Advanced
LIGO UK

Development issues for the UK Advanced LIGO project

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Overview

Aspects of:

- OSEMs
- Silica ribbons and dumbbell fibres
- Silica suspensions
- Silicate bonds
- Blade springs
- Future work

Note:

Losses in coatings will be dealt with in separate talk by P. Sneddon

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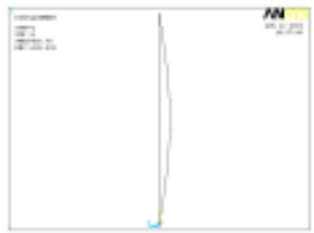
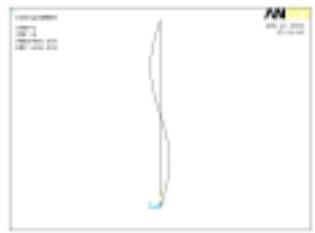
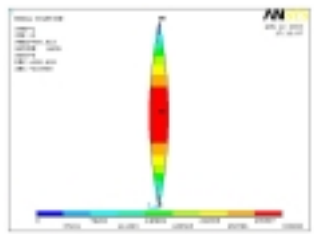
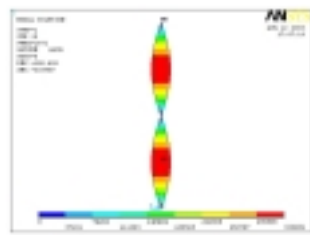
OSEM noise performance

- Current OSEM noise performance (10^{-10}m/$\sqrt{}$Hz) acceptable for quad d.o.f.'s using the following approaches:
  - take over sensitive (long/yaw/pitch) d.o.f.'s using global control when locked
  - for other modes (e.g. vertical and roll) active damping may give way to eddy current damping when in science mode
  - more aggressive filtering
  - consider relaxation of damping times in science mode
- To alleviate dependency on eddy current damping, OSEM 'improvement' programme initiated to try to achieve lower noise
  - lensed flag optical lever
  - LED arrays
  - position sensitive photodiode

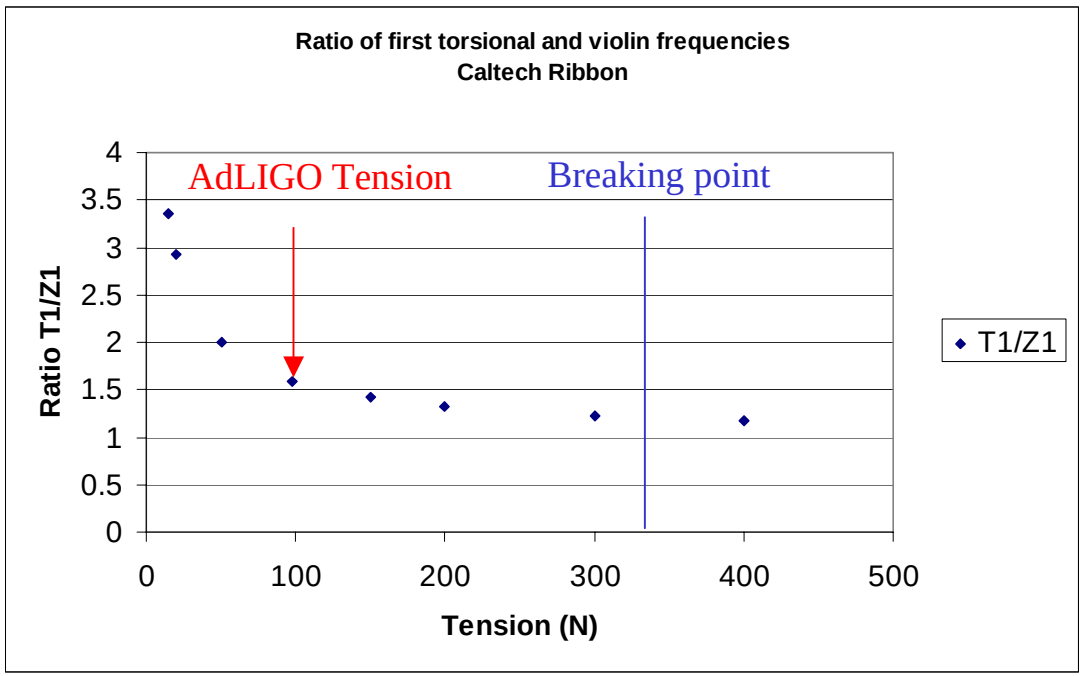
FE Analysis of silica ribbons and dumbbell fibres

- AdLIGO silica ribbons – modal frequencies
  - AdLIGO ribbons (600mm x 1.13mm x 113µm:10kg)
  - Violin modes
    - Fundamental 493Hz
    - Modes in two axes similar when under tension
    - String model essentially fits
  - Torsional modes
    - Fundamental 786Hz
    - Related to violin mode frequencies

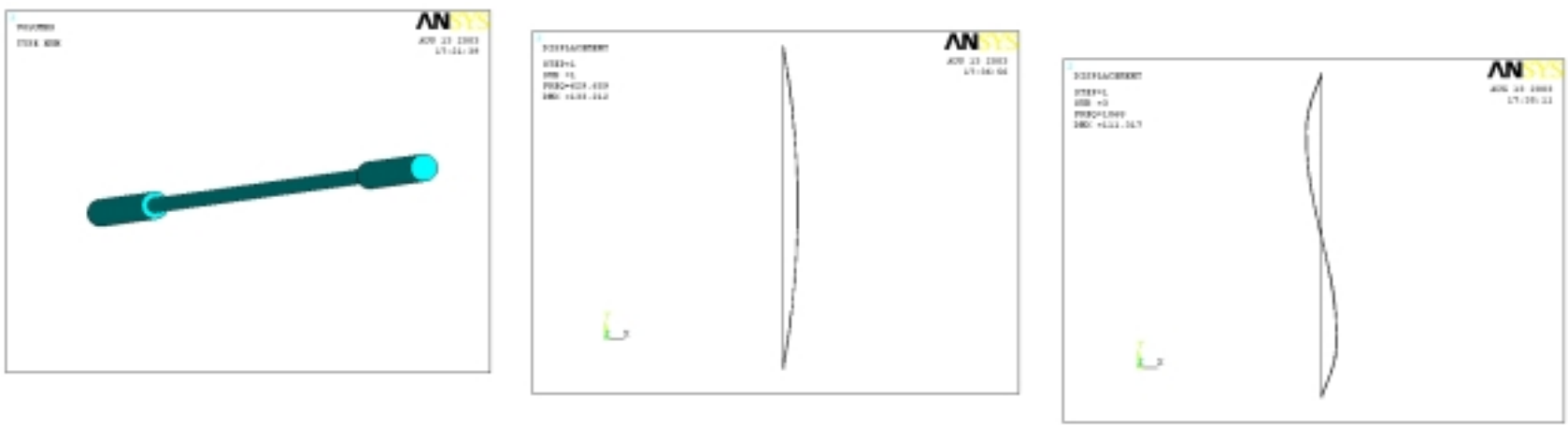
FE Analysis of silica ribbons and dumbbell fibres

- Silica ribbons - effect of tension
  - Torsional and violin modal frequencies converge as tension increases
  - For Advanced LIGO tension the frequency ratio is ~1.5



FE Analysis of silica ribbons and dumbbell fibres

- AdLIGO dumbbell fibres – modal frequencies
  - Section lengths 100mm:400mm:100mm
  - Section radii 359µm:190µm:359µm
  - Mass on each fibre: 10kg
  - Violin modes higher frequency than for AdLIGO ribbon
    - 1st violin mode 630Hz compared with 493Hz for ribbon
  - First ‘non-violin’ mode is torsional mode at ~6kHz



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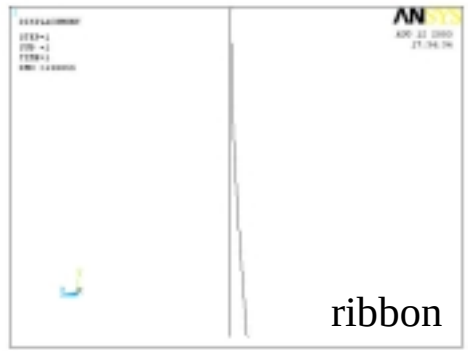
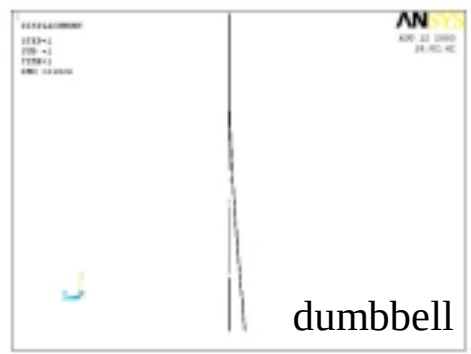
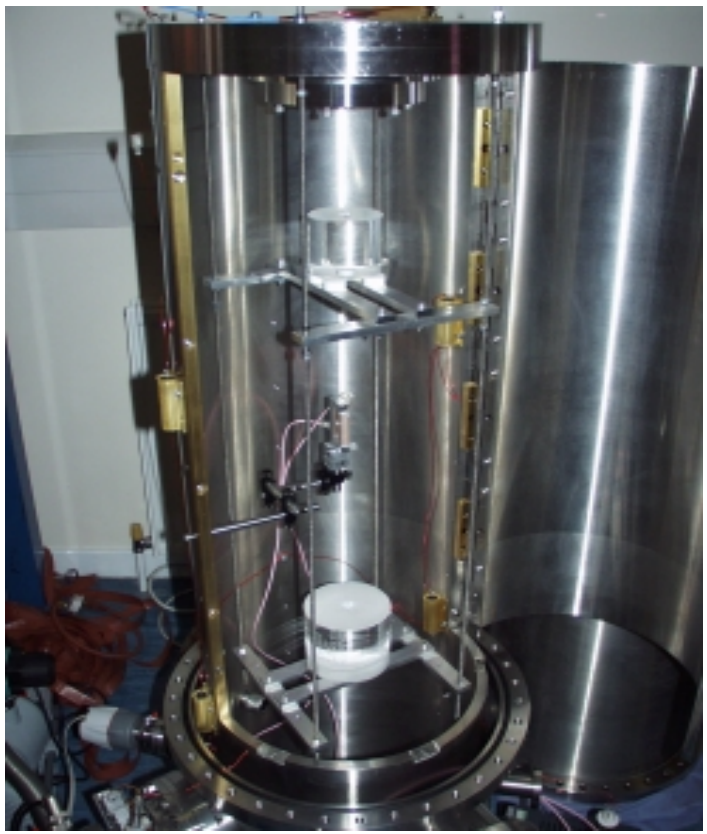
FE Analysis of silica ribbons and dumbbell fibres

- Comparison of flexure point
  - FE analysis
    - Ribbon/fibre modelled under tension, fixed at top
    - Transverse force applied at base
  - Theoretical flexure point
    - RIBBON → 0.32mm from top
    - DUMBBELL → 3.1mm from top
  - FE allows accurate prediction for pendulum dynamic design
  - Future work
    - Continue FE modelling & theoretical analysis
      - Extend to ribbon-ear system / ribbon-ear-mass
    - Experimental verification
      - modal analysis
      - flexure point investigation





Silica suspensions



- Ribbon violin mode experiment
  $Q_{unloaded}$ = 1 to 3 x 10^6
  Q_{loaded} = 3.5 x 10^7
  Dilution (theory) = 140
  Discrepancy to be investigated
- Silica ribbon suspension
  400g mass
  Q = 4 → 1 → 1.6 x 10^8
  Electrostatic charge (during pump down?) is thought to cause such variation
- Investigate methods of discharging
  - UV or Beta particles??

Silica suspensions – strength tests

- 21kg suspended on two glued ribbons for several weeks in air
- Latest data:
  - average breaking strength 1.18GPa
  - 1.53GPa max
  - one early sample showed a strength of 3.7GPa
- Shear stress due to shape imperfections is crucial in limiting breaking strengths

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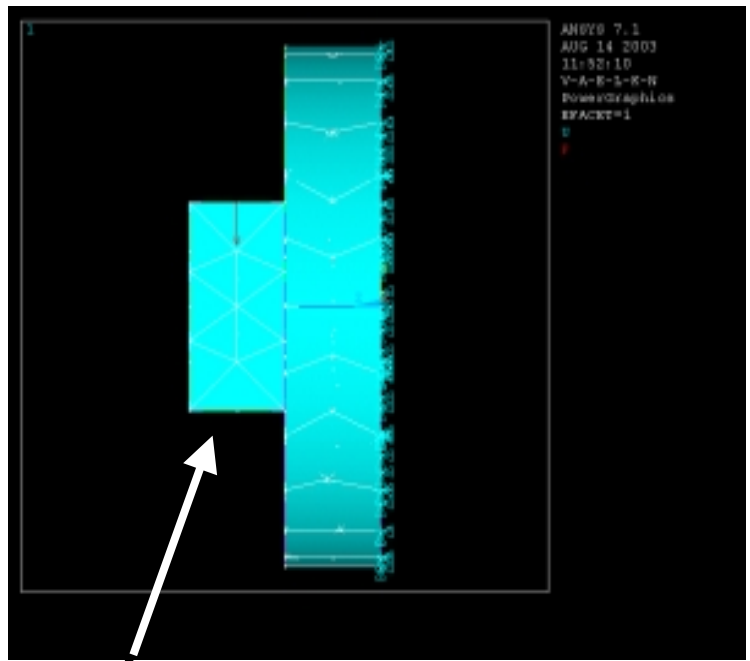
Silicate bonding – strength tests

- Bonding solutions LiOH:H_2O (and Na, K, Rb, Cs)
- Molecular ratio 1:500
- Bonds cured for 5 weeks at room temp
- Bond strength appears to increase with pH value (more hydroxide), maximum value being with NaOH
- Further investigation required
  - Others may give maximum at different molecular ratio?



Block 10mm x 5mm x 5mm

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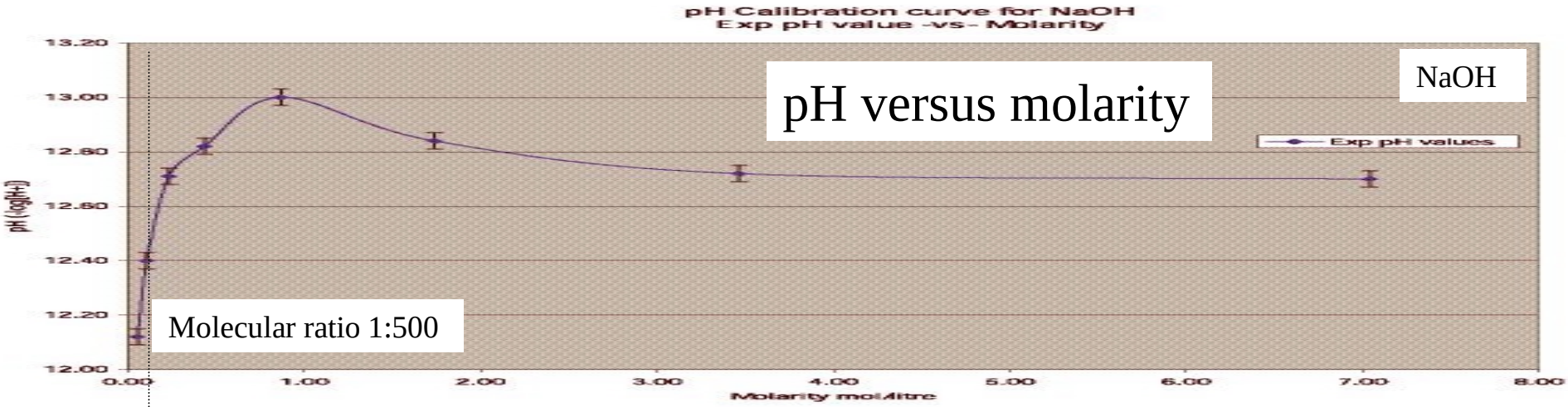
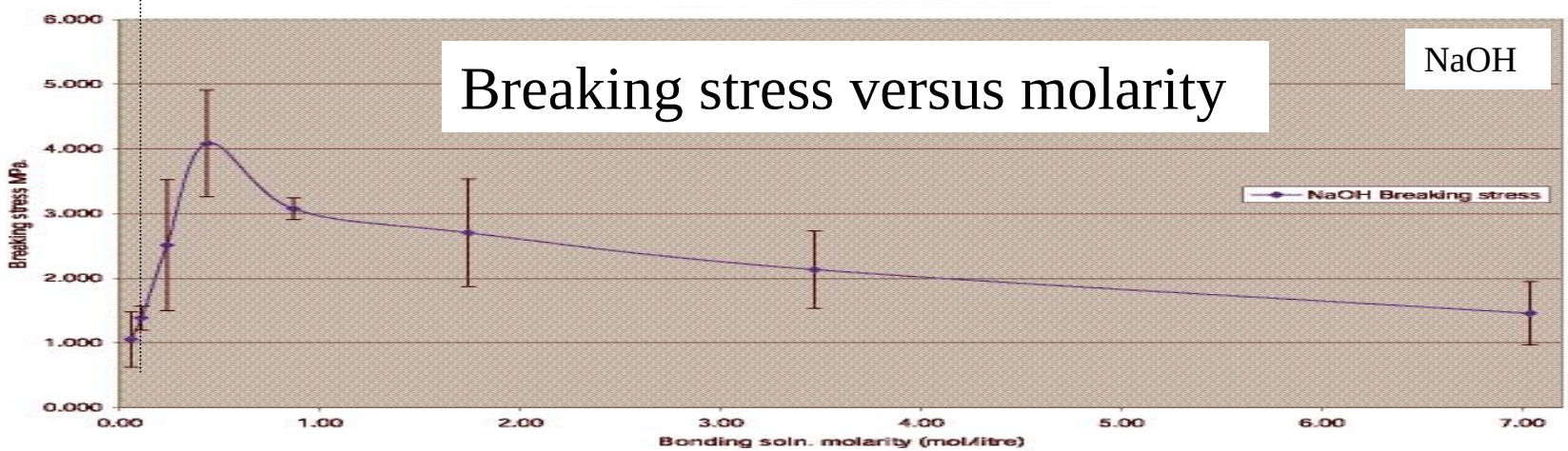
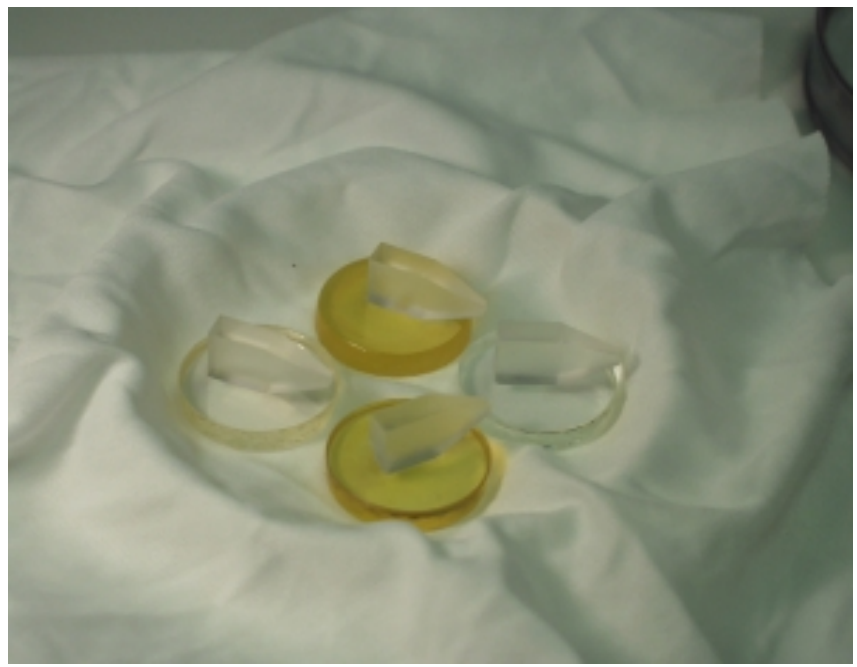
Silicate bonding – strength tests





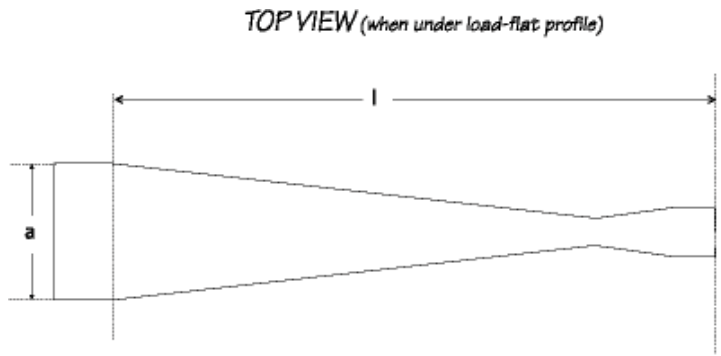
Silicate bonding – strength tests

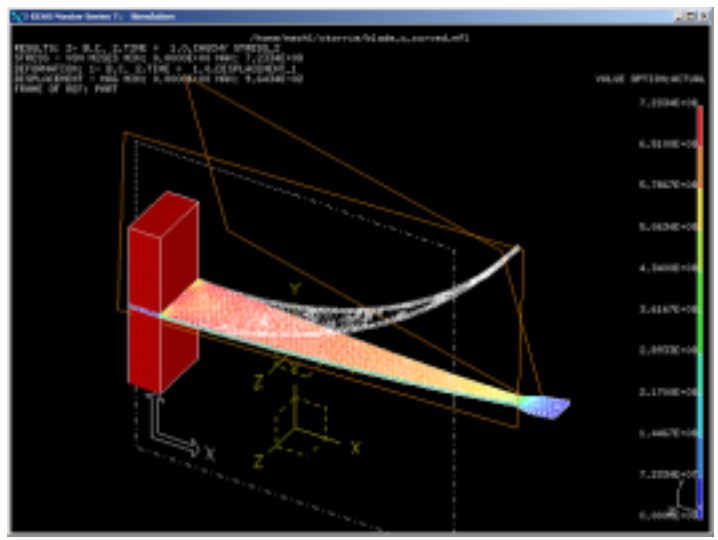
- Sapphire bonded with sodium silicate. Typical breaking stress 1.5MPa
- Heavy glass bonded with sodium silicate
- Breaking stress comparable with silica-silica bonds as in GEO600



Blade springs

- Problems with variations in Maraging Steel blade parameters
  - deflection: alignment issues
  - affects pendulum mode coupling
  - thickness, material, manufacturing
- Blade pairs need to be carefully matched
- Proposed blade test facility (at RAL)





Future work

- OSEMs:
  - further sensor design ‘improvement’ work will be concluded early 2004
- Silica ribbons and dumbbell fibres:
  - continue FE modelling, ribbon strength tests and welding strength tests
- Silicate bonds:
  - continuing strength tests & FE modelling
- Test mass electrostatic charging:
  - discharging methods will be further investigated
- Blade springs:
  - blade test facility to be set up and testing/analysis programme developed