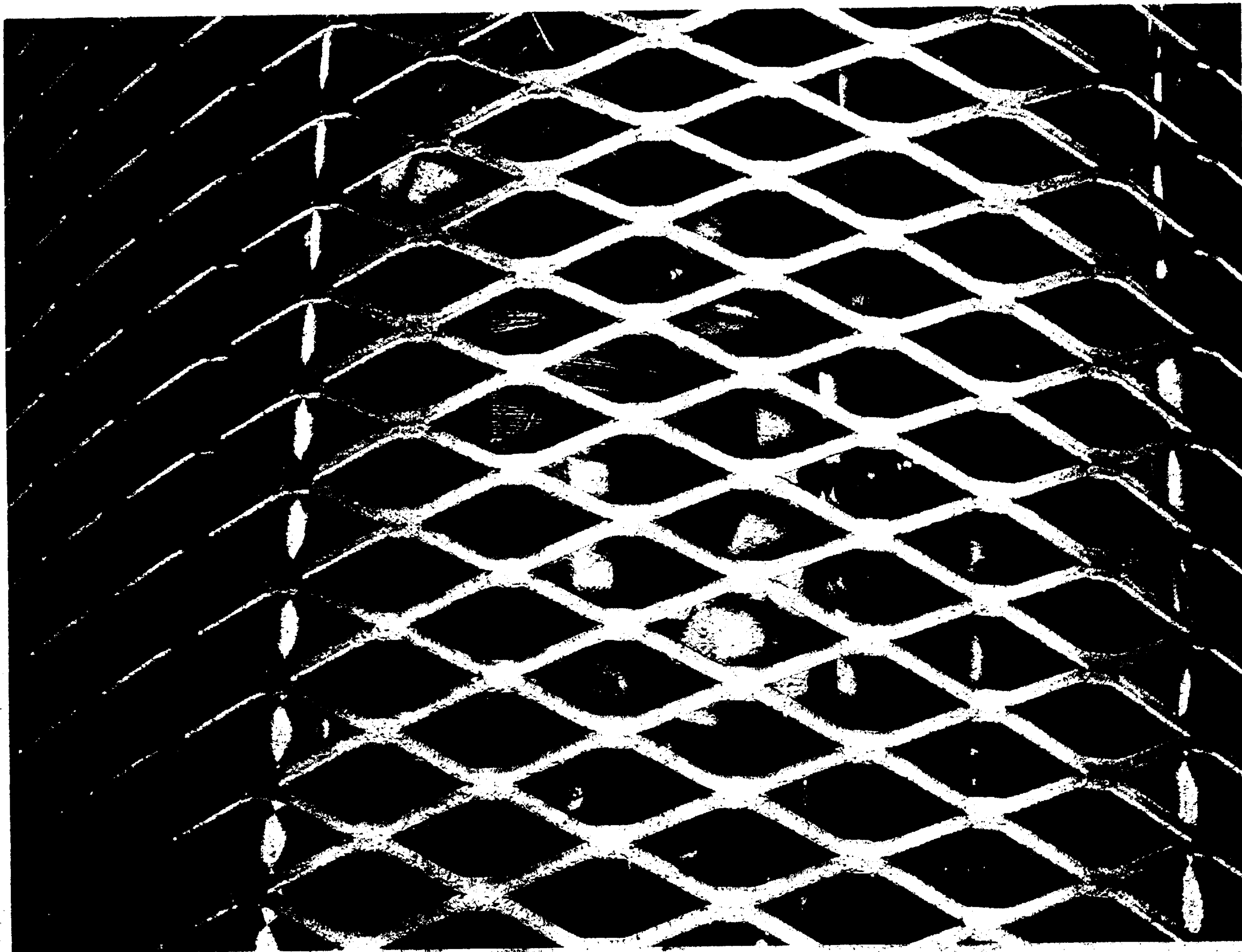
Larger sample coating experiment

- Fused silica disk
- Diameter 16.5 cm, thickness 1.9 cm
- Flatness $\lambda/12$ and $\lambda/40$
- Roughness <4 Å (rms)
- Scratch/Dig 60/40
- Silicate bonded to suspension

Large sample coating experiment







Results from disk and plans

- Found several modes, excited 1st drum head mode at 3591 Hz
- $Q = 1.25 \times 10^6$, uncoated, for first mode
- Low Q and sensitivity to external excitation suggest failure of double bob suspension
- Remake suspension with larger bob and thinner support fibers
- Ordered thinner disks (3 in ϕ X 0.1 thick), not flat but superpolished

LIGO II sensitivity with coated fused silica mirrors

- Slide results imply increase in internal mode thermal noise for fused silica by roughly $\sqrt{2}$
- If similar coating dissipation holds in superpolished samples, will noticeably effect LIGO II sensitivity
- Sensitivity with coated sapphire mirrors is unknown, but if loss is solely due to coating it could limit sapphire thermal noise to near fused silica levels

Difficulties in applying resonant Q data to LIGO II thermal noise

- Sources of loss near/in reflecting surface are emphasized
  - Y. Levin calculation
- Quantifying the effect of surface loss is geometry dependant
  - A. Gretarsson and G. Harry
- Possible frequency dependence of ϕ
  - ? (maybe use anelastic aftereffect and ellipsometry)

Calculations of thermal noise in LIGO II masses

- Laser most sensitive to thermal noise in a non-modal deformation
- Can be calculated directly from definition of thermal noise (FDT, statistics, etc.)
- Some subtleties require further thought
- Work at Caltech, Stanford, Orsay, Syracuse, etc. (see Levin, Bondu, Gustafson publications)

Ellipsometry and anelasticity

with P. Willems and E. Gustafson

- Modify existing apparatus for reflection
- Squeeze coating by pushing normal to face
- Will mounting of sample be crucial?
- Can coating be stressed without substrate?
- Will stressing damage coating?
- Start research on damage to coatings from squeeze using slides

Note 1, Linda Turner, 05/09/00 01:35:11 PM
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