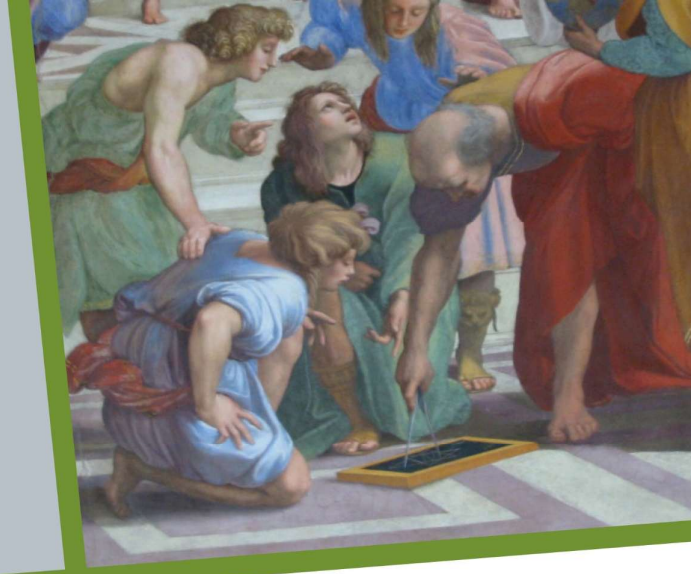
UNIVERSITÀ DI TRENTO
Dipartimento di Matematica



DOTTORATO

ADMISSION TO THE FINAL EXAMINATION - PHD PROGRAMME IN MATHEMATICS
Seminar Room of Department of Mathematics
The event will take place in presence and online through the ZOOM platform.
To get the access codes please contact the secretary office.

Tuesday 17th February 2026

9.00 - Dalmaso Caterina

Modelling cardiopulmonary interactions. Towards anatomically detailed and physiologically accurate cardiorespiratory models.

Abstract: We present a model of the cardiorespiratory system that includes a 1D-0D description of the cardiovascular system, a 0D description of lung mechanics, a 1D-0D description of gas transport and exchange in the systemic and pulmonary vessels, and local autoregulatory mechanisms. We highlight the numerical issues encountered in developing the model, present several examples that demonstrate its predictive capabilities and explore physiologically relevant scenarios.
Simulations are performed on two 1D arterial-venous network models characterized by different degrees of anatomical detail, coupled to a 0D description of lung mechanics. These networks are calibrated to ensure comparable cardiac output, mean arterial pressure, and flow rates in selected arteries. Respiratory gases are modeled as passive scalars transported by blood, enabling investigation of how vascular network resolution influences tracer dynamics. Specifically, we analyze the time required for a bolus injected into the antecubital vein to reach the aortic arch and cerebral vessels. Gas exchange is simulated both at the level of the lungs, assuming instantaneous diffusion across the hemato-alveolar membrane, and between peripheral capillaries and tissues, under the assumption of a homogeneous blood-tissue compartment. The gas exchange module is calibrated accounting for the anatomical detail provided by the arterial network: we consider five gas consumption/production rates, defined for a baseline state based on Fick's principle, and twenty-five perfused tissue regions, each characterized by a specific volume. Additionally, we include a description of basic autoregulation phenomena, which capture metabolic responses to blood gas concentrations and myogenic responses to flow.

Supervisor: Lucas Omar Müller (co-supervisori: Annunziato Siviglia, Pablo Javier Blanco)

9.20 - Campanile Elio

Multiscale mathematical models of immune agent trafficking to support innovative cancer treatments

Abstract: We present a multiscale mathematical modeling framework for immune agent trafficking in cancer therapies, with applications to mRNA-encoded therapeutics and CAR T-cell treatment of B-cell lymphomas. The work combines Physiologically Based Pharmacokinetic (PBPK) modeling and localized tumor–immune interaction models, formulated as systems of ordinary differential equations operating across multiple biological scales.
First, we introduce an extension of whole-body PBPK models to describe lipid nanoparticle–mediated delivery of mRNA-encoded therapeutics. The model accounts for key mRNA reactions, leading to a coupled linear–nonlinear ODE system with mechanistic organ compartments and a tumor-specific site. Parameter influence is investigated through sensitivity and identifiability analyses using in vivo data. Second, we present a minimal PBPK-informed model for CAR T-cell trafficking between blood and lymph nodes, coupled to nonlinear tumor–immune dynamics describing interactions with malignant B

cells. A study of the model parameters was performed through sensitivity analysis and the development of a reduced model to allow equilibria and stability investigation, while remaining consistent with available clinical observables.
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Supervisors: Luca Marchetti - Andrea Pugliese

9.40 - Di Petrillo Gemma

Deformations of hyperbolic 3-manifolds in the 5-dimensional hyperbolic space: a combinatorial approach featuring quaternions

Abstract: My work focuses on 3-dimensional hyperbolic manifolds with finite volume. By Mostow-Prasad rigidity, these manifolds admit a unique complete hyperbolic structure. However, one can try to deform this structure in higher dimensional spaces, in the following sense: every such manifold M naturally induces a 5-dimensional hyperbolic manifold M', with infinite volume, which is diffeomorphic to $M \times \mathbb{R}^2$ and into which M lies geodesically as the horizontal section $M \times \{0\}$. Does the new manifold M' admit new hyperbolic structures? In this short seminar, I will present a possible approach to this deformation problem, based on the work of Thurston on the hyperbolic Dehn filling theorem. The main idea is to equip the manifold M with an ideal triangulation, realize the tetrahedra geometrically in the hyperbolic space, and then glue them back together with isometries. In the three-dimensional case, this procedure admits an algebraic translation via complex shape parameters and gluing equations. In our setting, the hyperbolic 5-space is identified with $H \times \mathbb{R}^+$, where H is the algebra of quaternions. I will show how this leads to quaternionic shape parameters and consistency equations, and present explicit families of deformations found for the figure-eight knot complement.

Supervisors: Bruno Martelli (Università di Pisa), Riccardo Ghiloni (Università di Trento)

10.00 - Vielmo Carlotta

Towards data-informed rationality: investigating students' argumentation in decision-making contexts

Abstract: Being able to construct, evaluate, and negotiate data-based arguments are increasingly recognised as key competences for informed citizenship, especially in stochastic decision-making contexts involving uncertainty and variability. This PhD project investigates how such data-based argumentative competence unfolds in classroom settings, focusing on moments when students collectively negotiate what counts as legitimate evidence, acceptable reasoning, and effective communication. Drawing on Habermas' framework, students' argumentation is conceived as a form of data-informed rational behaviour, shaped by epistemic, goal-oriented and communicative considerations. Toulmin's model is here adapted and integrated to analyse the structure of students' arguments, particularly how evidence, conclusions, and warrants are coordinated. Through the design, implementation, and iterative refinement of a teaching sequence, tested in two 10th grade classes, the project offers a case study on how data-based argumentative competence develops at high school level and how it may be supported. Specifically, it aims to inform: how students spontaneously build and justify claims from data and how this process can evolve during activities; how justifications are negotiated collectively; and how criteria for argument quality are co-constructed in the classroom community. The project also offers design insights into activities and practices that may foster this argumentative competence and contributes to clarifying and operationalising data-based argumentation as a construct in educational research.

Supervisors: Alessandro Oneto, Luigi Amedeo Bianchi - Co-supervisors: Mirko Maracci (University of Pisa)

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CONTATTI
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