Effect of Temperature on Coating Thermal Noise in Advanced LIGO

Matt Abernathy
Gregg Harry
Flavio Travasso
LIGO/MIT

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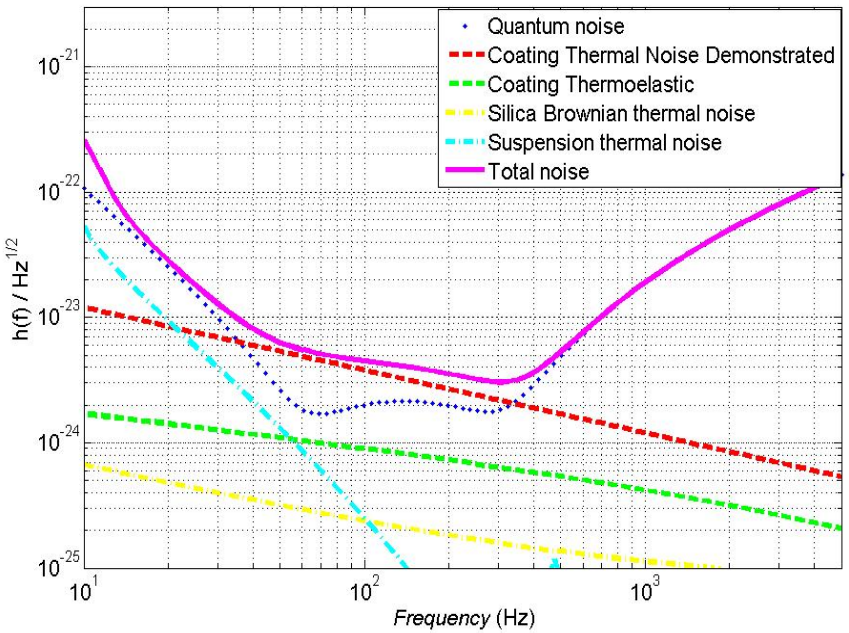
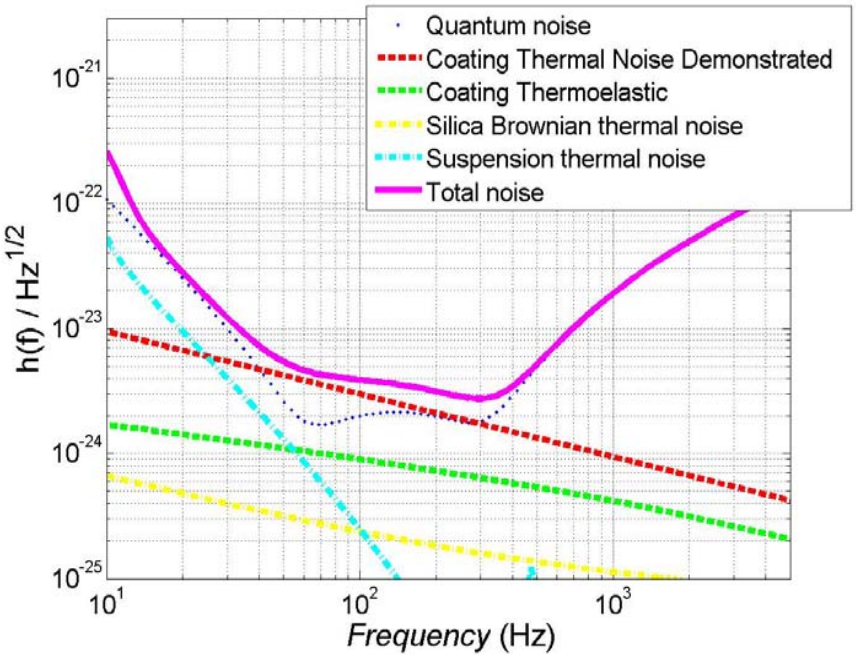
Thermal Noise





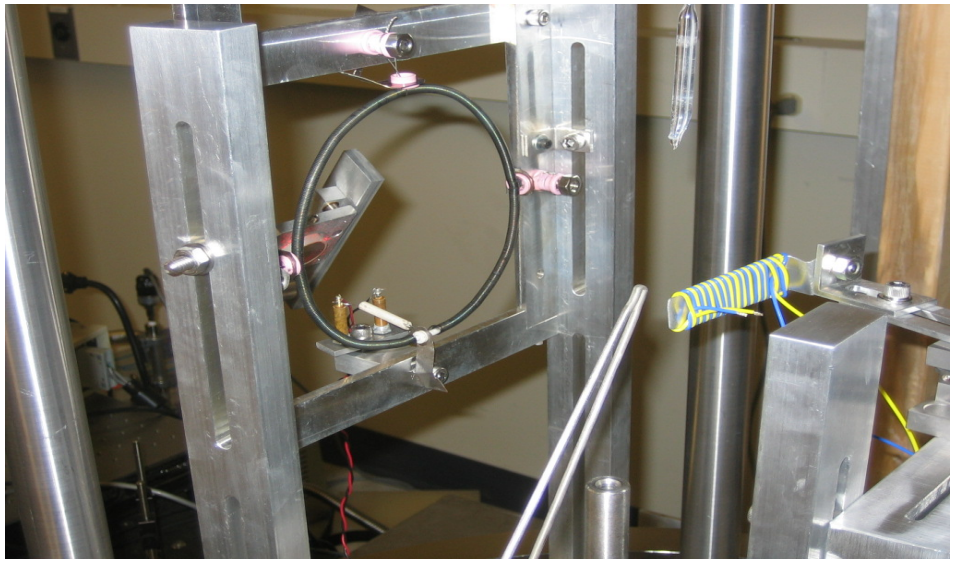
- What is Thermal Noise?
- The effect of thermal noise on Advanced LIGO
  - Initial LIGO coatings: Silica/Tantala
    - NS/NS 155 Mpc BH/BH 675 Mpc
  - Our Best coatings so far: Titania doped Tantala
    - NS/NS 175 Mpc BH/BH 775 Mpc

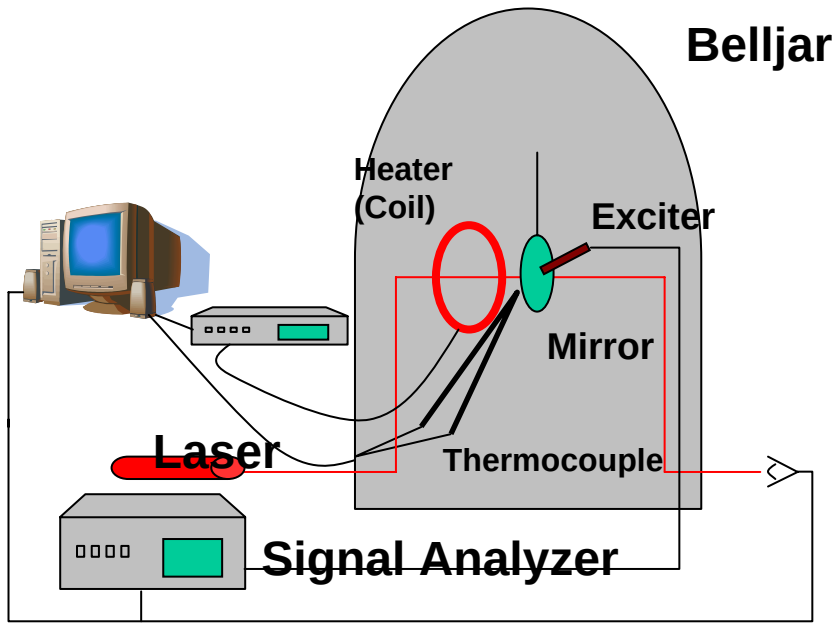
Mirror heating in Advanced LIGO

- 180 W in adLIGO, 8 W in initial
- 1 MW in adLIGO, 20 kW Initial LIGO
- What does this mean for developers?
  - < 1 ppm of optical absorption in coatings
  - 20 degrees above room temperatue operating point
- How does this effect coating thermal noise?

Coating lab

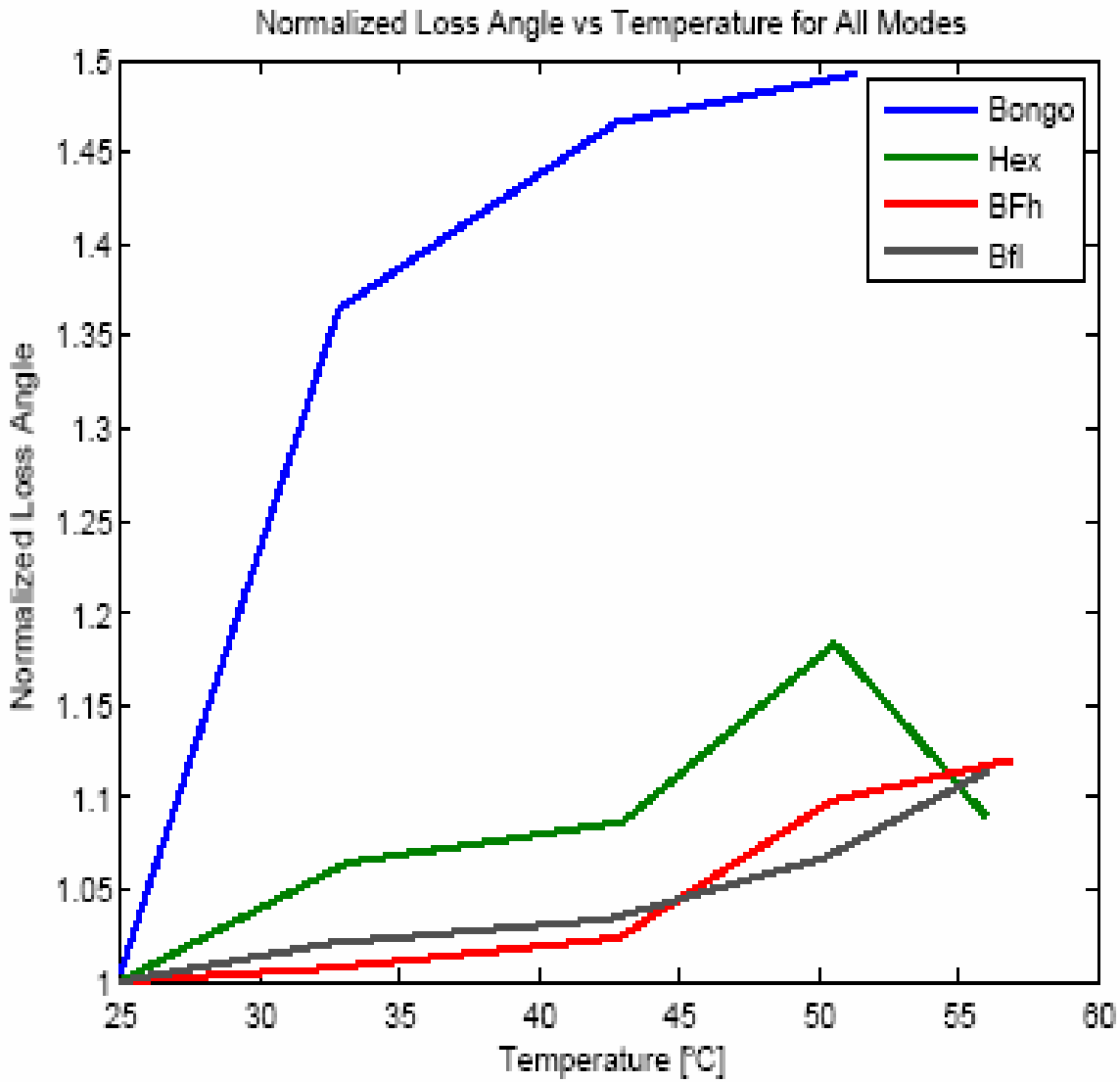
- Fluctuation-Dissipation
- Birefringence Sensor
  - No touching
- Coating Samples
  - 30 layers λ/4 silica tantala
- Temperature Experiment

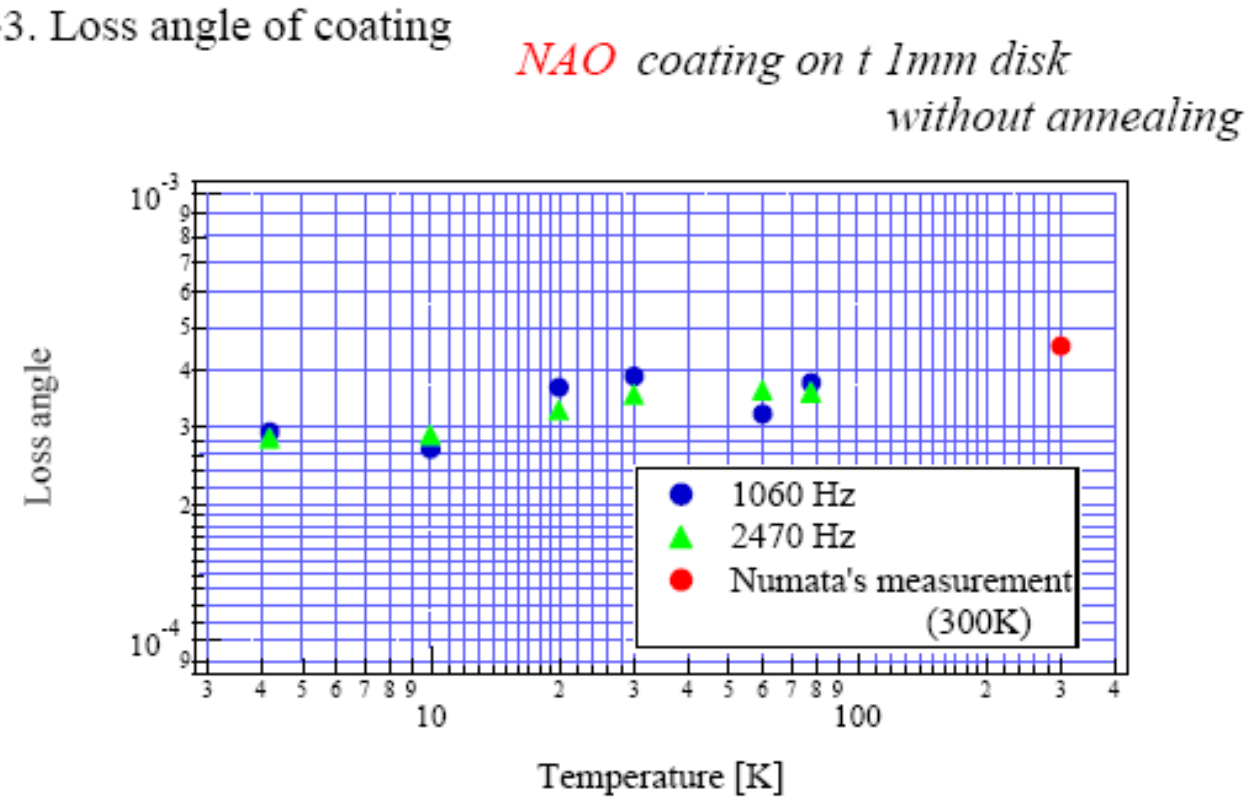




Results

- Loss Angle Increases with Temperature
- Effect Decreases with Frequency
  - More dramatic effect
- Change in sensitivity
  - <1% decrease in NS range

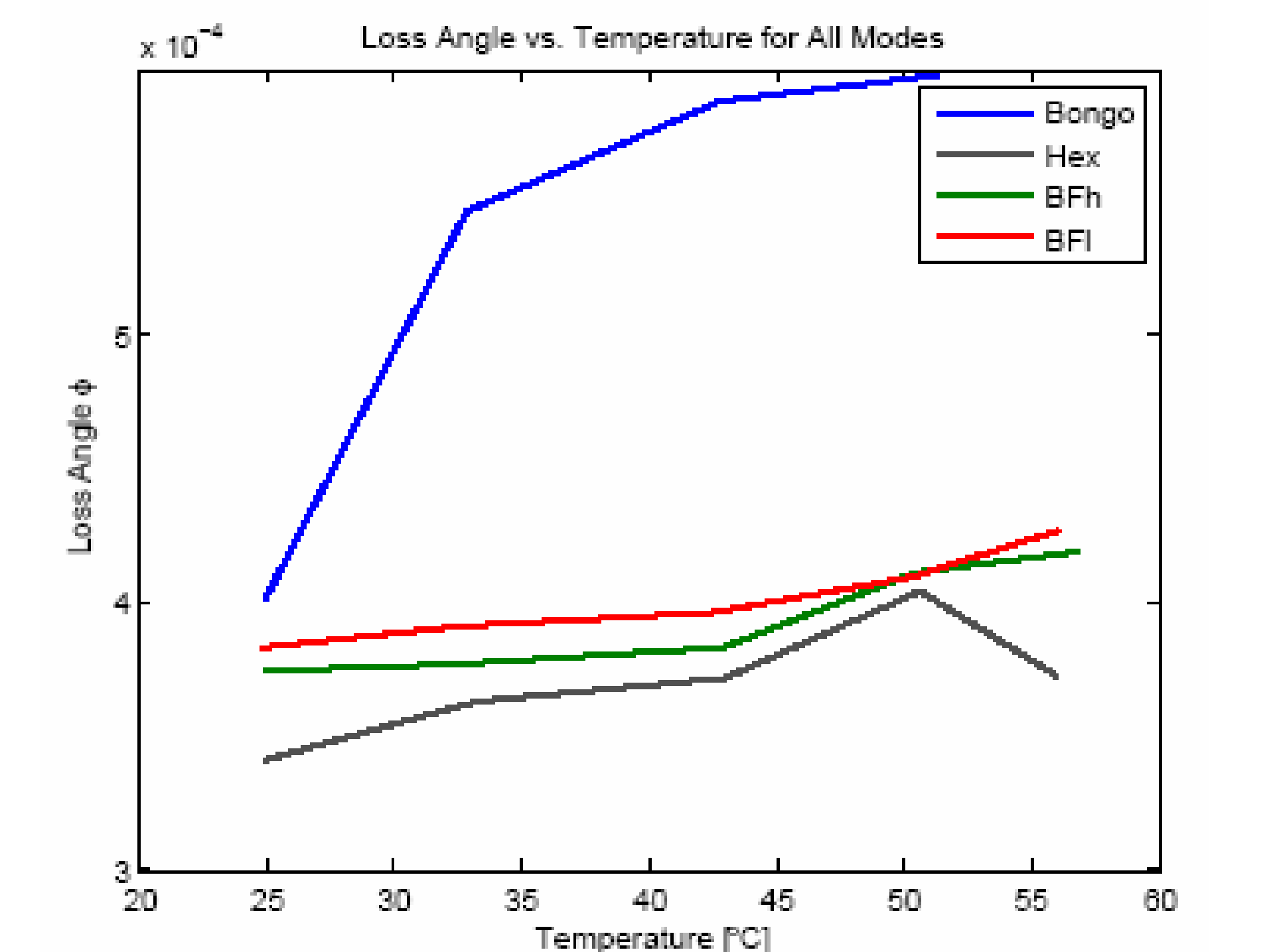




- Japanese Results--Kazuhiro Yamamoto 2003
  - Shows no temperature effect below room temperature
  - Agrees with our results—loss angles appear to converge near room temperature

Further Comments

- As Always, more, better data points are most helpful
  - With a wider frequency range, we can start looking for mechanical loss mechanisms
    - Combine with low temperature data
    - Silica has understood loss mechanisms
    - Might be possible to develop understanding for tantala
  - Wider temperature range
    - Third generation detectors


Loss Angle vs. Temperature for All Modes
x 10^-4
Loss Angle ϕ
Temperature [°C]
Bongo
Hex
BFh
BFl
3
4
5
20
25
30
35
40
45
50
55
60