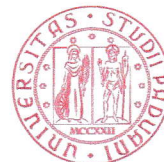


1222-2022
800
ANNI



UNIVERSITÀ
DEGLI STUDI
DI PADOVA

**PhD course of National Interest in Technologies for
Fundamental Research in Physics and Astrophysics**

Annual report

Name and surname: Moreno Nacca

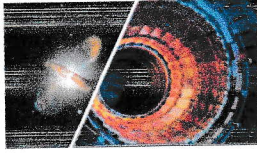
Cycle and a.a.: XL cycle A.A 2025/2026

Supervisor: Prof. Luca Esposito

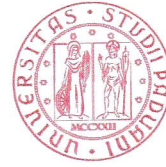
- Research activity carried out during the year**

The research project aims to study and develop a new system able to filter out the seismic noise for the next generation of ground-based gravitational wave detectors. The main difference between the SuperAttenuator (SA) and this new system is the fact that rather than having one Invert Pendulum (IP) like the SuperAttenuator, this design relies on two IPs in cascade as a pre-isolator for the test mass. This new structure is called Nested Inverted Pendulum (NIP). To validate the simulated performances in terms of seismic isolation of the NIP, an experimental setup is required. Furthermore, the elastic stability of the system must be investigated both experimentally and theoretically thanks to simulation and to a reduced-scale prototype of the NIP, which will be built in the INFN Physics Laboratory in Naples for Einstein Telescope (PLaNET).

During the first year it has been necessary to obtain the required knowledge in the field of gravitational wave detectors and the understanding of the overall functioning of a system as complex as the SuperAttenuator. Then, an intensive study of the literature was mandatory. The simulation of the Nested Inverted Pendulum dynamics relies on OCTOPUS, a simulation tool (based on MATLAB) used in the simulation of the VIRGO dynamics, which was adapted to the case of the NIP. A basic knowledge of OCTOPUS is therefore necessary to simulate and design the NIP, and the first step in acquiring the required competencies was to study the available literature. In designing the NIP, ensuring the mechanical strength of all components is mandatory. Some components in NIP bear very high levels of mechanical stress, so an accurate FEM analysis and an appropriate choice of materials were fundamental to preventing the components failure. Also, the NIP is based on a very streamlined structure, so elastic stability was studied to understand its behavior when the compressive effect of gravity becomes predominant in the dynamics of the system. To study dynamic aspects of the NIP, a simplified model (both analytical and FEM) was developed with a focus on the longitudinal transfer function. This choice is motivated by the fact that for this system the first natural frequency is related to a longitudinal vibration and to elastic instability, representing a crucial point to explore.



1222-2022
800
ANNI



UNIVERSITÀ
DEGLI STUDI
DI PADOVA

**PhD course of National Interest in Technologies for
Fundamental Research in Physics and Astrophysics**

- **List of attended courses and passed exams**

1. STATISTICAL PROCESS MONITORING OF COMPLEX ENGINEERING DATA (3CFU)
2. Analysis and Modelling of the Additive Manufacturing
3. Generative Design for smart Additive Manufacturing
4. All models are Uncertain

- **List of attended conferences, workshops and schools, with mention of the presented talks**

1. ICEM-21 (INTERNATIONAL CONFERENCE ON EXPERIMENTAL MECHANICS)

- **List of published papers/proceedings**

1. A Nested Inverted Pendulum as a Possible Pre-Isolator for the ET-LF Seismic Isolation System
(<https://doi.org/10.3390/galaxies13020021>)

- **Thesis title (even temporary)**

New Generation SuperAttenuator (NGSA) for the Einstein Telescope Low Frequency detector (ET-LF)
Test Mass Suspension

Date, 08/09/2025

Signature...

Seen, the supervisor