LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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An Alternative to Wire Loops for Suspension of Penultimate and Reaction Masses

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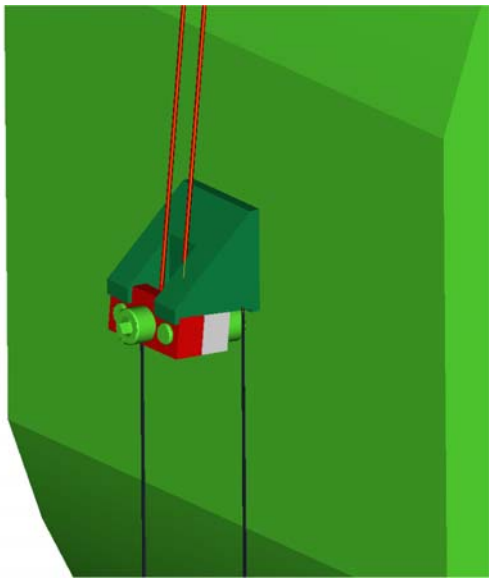
1 Introduction

Wire loops have commonly been used as a simple means of suspending penultimate and reaction masses in multiple pendulum suspension systems. However, there are some issues of concern with the use of wire loops which are quite difficult to quantify such as potential twisting of the loop on the underside of the mass and the potential for additional creak/frictional noise in the suspension. Assembly of multiple suspensions incorporating wire loops can also be quite challenging, particularly in the proposed design for the quadruple suspensions for Advanced LIGO where the penultimate mass wires are located between the silica ribbons suspending the optic.

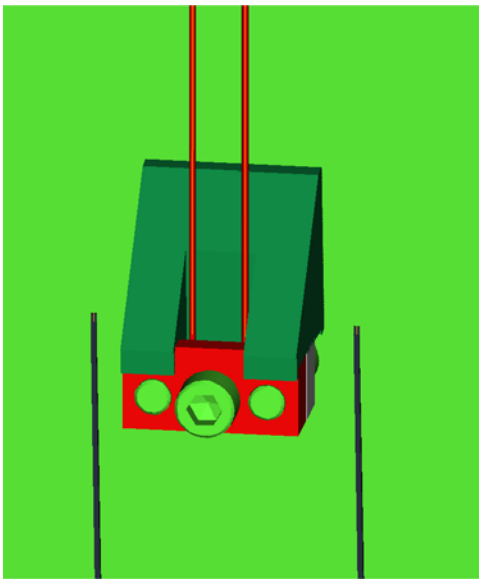
Motivated by the difficulty of fabricating 0.6 mm drum ended wires as long as ~ 1.7 m RAL and Glasgow have been looking at alternative ways of connecting a steel wire to a silica or heavy glass mass. This document outlines and discusses a promising concept that would solve this problem. At this point it should be stressed that this idea is purely conceptual, no experimentation has yet been carried out.

2 Concept

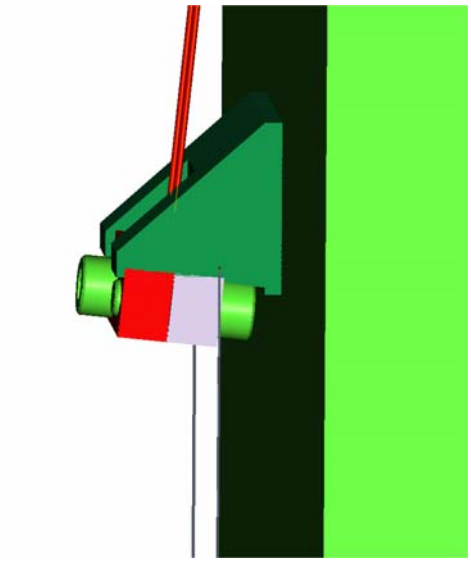
The wire loop represents the simplest way to hold a mass that can't be tapped. Clearly any alternative must also not require tapped holes in the mass. It is proposed that a simple way of satisfying this but avoiding the use of a loop would be to clamp the two wires to one another and then hook the clamp to a silica "nose" silicate bonded on to the mass. Graphically:-



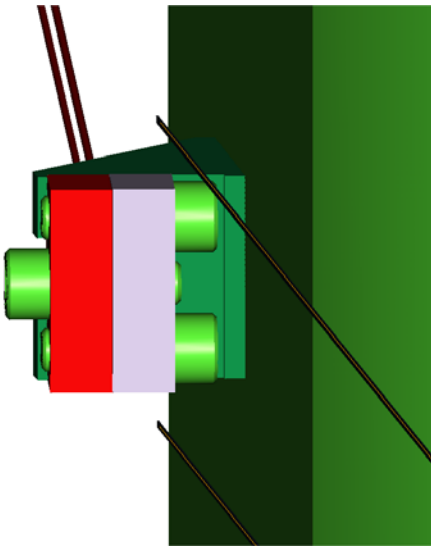
The red and grey wire clamp accommodates the two steel wires (also red) from above. The wire clamp then sits beneath the nose (dark green), and the ledge on the end of the nose prevents slippage in *y*



The wire clamp has a knobble on the outer jaw (the red one) which keys into the nose. This prevents slippage in *x*. Note the ribbons in this model terminate in space.



The wire clamp would need good contact with the nose. To get this an indium layer could potentially be added but this would require careful investigation.



From beneath it is evident that the bolt heads have to be staggered to keep the wire clamp as small as possible. This arrangement maximizes the space around the ribbons.

Clearly this idea is still very conceptual. However, it is fairly easy to list the benefits and drawbacks of the idea.

Benefits	Drawbacks
• The wires can be hooked in place subsequent to laser welding of the silica ribbons allowing clear access for the welding operation.	• This particular bond is now fully loaded; this will be the highest load bond in the suspension holding 40kg per bond, however bond area should not be limited by any thermal noise considerations so area can be made large to keep average stress levels within safe margin.
• Care is no longer needed to ensure tension is always on the wires once welding is complete.	• The silica component is now much more complex – the nose would have to be carefully designed to keep stress levels in the nose itself to acceptable levels
• Requirement for the wire loop is removed	
• The challenging requirement to fabricate a ~1.7m drum ended wire is removed.	
• If these wires needed to have their length changed after welding it would be possible	

It should be noted that the fibers attached to the penultimate main mass will mount to silica prisms attached to either side of the new nose. These could either be a separate component or an integrated part of the nose. Presently they are not shown on any of the illustrations above, however they would sit where the two purple ribbons can be seen ending in space.

3 Conclusion

There is still a lot of work to be done, if all the problems can be solved there is clearly a great deal to be gained by such an idea. As usual the devil will be in the detail, however none of the problems seem insurmountable, and all being well this concept could considerably simplify the assembly of both the noise prototype and the final suspensions.