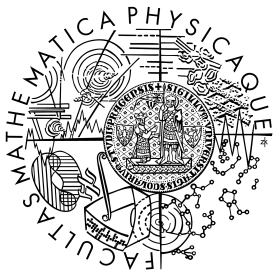


FACULTY
OF MATHEMATICS
AND PHYSICS
Charles University

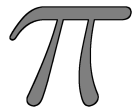
Book of Abstracts

of the

10th Day of Doctoral Students

of the School of Mathematics

June 3, 2024



Sokolovská 83
186 75 Praha 8

LaTeX editing by Petr Knobloch

http://www.karlin.mff.cuni.cz/~knobloch/DDS-M/2024/

Preface

In the beginning of 2014, the Management of the Faculty of Mathematics and Physics decided that the traditional conference of PhD students called the WDS (Week of Doctoral Students) would not be organized as an activity of the entire faculty. Instead, the decision as to whether to organize the conference or not was left to the respective Schools (of Computer Science, of Mathematics, and of Physics).

Since then, the School of Mathematics organized this event as WDS-M (Week of Doctoral Students of the School of Mathematics). Except for 2014, WDS-M was always a one-day conference and therefore, the new name DDS-M (Day of Doctoral Students of the School of Mathematics) was introduced three years ago. Since WDS-M was not organized in 2020 due to the COVID-19 Pandemic, the conference of PhD students at the School of Mathematics is organized for the 10th time in this year, see also `http://www.karlin.mff.cuni.cz/~knobloch/DDS-M/2024/`. The original WDS will continue at the School of Physics in its 33rd edition (June 4–6, 2024) as a conference for PhD students of physical study programs, see `http://www.mff.cuni.cz/veda/konference/wds/`.

This year, 14 students have registered as active participants to the conference. They will present 13 lectures and one poster. The abstracts of the lectures and the poster are contained in this Book of Abstracts. We believe that this event, which takes place in the "mathematical" Karlín building of the faculty, will attract the attention of the students but also of the broad mathematical audience. We thus encourage all of those interested in the scientific activities of our doctoral students to attend this meeting.

The conference is co-organized by the *School of Mathematics, Faculty of Mathematics and Physics, Charles University*, and *Charles University Chapter of SIAM*.

Prague, June 3, 2024

doc. Mgr. Petr Knobloch, Dr., DSc.
Coordinator of the Doctoral Studies at the School of Mathematics
Faculty of Mathematics and Physics
Charles University

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Algebraic methods for complexity of constraint satisfaction problems

M.Sc. Max Hadek

E-mail: maximilian.hadek@matfyz.cuni.cz
Study branch: P4M1
Year of study: 1
Supervisor: doc. Mgr. Libor Barto, Ph.D.

Abstract

CSP is a computational problem, where given variables are assigned values from a fixed domain set such that certain given constraints are satisfied. Since 2017 there is a classification of the hardness (P vs. NP-complete) of finite domain CSPs given by algebraic invariants, namely polymorphism minions. I will discuss these in the finite case and the problems encountered when trying to extend the notions to infinite domains.

Łukasiewicz unbound logic

RNDr. Filip Jankovec

E-mail: jankovec@karlin.mff.cuni.cz
Study branch: P4M1
Year of study: 2
Supervisor: doc. Ing. Petr Cintula, Ph.D.

Abstract

In this talk, we intend to study the connection between the family of comparative logics including Abelian logic and the family of Łukasiewicz logics and some generalizations thereof. Abelian logic is a well-known (finitary) contraclassical paraconsistent logic. This logic was independently introduced by Meyer and Slaney and by Casari and it is also called the logic of Abelian l-groups or Abelian Group Logic. This terminology follows from the fact that the matrix models of Abelian logic consist of Abelian l-groups and their positive cones as filters of designated elements. During the talk we will introduce pointed Abelian logic pA as the expansion of Abelian logic with the truth-constant 0 with no additional rules/axioms and we will discuss philosophical and mathematical properties of this logic.

Möbius function for modules

Mgr. Dominik Krasula

E-mail: resitelmam@gmail.com
Study branch: P4M1
Year of study: 1
Supervisor: doc. Mgr. et Mgr. Jan Žemlička, Ph.D.

Abstract

Möbius function on a poset is a classical tool in enumerative combinatorics and finitary geometry. Using the Möbius function on a poset of submodules over a finite ring, A. A. Nechaev gave a new characterisation of finite QF rings, which inspired my research. In the talk, I will define the Möbius function and explain its connection to the Euler characteristic and the Möbius function, which you may know from the number theory. Then, I will show how to calculate the Möbius function on a module over an arbitrary ring. As a running example, I will use vector spaces as they can be viewed as a particular class of modules.

There is no analogue of 290-theorem for higher degree forms

M.Sc. Om Prakash

E-mail: prakash@karlin.mff.cuni.cz
Study branch: P4M1
Year of study: 1
Supervisor: doc. Mgr. Vítězslav Kala, Ph.D.

Abstract

A universal quadratic form is a positive definite quadratic form with integral coefficients which represents all positive integers - a classical example being the sum of four squares $x^2 + y^2 + z^2 + w^2$. The 290-theorem of Bhargava and Hanke characterizes positive definite quadratic forms over rational integers that are universal as exactly the forms that represent $1, 2, 3, \ldots, 290$.

In this talk, I will discuss universality of higher degree forms (i.e. homogeneous polynomials of degree $m > 2$) and I will prove that no statement like the 290-Theorem can hold for them. If time permits, I will conclude with the more general case of forms over totally real number fields. This is a joint work with Vítězslav Kala.

Courant algebroid reduction and Poisson-Lie T-duality

M.Sc. Aditya Basu

E-mail: aditya.basu@matfyz.cuni.cz
Study branch: P4M2
Year of study: 3
Supervisor: prof. Ing. Branislav Jurčo, CSc., DSc.

Abstract

Given a generalized metric, Poisson-Lie T-duality manifests as the equivalence of the equations of motion for string sigma models targeted in mutually dual Poisson-Lie groups. Earlier work formulated a version of Poisson-Lie T-duality for string effective actions, using the formalism of Courant algebroids over a point. We now explicitly describe reductions of Courant algebroids over a smooth manifold and associated structures like the generalized metric, connection, and dilaton to formulate Poisson-Lie T-duality for this case.

Lie derivative of Courant algebroid connections

Mgr. Frederik Ďalak

E-mail: frederik.dalak@gmail.com
Study branch: P4M2
Year of study: 1
Supervisor: prof. Ing. Branislav Jurčo, CSc., DSc.

Abstract

Connections on vector bundles play an increasingly significant role in modern day geometry. Lie derivative of a linear connection on a manifold M is a formalism which allows to find symmetries of the connection given by automorphisms of M respecting the connection in a well defined way. Here we briefly introduce the concept and we present a way to generalize it to connections on Courant algebroids. After introducing Courant algebroid axioms and the affine space of Courant algebroid connections, we focus on the prominent case of Levi-Civita connections and the properties of symmetries in this case.

Interesting combinatorics in higher Auslander theory

Mgr. Adam Klepáč

E-mail: djklepy@gmail.com
Study branch: P4M2
Year of study: 2
Supervisor: doc. RNDr. Jan Šťovíček, Ph.D.

Abstract

Following the construction of d-representation-finite algebras by Iyama and the description of the correspondence between certain types of cluster algebras and triangulations of bordered surfaces with marked points by Fomin and Zelevinsky, links have appeared connecting d-representation-finite algebras to higher dimensional variants of said surface. One such link was discovered by Thomas and Oppermann between higher Auslander algebras of the path algebra of linearly oriented Dynkin quiver of type A and cyclic polytopes. I will present this correspondence and, if time permits, talk about possible generalizations to path algebras of quivers of different types.

Agglomeration and refinement of polytopic meshes for the discontinuous Galerkin finite element method

M.Sc. Prabhat Mishra

E-mail: mishra@karlin.mff.cuni.cz
Study branch: P4M6
Year of study: 2
Supervisor: Scott Congreve, Ph.D.

Abstract

In this talk, we briefly introduce the overview of agglomeration technique to refine the mesh and present the idea of mesh quality agglomeration based on geometrical properties of the problem polygon mesh in Discontinuous Galerkin framework.

Differential equations driven by Besov-Orlicz paths

Mgr. František Hendrych

E-mail: hendrychfrantisek@karlin.mff.cuni.cz
Study branch: P4M9
Year of study: 2
Supervisor: RNDr. Petr Čoupek, Ph.D.

Abstract

In differential equations, stochastic processes like Brownian motion can be incorporated to address non-systematic errors or uncertainties in models. These processes typically yield sample paths devoid of differentiability everywhere, necessitating a distinct approach to integration and solution methods. Commonly, integrals are constructed as limits of Riemann-type sums within the L^2 space, which holds true for both Itô and Stratonovich integrals. However, this approach does not yield a path-by-path solution, which we would naturally expect. Rough path theory offers, in a certain sense, a way to overcome this problem. Initially, we construct the iterated integral of the path probabilistically, and then we solve the now deterministic equation using both the path and its iterated integral as input. Various function spaces can be utilized in building particular forms of rough path theory.

Bagging and regression trees in individual claims reserving

Mgr. Jan Janoušek

E-mail: janousek@karlin.mff.cuni.cz
Study branch: P4M9
Year of study: 1
Supervisor: doc. RNDr. Michal Pešta, Ph.D.

Abstract

This lecture provides a practical exploration of classification and regression trees, alongside bootstrap aggregating, in the context of individual reserving in insurance. Beginning with a thorough overview of theoretical foundations often overlooked in introductory materials, we establish mathematical formalities crucial for understanding. Expanding upon prior research, we integrate regression trees and bagging techniques to enhance the accuracy of reserve estimates, particularly in modeling claim sizes. By applying these methods to insurance data, empirical distributions are derived, enabling the calculation of confidence intervals and quantiles necessary for determining reserves for both the upcoming year and ultimate reserves. Through this examination, attendees gain insights into leveraging machine learning for more effective individual reserving strategies within the insurance sector.

Towards extension of Turek benchmark: Different approaches to calculating pointwise traction in flow

Mgr. Jakub Cach

E-mail: cach@karlin.mff.cuni.cz
Study branch: P4F11
Year of study: 1
Supervisor: RNDr. Karel Tůma, Ph.D.

Abstract

For an incompressible Navier-Stokes fluid flowing around an obstacle, we are interested in the pointwise traction acting on it. To determine the local deformation of a solid obstacle, an accurate traction calculation is required. Besides the classical approach, which concerns a direct calculation of the traction from the Cauchy stress tensor, we investigate the Poincaré-Steklov method based on calculating a dual problem, and it seems to provide more accurate results. Indeed, we analytically indicate a better convergence rate of the latter method with respect to the direct approach for the Stokes equation. The method is applied to the Turek benchmark, which considers a Navier-Stokes flow past a rigid cylinder. We also consider a rigid square prism as an obstacle due to its non-smooth boundary. In this benchmark, the total drag and lift acting on the cylinder are computed. We aim to extend the benchmark by computing the pointwise traction for different mesh resolutions and Reynolds numbers.

A thermodynamic framework for non-isothermal phenomenological models of isotropic Mullins effect

Mgr. David Cichra

E-mail: cichra.david@gmail.com
Study branch: P4F11
Year of study: 4
Supervisor: doc. Mgr. Vít Průša, Ph.D.

Abstract

The Mullins effect is a common name for a family of intriguing inelastic responses of various solid materials, in particular filled rubbers. Given the importance of the Mullins effect, there have been many attempts to develop mathematical models describing the effect. However, most of available models focus exclusively on the mechanical response, and are restricted to the idealised isothermal setting. We lift the restriction to isothermal processes, and we propose a full thermodynamic framework for a class of phenomenological models of the Mullins effect. In particular, we identify energy storage mechanisms (Helmholtz free energy) and entropy production mechanisms that on the level of stress–strain relation lead to the idealised Mullins effect or to the Mullins effect with permanent strain.

Implicit constitutive relations on the level of thermodynamic potentials

Mgr. Martin Vejvoda

E-mail: martin.vejvoda@email.cz
Study branch: P4F11
Year of study: 1
Supervisor: doc. Mgr. Vít Průša, Ph.D.

Abstract

The standard approach to elasticity assumes that the stress is expressed in terms of the strain. An alternative approach is possible with the strain assumed to be expressed in terms of the stress. Both of these approaches can be seen as special cases of an implicit relation between the stress and the strain. There is a suitable thermodynamic background for both explicit cases. This is not the case for the implicit relations. In this talk we introduce the implicit consitutive relations and present possible strategies to obtain the thermodynamic background.

Poster

Employing random effects in variance components modelling

Mgr. Kristína Sakmárová

E-mail: sakmarova@karlin.mff.cuni.cz, *Study branch:* P4M9, *Year of study:* 1
Supervisor: doc. RNDr. Arnošt Komárek, Ph.D.

Abstract

The uniformity of dosage units of oral solid dosage (i.e. tablets) refers to the degree of variability of the content of the active pharmaceutical ingredient (API) in the tablet. It is the critical quality attribute, as the amount of the API needs to be tightly controlled in order to deliver to patient the required dose. Both underdosing and overdosing can have severe implications for the patient. Further, stratified content uniformity is often assessed during the process development for a deeper understanding of the variability within the batch, separating location-to-location variability and residual variability. Typical models used for the analysis of the API include fixed run effects model and random run effects model, while both models assume homogenous random location and residual effects. Location and residual errors however do not have to be necessarily i.i.d., which invokes need for population effect and random effect parametrization. For parameter estimation Bayesian methods were used, using brms package. Assuming hierarchical random effects model we provide results for population residual and location-to-location variability among batches.