ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Characterization of stitched sensors for the new Inner Tracking System (ITS3) of the ALICE experiment

SUPERVISOR(S): Paola La Rocca

SUPERVISOR(S) contact- email: paola.larocca@ct.infn.it Telephone: +39 095 378 5214
email: Telephone:

UNIVERSITY/RESEARCH CENTER: Unicversity of Catania / INFN Section of Catania

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

The activity will be carried out in the context of the ALICE experiment and in particular of the upgrade of its Inner Tracking System (ITS3).
The activity involves the characterization of monolithic pixel sensor (MAPS) prototypes in 65 nm CMOS technology manufactured as part of the R&D for the ITS3 detector, consisting of only 3 layers of MAPS sensors thinned to approximately 50 um with purely cylindrical geometry, supported only by minimal carbon foam supports and air-cooled. The performance of the prototypes, particularly the ones with large area fabricated with the stitching technique, will be studied with laboratory and particle beam tests. The result of the tests will allow us to provide feedback to designers for the optimization of the sensor design and will contribute to the creation of the final sensor for the ITS3.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Dating by stimulated luminescence : improvement of methodologies for annual dose measurements

SUPERVISOR(S): Anna M. Gueli and Giuseppe Stella

SUPERVISOR(S) contact- email: anna.gueli@unict.it Telephone: +39 095 378 5354
email: giuseppe.stella@unict.it Telephone: +39 095 378 5318

UNIVERSITY/RESEARCH CENTER: University of Catania – Department of Physics and Astronomy – PH3DRA laboratory

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

Accuracy in determining annual dose contributions plays a crucial role in determining the age of samples of archaeological and art-historical interest.

The planned research work is aimed at developing methodologies to be used both in situ and extra-situ so as to minimize the sources of uncertainty also by optimizing the procedures for sample preparation and measurement of luminescence signals.

Measurements will be carried out in the PH3DRA laboratory, Physics for Dating Diagnostics Dosimetry Research and Applications, and at the archaeological sites and historic buildings of provenance of the artifacts object of the chronological studies.

ERASMUS MUNDUS JOINT MASTER DEGREE IN NUCLEAR PHYSICS

Co-funded by the Erasmus+ Programme of the European Union

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Clustering and Symmetries in Light Nuclei

SUPERVISOR(S): Ivano Lombardo

SUPERVISOR(S) contact- email: ivano.lombardo@dfa.unict.it Telephone:
email: Telephone:

UNIVERSITY/RESEARCH CENTER: Univ. Catania, INFN-Sez. Di Catania

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

The thesis work will be focused on the study of the cluster structure of light nuclei, with particular emphasis to self-conjugate ones, for which alpha-particle condensation effects can occurr. In doing this, we will perform high-precision nuclear reaction experiments aimed to probe the spectroscopy of such nuclei with unprecedented precision. Such experiments will be performed at the INFN-LNL and GANIL laboratories by using the OSCAR, GARFIELD (LNL) or INDRA-FAZIA detectors. During the thesis activity, the Candidates will be strongly trained both in the detection techniques used to perform the experiments and to the main theoretical toolkits useful to understand the nuclear properties starting from the experimental data. The period of thesis activities will be of the order of six months.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Study of axions as a dark matter candidate

SUPERVISOR(S): Jorge Segovia (Universidad Pablo de Olavide, Sevilla, Spain), Isaac Vidaña (INFN Sezione di Catania, Italy)

SUPERVISOR(S) contact- email: jsegovia@upo.es Telephone: +34 954 977 455
email: isaac.vidana@ct.infn.it Telephone: +39 095 378 5360

UNIVERSITY/RESEARCH CENTER: Università di Catania, Dipartimento di Fisica e Astronomia "Ettore Majorana"

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

Despite the broad consistency of the Standard Model there are still unsolved problems within it. The lack of violation of the charge-parity (CP) symmetry in the strong nuclear force, better known as the 'strong CP problem', is one of them. Basically, the Standard Model does not provide any mechanism to explain why the CP symmetry is not broken within Quantum Chromodynamics (QCD). Meanwhile at the astronomical scale, several experimental observations (galactic rotation curves, gravitational lensing, measurements of the amount of matter in galaxy clusters, etc.) have led the scientific community to conclude that there is a greater amount of matter than the accounted by baryons. This deficit of matter only interacts at large scales by means of gravity and is practically invisible in the electromagnetic spectrum. This last characteristic gives it the name Dark Matter (DM). The Standard Model does not provide any particle that is a valid dark matter candidate. Therefore, it is necessary to extend the Standard Model to explain this conundrum. Historically, the main hypothetical dark matter candidates have been the Weakly Interacting Massive Particles (WIMP). However, research focused on their search has been unsuccessful.

A common feature of scientific methodology is to search for a small number of causes to explain a wide range of phenomena. In the case of the strong CP

problem and dark matter, the axion is proposed as a common solution. The axion is a hypothetical particle of spin-0 postulated in 1977 by Roberto Peccei and Helen Quinn with the aim of introducing a mechanism to solve the strong CP problem. Currently, it is still the most relevant explanation. Furthermore, due to its weak interaction with the other Standard Model particles, the axion is an excellent DM candidate. Specifically, it would be part of the 'cold' dark matter in the sense that its velocity of motion is low (in a relativistic context).

The axion is described by a real scalar field satisfying the Klein-Gordon equation with a non- trivial interaction potential. Some aspects of axions can be more easily described by a Non- Relativistic Effective Field Theory (NREFT). As the name implies, a NREFT aims to approximate a relativistic field by transforming the real scalar field into a complex scalar field whose Lagrangian correctly describes the field in the classical regime. Furthermore, since axions are low velocity bosonic particles, it is possible that self-interaction between axions or that gravitational interactions have succeeded in forming macroscopic structures of axions. Thus, it is essential to somehow incorporate gravity to the non-relativistic axion description in order to better understand these hypothetical astrophysical-shape structures.

The aim of this investigation project is to implement gravity to the NREFT description of axions and try to predict if and how an axion cloud could collapse into a macroscopic structure either due to its self-interactions or gravitational attraction.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Development and characterization of a portable graphite calorimeter for FLASH Radiotherapy Dosimetry

SUPERVISORS: Prof. Giuseppe Stella; Dott. Francesco Romano

SUPERVISOR(S) contact- email: giuseppe.stella@unict.it Telephone: +39 095 3785318
email: francesco.romano@ct.infn.it Telephone: +39 0953785244

UNIVERSITY/RESEARCH CENTER: UNICT/INFN – Catania Division

ABSTRACT

Preclinical studies have shown that ultra-high dose rate (UHDR) beams can significantly improve normal tissue sparing (known as the FLASH effect) while maintaining high tumor control probability (TCP) compared to conventional dose-rate radiotherapy. The clinical transition to FLASH radiotherapy, characterized by dose rates of dozens/hundreds of Gy/s instead of a few Gy/min, requires new protocols and guidelines for dosimetry [1, 2].
The proposed activity aims to characterize new detectors for reference dosimetry in FLASH radiotherapy, focusing on a novel small portable graphite calorimeter as a secondary standard. This calorimeter has shown suitability and advantages with UHDR beams. A prototype was created at the National Physical Laboratory (NPL) in the UK and a preliminary characterization performed within the INFN project “FLASH Radiotherapy with high Dose-rate particle beAms” (FRIDA) at the INFN Catania Division.
Systematic and more comprehensive experimental campaigns with conventional and UHDR electron and proton beams will be conducted at various facilities to establish the dosimeter’s performances. The student will also be involved in modeling the calorimeter through Monte Carlo simulations, in collaboration with NPL researchers.
The student will have the opportunity to learn both experimental and simulation methods through the collaboration between UNICT and INFN – Catania Division.

[1] F. Romano et al., Med Phys, vol. 49, no. 7, pp. 4912–4932, Jul. 2022
[2] A. Subiel and F. Romano, *Br J Radiol*, 2023, doi: 10.1259/bjr.20220560.

ERASMUS MUNDUS JOINT MASTER DEGREE IN NUCLEAR PHYSICS

UNIVERSIDAD DE SEVILLA

Co-funded by the Erasmus+ Programme of the European Union

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS

Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: The Photon Detector System in ICARUS: simulation and reconstruction of the optical signals.

SUPERVISOR(S): Prof. Catia M. A. Petta
Dr. Vanessa Brio

SUPERVISOR(S) contact- email: catia.petta@ct.infn.it Telephone:
email: vanessa.brio@ct.infn.it Telephone:

UNIVERSITY/RESEARCH CENTER: Università degli Studi di Catania

ABSTRACT

(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

Liquid argon detectors have been widely used in the field of neutrino physics and dark matter search. The ICARUS T600 detector is the biggest liquid argon time projection chamber (LAr-TPC) ever built so far. From 2010 to 2012 it was placed in the Gran Sasso laboratory (LNGS) and exposed to the CNGS (CERN Neutrinos to Gran Sasso) neutrino beam. After a refurbishing at CERN, the T600 was transported to Fermilab, to become the Far Detector of the Short Baseline Neutrino (SBN) program.

Nowadays, ICARUS is taking data, exposed to both BNB and NUMI neutrino beam. The SBN experiment will give a definitive answer to the LSND-anomaly, to confirm or reject the possible presence of a fourth neutrino state, the sterile neutrino. The ICARUS Collaboration is also involved in a long-time project, called DUNE (Deep Underground Neutrino Experiment): it will be a long baseline experiments, with a modular kilotons LAr-TPC, to be built in the next 20 years in a South Dakota mine. The goal is to study all the fundamental properties of neutrinos, such as CP violation, mass hierarchy and so on.

The ICARUS Photon Detector System is a crucial sub-detector, consisting of 8” PMTs and used for detector calibration and triggering. This proposal of Thesis work aims to simulate and reconstruct the scintillation light signals and compare them to physical data, in order to assess the full validation of Montecarlo and reconstruction tools.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Effects of cross section uncertainties in the interaction rate through the Earth

SUPERVISOR(S): S.Cherubini-Silvio.cherubini@unict.it-

SUPERVISOR(S) C. Distefano-distefano_c@lns.infn.it

UNIVERSITY/RESEARCH CENTER:
DFA University of Catania and INFN-LNS The master Thesis is focused

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

The Goal of Master Thesis is the challenging study of the systematics in the cross section calculation of the neutrino transmission through the earth. Moreover in the framework of the Master thesis the general studies of ARCA neutrino telescope systematics will be carried out.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Nuclear Matrix Elements for neutrinoless double beta decay

SUPERVISOR(S): D.Gambacurta (INFN-LNS), M.Colonna (INFN-LNS and UniCT)

SUPERVISOR(S) contact- email: colonna@lns.infn.it Telephone: 0039 095 542111
email: gambacurta@lns.infn.it Telephone: 0039 095 542648

UNIVERSITY/RESEARCH CENTER: Laboratori Nazionali del Sud (INFN) – Catania (Italy)

ABSTRACT

The experimental observations of neutrino's oscillations indicate that they have non- zero mass but do not provide any information on the absolute scale of their masses. The neutrinoless double beta decay, if observed, would shed light on many fundamental aspects such as: the absolute neutrino mass scale; whether the neutrino is a Dirac or a Majorana particle; the type of neutrino mass ordering (normal or inverted). The neutrinoless double beta decay rate can be factorized in terms of a phase-space factor, the Nuclear Matrix Element (NME) containing the nuclear structure information and a term depending on the combination of the neutrino's masses, the mixing coefficients and the Majorana phases. A reliable extraction of the neutrino masses is possible only if the NMEs are known with sufficient precision. One of the most employed and promising approaches for the evaluation of NMEs is the Skyrme-Quasiparticle Random Phase Approximation (QRPA). The goal of this thesis is to employ and extend a Skyrme-QRPA code for the calculations of the NMEs. Moreover, the role of the proton-neutron pairing and deformation on the NMEs will be studied.

MASTER THESIS PROPOSAL

TITLE: Modeling of charge-exchange nuclear reactions and study of the analogies with electroweak (beta and double beta decay) processes

SUPERVISOR(S): M.Colonna (INFN-LNS and UniCT), S.Burrello (INFN-LNS), D.Gambacurta (INFN-LNS)

SUPERVISOR(S) contact- email: colonna@lns.infn.it Telephone: 0039 095 542111
email: burrello@lns.infn.it Telephone: 0039 3891772214
email: gambacurta@lns.infn.it Telephone: 0039 095 542648

UNIVERSITY/RESEARCH CENTER: Laboratori Nazionali del Sud (INFN) – Catania (Italy)

ABSTRACT

Heavy ion reactions at low energies are modeled with quantum scattering theory. We propose to investigate reaction mechanisms of current experimental interest, inducing charge-exchange excitations in nuclei (changing their charge, but not their mass). These nuclear excitations present interesting connections with electroweak processes, such as (double) beta-decay and can be described employing modern nuclear structure models (such as QRPA and shell model). Comparing the calculated reaction cross section with experiments allows one to extract data-driven information on the Nuclear Matrix Elements characterizing these relevant nuclear excitations, establishing a link with beta decay processes and, in particular, with the search of neutrino-less double beta-decay.

ERASMUS MUNDUS JOINT MASTER DEGREE IN NUCLEAR PHYSICS

UNIVERSIDAD DE SEVILLA

Co-funded by the Erasmus+ Programme of the European Union

MASTER THESIS PROPOSAL

TITLE: Theoretical description of dissipative Heavy Ion Collisions and impact on the nuclear Equation of State

SUPERVISOR(S): M.Colonna (INFN-LNS and UniCT), S.Burrello (INFN-LNS)

SUPERVISOR(S) contact- email: colonna@lns.infn.it Telephone: 0039 095 542111
email: burrello@lns.infn.it Telephone: 0039 3891772214

UNIVERSITY/RESEARCH CENTER: Laboratori Nazionali del Sud (INFN) – Catania (Italy)

ABSTRACT

Dissipative heavy ion collisions (HIC) allow to explore nuclear matter under extreme conditions of density, temperature and charge asymmetry. We propose to model HIC at intermediate energies with semi-classical transport theories employing refined nuclear effective interactions, which are linked to the features of the nuclear Equation of State (EoS). The latter is a very important object, which also plays a crucial role in the modeling of compact stars and the emission of gravitational waves. An interesting research path is represented by the implementation of emulators, based on Machine Learning techniques, of these transport models, aiming at a significant reduction in computational times. This would facilitate the direct comparison of the simulations with the data, to ultimately extract the desired information on the EoS.

MASTER THESIS PROPOSAL

TITLE: Bayesian Inference of the Nuclear Matter Equation of State: Integrating Gravitational Wave Observations and Nuclear Physics

SUPERVISOR(S): S.Burrello (INFN-LNS), M.Colonna (INFN-LNS and UniCT), D.Gambacurta (INFN-LNS)

SUPERVISOR(S) contact- email: colonna@lns.infn.it Telephone: 0039 095 542111
email: burrello@lns.infn.it Telephone: 0039 3891772214
email: gambacurta@lns.infn.it Telephone: 0039 095 542648

UNIVERSITY/RESEARCH CENTER: Laboratori Nazionali del Sud (INFN) – Catania (Italy)

ABSTRACT

The study of dissipative heavy-ion collisions (HIC) at Fermi/intermediate energies offers a valuable approach to probe the nuclear matter Equation of State (EoS) in regions far from normal conditions, which is crucial for understanding compact stars. Recent astrophysical observations, such as gravitational waves from neutron star mergers detected by LIGO/VIRGO, along with precise neutron star mass and radius measurements, should be then combined with nuclear physics experiments to impose new constraints on the EoS. This thesis proposes to use a Bayesian inference framework that integrates nuclear structure data, HIC experiments, and gravitational wave observations to refine the EoS and provide deeper insights into the behavior of ultra-dense matter, accounting for uncertainties in both nuclear matter theory and observational data.

ERASMUS MUNDUS JOINT MASTER DEGREE IN NUCLEAR PHYSICS

UNIVERSIDAD DE SEVILLA

Co-funded by the Erasmus+ Programme of the European Union

MASTER THESIS PROPOSAL

TITLE: A Unified Theoretical Framework for Describing Many-Body Correlations and Clustering Phenomena in Nuclear Matter

SUPERVISOR(S): S.Burrello (INFN-LNS), M.Colonna (INFN-LNS and UniCT)

SUPERVISOR(S) contact- email: colonna@lns.infn.it Telephone: 0039 095 542111
email: burrello@lns.infn.it Telephone: 0039 3891772214

UNIVERSITY/RESEARCH CENTER: Laboratori Nazionali del Sud (INFN) – Catania (Italy)

ABSTRACT

Nuclear matter at densities below saturation in nuclei is expected to be inhomogeneous, due to the existence of many-body correlations, which constitutes an essential feature in constructing a reliable equation of state. One prominent phenomenon related to this aspect is the fragmentation process, experimentally observed in heavy-ion collisions at intermediate energies, driven by mechanical instabilities. Additionally, owing to residual few-body correlations, the formation of light clusters, which dissolve with increasing density due to the Pauli exclusion principle, is well established. However, a consistent theoretical framework that unifies the description of both light cluster and heavy fragment formation remains lacking. The aim of this thesis would be to develop such a framework, through suitable extensions of density functional theories, investigating implications for general aspects of reactions dynamics and in the widest scope of astrophysical applications.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: **Study of transport coefficients in a Relativistic Transport Approach Using the Green-Kubo Relation**

SUPERVISOR(S): V. Greco (University of Catania, INFN-LNS), S. Plumari (University of Catania, INFN-LNS)

SUPERVISOR(S) contact- email: greco@lns.infn.it Telephone: 0039 095 542276
email: salvatore.plumari@dfa.unict.it Telephone: 0039 3925543554

UNIVERSITY/RESEARCH CENTER: University of Catania, Catania (Italy)

ABSTRACT

Ultra-Relativistic Heavy-Ion Collisions (uRHICs), such as those performed at LHC or at RHIC, provide a valuable tool for studying the formation and evolution of the Quark-Gluon Plasma (QGP) a state of matter where quarks and gluons are deconfined. Transport properties, such as shear and bulk viscosity, play a critical role in characterizing the QGP's behavior, influencing its evolution of the system as it expands and cools. The scope of the thesis is to study the temperature dependence of the bulk viscosity of the QGP using relativistic transport approach, The aim is to calculate numerically the bulk viscosity using the Green-Kubo relation and also compare numerical results with analytical formulas derived from the Relaxation Time Approximation (RTA) and the Chapman-Enskog approximation (CE). The primary goal is to explore the discrepancies and consistencies between these methods and provide insights into how these models apply to the QGP formed in ultra-relativistic heavy-ion collisions. Understanding the properties of QGP are crucial for studying the strong interaction under extreme conditions and the early universe moments after the Big Bang.

MASTER THESIS PROPOSAL

TITLE: Investigation of universal behaviors in Heavy Quark Dynamics in Ultra-Relativistic Heavy-Ion Collisions

SUPERVISOR(S): S. Plumari (University of Catania, INFN-LNS), V. Greco (University of Catania, INFN-LNS),

SUPERVISOR(S) contact-email: salvatore.plumari@dfa.unict.it Telephone: 0039 3925543554
greco@lns.infn.it Telephone: 0039 095 542276

UNIVERSITY/RESEARCH CENTER: University of Catania, Catania (Italy)

ABSTRACT

Ultra-Relativistic Heavy-Ion Collisions (uRHICs) provide a valuable framework for investigating the Quark-Gluon Plasma (QGP), a deconfined state of matter where quarks and gluons interact strongly. Recent experimental observations have shown collective effects even in smaller collision systems, such as proton-nucleus and proton-proton collisions in high-multiplicity events. These findings challenge the conventional view that QGP formation is exclusive to large systems like nucleus-nucleus collisions. Theoretical studies have shown a universal behavior emerging from the scaling properties of relativistic hydrodynamic and microscopic transport models. This scaling behavior could explain why different collision systems, despite differing initial conditions and system sizes, exhibit similar macroscopic properties. In this thesis, we will employ a 3+1D transport approach to explore the universal behavior of observables for heavy quarks. This study aims to provide deeper insights into the dynamics of heavy quarks in high-energy collisions, furthering our understanding of QGP evolution across different system sizes.

MASTER THESIS PROPOSAL

TITLE: Development of an Open Quantum System approach to study quarkonium decoherence with quantum master equations

SUPERVISOR(S): G, Coci (University of Catania, INFN-LNS), S. Plumari (University of Catania, INFN-LNS), V. Greco (University of Catania, INFN-LNS),

SUPERVISOR(S) contact- email: gabriele.coci@dfa.unict.it Telephone: 0039 3934362432
email: salvatore.plumari@dfa.unict.it Telephone: 0039 3925543554
email: greco@lns.infn.it Telephone: 0039 095 542276

UNIVERSITY/RESEARCH CENTER: University of Catania, Catania (Italy)

ABSTRACT

The study of quarkonium suppression - bound states of heavy quarks with their respective antiquarks - as measured by experimental collaborations at the Relativistic Heavy-Ion Collider (RHIC) in Brookhaven and the Large Hadron Collider (LHC) at CERN, represents a highly active research field within heavy-ion physics. The mechanisms of dissociation and regeneration of quarkonia within strongly interacting matter at high temperatures and densities are not yet fully understood but can provide crucial informations into the QCD phase transition. This thesis aims to develop a theoretical Open Quantum System (OQS) approach using a one-dimensional Lindblad quantum master equation to describe the evolution of quarkonium bound states in a thermal bath. The interaction is driven by heavy-quark transport coefficients, which depend on the thermal bath's properties. This approach allows the study of quarkonia suppression and regeneration based on temperature-dependent interaction cross-sections from perturbative QCD or quasi-particle models. The results can be compared to semi-classical methods and further extended to simulate quarkonium evolution in an expanding medium.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: NArCoS (Neutron Array for Correlation Studies): a new hodoscope for the detection of neutrons and charged particles

SUPERVISOR(S): G. Politi (UniCT), B. Gnoffo (UniCT), E. Pagano (INFN-LNS)

SUPERVISOR(S) contact- email: giuseppe.politi@dfa.unict.it Telephone: +390953785398
email:brunilde.gnoffo@dfa.unict.it Telephone: +390953785111
email: epagano@lns.infn.it Telephone: +39095542275

UNIVERSITY/RESEARCH CENTER:
Dipartimento Fisica e Astronomia, Università di Catania, Italy
Laboratori Nazionali del Sud, INFN, Catania, Italy

ABSTRACT

The aim of the activity is to study and define the characteristics of the NArCoS correlator, suitable for the detection and discrimination of neutrons, gamma and charged particles emitted in reactions at low and intermediate energies, induced by stable and radioactive beams. The unit cell consists of an EJ276G plastic scintillator read by an array of 25 SiPMs. Different experimental tests will be performed and the data acquired as part of the CROSSTEST experiment will be analyzed for the detection of neutrons, with energy between 1 MeV and 4 MeV, produced through the reaction p + 7Li -> 7Be + n, with particular attention to neutron scattering between the various detection cells..

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Constraint Molecular Dynamics and Equilibration Phenomena

SUPERVISOR(S): E. Geraci (UniCT), M.Papa (INFN-sez Ct)

SUPERVISOR(S) contact- email: elena.geraci@dfa.unict.it Telephone: +390953785359
email: papa@ct.infn.it Telephone: +390953785382

UNIVERSITY/RESEARCH CENTER:
Dipartimento Fisica e Astronomia, Università di Catania, Italy
Sezione INFN di Catania, Catania, Italy

ABSTRACT

Nuclear Iso-vectorial forces determining the not-well known EOS for asymmetric matter lead in finite systems the "so called" Isospin equilibration phenomena. The project aims at investigating this equilibration process and the connection with the excitation and decay of the pre-equilibrium Dipolar ɣ-ray emission as a precursor messenger of the process.

The goal is to get information on the Iso-Vectorial forces at density far from the saturation one.

Calculations obtained with the recently improved Costraint Molecular Dynamics Model [Papa M, Phys. Rev. C 87 014001, M.Papa et al PRC 91 041601] will be performed for systems ^{48}Ca+^{27}Al and/or Ni+Ca isotopes at 20-40 AMeV. The study will be focused on reaction mechanisms mainly produced in central/semi-central collisions. For such systems some experimental data were collected with Chimera apparatus at Laboratori Nazionali del Sud, in Catania.

Therefore, comparisons of the calculations with experimental data could be performed.

The thesis project could thus include:
-calculation with the model of the dipolar signal from the charge and mass distribution of the produced clusters for different reaction mechanisms.
-calculation of the same quantity microscopically in the overlap region.
-calculation of the pre-equilibrium ɣ-ray yield
-improvement of the clusterization stage.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Study of Reaction Mechanisms and isospin equilibration dynamics at Fermi energies

SUPERVISOR(S): E. Geraci (UniCT), P. Russotto (INFN-LNS), E.V. Pagano (INFN-LNS)

SUPERVISOR(S) contact- email: elena.geraci@dfa.unict.it Telephone: +390953785359
email: russotto@lns.infn.it Telephone: +39095542275
email: epagano@lns.infn.it Telephone: +39095542275

UNIVERSITY/RESEARCH CENTER:
Dipartimento Fisica e Astronomia, Università di Catania, Italy
Laboratorio Nazionale del Sud, Catania, Italy

ABSTRACT

The project aims at investigating topics related to reaction mechanisms, peculiar of heavy ion collisions at Fermi energies.
The analysis of data collected in experiments performed with Chimera and Farcos multi-detectors, operating at Laboratori Nazionali del Sud, in Catania, will allow to study data analysis techniques employed in this energy domain. In particular, the influence of the isospin degree of freedom on reaction mechanisms will be investigated and variables useful to improve the knowledge of the behavior of nuclear matter will be analyzed.
In particular, the competition between reaction mechanisms and the Intermediate Mass Fragment production phenomenon will be analyzed for the reactions produced accelerating ^{124}Sn, ^{124}Xe and ^{112}Sn beams at 20 AMeV on targets of ^{64}Ni, ^{64}Zn and ^{58}Ni.
Comparisons of the experimental data with semiclassical transport models and/or molecular dynamics models will be encouraged.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Isospin dependence of Fragment Production in central collisions for 58,62Ni+40,48Ca systems at 35 AMeV

SUPERVISOR(S): E. Geraci (UniCT), E. De Filippo (INFN-sez Ct), B. Gnoffo (UniCT)

SUPERVISOR(S) contact- email: elena.geraci@dfa.unict.it Telephone: +390953785359
email: defilippo@ct.infn.it Telephone: +390953785359
email: brunilde.gnoffo@dfa.unict.it

UNIVERSITY/RESEARCH CENTER:
Dipartimento Fisica e Astronomia, Università di Catania, Italy
Sezione INFN di Catania, Catania, Italy

ABSTRACT

The project aims at investigating the influence of the isospin degree of freedom on fragment production for sources formed in central collisions of 58,62Ni+40,48Ca systems at 35 AMeV.
The experimental data, collected in an experiment performed with Chimera multi-detector at Laboratori Nazionali del Sud, in Catania, allow to investigate the multifragmentation process and to extract variables useful to study the decay path of sources of one hundred nucleons and excitation energies around 2-4 AMeV.
The isotopic composition of fragments emitted in the two systems will allow to study and to explore the isospin dependence of the nuclear equation of state (EOS) of nuclear matter under laboratory-controlled conditions.
In addition, information about the space–time evolution of the reaction zone could be obtained via fragment-fragment correlation functions.
Comparisons of the experimental data with semiclassical transport models will allow to characterize the entering of the system in the spinodal region and to obtain valuable information on fragment formation at sub saturation densities.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Advanced methodologies for the study of 12C excited states

SUPERVISOR(S): E. Geraci (UniCT), C. Cardella (INFN-CT), N. Martorana (INFN-CT)

SUPERVISOR(S) contact- email: elena.geraci@dfa.unict.it Telephone: +390953785359
email: cardella@ct.infn.it Telephone: +390953785359
email: martorana@ct.infn.it Telephone: +39095378111

UNIVERSITY/RESEARCH CENTER:
Dipartimento Fisica e Astronomia, Università di Catania, Italy
INFN sez. Catania, Catania, Italy

ABSTRACT

The proposed activity is focused on the study of the decay of the excited states of 12C, a topic of considerable interest in order to investigate the production of 12C and the heavier elements in the universe. In detail, the activity involves the application of an innovative method of analysis of the experimental data collected in the measurements of alpha+12C collisions at an incident energy E=64 MeV at the LNS-INFN, with CHIMERA multidetector and FARCOS correlator. The method is based on coincident measurements of all reaction products, such as light particles, heavy particles and gamma rays, which can be detected through the different identification techniques of CHIMERA and FARCOS experimental apparata.

ERASMUS MUNDUS JOINT MASTER DEGREE IN NUCLEAR PHYSICS

Co-funded by the Erasmus+ Programme of the European Union

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Dosimetric characterization of minibeam radiotherapy systems

SUPERVISORS: Prof. Giuseppe Stella; Dott. Francesco Romano

SUPERVISOR(S) contact- email: giuseppe.stella@unict.it Telephone: +39 095 3785318
email: francesco.romano@ct.infn.it Telephone: +39 0953785244

UNIVERSITY/RESEARCH CENTER: UNICT/INFN – Catania Division

ABSTRACT

Minibeam Radiotherapy (MBRT) is an irradiation modality based on the spatial fractionation of the dose. Specifically, it utilizes sub-millimetric parallel beams (0.5-1 mm) spaced 1-3 mm apart. This approach has recently garnered renewed interest due to its observed reduced toxicity in healthy tissues while maintaining or enhancing tumor control in both in-vivo and in-vitro experiments [1].

The thesis work will focus on the dosimetric characterization of various minibeam geometrical configurations, using electron and proton minibeams. It will explore the possibility of developing new high spatial resolution (<100 µm) dosimeters for dose distribution measurements.

Additionally, Monte Carlo (Geant4) simulations will be conducted to design the final collimators for the production of electron and proton minibeams.

The student will have the opportunity to learn both experimental and simulation methods through the collaboration between UNICT and INFN –Catania Division.

[1] Prezado Y et al. (2018) Proton minibeam radiation therapy widens the therapeutic index for high-grade gliomas. Scientific Reports 8, 16479.

ERASMUS MUNDUS JOINT MASTER DEGREE IN NUCLEAR PHYSICS

Co-funded by the Erasmus+ Programme of the European Union

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS

Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Aluminum DestructiON In Stars

SUPERVISOR(S): Prof. R.G. Pizzone, Dr. M. La Cognata

SUPERVISOR(S) contact- email: lacognata@lns.infn.it Telephone:
email: rgpizzone@lns.infn.it Telephone:

UNIVERSITY/RESEARCH CENTER:
DFA & INFN - LNS

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

The radioisotope ^{26}Al is of outstanding importance in astrophysics, as it plays a key role in constraining the circumstances and conditions of the solar system birth and of the chemical evolution of the Galaxy. Among others, ^{26}Al abundance is used to constrain the neutron star formation rate in our Galaxy, which is a key parameter in the field of Multimessenger Astronomy. Also, ^{26}Al is the most likely heat source for melting, differentiation and crust formation of planetary bodies in the early Solar System.
To ascertain the most likely ^{26}Al nucleosynthesis scenario, the ^{26}Al production and destruction mechanisms will be investigated, in the energy range up to about 1 MeV. Two reactions strongly affect ^{26}Al nucleosynthesis, the ^{26}Al(n,p)^{26}Mg and the ^{26}Al(n,α)^{23}Na . The Trojan Horse Method (THM) will be used for their study, using deuterons to transfer a neutron and populate ^{27}Al excited states, later decaying to the p+^{26}Mg and α+^{23}Na channels.
The method offers a great advantage with respect to direct approaches, thanks to the possibility to run at energies much higher than those of astrophysical interest, and to the capability of removing background sources. Within this framework, a high granularity detection setup will be used (NEFASTA: NEar FAr Silicon Telescope Array).
The candidate student will work on the development of algorithms for the detector calibration, starting from a variety of experimental data including sources, reactions, and scattering processes, with the aim to determine solid angles and fine angular corrections based on reaction kinematics. This is a key point in the THM application, fixing the new resonances discovery capability of NEFASTA.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: 11B+p interaction for nuclear astrophysics

SUPERVISOR(S): Prof. L. Lamia, Dr. G.L. Guardo

SUPERVISOR(S) contact- email: llamia@lns.infn.it Telephone:
email: guardo@lns.infn.it Telephone:

UNIVERSITY/RESEARCH CENTER:
DFA & INFN - LNS

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

Light elements in astrophysics represent one of the most interesting and intriguing topic. Their importance is indeed related to different scenario affecting the nucleosynthesis in the Cosmos, ranging from primordial nucleosynthesis to the stellar one. With respect to this last aspect, the trio of light elements lithium, beryllium and boron (LiBeB) is used for understanding stellar mixing phenomena acting inside stellar interiors. Besides the role in nuclear astrophysics, the 11B(p,α)αα reaction has gained prominence primarily due to its relevance in nuclear fusion reactor development, where it seems highly appealing to researchers, because of the lack of neutrons in the reactions products. For such a reason,
devoted cross section measurements have been performed during these years. In order to complement the already available information and to measure angular distribution at energy range where no or discordant measurements exist, we aim at investigating the 11B(p,α)8Be reaction with the ELISSA detection setup at the 3MV accelerator.
The research activity aims to analyze the experimental data (in ROOT format) starting from the calibration of the detectors involved and performing devoted simulation using GEANT4 in order to cross check the results.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Study of p-process at the HIGs gamma ray beam facility

SUPERVISOR(S): Prof. S. Romano, Dr. G.L. Guardo

SUPERVISOR(S) contact- email: romano@lns.infn.it Telephone:
email: guardo@lns.infn.it Telephone:

UNIVERSITY/RESEARCH CENTER:
DFA & INFN - LNS

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

The nucleosynthesis of the so-called p-nuclei is one of the most puzzling problems yet to be solved. In order to explain the abundances of these proton-rich nuclei (with mass A between 74 and 196) that cannot be synthesized by neutron-capture processes (s- or r-process), a third mechanism called p-process has been introduced. This mechanism, which is supposed to take place in explosive scenarios, involves s-nuclei as seeds and a succession of (γ,n), (γ,p), (γ,α) reactions and their inverse processes happening at high temperatures ($T > 10^9$K) and short time scales. Among the others, the crucial (γ,α) photodisintegration cross section of ^{112}Sn is still not directly measured. Thus, an experiment was performed at the High Intensity Gamma-Ray Source (HIgS, Duke University) with a collimated photon flux with energies from 11 MeV to 20 MeV using the SIDAR array. The research activity aims to analyze the experimental data (in ROOT format) starting from the calibration of the detectors involved and performing devoted simulation using GEANT4 in order to cross check the results.

TITLE: Photodissociation reaction

SUPERVISOR(S): Dr. G.L. Guardo, Prof. L. Lamia

SUPERVISOR(S) contact: email: guardo@lns.infn.it

email: llamia@lns.infn.it

UNIVERSITY/RESEARCH CENTER: DFA – UniCT, INFN – LNS

ABSTRACT

Silicon burning sets the chemical composition of a star right before the core collapse and the subsequent supernova explosion, thus constituting a key process for the understanding of core-collapse supernovae. Sensitivity studies show that the $^{24}Mg(\gamma,\alpha)^{20}Ne$ reaction governs the downward flow from ^{24}Mg to ^{4}He, thus determining the effective rate of ^{28}Si destruction, making its reaction rate critically important to stellar models. At present, the $^{24}Mg(\gamma,\alpha)^{20}Ne$ reaction rate has been calculated from the $^{20}Ne(\alpha,\gamma)^{24}Mg$ rate that in the temperature range of interest may be subject to systematic errors of the order of a factor of 2. A direct ^{24}Mg photodissociation measurement using gamma beams of energies 10-12 MeV will allow us to determine a much more accurate cross section to be used in nuclear reaction network calculations to improve the knowledge of the pre-supernova chemical composition. For this reason, a new direct measurement of the reaction cross section at astrophysical energies using the Compton backscattered gamma beam available at the High Intensity Gamma-Ray Source (HIγS) will be performed.

In the research activity, the GROOT code will be used to analyze the solid-angle coverage and the angular and energy straggling of the target together with resolution of detectors and gamma beam energy spread and emittance in order to determine the best setup for the experiment.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Improving gamma detection by isolating signal from background – a machine learning approach

SUPERVISOR(S): David Mascali (UniCT and INFN-LNS)
Eugenia Naselli (INFN-LNS), Angelo Pidatella (INFN-LNS)
Domenico Santonocito (INFN-LNS), Bharat Mishra (INFN-LNS)

SUPERVISOR(S) contact- email: davidmascali@lns.infn.it Telephone: +39 339 41 70 610
email: naselli@lns.infn.it Telephone:
email: pidatella@lns.infn.it Telephone:
email: santonocito@lns.infn.it Telephone:

UNIVERSITY/RESEARCH CENTER: University of Catania, INFN-LNS

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

In-plasma measurement of beta-decay rate is based on tagging the secondary gamma released by the excited daughter nucleus. The gamma photon emitted from radioisotopes considered lies in the keV range which overlaps with high energy bremsstrahlung from the plasma. In order to separate the gamma peak from the self-emission background with n-sigma level certainty, the plasma needs to be kept stable for days or weeks [1, 2]. This thesis will be a feasibility study to assess whether the measurement time can be reduced by using machine learning and deep neural networks as peak finding algorithms [3].
[1] D. Mascali et al, The PANDORA project: an experimental setup for measuring in-plasma beta-decays of astrophysical interest, EPJ Web of Conferences 227, 01013 (2020).
[2] E. Naselli et al., Design study of a HPGe detector array for β-decay investigation in laboratory ECR plasmas, Front. Phys. 10, 935728 (2022).
[3] S. Wu et al, Peak-searching method for low-count rate gamma spectrum under short-time measurement based on a generative adversarial network, Nuclear Inst. And Methods in Physics Research A 1002, 165252 (2021).

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Numerical and experimental study of the IRIS 3D metallic printed new resonant cavity for ion sources and magnetized plasmas

SUPERVISOR(S): David Mascali (UniCT and INFN-LNS)
Giueseppe Torrisi (INFN-LNS), Giorgio Mauro (INFN-LNS)

SUPERVISOR(S) contact- email: davidmascali@lns.infn.it Telephone: +39 339 41 70 610
email: giuseppe.torrisi@lns.infn.it Telephone:
email: mauro@lns.infn.it Telephone:

UNIVERSITY/RESEARCH CENTER: University of Catania, INFN-LNS

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

This thesis is proposed to work on a prototype of the IRIS-shaped plasma chamber for advanced ion sources to be used in fundamental science, medicine and industry. Reshaping of plasma chamber and launching systems recalling fusion reactors (e.g., Stellarators), where vessels closely imitate the magnetic field structure, is here considered for maximizing the RF power absorption into the ECR (Electron Cyclotron Resonance) plasma core. The realization of the chamber will be done by Additive Manufacturing Technology. Numerical modelling and experimental characterizations are expected to be carried out.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS

Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Investigation of kinetic instabilities in laboratory plasmas emulating astrophysical emission of radio and X-ray bursts

SUPERVISOR(S): David Mascali (UniCT and INFN-LNS)
Angelo Pidatella (INFN-LNS), Eugenia Naselli (INFN-LNS)

SUPERVISOR(S) contact- email: davidmascali@lns.infn.it Telephone: +39 339 41 70 610
email: pidatella@lns.infn.it Telephone:
email: naselli@lns.infn.it Telephone:

UNIVERSITY/RESEARCH CENTER: University of Catania, INFN-LNS

ABSTRACT

(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

Several experiments demonstrated that plasma kinetic instabilities limit the flux of highly charged ions extracted from Electron Cyclotron Resonance Ion Sources (ECRIS). Onset of the instability is typically characterized by fast RF and X-ray bursts and causes beam ripple and unstable ion source conditions. These instabilities are really relevant for astrophysical scenarios. Even if many studies have been carried out, the exact mechanism of turbulent regimes of plasmas is still under investigation. The thesis will be focused on the experimental setup that are able to reproduce and study these interesting phenomena of interest for astrophysics, such as the so-called Cyclotron Maser Instability, which is a typical kinetic turbulence occurring in astrophysical objects. The thesis activity will aim to investigate turbulent plasma regimes in Radio and X-ray domains in laboratory, performing space- and time-resolved spectroscopy simultaneously. The activities will be carried out at the INFN-LNS on the axis-symmetric Flexible Plasma Trap based on a Simple Mirror configuration. A multi-pins RF probe connected with a diode and an 80 Gs/s scope allows to obtain high-resolution time-resolved but fully integrated power emitted by the plasma to detect RF bursts (signature of the plasma instability regime), so this value will be used as trigger signal for an X-ray CCD camera to perform X-ray imaging and spectroscopy [1]

[1] E. Naselli et al., JINST, 17 C01009 (2022)

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Development of a movable Langmuir probe system for measuring local electron density and temperature in a magnetized plasma

SUPERVISOR(S): David Mascali (UniCT and INFN-LNS)
Angelo Pidatella (INFN-LNS)

SUPERVISOR(S) contact- email: davidmascali@lns.infn.it Telephone: +39 339 41 70 610
email: pidatella@lns.infn.it Telephone:

UNIVERSITY/RESEARCH CENTER: University of Catania, INFN-LNS

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

Langmuir probes are valuable diagnostics methods capable of measuring local plasma parameters such as electron density and temperature by reconstructing the current-potential (I-V) curve in both electrons and ions regions. Thermodynamical parameters are the reconstructed by appropriate models of electrostatic particle collection in the magnetized plasma. The thesis will consist in the theoretical investigation of an optimized tool to be used for the analysis of ECR plasmas, and then the realization of the probe to be tested in a real experimental setup.

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Photonic crystals for ultracompact dielectric accelerators

SUPERVISOR(S): David Mascali (UniCT and INFN-LNS)
Giueseppe Torrisi (INFN-LNS), Giorgio Mauro (INFN-LNS)

SUPERVISOR(S) contact- email: davidmascali@lns.infn.it Telephone: +39 339 41 70 610
email: giuseppe.torrisi@lns.infn.it Telephone:
email: mauro@lns.infn.it Telephone:

UNIVERSITY/RESEARCH CENTER: University of Catania, INFN-LNS

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

Laser acceleration of electrons with silicon dielectric structures was demonstrated in with accelerating gradients of more than 200 MeV/m. Many of the proposed configurations have an intrinsically limited interaction length, because they require a plane wave that impinges laterally throughout the whole structure's length. In order to have both high laser-induced accelerating gradients and adequate interaction length, this thesis work will focus on the EM design and beam dynamics study of hollow-core waveguides, based on photonic crystals, employed as accelerating structures (with possibly co-linear propagation of the accelerating electromagnetic field and the particle bunch to be accelerated).

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Studying spatial distribution of ion properties in ECR plasmas with self-consistent numerical codes for the PANDORA project

SUPERVISOR(S): David Mascali (UniCT and INFN-LNS)
Angelo Pidatella (INFN-LNS), Bharat Mishra (INFN-LNS)

SUPERVISOR(S) contact- email: davidmascali@lns.infn.it Telephone: +39 339 41 70 610
email: pidatella@lns.infn.it Telephone:
email: mishra@lns.infn.it Telephone:

UNIVERSITY/RESEARCH CENTER: University of Catania, INFN-LNS

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

Calculating the charge state distribution (CSD) and level population of ions as a function of their position in an ECR plasma is integral for understanding the nature of the extracted beam, as well as for estimating beta-decay rates of radioisotopes diffused into such systems [1,2]. To this effect, the thesis will be concerned with evaluating the 3D distribution of ion properties in ECR plasmas using self-consistent numerical codes connecting warm electron 3D space-resolved evolution in time with ion dynamics through collisional ionisation, charge exchange and particle transport models.
[1] D. Mascali et al., A novel approach to β-decay: PANDORA, a new experimental setup for the future in-plasma measurements, 2022 Universe 8, 80.
[2] K. Takahashi and K. Yokoi, Nuclear B-Decays of Highly Ionised Heavy Atoms in Stellar Interiors, Nucl. Phys. A 404, 3 (1983)

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Development of an experimental setup and measurement of magneto-plasma opacity in laboratory

SUPERVISOR(S): David Mascali (UniCT and INFN-LNS)
Angelo Pidatella (INFN-LNS)

SUPERVISOR(S) contact- email: davidmascali@lns.infn.it Telephone: +39 339 41 70 610
email: pidatella@lns.infn.it Telephone:

UNIVERSITY/RESEARCH CENTER: University of Catania, INFN-LNS

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

Opacity is a key ingredient in many relevant astrophysical scenarios, which impact on the energy transport and spectroscopic observations is still debated. Electromagnetic transient signal emitted from neutron-star mergers (kilonova - KN) is of interest in the multi-messenger astronomy frame because of delivered information on the expelled plasma ejecta's composition (r-process nucleosynthesis), however its interpretation strongly depends on the system opacity, which is an almost unfolded observable. The activity proposed in this thesis is in the context of experimental investigations of in-laboratory magneto-plasma opacities, for metallic species abundant in a specific time-stage of KN diffusion, at plasma electron density and temperatures resembling the ejecta plasma conditions [1, 2]. In this framework, the on-construction facility PANDORA, and the working Flexible Plasma Trap (FPT), both at the INFN – LNS (Catania, Italy) suite for the purpose. The thesis will concern the development of an experimental multi-diagnostic setup, based on optical spectroscopy and microwave interferometry, thus employing complementary techniques and methods, for studying opacity of gaseous plasmas magnetically confined in compact plasma traps. The setup assembling (design, calibration) and measurements will be carried out on the FPT, as ground experiments projected to be then extended in the PANDORA facility. The investigation will help in shedding light on atomic uncertainties on the KN problem, as well as to further extend knowledge on the stellar opacity problem for the Astrophysics and Nuclear Astrophysics interests.

[1] Pidatella, A., *et al.*, IL NUOVO CIMENTO 44 C (2021) 65.
[2] Pidatella, A., *et al.*, Frontiers in Astronomy and Space Sciences 9, 225 (2022).

ERASMUS MUNDUS MASTER IN NUCLEAR PHYSICS
Academic Year 2024/2025

MASTER THESIS PROPOSAL

TITLE: Microwave/mm-wave polarimetry for magneto-plasmas of ECR ion source

SUPERVISOR(S): David Mascali (UniCT and INFN-LNS)
Giueseppe Torrisi (INFN-LNS), Eugenia Naselli (INFN-LNS)

SUPERVISOR(S) contact- email: davidmascali@lns.infn.it Telephone: +39 339 41 70 610
email: giuseppe.torrisi@lns.infn.it Telephone:
email: naselli@lns.infn.it Telephone:

UNIVERSITY/RESEARCH CENTER: University of Catania, INFN-LNS

ABSTRACT
(just few lines 5-10 explaining briefly the idea of the proposed work and the place where it will be developed).

Polarimetric setup - able to measure the magnetoplasma-induced Faraday rotation in a compact size plasma trap - has been proven to provide reliable measurement of the plasma line-integrated electron density [1]. This thesis work will develop an analysis method for polarimetric measurements on a mm-wave testbench [2] – based on the detection of Lissajous figure from a two channels scope (80 gigasample) in an x-y representation of a direct probing RF signals crossing the magnetoplasma. The system was on purpose designed and developed for the PANDORA chamber case study [3], which represents an “intermediate” case between the ultra-compact plasma ion sources and the large-size thermonuclear fusion devices.
[1] E. Naselli et al. (2018) JINST ***13*** *C12020.*
[2] G. Torrisi et al. (2022) Front. Astron. Space Sci. ***9*** *949920.*
[3] D. Mascali et al. (2022) Universe ***8****, 80.*