SAPPHIRE FOR GRAVITATIONAL WAVE DETECTORS: MEASURING ULTRA LOW ABSORPTION LEVELS

LABORATORY : Institut Lumière Matière

LEVEL : M1 / M2
TEAM(S) : LUMINESCENCE

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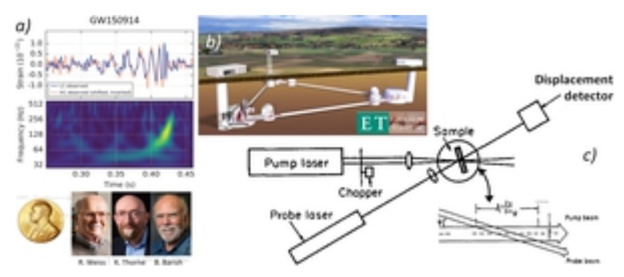
KEYWORD(S) : Gravitational Waves / Einstein Telescope / Sapphire

SCIENTIFIC CONTEXT :



a) GW first detection, b) Einstein Telescope, c) the setup to measure absorption

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].

The new European project for GW detection is called Einstein Telescope (ET) [3] and it will be built in the decade of the 30s. This detector will contain different interferometers, some of them at cryogenic temperatures. The group g-MAG at iLM is developing the technology of sapphire for mirrors substrates and suspensions to be used in the cryogenic environment thanks to the 1.2 M€ project OSAG. Absorption of substrate materials need to be at the ultra-low level of 10 ppm/cm or less and the research is focused on finding the origin of the absorption that converts the light energy in heat (photon to phonon conversion). Usually absorption is measured through the light attenuation but in this case scattering and photon-to-photon conversion processes contribute to absorption introducing a systematic error. Therefore, the group g-MAG at iLM is developing a bench that will measure only the light-to heat conversion (through the mirage effect [4]) at multiple wavelengths.

MISSIONS :

Although the mirage effect has been applied in several benches around the world, in the one we would like to develop at the iLM we will use tens of different wavelengths so that, at the end, the absorption measurement will become a spectrometric one. Since high power lasers are either not available or very dear, then an ultra-sensitive detector has to be developed. This is the minimal goal of this project: the design, realisation and characterization of a two-axis laser beam displacement detector. The displacement is detected by photodiodes and a feedback system will keep the detector always at the maximum sensitivity position.

Depending on the level of the stage and on the qualities of the selected candidate the project could continue with the assembling of the entire setup and possibly with the first measurement on a sapphire substrate.

OUTLOOKS :

This internship could be continued with a PhD work.

BIBLIOGRAPHY :

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

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

[3] http://www.et-gw.eu/
https://www.youtube.com/watch?v=HJGVs6-wJG4

[4] Jackson W.B. et al., 1981, APPLIED OPTICS, vol. 20, no.8, pp. 1333-1344

published on 08/10/2021