Curriculum 1 - Observation of the Universe

- (1A) Multi-wavelength observations of Galactic and extragalactic compact objects and transients

Funding institution: Scuola Universitaria Superiore IUSS of Pavia
Doctoral site: Scuola Universitaria Superiore IUSS of Pavia
Contact: Paolo Esposito [paolo.esposito@iusspavia.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months [Universiteit van Amsterdam, de Nederlandse]
Periods in companies/research centres/public administrations: optional

This position involves working on Galactic and extragalactic compact objects (white dwarfs, neutron stars and black holes) and astrophysical transients. Specifically, the scholarship is intended to study cutting-edge fields such as magnetars, ultra-luminous X-ray sources, bursts from compact objects, fast radio bursts, gamma-ray bursts, and tidal disruption events. The successful candidate will work on the analysis of data at all wavelengths from space and ground-based instruments, on their interpretation, and on the optimization of observation and data mining strategies. It will also be possible to participate in the development of new observatories and instruments.

- (1B) Combined Study of Data from Space Probes Observing Galactic, Extra-Galactic, Cosmological Systems, Methods of Combined Analysis, Interpretation, Theoretical Constraints [Progetto “Space It Up!” – Accordo di collaborazione ex art. 15 della L. n. 241/1990 con GSSI – Contratto ASI n. 2024-5.E.0 – CUP master: I53D24000060005 (nell’ambito del bando ASI PE M4 C2 I1.3, finanziato dall’UE – NextGenerationEU)]

Funding institution: Scuola Internazionale Superiore di Studi Avanzati
Doctoral site: Scuola Internazionale Superiore di Studi Avanzati
Contact: Carlo Baccigalupi [bacci@sissa.it]
Funds: Project Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

SISSA (sissa.it) participates with roles of responsibility to several global programs for the investigation of fundamental physics through Space Research for the Observations of the Universe, in an integrated manner with other Institutions in the network represented by the SST PhD. The targets of these campaigns concern Cosmological and Astrophysical Gravtational Waves (CGWs, AGWs), Cosmic Microwave Background (CMB), Large Scale Structure (LSS) and Dark Marter (DM), Galaxy Formation and Evolution (GFE), AstroChemistry (AC), High Energy Astrophysics (HEA) and Compact Objects (CO).

Space Programs at SISSA include the LiteBIRD Satellite for the observations of CGWs from CMB Polarization, as well as the Euclid Satellite for LSS, Global Astrometric Interferometer for Astrophysics (GAIA), the James Webb Space Telescope (JWST), and the preparatory work for the Interferometer Space Antenna (LISA).

In addition, SISSA leads areas of work in relation to Ground-Based observatories exploiting technology operating in Space, in particular for what concerns the combination of Ground and Space based probes, such as the Simons Observatory and CMB-Stage IV for CMB research of primordial

gravitational waves, the Atacama Large Millimeter/Sub-Millimeter Array (ALMA) and the Squared Kilometer Array (SKA) for LSS, GFE, AC, the LIGO/VIRGO and Eistein Telescope (ET) for the AGWs observations and CO investigations.

Moreover, SISSA leads the study and exploitation of innovative Data Science based methods of analysis in these contexts, with the design of the innovative Statistical and Learning algorithms which are necessary to deal with the complexity of the Datasets coming from the Probes listed above, both in the analysis and combination.

Applications are welcome on each of these research lines, characterized by diversity and balance in all respects, from motivated young scientist, to undertake a PhD Program in SST in relation to the programs above. The latter possesses an high level of integration between Italian institutions participating to the PhD and of course centers of research abroad, connected with the quoted projects. The students are expected to attend a series of courses to be specialized for the PhD Program, share the research with other Institutions within the SST PhD, and spend a minimum period of 6 months abroad.

- (1C) Compact objects and Physical Processes: Insights from Space Data

Funding institution: National Institute for Astrophysics - INAF

Doctoral site: National Institute for Astrophysics – INAF, IASF Palermo

Contact: Luciano Burderi [burderi@dsf.unica.it]

Funds: Own Funds

Mobility abroad: compulsory, minimum 6 months

Periods in companies/research centres/public administrations: optional

INAF is strongly involved in current and future space mission for high-energy astrophysics which are (also) dedicated to the physics of isolated or accreting compact objects (such as Neutron Stars and Black hole), and more in general to the transient Sky.

The research project involves analysing data from current X-ray and gamma-ray space instruments by using different techniques such as, spectral, timing and polarimetry.

Multi-wavelength observations will be also performed and analysed.

The student will be integrated into international projects within INAF and will have the opportunity to collaborate with colleagues from different INAF Departments (Rome, Milan, Padua) and Universities (Cagliari, Palermo) within a stimulating research environment.

- (1D) Theoretical, observational or experimental cosmology and multimessenger astrophysics at the University of Ferrara

Funding institution: University of Ferrara

Doctoral site: University of Ferrara

Contact: Paolo Natoli [paolo.natoli@unife.it]

Funds: Own Funds

Mobility abroad: compulsory, minimum 6 months [several choices are possible depending on the actual research project chosen in Europe, the US, China and Japan, including space agencies]

Periods in companies/research centres/public administrations: optional

The position is open to candidates interested in theoretical, observational or experimental cosmology and multimessenger astrophysics. Possible specific fields of interest are particle cosmology, the cosmic microwave background, the large scale structure of the Universe and their cross correlations with other probes, cosmology and astrophysics of galaxy clusters, gamma ray bursts,

multimessenger observations of compact object via electromagnetic and gravitational wave signatures. The candidate is expected to work on the interpretation of satellite data and in the planning of future space borne missions.

- (1E) Next-Generation Gravitational Wave Astronomy at INAF: Exploring Astrophysical Frontiers with LISA

Funding institution: National Institute for Astrophysics - INAF
Doctoral site: National Institute for Astrophysics – INAF, Osservatorio Astrofisico di Arcetri – Firenze
Contact: Filippo Mannucci [filippo.mannucci@inaf.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

INAF is involved in current and future space mission for relativistic astrophysics.
This research project focuses on the Laser Interferometer Space Antenna (LISA), the upcoming ESA-led mission for gravitational wave (GW) detection in space. The research aims to develop data analysis techniques for identifying and characterizing low-frequency GW sources, such as supermassive black hole binaries. The student will contribute to waveform modeling, simulation pipelines, and scientific exploitation strategies, helping to prepare for the mission's launch and first data.
The PhD candidate will also explore synergies and joint detection strategies between LISA and future ground-based detectors like the Einstein Telescope (ET), enabling multi-band GW astronomy.
The student will be integrated into international projects within INAF and will have the opportunity to collaborate with colleagues from different Research Institutes within a stimulating research environment.

Curriculum 2 – Earth and the Sun-Earth system

- (2A) Radiative transfer modelling in support of greenhouse gas source identification and emissions estimates (CUP: F63C25000370005)

Funding institution: Agenzia Spaziale Italiana - ASI
Doctoral site: University of Bologna
Contact: Tiziano Maestri [tiziano.maestri@unibo.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

The united Nation Environment Program has recently recognised the detection and reduction of unintended greenhouse gas (including methane) emissions from anthropogenic activities as a key mean to decrease the concentration of greenhouse gases in the atmosphere. The present project aims at implementing a pseudo-monochromatic radiative transfer model at shortwave radiation to support the identification of methane and other greenhouse and pollutant gas sources. The model shall be adapted to reproduce the Hyperspectral, Multispectral and Optical imagers of the Iride constellation that will provide key observations for the monitoring of environmental parameters including surface and aerosols. The identification of gas emission sources will be obtained using an

improved Matched Filter methodology applied to hyper-spectral optical instruments of the Irideconstellation. Prisma will be used as testbed for this task before the availability of the Irideconstellation's data. From the Iride multispectral and optical imagers, a classification of the surface properties will be achieved by applying machine learning methodologies and artificial intelligence. The characterisation of surface reflectivity is critical for the estimation of the emission fluxes and to disentangle anthropogenic from natural emissions.

- (2B) Study on the use of new observing technologies from space for spatially explicit estimation of forest variables (CUP: F63C25000370005)

Funding institution: Agenzia Spaziale Italiana - ASI
Doctoral site: University of Florence
Contact: Gherardo Chirici [gherardo.chirici@unifi.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

Technological advancement in the field of observation from space now makes available more and more data sources with increasing spatial resolution, temporal frequency, and spectral and radiometric detail, whether passive (multi or hyperspectral) or active (radar) technologies. On the other hand, the source of data for deriving official estimates of descriptive variables of forest ecosystems (extent, biomass, pollutant removal, biodiversity) and their dynamics over time are based on traditional forms of ground surveys based on formal statistical sampling plans. The theme of the doctoral project is the development of modern systems for spatially explicit estimation of these forest variables by integrating ground surveys with multi-sensor remote sensing imagery, such as that acquired by the IRIDE satellite system, with machine learning and artificial intelligence algorithms. These methods may in the future provide an innovative new approach for developing new forest monitoring systems, including in the context of climate change scenarios.

- (2C) The Solar Corona: Diagnostics and Instrumentation for Space Weather Investigations from Multiple Solar Missions (CUP Master: I53D24000060005; CUP INAF: C53C24000360005)

Funding institution: National Institute for Astrophysics - INAF
Doctoral site: National Institute for Astrophysics – INAF, Astrophysical Observatory of Turin
Contact: Silvano Fineschi [silvano.fineschi@inaf.it]
Funds: Project Funds “Space It Up”
Mobility abroad: compulsory, minimum 6 months. Royal Observatory of Belgium (TBC)
Periods in companies/research centres/public administrations: optional

INAF has developed space instruments and diagnostics of their data to derive the physical conditions of the solar corona. The Sun is the driving force behind the dynamics of the heliosphere and the interplanetary space, playing a critical role in shaping the space environment and triggering Space Weather events.
The goal of this PhD research is to improve our understanding of the solar coronal phenomena and their impact on the heliosphere. This will be achieved by analyzing data from solar missions with key INAF contributions: Solar Heliospheric Observatory (SOHO), Solar Orbiter, PROBA-3, CODEX/ISS, with a particular focus on multi-wavelength observations from UVCS/SOHO, Metis/Solar Orbiter, and ASPIICS/PROBA-3 coronagraphs. Diagnostic techniques, and theoretical and forward modeling

based on these data will provide the physical parameters of the coronal plasma and shed light on the mechanisms energizing its dynamics.
The student will be integrated into ongoing national-level projects within the framework of the ASI Space-It-Up and ESA SWESNET projects, which aim at developing advanced models, s/w tools and instrumentation for Space Weather prediction.

- (2D) Numerical Simulations for forecasting Extreme and Nonlinear Events in the Earth and the Sun-Earth system (Contract No. 2024-5-E.0 - CUP No. I53D24000060005)

Funding institution: University of Calabria
Doctoral site: University of Calabria
Contact: Sergio Servidio [sergio.servidio@fis.unical.it]
Funds: Project Funds – Space It Up
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

The PhD project focuses on the development of high-order shock-capturing numerical methods for accurately modeling nonlinear phenomena, such as shock waves and large-amplitude waves, in both magnetized plasmas (space weather) and unmagnetized fluids (oceanography). The research will advance theoretical and computational techniques in the framework of shock-capturing schemes, with particular emphasis on refined boundary condition modeling using innovative approaches like the surface gradient method and cut-cell techniques. The ultimate goal is to create a highly parallelized, GPU-optimized computational tool capable of real-time simulation of hazardous events, with direct applications to space weather forecasting and tsunami prediction in coastal regions.

- (2E) Modeling of Solar Wind and Magnetospheric Nonlinear Phenomena via Adavnced Simulations and Observations (Contract No. 2024-5-E.0 - CUP No. I53D24000060005)

Funding institution: University of Calabria
Doctoral site: University of Calabria
Contact: Sergio Servidio [sergio.servidio@fis.unical.it]
Funds: Project Funds – Space It Up
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

Understanding and predicting space weather events is crucial for safeguarding modern technological infrastructure, from satellite communications to power grids. This PhD project focuses on the nonlinear modeling of solar wind dynamics and its coupling with Earth's magnetosheath, magnetosphere, and ionosphere, combining state-of-the-art numerical simulations (magnetohydrodynamics, Vlasov, and Particle-in-Cell methods) with cutting-edge in situ data from missions such as Solar Orbiter, Parker Solar Probe, and the Magnetospheric Multiscale Mission (MMS). The research will investigate turbulence and large-scale plasma structures in the heliosphere, with a dual approach: (1) by using high-fidelity kinetic and fluid simulations to resolve multiscale plasma processes, and (2) with a data-driven validation using the latest spacecraft observations. The ultimate goal is to improve the comprehension of space weather phenomena, by bridging the gap between theory, simulations, and real-world measurements.

- (2F) Innovative methods for Earth Observation using the CSES Constellation (CUP E53D23004090006)

Funding institution: University of Trento with the financial support of the Autonomous Province of Trento
Doctoral site: University of Trento
Contact: Roberto Battiston [roberto.battiston@unitn.it]
Funds: Project Funds – PRIN 2022
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

The CSES 1/2 constellation consists of two state-of-the-art satellites launched into orbit in 2018 and 2025, respectively, in sun-synchronous orbit and offset by 180 degrees from each other. The constellation is dedicated to studying the environment “close” to planet Earth by measuring, for the first time simultaneously and in a correlated manner, the physical variables that characterize the ionosphere: electric fields, magnetic fields, trapped ions and particles, and ionospheric plasma. The thesis will focus on the study of the correlation between two satellites with the aim of improving the measurement of rapid geophysical phenomena (earthquakes, volcanoes, tsunamis), as well as the measurement of atmospheric, ionospheric, space weather, and astrophysical phenomena detectable with the instruments on board the constellation.

Curriculum 3 - Planetary Sciences

- (3A) The Moon’s Surface Composition, Environment, and Active Physical Processes: Insights from Space Data and Laboratory Experiments (CUP Master: I53D24000060005; CUP INAF: C53C24000360005)

Funding institution: National Institute for Astrophysics - INAF
Doctoral site: National Institute for Astrophysics – INAF, Astronomical Observatory of Capodimonte - Naples
Contact: Francesca Esposito [francesca.esposito@inaf.it]
Funds: Project Funds “Space It Up”
Mobility abroad: compulsory, minimum 6 months. Università di Nantes (TBC)
Periods in companies/research centres/public administrations: optional

INAF is developing space instruments for the exploration and mapping of lunar resources and for studying the Moon’s environment, focusing on dust-plasma-surface interactions.

The research project involves analyzing data from past and current lunar missions to identify promising landing sites for INAF’s goals and to support the definition of scientific requirements for instruments under development.

The project also includes the study of physical processes acting on the Moon through their reproduction in a simulated laboratory environment. INAF operates a lunar simulation chamber capable of reproducing the thermal, UV radiation, plasma, and dust conditions found on the lunar surface.

This setup allows for both the simulation of the physical phenomena to be studied on the Moon and the testing of instrument response under lunar-like conditions.

The student will be integrated into ongoing national-level projects within INAF and will have the opportunity to collaborate with colleagues from multiple institutes (Naples, Padua, Rome, Trieste, Bologna), within a stimulating and broad-reaching research environment.

- (3B) Future planetary missions will integrate autonomous robotics with human-led operations across mobility, mining, and habitat construction

Funding institution: University of Chieti- Pescara

Doctoral site: University of Chieti- Pescara

Contact: Francesco Salese [francesco.salese@unich.it]; Gian Gabriele Ori [giangabriele.ori@unich.it]; Valentina Sumini

Funds: Own Funds

Mobility abroad: compulsory, minimum 6 months [Universitat Politecnica de Catalunya, Barcelona; University of Technology Delft, The Netherland]

Periods in companies/research centres/public administrations: optional

This project investigates two strands: (1) developing a high-fidelity Virtual Reality environment for planning, controlling, and simulating complex surface operations with robotic rovers, crewed vehicles, and remote-control centers; and (2) designing swarm-based collaborative autonomy, where heterogeneous robots self-organize and adapt in unstructured environments.

The first strand emphasizes immersive platforms to test coordination and decision-making in realistic mission scenarios. The second explores decentralized intelligence for distributed task execution without central control.

Both components will be modeled and validated in advanced VR simulations with realistic physics, occlusion, and stochastic events. These items will support testing of multi-agent coordination, human-robot interfaces, and adaptive learning. The ideal candidate has a multidisciplinary background in robotics, VR simulation, and autonomy, with strong interest in space systems.

(3C) Artificial intelligence methodologies for the analysis of planetary radar sounder data (CUP E83C22000040006)

Funding institution: University of Trento

Doctoral site: University of Trento

Contact: Lorenzo Bruzzone [Lorenzo.bruzzone@unitn.it

Funds: Project Funds (ASI Missione JUICE Bruzzone)

Mobility abroad: compulsory, minimum 6 months

Periods in companies/research centres/public administrations: optional

The JUpiter ICy moons Explorer (JUICE) is the first mission directed in the outer part of the Solar system completely developed by the European Space Agency). It was launched in April 2023 toward the Jupiter system (see https://sci.esa.int/web/juice for more details on the mission). Some of the most challenging science objectives of this mission are related to the analysis of sub-surface processes in the Jupiter icy moons Europa, Ganymede and Callisto. These are of crucial importance for the possible detection of water in the subsurface that would support hypothesis on the presence of life.

The research activities of this grant are related to the Radar for Icy Moon Exploration (RIME), which is the instrument on JUICE that will explore the subsurface of the icy moons. The activity will be focused on the development of methodologies for the processing and the automatic analysis of RIME data. Special emphasis will be given to methodologies that exploit the most recent developments in

the framework of machine learning and artificial intelligence. The methodologies will be developed to be applicable also to other radar data from different missions.

Research will be developed at the University of Trento, Department of Information Engineering and Computer Science, Remote Sensing Laboratory (https://rslab.disi.unitn.it/).

Curriculum 4 - Astrobiology, Life Sciences and Space Medicine

- (4A) Human Life Science and Space Medicine - Physiological and biological bases of space adaptations: quantitative approaches (CUP E83C22000040006)

Funding institution: University of Rome “Tor Vergata”
Doctoral site: University of Rome “Tor Vergata”
Contact: Myrka Zago [myrka.zago@uniroma2.it]
Funds: Project Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

Future human space exploration programs represent extraordinary milestones for the sustainable development of our civilization, contributing to our social and economic well-being. However, these programs also pose significant challenges to human health. The main objective of the research is to study the physiological and biological bases of space adaptations, sensory deconditioning, and the internal model of gravity.

Understanding these aspects is crucial for developing effective countermeasures to protect astronauts' health during long-duration space missions. This research will provide insights into how the human body adapts to the microgravity environment of space and the implications for long-term human presence beyond Earth. The PhD program in Space Sciences and Technology, offered by the University of Rome Tor Vergata, focuses on Human Life Science and Space Medicine. This program specifically addresses the physiological and biological bases of space adaptations, aiming to equip researchers with the knowledge and skills needed to tackle these complex challenges and contribute to the future of human space exploration.

- (4B) Gender and Biological Differences in Space: Advancing Women's Psychophysical Well-being in Space Missions

Funding institution: University of Turin
Doctoral site: University of Turin
Contact: Raffaella Giovanna Nella Ricci [raffaella.ricci@unito.it]; Silvia De Francia [silvia.defrancia@unito.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

This project investigates the biological and gender-specific factors influencing the physical and neuropsychological well-being of women in space environments—a critical yet underexplored area

of research in human space exploration. The project addresses a wide spectrum of health-related challenges, including menstrual cycle regulation, hormonal variations, neurocognitive changes and psycho-physical wellbeing, particularly under the unique stressors of microgravity, isolation, confinement, and extreme environmental conditions. By exploring these gender-specific responses to space environments, the research aims to inform the design of more inclusive and effective countermeasures for long-duration missions. Beyond its implications for space exploration, the project is expected to yield valuable insights applicable to women's health on Earth, potentially improving medical practices and quality of life in remote, high-stress, or extreme environments.

- (4C) Therapeutic approaches for muscle wasting with repurposed drugs

Funding institution: University of Turin
Doctoral site: University of Turin
Contact: Paolo Ettore Porporato [paolo.porporato@unito.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months [Karolinska Institutet, Stoccolma, Svezia]
Periods in companies/research centres/public administrations: optional

This research project focuses on the prevention of skeletal muscle wasting induced by microgravity, a major challenge for long-term spaceflight and immobilization conditions. Building on ongoing research in cancer-induced muscle atrophy, the PhD candidate will repurpose available drugs to counteract microgravity-triggered muscle degradation. Using state-of-the-art techniques, the candidate will develop and validate innovative in vitro models, including organoids, to simulate microgravity conditions and study muscle atrophy mechanisms. This translational approach aims to identify effective therapeutic strategies for muscle preservation in space and clinical settings.

Curriculum 5 - Space sensing and instrumentation

- (5A) Foundation models for anomaly detection of ionospheric phenomena and correlation with seismo-induced events

Funding institution: Fondazione Bruno Kessler FBK
Doctoral site: Fondazione Bruno Kessler FBK
Contact: Marco Cristoforetti [marco.cristoforetti@fbk.eu]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

The Limadou project gathers some Italian institutions participating in the China Seismo Electromagnetic Satellite (CSES) mission. CSES consists of a constellation of satellites, designed to pursue the deepest campaign of observation of the ionosphere. One of the most important scientific goals of the mission is to look for correlations between transient phenomena in the ionosphere and seismic events. The successful candidate will develop and apply state-of-the-art machine learning techniques to enhance the detection of ionospheric anomalies and their potential correlations with seismic activities. In particular, the research will focus on employing foundation models that can interpret complex patterns in space and time observations. Candidates with a strong background in data science, machine learning, and space physics are encouraged to apply. This position offers the opportunity to work with leading experts and institutions, including collaborations with INFN-TIFPA and Fondazione Bruno Kessler.

Intellectual Property Notice for PhD candidates under the UniTrento-FBK Agreement

Please read the following information carefully before submitting your application.

Intellectual Property of Research Results.The intellectual property rights of research results generated by PhD students under scholarships within the UniTrento-FBK Agreement shall belong to FBK.

Transfer of Intellectual Property Rights. FBK will establish agreements with PhD students regarding the transfer of intellectual property rights related to their research results.

Collaboration with UniTrento. If UniTrento academic staff contribute to research results obtained through PhD scholarships funded by FBK, the determination of IP shares will be defined through separate written agreements based on each party's contribution. PhD students are required to collaborate with UniTrento in all necessary activities related to the joint management of IP.

- (5B) Development of Readout and Control Electronics for Silicon-Based Detectors Using FPGA Technologies

Funding institution: Fondazione Bruno Kessler FBK

Doctoral site: Fondazione Bruno Kessler FBK

Contact: Giancarlo Pepponi [pepponi@fbk.eu]

Funds: Own Funds

Mobility abroad: compulsory, minimum 6 months

Periods in companies/research centres/public administrations: optional

This PhD project focuses on the development of FPGA-based readout and control electronics for silicon-based detectors, with applications in high-energy physics and astroparticle physics, including cosmic ray studies, dark matter searches, and high-energy astrophysical phenomena. Silicon detectors are widely used in modern experiments due to their excellent spatial resolution, radiation hardness, and fast response time. However, achieving efficient data acquisition and real-time signal processing requires advanced electronic systems capable of handling high data rates with low latency and high reliability.

The research will involve designing and implementing FPGA-based architectures optimized for detector readout, including:

High-Performance Data Acquisition: Developing firmware and hardware solutions to ensure efficient signal processing, noise reduction, and synchronization in complex detector systems.

Real-Time Processing and Control: Implementing algorithms for fast decision-making, trigger logic, and error correction, leveraging FPGA parallelism and flexibility.

Scalability and Integration: Designing modular systems that can be adapted to different experimental setups, ensuring compatibility with large-scale high-energy physics and astroparticle physics experiments.

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Collaboration with UniTrento. If UniTrento academic staff contribute to research results obtained through PhD scholarships funded by FBK, the determination of IP shares will be defined through

separate written agreements based on each party's contribution. PhD students are required to collaborate with UniTrento in all necessary activities related to the joint management of IP.

- (5C) Advanced Silicon Sensors for Space Applications

Funding institution: Fondazione Bruno Kessler FBK
Doctoral site: Fondazione Bruno Kessler FBK
Contact: Matteo Centis Vignali [mcentisvignali@fbk.eu]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

This PhD project focuses on the development of advanced silicon radiation sensors with applications in materials analysis, high energy physics and astrophysics. Silicon detectors are widely used in modern experiments and differentiate design and process according to the main key parameter for the application, spectroscopy, timing, imaging/tracking and the spectral region addressed.
The study will involve sensors for charged particles timing and X-ray spectroscopy, in particular :

- Characterization of large-area sensors for timing, Low Gain Avalanche Diodes, LGADs
- Development and characterization of slim edge/active edge silicon drift detectors

The experimental activities will encompass, electrical characterization using probe stations, functional characterization using pulsed lasers and radioactive sources, data analysis. The candidate is expected to participate in the design and simulation of the silicon sensors.

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Transfer of Intellectual Property Rights. FBK will establish agreements with PhD students regarding the transfer of intellectual property rights related to their research results.
Collaboration with UniTrento. If UniTrento academic staff contribute to research results obtained through PhD scholarships funded by FBK, the determination of IP shares will be defined through separate written agreements based on each party's contribution. PhD students are required to collaborate with UniTrento in all necessary activities related to the joint management of IP.

- (5D) Photonics for space applications

Funding institution: Consorzio nazionale interuniversitario per le telecomunicazioni - CNIT
Doctoral site: Consorzio nazionale interuniversitario per le telecomunicazioni – CNIT, PNTLAB-PISA
Contact: Paolo Ghelfi [paolo.ghelfi@cnit.it]; Luca Rinaldi [luca.rinaldi@cnit.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

Photonics is an emerging technology for the space sector, transforming applications such as telecommunications, navigation, remote sensing, and Earth observation (EO).

The research group at PNTLab has a renowned experience in microwave photonics, with running activities on (i) RF over fiber for signal distribution, (ii) optical feeder links for high throughput satellites, (iii) photonics based radars and SARs for EO, including photonic RF beamforming, (iv) synchronized radar constellations, and (v) photonic generation of RF signals. The group is also approaching the field of astro-photonics (astronomical instrumentation, e.g., wideband spectrographs). These activities have a system-focused approach, designing and developing architectures to boost the systems' performance, using the most up-to-date photonic technologies, including integrated photonics, hybrid integration, and space-compliant photonic packaging.
The PhD activity will be inserted in this vivid environment, taking advantage of the network of direct contacts with world-level academic and industrial partners.

- (5E) Design and prototype characterization of innovative high energy particle detectors for space application

Funding institution: National Institute for Nuclear Physics - INFN
Doctoral site: National Institute for Nuclear Physics – INFN Bari or Rome – Tor Vergata
Contact: Fabio Gargano [fabio.gargano@ba.infn.it]; Roberta Sparvoli [roberta.sparvoli@roma2.infn.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

The design and characterization of innovative high-energy particle detectors for space applications is a critical area of research that seeks to develop advanced technology capable of detecting and measuring high-energy particles in space. These detectors are essential for studying the space environment, such as the radiation levels in space, the properties of cosmic rays, and the behavior of high-energy particles. The design process involves the development of advanced prototypes, which are then characterized using a range of techniques to evaluate their performance and suitability for use in space missions. Ultimately, this research aims to improve our understanding of the space environment and support the development of space-based technologies.

- (5F) Development of high-sensitivity X-ray detectors for astronomical imaging, spectroscopy, and polarimetry (Progetto ASIX, Codice - FISA-2022-00393 - Avviso FISA D.D. 1405 del 13/09/2022)

Funding institution: National Institute for Nuclear Physics - INFN
Doctoral site: National Institute for Nuclear Physics – INFN, Pisa
Contact: Luca Baldini [luca.baldini@pi.infn.it]
Funds: Project Funds
Mobility abroad: compulsory, minimum 6 months [Tentatively: Goddard Space Flight Center, Greenbelt, Maryland]
Periods in companies/research centres/public administrations: optional

The main focus of the proposed activity is the development, test and characterization of innovative, detector systems for X-ray astronomy, with a holistic approach covering all the relevant technological aspects: the active sensor, the associated (front-end and back-end) readout electronics and the data acquisition system. The unifying theme is the design and realization of pixelated readout chips with an event-driven architecture, to act as charge-collecting anodes of hybrid detectors, where the active

medium can be implemented either in the form of a gas cell, or as a solid-state sensor. This basic approach provides large flexibility, and is amenable to be exploited toward several, diverse science objectives, including high-resolution, large throughput spectral imaging and high-sensitivity X-ray polarimetry.
The research group that will host the successful candidate has a long and outstanding track record in the development of innovative detectors and detector systems for high-energy astrophysics---most notably the Fermi LAT silicon tracker and the IXPE gas-pixel detectors.

(5G) Distributed radar sounder for mapping ice in the Earth's polar regions

Funding institution: University of Trento
Doctoral site: University of Trento
Contact: Lorenzo Bruzzone [lorenzo.bruzzone@unitn.it]
Funds: Project Funds (ESA DistSound)
Mobility abroad: compulsory, minimum 6 months.
Periods in companies/research centres/public administrations: optional

A major source of uncertainty for climate models is related to the limited understanding of the conditions of the polar ice sheets in Greenland and Antarctica. This is due to the lack of satellite missions capable to measure the status of the ice from the surface to the bedrock. Recent studies and research activities resulted in the definition of the SaTellite RAdar sounder for earTh sUbsurface Sensing (STRATUS) mission concept. STRATUS is a satellite mission for Earth Observation with an innovative VHR distributed radar sounder (RS) having the unique capability to obtain continuous and large-scale subsurface measurements in the polar ice to get new fundamental data that have not been acquired by any other past or present remote sensing mission on the Earth. The distributed radar sounder is based on a flying formation that implements a multistatic radar.

The research activities of this grant are related to the STRATUS concept. The research will be focused on the development of methodologies for the modeling of the ice sheets and ice shelves and the related simulation of the distributed radar sounder data and/or on the study and definition of the signal processing techniques needed for the processing of the data acquired by the flying formation and the generation of the radar products at different levels. These activities will consider new concepts and methods and are expected to result in very relevant scientific returns.

Research will be developed at the University of Trento, Department of Information Engineering and Computer Science, Remote Sensing Laboratory (https://rslab.disi.unitn.it/).

Curriculum 6 - Satellite Platforms: Engineering and Technologies

- (6A) Model-based system-software engineering and formal methods for space systems

Funding institution: Fondazione Bruno Kessler FBK
Doctoral site: Fondazione Bruno Kessler FBK
Contact: Marco Bozzano [bozzano@fbk.eu]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

Space systems have reached an unprecedented degree of complexity. The design process has to guarantee not only the functional correctness of the implemented system, but also its dependability and resilience with respect to run-time faults. Hence, the design process must characterize the likelihood of faults, mitigate possible failures, and assess the effectiveness of the adopted mitigation measures.

Formal methods have been increasingly used over the last decades to deal with the shortcomings of designing complex systems, in different domains. Formal methods are based on the adoption of a formal, mathematical model of the system, shared between all actors involved in the system design, and on a tool-supported methodology to aid all the steps of the design, from the definition of the architecture down to the final implementation in HW and SW.

The objective of this study is to advance the state-of-the-art in space system design using formal methods. In particular, it will investigate new techniques for model-based system and software engineering, to support the design, mission preparation and operations of space systems. The potential research directions include fault detection, isolation, and recovery (FDIR) for satellites and space exploration systems; system-level diagnosability, diagnosis and root-cause analysis; anomaly detection and FDIR based on machine learning techniques. Topics to be investigated include techniques for contract-based design and contract-based safety assessment, the analysis of the timing aspects of fault propagation, the characterization of transient and sporadic faults, the analysis of the effectiveness of fault mitigation measures in presence of complex fault patterns, the use of machine learning techniques for anomaly detection and fault classification and their integration with FDIR.

Intellectual Property Notice for PhD candidates under the UniTrento-FBK Agreement

Please read the following information carefully before submitting your application.

Intellectual Property of Research Results.The intellectual property rights of research results generated by PhD students under scholarships within the UniTrento-FBK Agreement shall belong to FBK.

Transfer of Intellectual Property Rights. FBK will establish agreements with PhD students regarding the transfer of intellectual property rights related to their research results.

Collaboration with UniTrento. If UniTrento academic staff contribute to research results obtained through PhD scholarships funded by FBK, the determination of IP shares will be defined through separate written agreements based on each party's contribution. PhD students are required to collaborate with UniTrento in all necessary activities related to the joint management of IP.

- (6B) Development of millimeter/sub-millimeter-wave components for Space payloads through Advanced Manufacturing

Funding institution: Consiglio Nazionale delle Ricerche - CNR

Doctoral site: CNR-IEIIT (Torino) or CNR-STIIMA (Milano)

Contact: Oscar Peverini [oscarantonio.peverini@cnr.it]; Irene Fassi [Irene.Fassi@stiima.cnr.it]

Funds: Own Funds

Mobility abroad: compulsory, minimum 6 months

Periods in companies/research centres/public administrations: optional

Within this Ph.D., the candidate will investigate the manufacturability of radiofrequency breadboards for Space applications exploiting advanced manufacturing technologies, both subtractive, such as micro-EDM, and additive, such as metal extrusion-based additive manufacturing and precision 3D printing of functionally graded materials. Indeed, next-generation payloads for SatCom (in GEO and LEO orbits), Earth Observation, and Space Science will require high-volume production of high-performance RF instrumentation operating from the Ka/Q/V bands (30-50 GHz) up to sub-millimeter

frequencies (200-600 GHz). These applications require manufacturing technologies able to fabricate high precision components with complex geometry and accurate micro-features, with high throughput, zero waste and sustainable footprint. In this context, precision manufacturing technologies play an enabling role for the development of innovative payloads in terms of performance and compatibility with platforms. This multi-disciplinary study will be carried out at the two institutes STIIMA (https://www.stiima.cnr.it) and IEIIT (https://www.ieiit.cnr.it) of the CNR in synergy with the research activities that the CNR carries out within European Space Agency programmes.

- (6C) Power processing and control for CubeSat scale air-breathing electric propulsion (CUP J53C23001840006)

Funding institution: Sant'Anna School of Advanced Studies Pisa
Doctoral site: Sant'Anna School of Advanced Studies Pisa
Contact: Tommaso Andreussi [Tommaso.Andreussi@santannapisa.it]
Funds:
Mobility abroad: compulsory, minimum 6 months. Justus Liebig University Giessen (TBC)
Periods in companies/research centres/public administrations: optional

The growing demand for satellite-based services is driving spacecraft miniaturization and the deployment of large constellations. To reduce environmental impact, future missions are moving toward very-low Earth orbits (VLEO), which offer better performance, lower radiation exposure, and natural debris mitigation. Sustained operations in VLEO require electric propulsion, with air-breathing electric propulsion (ABEP) being a promising solution. This PhD project focuses on power processing and control for CubeSat-scale ABEP systems. It aims to define the constraints and requirements of propulsion power electronics, study integration strategies within CubeSat platforms, and develop optimal control approaches for orbit maintenance under power limitations and varying atmospheric conditions. A key objective is the development of a power processing and control prototype tailored to ABEP in small satellite systems.

- (6D) Advanced models for the design and characterization of deployable antennas

Funding institution: Politecnico of Turin
Doctoral site: Politecnico of Turin
Contact: Erasmo Carrera [erasmo.carrera@polito.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months [California Institute of Technology]
Periods in companies/research centres/public administrations: optional

The design and characterization of large deployable structures, such as antennas, star shields or solar sails, pose significant challenges that require advanced modeling techniques. This research focuses on developing advanced models to enhance the design and characterization process of those structures.

One aspect of this research involves utilizing high order finite element modeling. These advanced numerical models will enable accurate prediction of the mechanical behavior, structural integrity, and overall performance of deployable antenna systems for example. By incorporating multi-scale mechanics, the interactions between various structural components at different length scales will be comprehensively understood and analyzed.

Furthermore, the research will explore the use of advanced materials, such as carbon fiber-reinforced polymer (CFRP) composites or soft hyperelastic materials, to optimize the performance, weight, and reliability of deployable antennas. The design considerations and manufacturing techniques specific to these materials will be studied and incorporated into the modeling process. Particular attention will be focused on the mechanics and multi-field analysis of multi-functional membranes, TRAC booms, collapsible longeron etc.

In addition to finite element simulations, multi-body analyses will be employed to investigate the dynamic behavior and deployment mechanisms of the antennas. These simulations will analyze the complex interactions between the deployable antenna structure, deployment mechanisms, and external forces, leading to improved designs and enhanced operational efficiency.

To validate and refine the developed models, experimental testing will be conducted. This hands-on approach involves constructing scaled prototypes, performing structural tests, and measuring critical performance parameters. The experimental results will be correlated with the numerical models to ensure accuracy and reliability.

This PhD position offers a stimulating research environment, access to state-of-the-art facilities, and collaboration opportunities with leading experts in the field of aerospace engineering. Prospective candidates with a strong background in aerospace engineering, mechanical engineering, or a related discipline are encouraged to apply. Proficiency in numerical modeling, finite element analysis, and programming languages will be advantageous.

- (6E) Computational modelling of damage and aging of structures and materials exposed to harsh extraterrestrial environments

Funding institution: University of Palermo
Doctoral site: University of Palermo
Contact: Ivano Benedetti [ivano.benedetti@unipa.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

Space missions like NASA's Artemis and ESA's ExoMars are pushing material science limits, exposing structures to extreme space environments, e.g. high and cryogenic temperatures, rapid thermal cycles, radiation, and particulate abrasion—causing thermal fatigue, aging, cracking, and wear that threaten long-term integrity. Mission success requires tools to simulate these coupled degradation modes.

The project will develop a multi-scale/physics high-performance computational framework for heterogeneous materials able to capture material and structural performance degradation under such complex loads. Starting from a tool already available in the research team, the framework will include: (i) extended multi-physics coupling, e.g. thermochemical and radiation effects, thermal cycles, etc.; (ii) extended constitutive modelling capabilities. It will support material selection, lifetime prediction, and mitigation strategies, including self-healing systems, for safer deep-space missions.

- (6F) Deep Learning techniques for inverse problem in imaging

Funding institution: University of Brescia & Be2net s.r.l.
Doctoral site: University of Brescia
Contact: Davide Pagano [davide.pagano@unibs.it]
Funds: Own Funds

Mobility abroad: compulsory, minimum 6 months [Laboratoire Hubert Curien, 18 RUE Pr Benoît Lauras 42000 SAINT-ETIENNE FRANCE]
Periods in companies/research centres/public administrations: optional

Inverse problems deal with the reconstruction of an unknown signal, image, or multi-dimensional volume from a set of observations, which are generally the result of a non-invertible forward process. A wide range of scenarios fall within this definition, such as deconvolution, image deblurring, inpainting, and so on. As inverse problems are usually ill-posed, in general, it is not possible to find a unique solution that describe the observation, unless some prior knowledge about the data is available. Traditional approaches, based on the minimazion of a cost function and a regularizer taking into account possible prior knowledge on data, are found to underperform with respect to recent deep learning techniques. The goal of the project is to explore the potentiality of modern deep learning techniques in selected imaging cases, such as cosmic-rays applications, which are relevant to science and industry.

Curriculum 7 - Economics, law and space diplomacy

- (7A)

Funding institution:
Doctoral site:
Contact:
Funds:
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

[RESEARCH THEMES]

Curriculum 8 – Gravity

- (8A) The "global fit" challenge in the data analysis of the space mission LISA (CUP: F63C25000370005)

Funding institution: Agenzia Spaziale Italiana - ASI
Doctoral site: University of Milan “Bicocca”
Contact: Monica Colpi [monica.colpi@unimib.it]; Riccardo Buscicchio [riccardo.buscicchio@unimib.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

The student will contribute to identifying and characterizing the gravitational wave sources of the space mission LISA, as part of the Italian distributed data processing center and in collaboration with other national and European universities. In this role, the student will execute and expand existing data analysis pipelines, integrating machine learning-assisted inferences and inference tools into a single, coherent environment to enhance the construction of the so-called "global fit" and reconstruct the LISA sky. GPU acceleration and modern programming design patterns will be utilized to optimize

performance. The student is expected to have excellent coding skills, strong proficiency in statistical modeling, and a solid understanding of LISA astrophysical sources.

- (8B) Development of algorithms for low-latency observations of mergers of massive black holes with the LISA space mission (CUP: F63C25000370005)

Funding institution: Agenzia Spaziale Italiana - ASI
Doctoral site: University of Milan “Bicocca”
Contact: Massimo Dotti [massimo.dotti@unimib.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

Description: The student will contribute to identifying and characterizing the gravitational wave sources for the LISA space mission, within the framework of the Italian distributed data processing center and in collaboration with other national and European universities. In this role, the student will develop and deploy novel analysis methods for identifying emerging sources in low-latency pipelines, as well as execute and expand existing data analysis pipelines. The student is expected to have a solid understanding of the astrophysics of LISA sources and demonstrate exceptional coding skills, along with proficiency in advanced computing techniques. This thesis will be co-supervised by experts from SISSA.

- (8C) Multi-sensor analysis of the data stream from terrestrial and space (LISA) gravitational wave observatories (CUP: F63C25000370005)

Funding institution: Agenzia Spaziale Italiana - ASI
Doctoral site: University of Pisa
Contact: Walter Del Pozzo [walter.delpozzo@unipi.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

Future gravitational wave detectors, such as the LISA space mission and the third-generation ground-based interferometer Einstein Telescope, will operate in the signal-dominated regime, where multiple overlapping signals are constantly present in their data streams. This presents significant challenges that require analysis methods beyond current state-of-the-art algorithms, which must be addressed to fully exploit the immense scientific potential of these instruments. The student will actively contribute to the development, deployment, and characterization of novel analysis methods to accurately infer the astrophysical properties of multiple overlapping signals. The student is expected to have a solid understanding of the astrophysics of potential LISA and ET sources and demonstrate exceptional coding skills, along with proficiency in advanced computing techniques.

- (8D) From the LISA Pathfinder mission to the LISA observatory for gravitational waves at mHz frequencies: measurements of the fundamental limits for free-falling masses (CUP: F63C25000370005)

Funding institution: Agenzia Spaziale Italiana - ASI
Doctoral site: University of Trento
Contact: William Joseph Weber [williamjoseph.weber@unitn.it]
Funds: Own Funds
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

The proposed doctoral research aims at the design and implementation of measurement techniques addressing the leading experimental challenges to opening the mHz and sub-mHz band of gravitational wave measurement from space, namely stray forces acting on the geodesic reference test masses that form the constellation of free-falling test particles in the ``antenna'' of the observatory. The proposing group is the scientific lead team for the ``gravitational reference system'' that is the Italian (ASI) contribution to the LISA mission, currently under development by ESA for launch in 2035. Much of the test mass acceleration noise budget has been measured and quantitatively consolidated by the LISA Pathfinder (LPF) mission, and the system under development for LISA inherits a solid base from LPF. However, a number of experimental questions remain open and require challenging, innovative ground measurements to reliably guarantee the femtoNewton -- or lower -- force noise levels needed for LISA. Specifically, the doctoral research will focus on measurements of surface electrostatic and gas desorption properties, which are related through surface physics and material (thermal, contamination) histories and are related to a wide range of stray force effects -- from Brownian motion from molecule impacts and collective outgassing glitch'' events, to static and slowly varying stray electrostatic fields and the photoelectric discharge of a gold-coated test mass. The doctoral student will join the Trento GRS PI team and will have opportunities to contribute both in our small force measurement laboratory and to the larger LISA team, involving our partners in industry, ESA, and at various institutes, spread through Italy, Europe, and the US.

- (8E) Design, analysis, and testing of a gravitational reference test mass system for geodesy (Progetto "SPACE IT UP! Contratto ASI n.2024-5-E.0 CUP Master n. I53D24000060005" e il CUP di progetto n. E63C24000530003. Fonte di finanziamento "Osservazione della Terra" "Finanziamento dalla Presidenza del Consiglio dei Ministri ai sensi dell'Art. 1, comma 254, della legge 160/2019, anno di riferimento 2024)

Funding institution: University of Trento
Doctoral site: University of Trento
Contact: William Joseph Weber [williamjoseph.weber@unitn.it]
Funds: "ASI SPACE IT UP SPOKE 4" – CUP: E63C24000530003
Mobility abroad: compulsory, minimum 6 months
Periods in companies/research centres/public administrations: optional

The PhD research aims at the design and test of a free-falling reference test mass system for future geodesy missions for monitoring the spatial-temporal variations in the Earth's gravitational field. The

current state-of-the-art for interspacecraft geodesy with the GRACE-FO mission is limited by the residual test mass acceleration noise at the 100 pm/s^2/sqrt(Hz) level. This research targets a system working at the pm/s^2/sqrt(Hz) level, using as a starting point techniques and experimental heritage from the LISA gravitational reference system (GRS), developed in our lab for the fm/s^2 performance needed for mHz gravitational wave observation with the LISA mission. The study will include a review of requirements for a GRS in low-Earth orbit, design of the system -- in particular the test mass and surrounding electrode housing -- and the realization and testing, for capacitive sensing and small force calibration, of a prototype TM/EH system. We seek candidates with a background in experimental physics, electrical engineering, or geophysics.