HYDRODYNAMIC PROBLEM IN SILICA-FIBRE-PULLING FOR GRAVITATIONAL WAVES DETECTORS

LABORATORY : Institut Lumiere Matiere

LEVEL : M1 / M2
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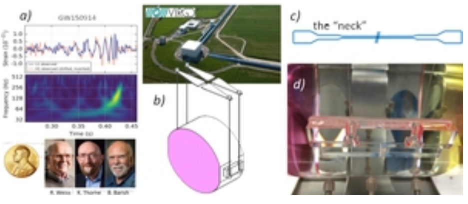
SCIENTIFIC CONTEXT :

The first detection of Gravitational Waves (GW) in 2015 [1] opened a new window on the Universe. The new born field of GW Astronomy has claimed already about 80 GW signals coming from ultra-high energetic events involving Black Holes and Neutron Stars and now all the 5 GW detectors around the World are going through major upgrades to become more sensitives [2].



a) GW first detection, b) Virgo and a mirror, c) typical fibre profile, d) mounted fibres.

It is not of public knowledge the fact that GW have been discovered thanks to glasses [3]. Synthetic Fused Silica is the quietest material in the World at room temperature. The use of fused silica for mirror substrates and suspensions and other special glasses for the reflecting coatings made the internal noise of detectors LIGO and Virgo so low that GW detection was finally possible. The glasses used on coatings have a large margin of improvements and they are one of the main limits to the GW detection.

The research group g-MAG at the iLM is member of the project Virgo and is formed by people that have more than 30 years of expertise on developing ultra-low noise materials for all the GW detectors around the world.

Mirror suspensions are made by fused silica fibres melt by a 200W CO2 laser and pulled by a very precise machine installed at the Virgo detector site in Italy [4]. Suspension thermal noise depends strongly on the specific profile that the fibre has at its ’neck’, i.e. the transition region from thick to thin diameter. So far there is not a model that can predict the fibre profile.

MISSIONS :

The proposed work is completely theoretical. The Navier-Stokes equation for an incompressible fluid has to be solved numerically in hypothesis of cylindrical symmetry. The laser is supposed to provide a perfectly circular heat with a specific profile and penetration depth inside the material. The viscosity temperature dependence can be taken from the vast literature available on fused silica (Suprasil®). Equilibrium temperature is fixed by modelling radiation emission and convection of the surrounding atmosphere. Input variables are the speed of the two ends of the fibre.

The interested candidates need to have a certain familiarity with a software of their choice that has to be used to solve the differential equations.

A video of the fibre pulling is here: https://www.youtube.com/watch?v=6jPLpPbQnWw

OUTLOOKS :

This internship could be continued with a PhD work on a related subject (sapphire suspensions).

BIBLIOGRAPHY :

[1] https://fr.wikipedia.org/wiki/GW150914

[2] https://gwic.ligo.org/

[3] https://www.heraeus.com/en/group/press_group/corporate_news/2016/page_25.html and Interview of Prof. James Hough in https://ligo.org/magazine/LIGO-magazine-issue14.pdf

[4] https://slidetodoc.com/monolithic-suspensions-fibres-and-clamping-in-virgo-francesco/

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