Contribution ID: **33** Type: **Contributed Talk**

Cryogenic Mechanical Loss Measurements using a Gentle Nodal Support

Monday, 6 June 2022 11:55 (20 minutes)

Mechanical loss and thermal noise from both the test mass substrates and their coatings are important factors in the sensitivity of current gravitational wave detectors The next generation of gravitational wave detector are proposed to operate at low temperatures, requiring a change in test mass material and coatings designed to work at higher wavelengths. Silicon has been proposed as an alternative test mass substrate material, however, it is not straightforward to find types with low optical absorption, low mechanical loss and available in the ~200kg sizes required to be used in a future detector. Amorphous silicon similarly shows potential for reducing thermal noise, but due to its high optical absorption, care has to be taken when considering coatings incorporating silicon. New substrates and coating materials with low mechanical loss (and absorption) are being investigated at the University of Glasgow using a pulse cooled cryogenic gentle nodal support (CryoGeNS).
In recent months research has focussed on three areas:

• The cryogenic mechanical loss of "quasi-monocrystalline"silicon, which has the potential to be used to create large low loss silicon test masses.
• Investigations have been made into the loss of ion implanted layers, where a high-energy ion beam is used to implant oxygen to create silica layers within a silicon substrate, and
• Multimaterial coatings have been studied at low temperatures. These coatings allow the use of amorphous silicon to reduce thermal noise while minimising it's impact on the total absorption of a mirror coating. We have been working to verify the multimaterial concept at low temperature, by integrating aSi layers into the lower component of a highly reflective silica and tantala multilayer coating stack, deposited by ion plating.

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Session Classification: Optical coatings

Track Classification: Optical coatings