SEARCHING THE PERFECT GLASS FOR THE GRAVITATIONAL WAVE DETECTION

LABORATORY : Institut Lumiere Matiere

LEVEL : M1 / M2
TEAM(S) : SOPRANO

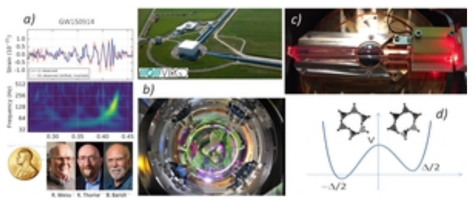
CONTACT(S) : CAGNOLI Gianpietro
MARTINEZ Valérie

CONTACT(S) DETAILS: gianpietro.cagnoli@univ-lyon1.fr / Tel. 0472448568
valerie.martinez@univ-lyon1.fr / Tel. 0472448568

KEYWORD(S) : Gravitational Waves / Thermal Noise / Amorphous Materials

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) a glass reed under test, d) the TLS mechanism

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 who have more than 30 years of expertise on developing ultra-low noise materials for all the GW detectors around the world. We are developing the perfect glass, i.e. the glass with the lowest noise and optical absorptions. In our laboratory we are able to measure precisely the mechanical losses of materials using a very innovative system called GeNS [4]. With that system we are able to study the dynamics of the Two Level Systems [5] that are at the origin of thermal noise and dissipation in materials.

MISSIONS :

The minimal goal is to validate 3 types of glasses from Schott as materials for future GW detectors. The validation goes through the optical and mechanical characterizations that will be done at iLM. The former will be done using the spectrophotometer to analyse the transmitted light and the Raman scattering, whereas the complex elastic constants will be measured through the Gentle Nodal Suspension (GeNS) equipped with the electrostatic actuation and the interferometric displacement sensing. From these measurements and following the theoretical models already developed for GW detectors the student will estimate the impact a specific material has on the sensitivity curve of a GW detector.

Depending on the level of the selected candidate the project could continue studying the effect of thermal treatment: annealing is able to change significantly the thermal noise performance of materials and it is well monitored by changes in mechanical and optical responses. Finally, there will be the possibility to develop an interferometer that will detect vibrations through the measurement of the optical thickness variation.

OUTLOOKS :

This internship could be continued with a PhD work.

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] Cesarini E. et al. 2009, Rev. Sci. Instrum. vol.80, 053904 DOI: 10.1063/1.3124800

[5] Gilroy K.S. and Phillips W.A. 1981, Phis. Mag. B vol. 43, no. 5, pp. 735-746