Research options available for topic A

Research topics a) and b) offered by every Doctoral Course involved in UNIPhD are frameworks within which every applicant has to present an original research project in collaboration with a Supervisor at the University of Padua.

Potential Supervisors at Unipd have proposed the following detailed research options, which are related to the research topic. They are offered as a guideline and should facilitate your contact with potential Supervisors. Supervisors' e-mail is specified in every research option table. You are welcome to contact them directly.

Note that this research option list is not at all exhaustive and, within the topic you have chosen, you are free to propose a different research project.

Doctoral Course	**PHYSICS**
Macro-area	Physical Sciences and Engineering
Department name	Department of Physics and Astronomy
Webpage	*https://www.dfa.unipd.it/didattica/dottorati-di-ricerca/phd-physics/*
Research topic A	**Physics of the universe, from the micro to the macro-cosmos** Understand the universe evolution, through synergy of astrophysics, cosmology and the study of the interactions between elementary particles. Unveil the origin of dark matter and dark energy, of matter-antimatter asymmetry, of the mass hierarchy of fundamental particles, etc., through experiments at colliders, underground labs, and multimessenger astroparticle, including gravitational waves. Interpret the results in the light of phenomenological models and of more fundamental theories.
Link to the UNIPhD Call (Academic Year 2022/2023)	*https://www.unipd.it/en/uniphd*
Latest Update	*11.01.2022*
#Number of available Research Options	*10* *Scroll down to see all the Research Options*

#1 Research Option Description

Doctoral Course	**Physics**
Department name	Department of Physics and Astronomy (DFA)
Research topic A	Physics of the universe, from the micro to the macro-cosmos
Research option	Multi-messenger experimental astrophysics: high energy radiation, neutrinos and gravitational waves from the extreme universe
Supervisor	Giovanni BUSETTO giovanni.busetto@unipd.it Members: Elisa PRANDINI (Multi-wavelength EM radiation astrophysics), Michele DORO, Riccardo RANDO (gamma ray astrophysics), Chiara SIRIGNANO, Alessandro RENZI (infrared component), Eugenio BOTTACINI (x-ray component), Elisa BERNARDINI (high energy neutrino astrophysics), Giacomo CIANI, Claudia LAZZARO (gravitational waves astrophysics)
Webpage	https://www.dfa.unipd.it/en/research/research-areas-and groups/
Context of the research activity and objectives	Multi-messenger astrophysics is a distinct discipline providing unique and valuable insights into the properties of the Universe. It builds upon a combination of information from photons, gravitational waves, neutrinos and cosmic rays to achieve a comprehensive understanding of astrophysical sources and physical processes at work. The research community at the Padova Physics and Astronomy Department is involved in major international collaborations in the field, like MAGIC and CTA for the Imaging Atmospheric Cherenkov Telescopes, Fermi for the gamma ray detection on satellite, INTEGRAL and SWIFT for the X-ray detection, EUCLID infrared large scale structure survey on satellite, IceCube for high energy neutrino observations and LIGO-Virgo for gravitational wave detection. Observations across the electromagnetic spectrum, from radio waves through visible light, all the way to gamma-rays are nowadays based upon data from many other telescopes and experimental facilities, through dedicated cooperation programs. The candidate will have the opportunity to conduct state-of-the art research, focus on hardware, data analysis and/or observations, in either one of these areas.
Infrastructures	Access to international observatories and laboratories, instruments and corresponding proprietary data and codes, Virgo-ET optics laboratory. CNAF IT center, CINECA/MARCONI100, Cloud IT (3k cores, 1PB storage).
Skills and competencies for the development of the activity	The candidate should be motivated to intersect topics across classical fields of modern fundamental physics and astrophysics. Good English level required.
Training offer	The candidate will have the opportunity to get involved and contribute to one or more of the fields related to multi-messenger astrophysics by engaging with the most advanced instrumentation, computing algorithms and investigation techniques, joining international scientific collaborations. Several PhD courses in Physics are available, covering subjects as particle-physics, astrophysics, cosmology and instrumentation developments.
Possible Secondments	Academic: Istituto de Astrofisica de Canarias (IAC), C. W. Reserve University-Cleveland (US); Université de Paris-PSL; Observatoire de Paris and IAP, European Gravitational Observatory (EGO), DESY, CERN Non-academic: Media Lario S.r.l., IVG Colbachini S.p.a

#2 Research Option Description

Doctoral Course	**Physics**
Department name	Department of Physics and Astronomy
Research topic A	Physics of the Universe, from the micro to the macro-cosmos
Research option	The precision frontier: Flavour Physics at colliders
Supervisor	Supervisor: Franco Simonetto, franco.simonetto@unipd.it Co-supervisors: Gabriele Simi; Alessandro Gaz.
Webpage	http://www.dfa.unipd.it/en/research/research-areas-and-groups/experimental-physics-of-fundamental-interactions/experimental-particle-physics/
Context of the research activity and objectives	Lack of evidence of new physics (NP) from direct searches at the LHC (the "energy frontier"), draws the attention to flavor physics (FP) as a "precision frontier": very precise measurements of the time evolution and decays of heavy flavors (b and c hadrons, τ leptons) with existing facilities do push the sensitivity to NP far beyond the present reach of direct searches, to a scale of tens of TeV which will be directly reached only by future facilities in at least thirty years from now. In fact few anomalies in FP have emerged and need deeper inspection and/or further confirmation. Our institution is involved in three different experiments focused on FP: CMS and LHCb at CERN and Belle2 at KEK. The three groups are involved in the measurement of time dependent CP violation of B_d and B_s mesons, each with different and original approaches, using decay modes that are sensitive to the presence of new particles which could explain the nature of the dark matter. The LHCb and CMS groups are also involved in the test of Lepton Universality violation in B mesons and baryons decays as well as the direct search of exotic particles and dark matter candidates. Deeper insight on each group proposal and activity can be found in the web page. The PhD path will be accomplished by the publication of the results of the work in a high-profile international review. We expect the candidate to regularly report the advance of her/his studies in collaboration meetings and in workshops and conferences in Italy and abroad.
Infrastructures	Each group owns its computing network for daily data analysis. Students can also access the Padova CPU-GPU cloud, or the facilities provided by CERN, KEK, and other computing centres in LNL, CNAF.
Skills and competencies for the development of the activity	Students should be fairly acquainted with the use of computers, including basic programming skills. More advanced skills (OO programming, use of dedicated and commercial analysis tools and other abilities eagerly looked for also by private enterprises) will be developed thanks to the PhD training.
Training offer	1) daily tutoring by the supervisor and his associates 2) academic training 3) high profile international schools on advanced Physics topics (see the Phd scool web page: https://www.dfa.unipd.it/didattica/dottorati-di-ricerca/phd-physics/
Possible Secondments	1) CERN lab (https://home.cern/) - at least six months 2) KEK lab (https://www2.kek.jp/accl/eng/) - at least six months

	3) SDG Group | Strategy. Decision. Governance. (private enterprise dealing with advanced software research, three or more months).

#3 Research Option Description

Doctoral Course	**Physics**
Department name	Department of Physics and Astronomy
Research topic A	Physics of the universe, from the micro to the macro-cosmos
Research option	Detectors for future experiments
Supervisor	Roberto Rossin (UNIPD) roberto.rossin@unipd.it Research group: M.Tosi(UNIPD), P. Azzi, T. Dorigo, E. Conti(INFN)
Webpage	https://www.pd.infn.it/eng/research-at-infn-padova/particle-physics/ https://fcc-ped.web.cern.ch/,https://mode-collaboration.github.io , https://web.infn.it/MUonE/
Context of the research activity and objectives	We propose to investigate the demands of future experiments in particle physics and the possibility to meet them with the use of new technologies. One example is the application of timing detectors to future high energy physics experiments which is essentially unexplored. The FCC-ee is a proposed circular e+e- collider running at a centre-of-mass energies from the Z-pole up to the top-pair production threshold. Timing detectors have the potential to provide key information for several measurements: particle identification in beauty, charm but also strange hadron decays, in momentum ranges too challenging for other techniques; discovery of new long-lived particles or detection of displaced vertices; precise determination of the position of the collision point in the crossing bunches. The performance on physics measurements from the additions of the timing information would be studied with state-of-the-art deep learning techniques. In addition, and in connection to the above, a new line of research where Padova is at the forefront is the use of deep learning techniques for the end-to-end optimization of the detectors meant for future colliders. In Padova the two activities that have started involve the optimization of detectors performing the scanning of unknown volumes with muon tomography, and the optimization of a calorimeter for a Muon collider. The latter also involves very open-ended studies of how the design of calorimeters for particle physics and industrial applications can be improved with the scanning of the multi-dimensional parameter space of its design and construction choices. A possible use case is also the MuOnE calorimeter. MuOnE is designed to ascertain if the four sigma discrepancy between the measured value of the muon gyromagnetic moment and the prediction from a precise QED calculation is to be ascribed to the very-poorly-known contributions from hadronic diagrams or to new physics. The experimental apparatus, composed of a silicon tracking system complemented by an electromagnetic calorimeter, where we are mostly involved, measures the cross section of the elastic muon-electron scattering with very high precision. Challenges are connected to the use of edge-of-technology detectors, to the very high intensity of the muon beam, to the triggerless data acquisition, to the severe control of all systematics needed to reach the required precision. In any case the work of the PhD student will result in publications in high

	rank international reviews and presentations in workshops and conferences in Italy and abroad.
Infrastructures	The labs provided by the DFA, the Legnaro National Lab and CERN
Skills and competencies for the development of the activity	Some knowledge of python and C++ is necessary, as familiarity with word processing and web page editing.
Training offer	During this programs student will obtain excellent knowledge of programming tools (including machine learning algorithms and their applications) and state-of-the-art statistical methods to assess performance and validity of the results obtained. She/he will also learn how to successfully work in an international team and present the results orally in scientific conferences and in writing via the preparation of peer reviewed articles. Through the secondment it will be possible to gain insight on the soft skills needed to successfully be employed in modern companies.
Possible Secondments	Laboratori nazionali di Legnaro (www.lnl.infn.it/en) CERN (www.cern.ch) SDG (https://www.sdggroup.com/en), a private enterprise involved in advanced analysis and consulting exploiting deep learning technologies.

#4 Research Option Description

Doctoral Course	**Physics**
Department name	Physics and Astronomy “Galileo Galilei”
Research topic A	Physics of the universe, from the micro to the macro-cosmos
Research option	Nuclear Structure, Reaction Dynamics and Nuclear Astrophysics
Supervisor	Silvia Monica LENZI silviamonica.lenzi@unipd.it Group members: Carlo Broggini, Antonio Caciolli, Daniela Fabris, Marco Mazzocco, Roberto Menegazzo, Daniele Mengoni, Giovanna Montagnoli, Sandra Moretto, Francesco Recchia
Webpage	http://www.dfa.unipd.it/en/research/research-areas-and-groups/experimental-physics-of-fundamental-interactions/nuclear-physics-and-astrophysics/
Context of the research activity and objectives	Nuclear physics studies the properties and nature of the forces that take the nucleus bound. It investigates how they have been formed in the universe, the limits of existence of the atomic nuclei, how the underlying symmetries manifest in their structure and the reaction mechanisms that are at the basis of the dynamical processes between nuclei. The Padova group is leader in these studies operating at the main international laboratories with radioactive and stable beams, using state-of-the-art detectors and also in underground laboratories for nuclear astrophysics experiments. The group is also devoted to the development of innovative instrumentation. The PhD student will join a very lively group, involved in international networks that guarantee the growth of young researchers, and will develop a variety of skills in an environment full of new ideas and opportunities. The student is expected to actively participate in projecting and performing experiments in Italy and abroad, carry out data analysis, interpret and publish the results in prestigious scientific journals.
Infrastructures	LNL, LNGS, GSI, FRIB, JYFL, GANIL, RIKEN, HZDR
Skills and competencies for the development of the activity	Knowledge of Nuclear Physics, Programming skills, Knowledge of the basic functionality of particles, gamma and neutron detectors
Training offer	Hands-on training on different type of detectors at LNL. Courses: Advanced instrumentation for nuclear structure and reaction dynamics, Nuclear reactions with heavy ions, Statistical data analysis, Nuclear structure and reaction dynamics with exotic beams.
Possible Secondments	The student will spend at least 3 months in one research laboratory such as LNGS, GSI, LBNL, JYFL, HZDR, ATOMKI and (optional) in an industry such as e.g. CAEN, HZDR Innovation, Isotoptech Zrt. company, FBK foundation.

#5 Research Option Description

Doctoral Course	**Physics**
Department name	Physics and Astronomy "Galileo Galilei"
Research topic A	Physics of the universe, from the micro to the macro-cosmos
Research option	Cosmology with Gravitational Waves
Supervisor	Sabino MATARRESE sabino.matarrese@unipd.it (*Research group:* Nicola Bartolo, Daniele Bertacca, Michele Liguori, Alvise Raccanelli, Angelo Ricciardone)
Webpage	https://www.dfa.unipd.it/en/research/research-areas-and-groups/astronomy-astrophysics-and-physics-of-the-earth-and-planets/theoretical-astrophysics-and-cosmology/
Context of the research activity and objectives	The project will focus on crucial theoretical modelling and data analysis aspects lying at the forefront of *Gravitational Wave (GW) Cosmology*, addressing the following topics and scientific goals:: ***1. Early Universe**:* The generation of primordial GWs is a crucial prediction of inflationary scenarios. We focus on: i) GWs from inflation, non-Gaussianity, quantum decoherence; ii) connection with CMB anomalies; iii) tests with the next CMB satellite LiteBIRD and future GW interferometers (LISA, ET); iv) Cross-correlation between GWs and other cosmological probes (CMB, galaxy surveys, HI, ...); ***2. GW clustering:*** The large-scale clustering of astrophysical GW events carries information on cosmological parameters and structure formation. Main goals: i) Modelling the GW power-spectrum; ii) Development of data analysis tools and simulation of mock GW surveys, via machine learning methods; ***3. Primordial Black Holes (PBH):*** PBHs can form during the early stages of the Universe and are possible candidates of dark matter. We focus on: i) Cross-correlation of GWs sourced by PBHs with the large-scale structures; ii) Effects of PBHs on the neutral hydrogen distribution; iii) secondary GW production.
Infrastructures	Padova University, Department of Physics and Astronomy "G. Galilei"
Skills and competencies for the development of the activity	A solid background in Cosmology and General Relativity. Knowledge of a programming language (e.g., Python, C++) is preferred, but not compulsory.
Training offer	PhD thematic courses and schools. Weekly seminars, journal clubs, and group meetings. Possible involvement in international collaborations, e.g., LiteBIRD, SKA, LISA, ET.
Possible Secondments	Johns Hopkins University (US) (3 months); ICREA (Barcelona, Spain) (3 months)

#6 Research Option Description

Doctoral Course	**Physics**
Department name	Physics and Astronomy "Galileo Galilei"
Research topic A	Physics of the universe, from the micro to the macro-cosmos
Research option	QCD extended systems, nuclear matter under extreme conditions
Supervisor	Supervisor: Francesca Soramel, francesca.soramel@unipd.it Members: Federico Antinori, Andrea Dainese, Piero Giubilato, Marcello Lunardon, Andrea Rossi, Rosario Turrisi
Webpage	https://www.pd.infn.it/it/gruppo3-fisicanucleare/
Context of the research activity and objectives	Fundamental questions concerning the behavior of nuclear matter are since long the motivation behind intense research programs at the world main laboratories: how quarks and gluons combine into hadrons with specific mass and spin, how the strong interaction drives the transition to a different medium, the Quark Gluon Plasma, overcoming the confinement of partons and reproducing the inverse road followed by the early universe after Big Bang. Strategies among the most promising are those based on heavy quark production measurements, pursued at the ALICE experiment at CERN, and part of the physics programme of future experiments like NA60+ at CERN and ATHENA at the EIC accelerator. This quest has driven key developments both on the instrumentation side, like ultra-thin silicon detectors, and on the data-analysis side, opening a wide variety of opportunities to collaborate in our team. The student will be part of one of the aforementioned experiments, to get acquainted with physics concepts relevant in research also beyond nuclear and particle physics, will exploit state-of-the-art analysis techniques, as f.e. machine-learning algorithms and distributed computing, and/or contribute to the development of MAPS silicon detectors.
Infrastructures	CERN
Skills and competencies for the development of the activity	A background in nuclear or particle physics is required. Familiarity with computing programme languages (C++ or PYTHON) is advisable but not mandatory (adequate training is offered).
Training offer	The Physics and Astronomy Department offers high-level PhD courses covering a wide range of physics topics, including nuclear and particle physics. Training courses on computing and machine learning analyses are also offered by the Padua University, as well as by the Istituto Nazionale di Fisica Nucleare. The student will participate in two international PhD schools, dedicated to high-energy particle physics, quark-gluon plasma physics or big-data analysis.
Possible Secondments	Secondments, from 3 to 12 months: Academic, mandatory: CERN Non-academic: E4-Computer Engineering; Fondazione B. Kessler-FBK

#7 Research Option Description

Doctoral Course	**Physics**
Department name	Physics and Astronomy "Galileo Galilei"
Research topic A	Physics of the universe, from the micro to the macro-cosmos
Research option	Neutrino Physics
Supervisor	Luca STANCO luca.stanco@unipd.it Members: Gianmaria COLLAZUOL (T2K, Hyper-K), Alberto GUGLIELMI (ICARUS/DUNE), Alberto GARFAGNINI (JUNO), Riccardo BRUGNERA (LEGEND), Gianni CARUGNO (QUAX), Andrea LONGHIN (ENUBET).
Webpage	https://www..infn.it/eng/research-at-infn-padova/astroparticle-physics/ https://www.dfa.unipd.it/en/research/research-areas-and-groups/experimental-physics-of-fundamental-interactions/astroparticle-physics/
Context of the research activity and objectives	Neutrinos play a pivotal role in the scenario of current research on the fundamental constituents of the Universe. All the most interesting aspect of research in the neutrino field are represented in the large neutrino group present in Padova through the experiments DUNE, T2K, Hyper-K, JUNO, LEGEND, ENUBET, ICARUS and QUAX. The research lines include the measurement of the pattern of the absolute masses (hierarchy), the possible violation of the CP-symmetry (studied with □□→□e oscillations), the oscillation parameters and the intrinsic nature of neutrinos - Dirac or Majorana fermions - by searching for 0vbb decays from ^{76}Ge nuclei. Almost all of them have a potential to search for exotic particles, many of which could be dark matter candidates. The ENUBET ERC program is intended to boost the field with an innovative neutrino source obtained by monitoring the leptons in the production region. The ICARUS Liquid Argon Time Projection Chamber experiment is taking data at FERMILAB to say a final word on the possible existence of additional ("sterile") neutrinos without an associated charged lepton (e, □, □). QUAX is searching for axions by exploiting resonant cavities within a 14 T magnetic field and superconducting parametric amplifiers in a cryogenic environment. The proposed activities are at the forefront of detector technologies and data analysis and will offer the possibility to get a sound expertise on both aspects.
Infrastructures	International and National Laboratories: FNAL (USA), CERN (Switzerland), KEK (Japan), IHEP (China), LNGS (Italy), LNL (Italy)
Skills and competencies for the development of the activity	The candidate must have developed an exceptional knowledge and skilfulness for fundamental and modern physics although not at high theoretical level. Knowledge about the principle of the particle detection is also appreciated.
Training offer	Several PhD courses in Physics at Padova cover particle-physics and cosmology, not forgetting the statistics analysis and the hardware developments. The PhD's must follow at least 4 of these courses with a final exam to pass.
Possible Secondments	Academic: FNAL, CERN, KEK and J-PARC, LNGS, GSSI, TUM, IHEP Non-academic: CINEL (Padova), CAEN (Viareggio, PI)

#8 Research Option Description

Doctoral Course	**Physics**
Department name	Physics and Astronomy "G. Galilei"
Research topic A	Physics of the universe, from the micro to the macro-cosmos
Research option	Unveiling ultra-magnetized neutron stars with X-ray polarimetry
Supervisor	Roberto TUROLLA (supervisor) roberto.turolla@unipd.it Roberto TAVERNA (co-supervisor) roberto.taverna@unipd.it
Webpage	https://www.dfa.unipd.it/en/research/research-areas-and-groups/astronomy-astrophysics-and-physics-of-the-earth-and-planets/theoretical-astrophysics-and-cosmology/
Context of the research activity and objectives	2022 will witness the launch of the Imaging X-ray Polarimetry Explorer (IXPE, a NASA-ASI collaboration), the first ever satellite devoted entirely to polarimetry in the X-rays (2-8 keV). This will open a new window in the study of several classes of astrophysical sources, including Black Holes and Neutron Stars. Ultra-magnetized neutron stars (magnetars), are expected to sport a high degree of polarization and are a primary target for IXPE. The coming data will allow to test vacuum birefringence, a QED effect still to be validated in a lab, and to finally probe the physical properties of the neutron star surface. The applicant will take active part in the IXPE data reduction and analysis, and in the development of theoretical models, within an internationally leading team in magnetar astrophysics.
Infrastructures	Padova University, Department of Physics and Astronomy
Skills and competencies for the development of the activity	Strong background both in Physics and Astronomy. Working knowledge of python/F90 and of standard packages for X-ray data analysis, like XSPEC, is a plus.
Training offer	PhD courses, PhD schools, seminars
Possible Secondments	Mullard Space Science Laboratory, University College London (UK) (3 months) INAF-IAPS Rome (I) (3 months), NASA MSFC (US) (3 months)

#9 Research Option Description

Doctoral Course	**Physics**
Department name	Physics and Astronomy "Galileo Galilei"
Research topic A	Physics of the universe, from the micro to the macro-cosmos
Research option	Learning Quantum Gravity
Supervisor	Supervisor: Gianguido Dall'Agata gianguido.dallagata@unipd.it Fabio Zwirner, Marco Peloso, Luca Martucci, Stefano Massai, Davide Cassani, Gianluca Inverso
Webpage	http://active.pd.infn.it/g4/gss http://www.dfa.unipd.it/en/research/research-areas-and-groups/theoretical-physics-of-fundamental-interactions/theoretical-physics/
Context of the research activity and objectives	Quantum gravity is at the heart of the most interesting and challenging problems in theoretical physics, like the resolution of the Big Bang singularity, the origin of Dark Energy, the consistency of the high-energy limit of elementary particle interactions and the black hole information paradox. A complete and working theory of quantum gravity still eludes us. This challenge requires a paradigm shift in the way of facing it, which leads to distil the necessary requirements for any effective theory of elementary interactions to be compatible with quantum gravity. This is obtained by means of conjectures, named "swampland conjectures", which differentiate between the models that are compatible with quantum gravity (the "landscape") and those that are not (the "swampland"). The main avenue to verify such conjectures is to study the landscape of string theory, which is a prototype of a consistent quantum theory of gravity. Unfortunately, such analysis cannot be exhaustive because often we face NP-complete or undecidable problems. The researcher will study various aspects of quantum gravity, ranging from cosmological implications (for example, the phenomenology of models of inflation and dark energy in steep potentials, or, the impact of modified dispersion relations to the gravitational wave generation and propagation in the early universe, and to the large scale CMB anisotropies), to black hole physics (like understanding the black hole information paradox, constructing black hole microstates or devising new counting techniques) and string phenomenology (analyzing string effective theories, flux compactifications and non-geometric backgrounds). This will be done by means of state-of-the-art techniques in string and field theory, such as holography and exceptional field theory, as well as data science, from which we plan to borrow machine learning techniques to access approximate results inaccessible to analytic and geometric techniques.
Infrastructures	Our group is associated to the Italian Institute of Nuclear Physics (INFN). This means that the candidate will be able to use the computing infrastructures of the Institute, in addition to the ones of the University. In addition, the student may take part to seminars, schools and other activities organized by the Institute.

Skills and competencies for the development of the activity	The candidate should have a working knowledge of General Relativity and Quantum Field Theory.
Training offer	The execution of the project will involve regular meetings (at least once a week) with the project supervisor. The close collaboration with the supervisor will result in the acquisition and mastery of theoretical concepts and computational techniques related to quantum field theory, cosmology, supergravity, string compactifications and related topics. As a member of the Padova theory group, the candidate will attend formal seminars and internal journal club meetings and discussion groups. These activities as well as frequent individual discussions with other group members, will serve to broaden her/his research horizons and improve her/his organizational and management skills. Frequent participation in conferences will simultaneously serve as an opportunity to engage with other renowned experts and stay up-to-date on the latest research developments in the field. The Ph.D. school has a very diversified offer of regular courses on the first year of attendance, and the student is also invited to attend courses at the international schools organized at the INFN Galileo Galilei Institute in Florence.
Possible Secondments	Possible academic secondments: Universidad Autonoma de Madrid, KU Leuven, Université Paris-Saclay Possible non-academic secondments: SISSA Medialab

#10 Research Option Description

Doctoral Course	**Physics**
Department name	Physics and Astronomy "Galileo Galilei"
Research topic A	Physics of the Universe, from the micro- to the macro-cosmos
Research option	Challenging Particle and Astroparticle Physics
Supervisor	Supervisor: Stefano RIGOLIN stefano.rigolin@unipd.it Research group: F. D'Eramo, R. Gröber, A. Masiero, P. Mastrolia, P. Paradisi, M. Passera, L. Vecchi, A. Wulzer
Webpage	http://www.dfa.unipd.it/en/research/research-areas-and-groups/theoretical-physics-of-fundamental-interactions/theoretical-physics/
Context of the research activity and objectives	The next generation of experimental Space- and Earth-based endeavors are expected to improve our understanding of the most pressing unresolved puzzles in Elementary Particle and Astroparticle Physics related to Flavor, Higgs boson interactions, the Muon g-2 anomaly, the existence of Axions and Dark Matter in the Universe, the physics of Gravitational Waves, and to hidden relations among the Fundamental Interactions and their underpinning mathematical structures. This research project offers the necessary theoretical support to address one or more of the mentioned open challenges, through an interdisciplinary, multi-pronged approach, during which the PhD student will acquire competences in Effective Field Theory methods, modern techniques for Scattering Amplitudes, Multi-process Event generation and Data-Analysis, Quantum-calculus and Artificial Intelligence-based algorithms, for inspecting the Standard Model at high-accuracy, as well as to identify possible elusive signatures of an underlying New Physics and to develop novel theoretical frameworks beyond the current paradigms. Scientific training and research activities are complemented by team-work experiences at international institutions, and private partners.
Infrastructures	UNIPD, INFN Padua, and LNL Legnaro. Computing infrastructure of Veneto Cloud and INFN. Optional associations to CERN, GSSI, GranSasso Lab, GGI.
Skills and competencies for the development of the activity	Good knowledge of Quantum Field Theory.
Training offer	-PhD courses, group seminars, journal clubs, soft skills courses; -International Schools and Workshops (physics/programming); -International Visiting and Research Collaborations; -Training at Academic and non-Academic Partners.
Possible Secondments	*Academic* (4 months): CERN, GSSI and GranSasso Lab, IHES, MPP MPI, SISSA. *Non-Academic* (4 months): Maple Software, Wolfram (Mathematica), SISSA MediLab, STMicroelectronics.