**Advantage of cryogenic interferometer**
(thermal noise of mirror)

(1) Loss of substrate

(i) **Structure** damping : $f^{-1/2}$

\[ Q = 3 \times 10^7 \text{ (fused silica)} \quad Q = 1 \times 10^8 \text{ (sapphire)} \]

(ii) **Thermoelastic** damping: $f^{-1}$ (room temperature)
\[ f^{-1/4} \text{ (low temperature)} \]

(2) Loss of **reflective coating**

**Structure** damping : $f^{-1/2}$
\[ \phi = 10^{-4} \]
Noise budget of LCGT

- Total
- Standard quantum limit
- Fused Silica
- Sapphire

Sensitivity [Hz^{1/2}]

Frequency [Hz]

thermoelastic
structure
coating
Noise budget of LCGT

- Total
- Standard quantum limit
- Fused Silica (3cm)
- Sapphire (3cm)
- Fused Silica (6cm)
- Sapphire (6cm)
Sensitivity [Hz$^{-1/2}$]

Frequency [Hz]

(LIGO I) > (LIGO II) > (SQL) > (LCGT)

Noise budget of LCGT
- Total
- Standard quantum limit
- Fused Silica (3cm)
- Sapphire (3cm)
- Fused Silica (6cm)
- Sapphire (6cm)
- Sapphire 20K

coating

thermoelastic
Thermoelastic damping

(1) $T : 300K \rightarrow 20K$ $1/9$
(2) $r : 3cm \rightarrow 6cm$ $1/3$

Coating loss

(1) $T : 300K \rightarrow 20K$ $1/4$
(2) $\phi : 10^{-4} \rightarrow 10^{-5}$ $1/3$
(3) $r : 3cm \rightarrow 6cm$ $1/2$

Structure damping

(1) $T : 300K \rightarrow 20K$ $1/4$
(2) $r : 3cm \rightarrow 6cm$ $1/1.4$
Too cool?

S/N (Binary coalescence)

(1) improvement of bottom

S/N : 1.4 times larger ???  → check!

(2) higher frequency

bottom sensitivity : 4 times larger

S/N : 2 times larger than Ad. LIGO ?→ check!

high power → possible?

(3) SQL suppression ???  large mirror → possible?

(4) detune ??