XGCD, February 10, 2025: Suspensions and fibers

All slides will be uploaded to indico page: https://indico.gssi.it/e/xgcd
53 participants

Giles Hammond
Introduction
Fused silica

- Initial development for GEO600
- Used flame to melt silica and pull the fibers
- Later switched to laser-drawn fibers; led to stronger and well-formed fibers
- Leads to low mechanical loss and good geometric accuracy (within 5%)

DS: How well have we measured thermal noise to be able to verify the details of the theoretical models?
GH: When ringing up violin modes, we see quality factors of 1-2 billion, which is close to what we expect. The quality factor should be similar in the pendulum mode.

- Demonstrated suspension of loads of 160 kg and aiming for larger loads (like 320 kg for CE)
- Needs to do R&D and engineering for welding and holding a load of order 300 kg

Flavio Travasso
Large masses for Virgo O5

- Bonded area needs to be increased to keep similar stress value
- Would like to stay around 2-3 MPa
- Were able to perform a full-size dummy suspension

LB: We switched to 400 kg for CE at some point, and it seems that this should not pose a problem according to what you said, right?
GH: Yes indeed, we should be able to suspend 400 kg. When you weld the masses, you need to position them to within 0.1-0.2 mm, which becomes harder for larger masses.
ME: In CE, we are considering moving away from the LIGO-type symmetric penultimate - test mass suspension setup. Do you have thoughts about this?
FT: It might be advantageous to mix the LIGO (at test mass) and Virgo (at Marionetta stage) style of the suspension.
GH: Modeling of loss at glass-metal contacts must be improved.
FT: In Virgo we have the metal marionetta. We just glue the anchors on the steel. There is some problem with losses, and this is one of the reasons why we are also looking into the idea of suspending this part with fused-silica fibers.

Giles Hammond
Sapphire and silicon

- At Glasgow, we have developed CO2 machines to grow sapphire fibers. Sapphire is an interesting technology for ET-LF (breaking strength very good, quality factor high).
- Can now make nice welds as well. Highest observed stress is 1.4GPa.

- Laser polishing significantly strengthens them.

FT: The plot on slide 24 does not give credit to the strength of the fiber and weld

- Thermal conductivity must be high enough for ET-LF.
- Results on the quality factor are promising even with 3mm fiber diameter.

Iryna Buchovska

At IKZ, we are experts in crystal growth. Silicon is a very attractive candidate for ET-LF suspensions.

- Float zone method for crystal growth.
- Coil melts the silicon rod. Pull one part from the other
- The minimum diameter developed in industry was 8-10mm, while our goal was 3 mm (the ET-LF design goal).
- Use 8mm slim feed rods.
- Achieved fiber growth with 3 mm diameter and <0.1 mm variation. Length up to 1.5 m.
- Started with investigation of structural perfection. Knew that the method ensured monolithic structure, defect free. Dislocations might be created in the beginning of the pulling process, but they move out of the fiber during the pulling process.
- Mechanical tests at Glasgow showing medium breaking stress around 300 MPa when using a good clamping method.
- Have made first trials with fiber welding, which does not yield good shapes yet.

FT: Being able to weld larger parts means less problems with breaking strength at the weld.

ME: I am surprised by the 3mm diameter, which is an order of magnitude larger than what I am used to. How is this not a problem for the detector?

FT: The 3 mm diameter decision is connected to the heat flow required to get the 0.5 W out of the ET-LF test masses.

GH: Needs careful design. Lower diameter pushes down the bounce mode (ideally below the observation band) and the violin modes up (ideally above the ET-LF bucket).

AE: Is the Q-factor of these fibers still high?

GH: Surface loss of a few times 1e-11, which is lower than in fused silica. The Q-factor probably won't be in the billions but hundreds of millions.

Flavio Travasso

- SiO2 fibers with Si core
- Impex company is working on bonding together sapphire with melt going through capillary channels

LB: As a summary, I would say, for fused silica, some R&D needs to be done, but the technology is mature.

GH: The A# and AdV+ work brings us towards the suspension of larger test masses. When it comes to crystalline fibers, there are promising results for silicon and sapphire. Geometry and length of fibers are possible for silicon. For sapphire, we are looking at thinner fibers to achieve the required heating profile. Samples go to various groups. We need to start to demonstrate the initially smaller prototype systems.

FT: Have added some missing slides to the shared files.