Modecleaner Suspension Design: Steel or Silica Fibres

Responses to questions raised by ribbon/fibre review committee

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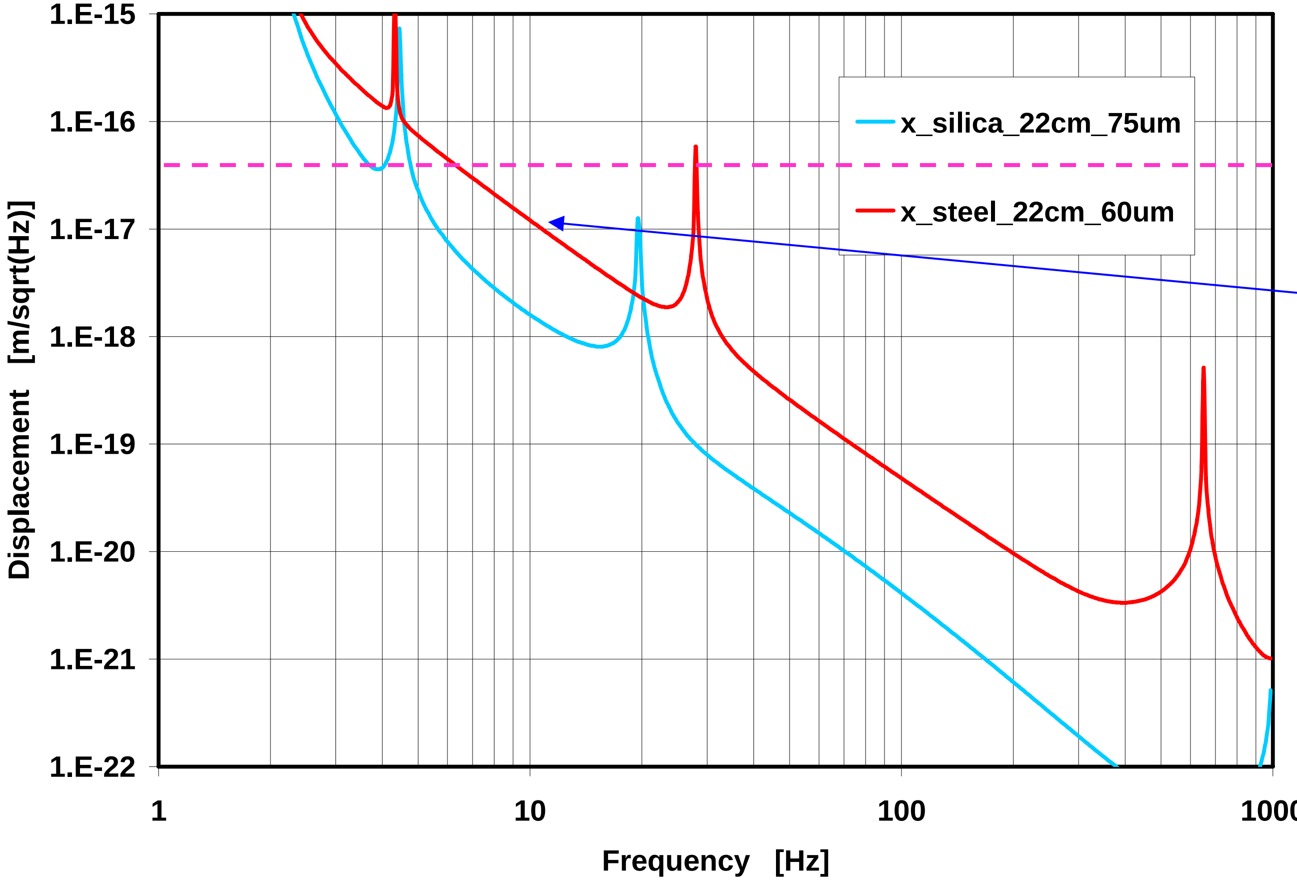
G060013-00-R

1) How much loss from friction between wire loops and the optic is being assumed for the MC suspension? Where does this come from? How well coupled are these plans and what we are learning from initial LIGO suspensions?

- The case for using steel wires is presented in “The Use of Steel Wires for the Advanced LIGO Modecleaner Suspensions” T060008-00-R (see also next slide)
- We have considered both the case where there is no significant loss from friction, using an intrinsic material loss of 2×10^{-4}, and where the loss is assumed to be 10 times larger than this value, based on the findings with Initial LIGO
- Initial LIGO findings:
  - Measurements of violin mode Qs in initial LIGO give a value of the largest to be ~150,000. This is in agreement with expectations of the intrinsic material loss in wire plus loss due to the thermoelastic effect and the dilution factor as expected. (ref Fritschel et al, T050252-00-1).
  - Since some variability of Qs was seen, we also consider the implications of taking a value for the total effective loss of 2×10^{-3} excluding thermoelastic (the model includes thermoelastic effect).

Modecleaner Suspension Thermal Noise Estimate (quadratic sum of longitudinal and vertical*)



1.2×10^{-17} m/√ Hz @ 10 Hz

If losses are 10 times larger, this value becomes √10 larger, still within current noise requirement

Blue: silica, material loss 5×10^{-7}, 75 micron radius, (stress 0.4 GPa).
Red: steel, material loss 2×10^{-4}, 60 micron radius (stress 0.65 GPa)

Dotted magenta line = current noise requirement: 4.2×10^{-17} m/√ Hz @ 10 Hz (long + vert)

* Assuming 0.1% cross-coupling)

Graphs from G Cagnoli

2) The planned wires seem very small and highly stressed compared to initial LIGO suspensions. How near the breaking stress are they planned to be? Are there concerns here?

- The current proposal is to use wires stressed to the same level as in initial LIGO, namely around 0.65 GPa (approximately a factor of three below breaking stress). We are not aware of concerns at this stress level.

3) Can the decision to use wire suspensions in the MC be postponed until more initial LIGO research is done?

- The detailed design of the noise prototype modecleaner suspension is due to start early in 2006. It would be preferable that the decision has been taken by that time.

4) Is there a requirement on violin mode frequency equilization? What sets this?

- There is currently no requirement on violin mode frequency equilisation

- However it has been suggested by P Fritschel that a 2% spread within a suspension and a 5% spread among suspensions would be desirable.
  - Silica: experience with GEO
    - dimensional tolerances of +/- 2.1% (corresponding to bounce mode frequency spread of +/- 3.1%) were achieved
    - Required spread in violin mode frequency was +/-5% for first two modes, achieved values f1 = +/- 3.86%, f2 = +/- 4.86% (ref Stefan Gossler thesis) However note that this is not directly relevant to Adv. LIGO since some of the tuning was done using teflon damping material (applied to damp the Qs)
    - Using the laser-pulling and welding machine currently being developed for Adv. LIGO, the reproducibility of fibres should be better than obtained for GEO.
  - Steel: matching to 2% should not be a problem. Standard tolerance for the proposed wire diameter is 2.1% as bought, and short lengths should be better. Length control to 1mm (pessimistic) in 22cm corresponds to 0.45%

  - We note two advantages for steel:
    - the quality factor of the resonances will be reduced by at least two orders of magnitude, therefore easing the notch/control requirements.
    - the matching of violin modes should be easier to achieve.

5) Will there be a problem with matching stress in all the wires? Will yaw and roll be able to be controlled well enough?

- To date no requirement has been given to SUS concerning matching stress in all the wires. See also response to 4) above.

- Regarding yaw control, we have provision for actuation at both the penultimate and test mass, using LIGO 1 style OSEMs. Current estimates give ~ 2mrad peak motion and ~0.7 mrad continuous at the mirror (further details in written documentation). We believe this is adequate. However control will be tested at LASTI. If necessary, OSEMS developed for the heavier quadruple suspension could be adapted for use here.

- We are not aware of any requirement on roll control, apart from adequate damping of the low frequency roll modes. We welcome clarification from the review team as to why they believe such control might be necessary.

6) Is beam jitter in the mode cleaner being studied? Will the wire suspension meet the specifications for this? How coupled to initial LIGO experience is planning here?

- There will be pitch control similar to the yaw control described in 5) which should give adequate authority.
- Our design more than adequately meets noise performance requirements in terms of isolation from 10 Hz and above.
- There should be essentially no difference in terms of seismic isolation between a wire or silica suspension.
- From D Reitze : “The jitter requirements for Advanced LIGO are tight, but should be met if the PSL delivers on its jitter performance”

- We welcome clarification from the review committee as to what particular aspects of beam jitter and LIGO 1 experience is being referred to in this question

7) Need more information on Peter Fritschel's argument that requirements can be relaxed

- See Fristchel's presentation at the HAM requirements review meeting held in Caltech, July 2005, available at

  http://www.ligo.caltech.edu/~coyne/AL/SYS/default.htm

  under meeting on 11-13 July 2005

- We note that our proposal to use steel wires (presented in T060008-00-R) does not assume a relaxation of the HAM requirements.