

PhD in Mathematics – Cycle 39 Research topics 2023

Bando 2023/Call 2023

Dipartimento di Matematica – Università di Trento Borse di studio/ Scholarships

H2020 ERC CHANGE

A Geometric Analysis

Topic: Geometric Analysis

P.I.: ALESSANDRO CARLOTTO

Contacts: alessandro.carlotto@unitn.it

Synthetic description of the activity and expected research outcome

The fellowship is meant for distinguished candidates wishing to be introduced to some central themes of research in the field of Geometric Analysis under the direction of Prof. Alessandro Carlotto, who serves as principal investigator for the European project in question. Some focus topics are the study of minimal surfaces (in different contexts), the study of scalar curvature constraints, and the interplay between the two things possibly in connection with the investigation of initial data sets for the Einstein field equations.

Further information

potential candidates are referred to the project webpage https://r1.unitn.it/change

Ideal candidate

Fluency with the ideas and methods of Riemannian Geometry on the one hand, and partial differential equations (mainly of elliptic and parabolic type, plus standard background on Functional Analysis and Sobolev spaces) on the other hand are a must. Additional, more specific background (such as, for instance: some working knowledge of Geometric Measure Theory, variational and Morse-theoretic methods for nonlinear problems, or perhaps a first exposure to mathematical aspects of General Relativity) although not strictly necessary, may be a plus. The ideal candidate is expected to display a high degree of commitment and motivation for mathematical research.

HORIZON EUROPE PRIZE

В	Mathematical models for vector-borne infections

Topic: Mathematical and computational modelling of vector-borne infections

P.I.: ANDREA PUGLIESE

Contacts: andrea.pugliese@unitn.it



Synthetic description of the activity and expected research outcome

The research developed during the Ph.D. will focus on advancing the formulation and analysis of models for infections transmitted by vectors, especially mosquitoes. Among the possible objectives are:

- the development of detailed models for specific infections, especially West Nile Virus, and on fitting them to available data;
- the analysis of models with realistic distributions for the periods of infectivity, and the length of life;
- the analysis of models with spatially distributed populations, and periodic environment.

References

Marini, G., Calzolari, M., Angelini, P., Bellini, R., Bellini, S., Bolzoni, L., Torri, D., Defilippo, F., Dorigatti, I., Nikolay, B., Pugliese, A., Rosà, R., Tamba, M., (2020). A quantitative comparison of West Nile virus incidence from 2013 to 2018 in Emilia-Romagna, Italy. PLoS Negl. Trop. Dis. 14, e0007953. https://doi.org/10.1371/journal.pntd.0007953

Bacaër, N. (2007). Approximation of the basic reproduction number R0 for vector-borne diseases with a periodic vector population. *Bulletin of Mathematical Biology*, *69*(3), 1067–1091. https://doi.org/10.1007/s11538-006-9166-9

Rashkov, P., Venturino, E., Aguiar, M., Stollenwerk, N., & Kooi, B. W. (2019). On the role of vector modeling in a minimalistic epidemic model. *Math. Biosci. Eng.*, *16*(x), 4314–4338.

Ideal candidate

Ideal candidates will have a degree in applied mathematics or related areas, some experience in mathematical modelling, and scientific programming; a good knowledge of basic statistical methods.

Fondazione Bruno Kessler – FBK

Borse di studio/ Scholarships



C - scholarship on reserved topics

Funded by: project PNRR MS4 C2 I1.3 PE00000007 – INF-ACT - "One Health Basic and Translational Research Actions addressing Unmet Needs on Emerging Infectious Diseases" – SPOKE 4 — CUP C63C22000800006.

Title: Mathematical models of infectious disease transmission and control

Topic: Computational approaches to investigate emerging and re-emerging pathogens

Contacts: guzzetta@fbk.eu

Synthetic description of the activity and expected research outcome

Research activity conducted during the Ph.D. will focus on the development of mathematical and computational models to analyze the potential spread of emerging and re-emerging infectious diseases in human populations. This may include the analysis of drivers influencing the spread of an infectious disease, the estimation of key parameters describing the epidemiology and the natural history of the analyzed pathogen, the simulation and evaluation of control measures and interventions that could be implemented to interrupt the transmission and avoid widespread epidemics. Envisioned approaches range from the development and simulation of mechanistic mathematical models to the use of statistical inference applied to available epidemiological data.



References

- [1] Zhang, Q et al. Spread of Zika virus in the Americas. PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA (2017), Vol. 114(22), pp. 201620161.
- [2] Guzzetta G et al. Spatial modes for transmission of chikungunya virus during a large chikungunya outbreak in Italy: a modeling analysis. BMC MEDICINE (2020), Vol. 18(1).
- [3] Di Ruscio F et al. Quantifying the transmission dynamics of MRSA in the community and healthcare settings in a low-prevalence country. PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA (2019), pp. 201900959.
- [4] Trentini F et al. Measles immunity gaps and the progress towards elimination: a multi-country modelling analysis. THE LANCET INFECTIOUS DISEASES (2017), Vol. 17(10), pp. 1089–1097.
- [5] Poletti P et al. Evaluating vaccination strategies for reducing infant respiratory syncytial virus infection in low-income settings. BMC MEDICINE (2015), Vol. 13(1), pp. 49.
- [6] Marziano V et al. The effect of COVID-19 vaccination in Italy and perspectives for living with the virus. NATURE COMMUNICATIONS (2021), Vol. 12(1), pp. 7272.
- [7[Manica M, et al. Intrinsic generation time of the SARS-CoV-2 Omicron variant: An observational study of household transmission THE LANCET REGIONAL HEALTH. EUROPE (2022) 19, 100446

Ideal candidate (skills and competencies)

Ideal candidates will have a degree in applied mathematics or related areas, some experience in mathematical modelling, and scientific programming; a good knowledge of basic statistical methods.

D Mathematical Analysis of Spatially Embedded Networks with Applications to Urban Systems

Topic: The objective of this thesis is to advance mathematical models and analytical tools for the investigation of spatially embedded networks and their influence on urban systems. The study will utilize the expertise of several fields, including graph theory, topology, geometry, and spatial statistics, to analyze the structure, function, and dynamics of spatial networks.

P.I.: RICCARDO GALLOTTI

Contacts: rgallotti@fbk.eu

Synthetic description of the activity and expected research outcome

Through our research, we aim to contribute to the comprehension of urban systems by developing appropriate mathematical and statistical tools with the ultimate goal of providing insightful information to policy decisions concerning urban planning and transportation. Our study will focus on (i) theoretical properties of spatially embedded networks (ii) their design for modeling urban systems and (iii) the statistical tools for their analysis.

To achieve these objectives, we will adopt a multidisciplinary approach that will advance our understanding of spatially embedded networks as a mathematical model and their use in the analysis of urban systems. Our focus will be on the development of mathematical models that effectively capture the complexity of urban spatial networks such as transportation and utility networks. The analysis will try to identify patterns, predict outcomes, and classifying spatial networks based on their properties.

Computational issues is an aspect will be covered by the project as well. By combining traditional statistical methods with machine learning algorithms, we will be able to process large networks to extract insights that would be otherwise challenging to obtain. Moreover, machine learning techniques will be utilized to optimize network design and allocate resources, resulting in more sustainable and efficient urban systems.



References

Barthelemy, Marc. Spatial Networks: A Complete Introduction: From Graph Theory and Statistical Physics to Real-World Applications. Springer Nature, 2022.

Ideal candidate

Master in a data-oriented field (Physics, Math, Data Science, Computer Science, Computational Social Science, ...) Software development skills (preferably in Python) Attitude towards analytical thinking Good knowledge and proficiency of the English language

Team working attitude Good communication and relation skills

Fondazione The Microsoft Research – University of Trento Centre for Computational and Systems Biology - COSBI

Borsa di studio/ Scholarship

E Applications of multi-scale mathematical modeling to complex disorders: from systems biology to precision medicine

Topic: Applications of multi-scale mathematical modeling to complex disorders

P.I.: LUCA MARCHETTI

Contacts: luca.marchetti@unitn.it

Synthetic description of the activity and expected research outcome

Precision medicine is a novel medical model that proposes the customization of healthcare with medical decisions, treatments, and practices tailored to the individual patient. Within the project, the candidate will define and apply novel holistic mathematical approaches to support the description of complex diseases at the system level that can be effectively calibrated based on individual data. The research will start with a comprehensive literature review that will provide the basis for defining innovative modeling pipelines. The resulting methodologies will then be applied to test cases related to the several international collaborations that COSBI has in place in the pharma world.

Ideal candidate

The ideal candidate will be a highly motivated student with a MSc in Mathematics, Bioinformatics, Biostatistics, Computer Science, Computational Biology, or equivalent degrees, ideally with some experience in mathematical modeling and scientific programming who will be willing to explore a rapidly advancing and interdisciplinary field of research. The candidate is expected to work independently and in multidisciplinary teams in close collaboration with COSBI scientists and external institutions