PhD Programme table 37th cycle – PON Call for application "Ricerca e Innovazione" 2014 – 2020

PROGRAMME'S NAME	MATHEMATICS
DURATION	3 years
PROGRAMME START DATE	01/01/2022
LANGUAGE	Italian, English
COORDINATOR	Prof. Valeria Simoncini (valeria.simoncini@unibo.it)
CURRICULA	N/A
RESEARCH TOPICS	Detailed list at the bottom of the present document
PhD POSITIONS	5
ADMISSION PROCEDURE	Qualifications and research proposal evaluation

Available Positions and Scholarships

Actions	**Pos. n.**	**Financial Support**	**Research topic**
Action IV.5 – PhDs on green topics	1	PhD Scholarship	A mathematical-physics approach to improve energy efficiency in classical and quantum machine learning
	2	PhD Scholarship	Stochastic climate modelling for risk management
	3	PhD Scholarship	Forecast models of Storm Surges and of their effects on coastal systems
	4	PhD Scholarship	Mathematical models and numerical methods for environmental applications of Fast Field Cycling Nuclear Magnetic Resonance
	5	PhD Scholarship	Black-Box optimization for clean energy technologies

Required and Supporting Documents to be attached to the application

(only documents in Italian, English, French, German and Spanish shall be considered as valid and be assessed by the Admission Board)

Only qualifications obtained during the last 5 calendar years shall be taken into consideration, except for the University Degree. **The Admission Board will assess the relevance of the supporting documents to the criteria listed in Art. 3 of the Ministerial Decree 1061/2021 (see also Art. 4 of the Call for applications)**.

REQUIRED DOCUMENTS	
Identity document	Valid identity document with photo (i.e. identity card, passport)
Curriculum Vitae	No specific CV format is required
Degrees	Documents attesting the awarding of the first and second cycle degrees (see Art. 3 of the Call for Applications)
Research proposal	Multi-annual research proposal, with special emphasis on the activities to be completed during the first-year course. The proposal must meet the following requirements: - it **cannot exceed 20,000 characters**, including spaces and formulas, if present. This figure does not include: the title, the outline, references and images (such as graphs, diagrams, tables etc. - where present);

	- it must be written following the template provided for Action IV.5 “PhDs on Green topics”. The template is attached to the Call for Application and available for download on the University website.
SUPPORTING DOCUMENTS	
Publications	Lists of publications (i.e. monographs, articles on scientific journals), minor publications (conference papers, etc.), abstracts and posters presented during national and international conferences, etc.
Further experiences (training, work, research, teaching, etc.)	- Research activity - whether basic, applied, translational, etc. - carried out in any capacity, including when covered by research grants, and as a staff member of research units - Periods of study abroad, outside the country of origin (e.g. Erasmus programme or other similar mobility programmes) - Other qualifications attesting the suitability of the applicants (scholarships, prizes, etc) - Language certificates - Teaching assistantship - Work experience

Evaluation criteria

The **results of the admission exams** will be available **from 03/11/2021** on Studenti Online (select “summary of the requests in progress” > “see detail” and open the .pdf file at the bottom of the page). **No personal written communication will be sent to applicants concerning the examinations results**.

Scores will be expressed in points out of 100, as follows.

Minimum score for eligibility: 60 points, Maximum score: 100 points

Qualifications evaluation	University degree final mark. Graduands shall be evaluated according to the Weighted Average Mark (WAM)	10 points max
	Publications	25 points max
	CV and further experiences	15 points max
Research proposal evaluation		50 points max

Research Topics

n. 1 - GREEN

Thematic area SNSI 2014-20	Intelligent and sustainable industry, energy and environment
PNR 2021-2027*	4.3 Artificial Intelligence, 4.7 Aerospace, 5.3 Industrial Energetics
Project title	A mathematical-physics approach to improve energy efficiency in classical and quantum machine learning
Project description	The aim is to reduce the computational complexity of machine learning devices, eliminate the enormous redundancy they come with, and drastically cut their energy consumption. The answer requires a paramount detailed knowledge on the principles those machines work on, nowadays still largely lacking. The statistical mechanics approach to the Boltzmann Machines is one of the major and most promising paths toward their clarification. The project plan to use one of the methods of coming from the theory of equilibrium, non-equilibrium, classical and quantum.
Mandatory traineeship	6 months
Company type	Precision Mechanics, Space Sector
Stay abroad	6 months

n. 2 - GREEN

Thematic area SNSI 2014-20	Intelligent and sustainable industry, energy and environment
PNR 2021-2027	5.5.2 Climate change, mitigation and adaptation
Project title*	Stochastic climate modelling for risk management
Project description	The purpose of the research is the development of models for the simulation of probabilistic scenarios of climate variables for the realization of insurance instruments that reduce the impact of climate change on Economy and Society. Objective1. Study of theoretical models for climate evolution, expressed in terms of stochastic partial differential equations. Objective2. Development of a model for the prediction of the distribution of climate variables on medium-long time scales and high spatial resolution based on state-space models and dynamic factors.
Mandatory traineeship	6 months
Company type	Insurance
Stay abroad	NO

n. 3 - GREEN

Thematic area SNSI 2014-20	Intelligent and sustainable industry, energy and environment
PNR 2021-2027*	5.5.2 Climate change, mitigation and adaptation
Project title	Forecast models of Storm Surges and of their effects on coastal systems
Project description	Study, analysis, and re-processing of predictive models of Storm Surge and ecological response of coastal habitats. Both components are strongly non-linear and their modeling represents a decisive step forward in terms of information available to decision makers. Training of a machine learning model on a historical database of Arpa-Emilia Romagna. Acquisition of the necessary mathematical skills: Navier-Stokes equations; the Scaling Gyroscopes Cascade model; tools for processing datasets.
Mandatory traineeship	6 months
Company type	Geographic Information System
Stay abroad	6 months

n. 4 - GREEN

Thematic area SNSI 2014-20	Intelligent and sustainable industry, energy and environment
PNR 2021-2027*	5.6.1 Green technolgies

Project title	Mathematical models and numerical methods for environmental applications of Fast Field Cycling Nuclear Magnetic Resonance
Project description	Fast Field Cycling Nuclear Magnetic Resonance (FFC-NMR) is a low-field magnetic resonance imaging technique, which is particularly useful in non-destructive analysis to reveal information about slow molecular dynamics. FFC-NMR has a wide range of applications and is a crucial tool in improving industrial processes, reducing energy consumption and the waste of resources. From a mathematical point of view, this is a non-linear inverse problem, severely ill-conditioned, whose solution needs a comprehensive analysis of its mathematical properties and requires the study of efficient numerical methods. The activity of the PhD research consists of the analysis of the mathematical properties of the FFC-NMR models and the development of numerical methods for its solution to promote a green application of the FFC. The expected results are summarized as follows: - Analysis of the models well-posedness and stability, test of existing numerical methods. - Development of robust algorithms and validation on different type of FFC-NMR data Promotion of the employment of the algorithms for the analysis of NMR dispersion profiles in environmental applications through the implementation of user-friendly interfaces.
Mandatory traineeship	12 months
Company type	NMR scanners and analytical tools
Stay abroad	NO

n. 5 - GREEN

Thematic area SNSI 2014-20	Intelligent and sustainable industry, energy and environment
PNR 2021-2027*	5.5.3 Industrial Energy - Innovation for the Manufacturing Industry
Project title	Black-Box optimization for clean energy technologies
Project description	The solution of Black-Box optimization problems arising in real applications calls for the development of efficient and easy-to-use implementations of innovative derivative-free algorithms. In this context, the focus of the project is the mathematical and computational analysis of a large scale Black-Box industrial problem that will contribute to the development of low-emission energy technologies.
Mandatory traineeship	6 months
Company type	Manufacturing company - energy production technology sector
Stay abroad	6 months

*the translation of PNR 2021-2027 has been carried out by the PhD Unit