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Towards a better understanding of the influence of synthesis parameters on low thermal noise coatings structure

Three years ago, the LIGO-Virgo collaboration announced the first detection of gravitational waves generated by a merger of two black holes. This happens one hundred years after the predictions of Einstein and this event is the beginning of a new way to observe universe. Gravitational wave detectors are modified Michelson interferometer in which both 3km arms are Fabry-Perot cavities, each cavity being composed of two mirrors. Since 14 September 2015, five more signals were detected and more sensitive detectors are needed to acquire more signals in order to better understand universe and its formation. At the present time, detection is mainly limited by thermal noise of the Bragg mirror coatings which is directly connected to mechanical losses (also named internal friction) via the fluctuation-dissipation theorem. At the moment, mirrors are composed of alternative thin films made of amorphous SiO_2 as low index material and amorphous TiO_2 doped Ta_2O_5 as high index material. In few years, new materials having mechanical losses three times lower than the current materials have to be proposed as new mirror coatings in order to allow a better understanding of universe thanks to gravitational astronomy.

In this context, we propose a master subject on the impact of deposition parameters on the structure of amorphous films at different scales (from atomic scale to hundreds nm). This systematic study wasn't performed at the moment and it is essential for improving mirror coatings. Different compositions (SiO_2, TiO_2, HfO_2) will be deposited by evaporation with ion assistance. This physical vapor deposition consists in vaporizing source material with ion beam and this vapor phase goes back to thin film condensed phase. In order to tune the compacity of the film, a neutral beam is used to irradiate the growing film. The current coatings (SiO_2 and TiO_2 doped Ta_2O_5) have been improved by an empirical way and now it's important to better understand the influence of each deposition parameter.

At the end of the internship, the master student will acquire skills on vibrational spectroscopies (Raman, Brillouin and acoustic spectroscopies) and will have a good knowledge on amorphous films.

Gianpietro Cagnoli and Valérie Martinez belong to Virgo collaboration and Gianpietro Cagnoli is the leader of the coating group (Virgo coating R&D). This internship is part of a project financed by the French research agency (ANR) whose aim is to better understand the fundamental physic of low temperature physical vapor deposition. This internship could lead to a PhD thesis.