

XXXIV CYCLE PH.D. COURSE IN PHYSICS:

Final year report

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Working with: Giacomo Ciani, Livia Conti

Research subject and activity

The second year of my PhD study has been dedicated to the study of the impact of stray light in the sensitivity of the gravitational wave detector Virgo (PI).

Starting from mid-October, I mastered the commercial raytracing software FRED and performed stray light numerical simulations focusing on the squeezing (SQZ) subsystem, with the goal of determining the most critical optical elements and developing mitigation strategies. The main results obtained from these studies have been the proposal of the installation of two baffles inside the vacuum minilink between the detection bench (SDB1) and the SQZ bench, and of two baffles inside the filter cavity (FC), which is under construction.

The stray light study triggered the beginning of a quasi-from scratch analysis of the dust particulate deposition in the cleanroom environments in Virgo. With the collaboration of an undergraduate student from the University of Florida, a new method for extracting the particle counts from dust witness samples has been developed. The idea is to extend the study to other Virgo subsystems, thus proving a reliable way to determine the surface particle distribution slope of the optics on the benches.

Research activity on site (Virgo interferometer)

In the first part of the year, the activity on site concerned only the laboratory located in the 1500W building, hosting a R&D experiment on quantum optics.

Carrying on the last year's research, at the moment the optical setup is complete and fully operating, and soon it will be modified in order to get its second phase, featuring a new technology involving the EPR entanglement.

In the second part of the year, the on-site activity was dedicated to the pictures of dust witness samples inside Virgo's detection cleanrooms. The images were taken by using a camera alongside a high-resolution lens and with an illuminating LED ring set.

Research activity in Padova (Legnaro National Laboratories)

Part of my simulation activity was done at LNL (PD), where under the supervision of L. Conti and G. Ciani I got familiar with the software FRED and started the first tests in order to understand how it works and how we could use it for our purposes.

Conferences and workshops

Seminar on FRED Optical Simulation in Munich, 15-18 October

Commissioning Training follow-up in Virgo, 3-5 December (presentation)

Virgo Week, 27-31 January

Virgo Week, 27-30 April (presentation)

Commissioning Training follow-up, 25th May (presentation)

Virgo Week, 06-09 July (presentation)

Commissioning Training follow-up, 24th July (presentation)

Papers

Increasing the astrophysical reach of Advanced Virgo via the application of squeezed vacuum states of light, B. D'Angelo et al. (Virgo Collaboration) *Phys. Rev. Lett.* 123, 231108 – Published 5 December 2019

Sensitivity enhancement via vacuum squeezed injection in Advanced Virgo, B. D'Angelo on behalf of the Virgo Collaboration *Journal of Physics: Conference Series*, Volume 1548, 10th Young Researcher Meeting 18-21 June 2019, Rome, Italy

EPR experiment for a broadband quantum noise reduction in gravitational wave detectors, B. D'Angelo et al. (2020). *Proceeding of the GRavitational-waves Science&technology Symposium (GRASS) 2019*. Zenodo. <http://doi.org/10.5281/zenodo.3554320>

Automated source of squeezed vacuum driven by finite state machine based software, B. D'Angelo et al. (Virgo Collaboration), to be submitted

Quantum back-action on kg-scale mirrors -Observation of radiation pressure noise in the Advanced Virgo detector, B. D'Angelo et al. (Virgo Collaboration), to be submitted