FH Vorarlberg
University of Applied Sciences

ÖMG Conference 2019

University of Applied Sciences Vorarlberg
September 16 – 20, 2019

Program and Book of Abstracts

ÖMG-Conference 2019

ÖMG-Conference
University of Applied Sciences Vorarlberg, Dornbirn
September 16–20, 2019

Program and Book of Abstracts

Österreichische
Mathematische
Gesellschaft

Contents

Welcome

The board of the *Austrian Mathematical Society* (ÖMG) and the local conference organizers welcome you to the *ÖMG-Conference* in Dornbirn, September 16–20, 2019. The meeting takes place in the lecture rooms of the

University of Applied Sciences Vorarlberg.

The scientific program starts on Monday, September 16, at 9:00 in room W211/12 and continues until the evening of Thursday, September 19, with an additional day on Friday, September 20, featuring the *Teacher's Day* (LehrerInnen-Tag) and the *Universities of Applied Sciences and Education Day* (Hochschul-Tag).

The scientific program consists of:

A plenary lecture of the *ÖMG Award Winner 2019*: Christopher Frei (University of Manchester).

Furthermore, 8 invited plenary lectures including Wilhelm Schlag (Yale University), Helmut Pottmann (KAUST and TU Wien), Marlis Hochbruck (KIT Karlsruhe), Özlem Imamoglu (ETH Zürich), Efstathia Bura (TU Wien), Josef Hofbauer (Universität Wien), Susanna Terracini (Università di Torino), and Fritz Gesztesy (Baylor University).

The program is then split up into 12 sections and 6 minisymposia with altogether 125 talks.

Moreover, a public lecture will be given by Karl Sigmund on Thursday evening, September 19, at 19:00 in room W211/12.

The list of participants includes about 200 people coming from Algeria, Armenia, Austria, Chile, Czech Republic, France, Germany, Hungary, India, Italy, Jordan, Kuwait, Mexico, Netherlands, Poland, Portugal, Romania, Saudi Arabia, Slovenia, Spain, Switzerland, United Kingdom, and United States.

The conference languages are English and German.

The scientific program is complemented by several social activities. Besides the coffee breaks there is a reception on Monday evening and a free Wednesday afternoon to enjoy the excursion to the beautiful *Bregenzer Wald*. The conference dinner is included in the participation fee and is scheduled for Wednesday evening at the *Karren*.

In this book you can find useful information and the program day-by-day. Moreover, all abstracts are contained here. For additional information and updates visit the conference webpage `http://www.oemg.ac.at/Tagungen/2019/`.

We hope that you will have a very fruitful and enjoyable time in Dornbirn.

K. U. would like to thank all section and minisymposia organizers for their effort and support. Special thanks to Thomas Fetz for help with the program booklet, Clemens Heuberger for assistance with the website, and finally Clemens Fuchs for support and permission to use his templates and all resources!

Dornbirn, September 2019 The Local Organizers

Sponsor and Cooperation Partners

We thank our sponsors and cooperation partners who provided generous support for the conference: the *University of Applied Sciences Vorarlberg*, the *Government of Vorarlberg*, the *City of Dornbirn*, and the *Julius Blum GmbH*.

Conference Opening

The opening ceremony takes place in room W211/12 on Monday, September 16, 9:00-9:30. The inaugural addresses will be given by:

- Prof. Dr. Karl Unterkofler (Chairman of the Local Organizing Committee),
- Prof. Dr. Barbara Kaltenbacher (President of the Austrian Mathematical Society).

The scientific program starts on Monday, September 16, at 9:30 with the plenary lecture of Wilhelm Schlag (Yale University) entitled “On no-return theorems in non-linear dispersive PDEs”.

After the first plenary lecture there will be a coffee break from 10:30 to 11:00.

The second plenary lecture entitled “Discrete geometric structures motivated by architecture and computational design” will be given by Helmut Pottmann (KAUST and TU Wien). This lecture concludes the Monday morning.

General Information

Conference Location

The conference takes place in the lecture rooms of the *University of Applied Sciences Vorarlberg* (FHV). The address is:

Hochschulstraße 1
6850 Dornbirn
Austria

The FHV can be contacted by phone at +43 (0)5572 792 0.

Conference and Registration Desk

The conference desk is located in room W207/08 on the 3rd floor (2. Stock). Its opening hours are:

Monday,	September 16,	08:00–12:00 and 14:00–17:00,
Tuesday,	September 17,	08:15–11:00,
Wednesday,	September 18,	08:15–11:00,
Thursday,	September 19,	08:15–11:00,
Friday,	September 20,	08:15–11:00.

E-Mail: `oemg2019@fhv.at`

Registration

Registration of participants takes place on Monday, September 16, 2019, 08:00–12:00 and 14:00–17:00 in room W207/08 as well as during the opening hours of the conference desk from Monday–Friday.

Information for Speakers

All rooms are equipped with PC and beamer. The lecture rooms are equipped with large blackboards. Technical assistants are present to help you transfer your file to the PC. We recommend that you do this before the session with your talks starts since the schedule is quite dense.

Please observe that the 30 minute time slots (exceptions are the talks of plenary speakers and speakers at LehrerInnen-Tag and Hochschul-Tag) allow 25 minutes for the talk including (sic!) discussion and a break of 5 minutes. There are some talks which may use two such slots; in which case the talk is 50 minutes including discussion followed by a 10 minutes break. We urgently ask you not to go over time as people may want to change rooms to listen to another talk. Thank you for your understanding!

Internet Access during the Conference

WLAN access will be available to conference participants. Access data can be found in the **conference folder**. There is also a good coverage for the eduroam network across the conference venue.

Lunch and Dinner

Lunch and a coffee or other refreshments in between can be taken (on one's own expense) at the FHV's Mensa & Café Schräg which is available at the venue of the congress. Please note that the semester already started and the capacity is restricted.

Alternatively you can visit the restaurants and shops nearby:

EUROSPAR, Marktstraße 67,
`https://www.spar.at/standorte/eurospar-dornbirn-6850-marktstrasse-67`

Gasthaus Gemsle, Marktstraße 62,
`http://www.gemsle.at`

Shao Kao, Hintere Achmühlerstraße 1,
`https://shaokao.at/`

La Scarpetta Ristorante - Pizzeria, Hintere Achmühlerstraße 1a,
`http://www.ristorante-lascarpetta.at`

Restaurant Krone, Hatlerstraße 2,
`https://www.kronehotel.at/hotel-dornbirn/restaurant`

Bella Napoli, Schillerstraße 1,

Gabriel's Cucina, Marktstraße 14,
http://www.gabrielscucina.at

Bierlokal, Marktstraße 12/2,
http://www.bierlokal.at

21 Steak & Fisch, Marktstraße 21,
https://www.steakhaus21.at

Rotes Haus, Marktplatz 13,
http://roteshaus.at

Pizzeria San Marco, Marktplatz 12,
http://sanmarco-dornbirn.at

On Monday evening there will be a reception at 19:00 at the foyer of the University of Applied Sciences Vorarlberg. You are invited free of charge to these event. Please be prepared that there will be only a small appetizer and that this will not replace your dinner.

The conference dinner takes place on Wednesday evening at 18:30 at *Karren* restaurant, Dornbirn. It is included in the conference fee. You can either take the cable car (included too) or take part in a guided walk (elevation up 500m).

Coffee Breaks

Refreshments (coffee, juices, mineral water, cookies) are served free of charge to participants on:

Monday,	10:30–11:00 and 14:45–15:15,
Tuesday,	09:30–10:00 and 15:00–15:30,
Wednesday,	10:30–11:00,
Thursday,	09:30–10:00 and 15:00–15:30,
Friday,	10:15–10:45 and 14:30–15:00.

In addition and for self-payment, the university cafeteria serves coffee and snacks.

Getting there and around

How to reach Dornbirn (international travel)

By plane

The nearest international airport is Zurich (Switzerland, 120 km from Dornbirn), the nearest local airport is Altenrhein (Switzerland, 20 km from Dornbirn).

How to reach the University of Applied Sciences Vorarlberg

The public transport network is very well developed in Dornbirn and Vorarlberg. Dornbirn can be easily reached by train and car. Dornbirn offers a comprehensive bus network. Due to its central location in Dornbirn, the University of Applied Sciences Vorarlberg (FH Vorarlberg) can also be reached easily on foot.

By Train

When travelling by train, we recommend that you leave the train at Dornbirn main train station (Hauptbahnhof). From there you can take a bus or walk to the University of Applied Sciences Vorarlberg. The walk takes 15 to 20 minutes.

Train connections - Österreichische Bundesbahnen - Austrian Federal Railways: `https://www.oebb.at/en`

By public buses

From the central bus station (located in front of the main train station in Dornbirn) you can take the following buses to reach the University of Applied Sciences Vorarlberg (exit at "Sägerbrücke" bus stop). The trip takes about 5 minutes; during the day buses run every 15 minutes.

- Line 50 (yellow buses) - Direction of “Lustenau-Gaissau”
- Line 22 and 23 (yellow buses) - Direction of “Götzis”
- Line 2 (red buses) - Direction of “Brehmenmahd”
- Line 3 (red buses) - Direction of “In Fängen”

Bus connections and app for tickets: `https://www.vmobil.at`

By car

Take the Rheintalautobahn A14 to the motorway exit of Dornbirn Süd and then follow the signs to the city centre (Zentrum). Turn left after the 5th set of traffic lights (at Dornbirn hospital), then right after the 2nd set of traffic lights and follow the signs to the "Fachhochschule Vorarlberg."

Parking at the University of Applied Sciences Vorarlberg:
https://www.fhv.at/fileadmin/user_upload/fhv/files/anreise/Parkmoeglichkeiten_an_der_FH_Vorarlberg.pdf

Information about the Conference Venue Dornbirn

Dornbirn is the largest town in Vorarlberg. For more information about its history and culture, please visit the web page: https://www.dornbirn.info

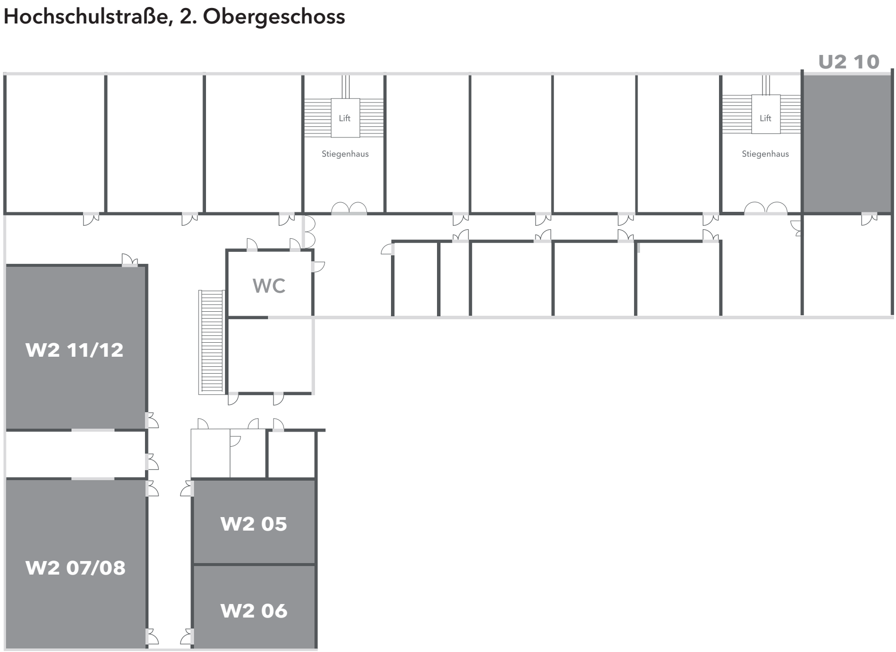
Information about the University of Applied Sciences Vorarlberg

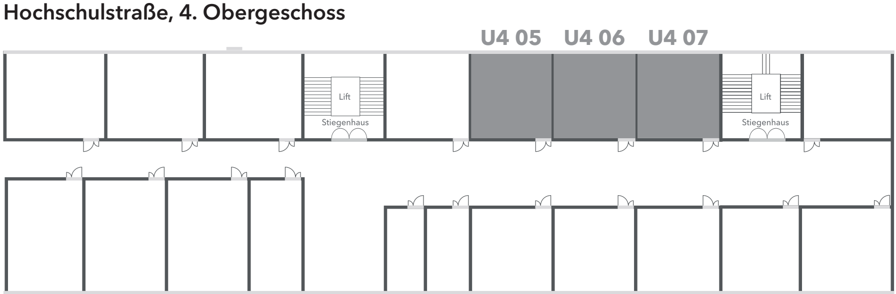
The University of Applied Sciences Vorarlberg was founded in 1992. For more information, please visit the web page: https://www.fhv.at

Floor Plans

Hochschulstraße 1, 2. Stock:
Rooms W205, W206, W211/12, U210, W207/08 (registration).

Hochschulstraße 1, 4. Stock: Rooms U405, U406, U407.





Conference Organization and Committees

Program Committee

András Bátkai (Feldkirch)
Mathias Beiglboeck (Wien)
Reinhard Bürger (Wien)
Michael Eichmair (Wien)
Barbara Kaltenbacher (Klagenfurt)
Alexander Ostermann (Innsbruck)
Hans-Peter Schröcker (Innsbruck)
Gerald Teschl (Wien)
Robert Tichy (Graz)
Karl Unterkofler (Dornbirn, Chair)

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Thomas Fetz (Innsbruck)
Steffen Finck
Michael Hellwig
Kathi Plankensteiner
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Natascha Senoner (Secretary)
Karl Unterkofler (Chair)

Organizers of Minisymposia

- **M1. Industrial and Applied Mathematics**
  Markus Haltmeier (Universität Innsbruck)
- **M2. Mathematical Finance in the age of Machine Learning**
  Josef Teichmann (ETH Zürich)
- **M3. Parallel and Distributed Optimization and Simulation**
  Steffen Finck (Fachhochschule Vorarlberg)
- **M4. Spectral Theory**
  Gerald Teschl (Universität Wien)
  Jussi Behrndt (Technische Universität Graz)
- **M5. Inverse Problems for Partial Differential Equations**
  William Rundell (Texas A&M University)
  Barbara Kaltenbacher (Universität Klagenfurt)
- **M6. Enumerative and Algebraic Combinatorics**
  Michael Drmota (Technische Universität Wien)
  Christian Krattenthaler (Universität Wien)

Sections Coordinators

- **S01. Logic, Set Theory, and Theoretical Computer Science**
  Vera Fischer (Universität Wien)
  Martin Goldstern (Technische Universität Wien)
- **S02. Algebra, Discrete Mathematics**
  Clemens Heuberger (Universtität Klagenfurt)
  Clemens Fuchs (Universtität Salzburg)
- **S03. Number Theory**
  Timothy Browning (IST Austria)
- **S04. Algebraic Geometry, Convex and Discrete Geometry**
  Tim Netzer (Universtität Innsbruck)
- **S05. Computational Geometry and Topology**
  Herbert Edelsbrunner (IST Austria)
  Michael Kerber (Technische Universtität Graz)
- **S06. Ordinary Differential Equations and Dynamical Systems**
  Peter Szmolyan (Technische Universtität Wien)

- **S07. Partial Differential Equations and Calculus of Variations**
  Roland Donninger (Universität Wien)
- **S08. Functional Analysis, Real and Complex Analysis**
  Eva Kopecká (Universität Innsbruck)
  Bernhard Lamel (Universität Wien)
- **S09. Numerical Analysis, Scientific Computing**
  Jens Markus Melenk (Technische Universität Wien)
  Olaf Steinbach (Technische Universität Graz)
- **S10. Optimization**
  Radu Bot (Universität Wien)
- **S11. Probability, Statistics**
  Evelyn Buckwar (Universität Linz)
  Michaela Szölgyenyi (Universität Klagenfurt)
- **S12. Financial and Actuarial Mathematics**
  Gunther Leobacher (Universität Graz)
  Stefan Thonhauser (Technische Universität Graz)

LehrerInnen-Tag

Bernd Thaller (Universität Graz)
András Bátkai (Pädagogische Hochschule Vorarlberg)

Hochschul-Tag

Karl Unterkofler (Fachhochschule Vorarlberg)
Susanne Teschl (Fachhochschule Technikum Wien)

Meetings and Public Program

General Assembly, ÖMG

The General Assembly of the Austrian Mathematical Society will not take place during the conference. Instead the General Assembly is planned for November 22nd in Graz during the Austrian Mathematics Day (Tag der Mathematik 2019).

Public Lecture

Participants of the conference are invited to attend the public lecture on Thursday, September 19, at 19:00 in room W211/12. The lecture is open to the general public and will be given in German.

Side Events

LehrerInnen-Tag 2019

Der LehrerInnen-Tag 2019 findet im Rahmen der ÖMG-Konferenz 2019 am Freitag den 20. September an der FH Vorarlberg im Hörsaal W211/12 statt. Die Teilnahme am LehrerInnen-Tag ist kostenfrei.

Der LehrerInnen-Tag widmet sich dem Thema *Computereinsatz im Mathematikunterricht - Top oder Flop?*

`http://www.oemg.ac.at/Tagungen/2019/index.php/program/lehrerinnentag-2019`

Hochschul-Tag 2019

Der Hochschul-Tag 2019 (ehemals FH-Tag) findet am Freitag den 20. September im Rahmen der ÖMG-Konferenz 2019 an der FH Vorarlberg im Hörsaal W206 statt. Er ist als Fortbildungstag für Mathematiklehrende an Fach- und Pädagogischen Hochschulen konzipiert.

Für die Teilnahme (nur am Hochschul-Tag) ist ein Unkostenbeitrag von Euro 60.- vorgesehen; die Anmeldung erfolgt über die Registrierungsplattform der Konferenz. Für Konferenz-Teilnehmer ist die Veranstaltung kostenfrei.

Die Themenkreise umfassen verschiedene Aspekte der *Digitalisierung im Mathematikunterricht*.

`http://www.oemg.ac.at/Tagungen/2019/index.php/program/hochschultag-2019`

Social Program

In the following you will find a list of social events and excursions offered throughout the week. The conference excursion on Wednesday in the afternoon is for everybody (facultative) and can be booked through the registration platform of the congress.

Reception

There will be a reception on Monday evening at 19:00 at Café Schräg sponsored by the City of Dornbirn and the Government of Vorarlberg.

A welcome address will be delivered by the Rector of the Fachhochschule Vorarlberg Prof. Dr. Tanja Eiselen, Mag. Gabriela Dür representing the Vorarlberg government, and Ms. Marie-Louise Hinterauer town councillor of Dornbirn on behalf of Major Dipl.-Vw. Andrea Kaufmann.

Conference Dinner

The conference dinner on Wednesday evening is included in the conference fee. It will take place at *Karren* restaurant, Dornbirn and starts at 18:30. You can either take the cable car (included too) or take part in a guided walk (elevation up 500m).

Excursion

The following excursion will take place on Wednesday afternoon and can also be booked directly by the registration procedure:

- Tour: Bregenzer Wald, Käsekeller Lingenau. Price: Euro 29.-

Further recommended self-organized tours:

- Visit Bregenz
  `https://www.bregenz.travel`
- Visit the Rolls Royce museum in Dornbirn
  `https://www.rolls-royce-museum.at`
- Hike through the Rappenlochschlucht
  `https://www.karren.at/wandern/rappenlochschlucht-8/`
- Visit the "Jüdisches Museum Hohenems"
  `https://www.jm-hohenems.at/en`

Public Lecture

A public lecture entitled *Open Code - Die Mathematik als Universalsprache* will be given by Karl Sigmund (Universität Wien) on Thursday evening at 19:00 in room W211/12.

Zum Vortrag:

Die Mathematik wird oft mit einer Sprache verglichen. Ihr Verhältnis zur Umgangssprache ist vielschichtig, was zu einem ganzen Spektrum von Codierungen führt. Außerdem ist die Sprache der Mathematik auf zweierlei Art universell: sie wird überall gesprochen - wohl auch von extragalaktischen Intelligenzen, falls es welche gibt - und sie ist auf alles anwendbar, worüber man exakt denken kann, sogar auf sich selbst.

FH Vorarlberg
University of Applied Sciences

OPEN CODE -
Die Mathematik als Universalsprache

Öffentlicher Vortrag von Univ.-Prof. Dr. Karl Sigmund (UNI Wien) im Rahmen der ÖMG-Konferenz, 16.09. – 20.09.2019 in Dornbirn.

Die Mathematik wird oft mit einer Sprache verglichen. Ihr Verhältnis zur Umgangssprache ist vielschichtig, was zu einem ganzen Spektrum von Codierungen führt. Außerdem ist die Sprache der Mathematik auf zweierlei Art universell: sie wird überall gesprochen - wohl auch von extragalaktischen Intelligenzen, falls es welche gibt - und sie ist auf alles anwendbar, worüber man exakt denken kann, sogar auf sich selbst.

19. September 2019 um 19.00 Uhr
FH Vorarlberg, Dornbirn, Hörsaal W211/212

Karl Sigmund ist emeritierter Professor der Mathematik an der Universität Wien und Autor des Buches „Sie nannten sich Der Wiener Kreis“. Sigmund befasste sich mit dynamischen Systemen, Ergodentheorie und mit mathematischen Fragen der Biologie (Ökologie, Populationsgenetik) und chemischen Kinetik. Er lieferte auch bedeutende Beiträge zur evolutionären Spieltheorie.

Alle interessierten Personen sind herzlich zur Teilnahme eingeladen!
www.oemg.ac.at/Tagungen/2019/

Österreichische Mathematische Gesellschaft

www.fhv.at

Program Overview and Detailed Program of Minisymposia and Sections

	Monday, September 16
08:00	Registration
09:00	Opening Ceremony
09:30	P.1 Wilhelm Schlag (Yale University)
10:30	
11:00	P.2 Helmut Pottmann (KAUST & TU Wien)
12:00	*Lunch*
13:45	P.3 Marlis Hochbruck (KIT Karlsruhe)
14:45	
15:15	M1. Industrial and Applied Mathematics, M3. Parallel and Distributed Optimization and Simulation, M6.Enumerative and Algebraic Combinatorics & Sections S01, S08, S11
16:45	*Break*
17:15	M1. Industrial and Applied Mathematics, M3. Parallel and Distributed Optimization and Simulation, M6.Enumerative and Algebraic Combinatorics & Sections S01, S08, S11
19:00	*Reception at Café Schräg*

	Tuesday, September 17
08:30	P.4 Özlem Imamoglu (ETH)
09:30	
10:00	M1. Industrial and Applied Mathematics, M6. Enumerative and Algebraic Combinatorics & Sections S01, S05, S07, S08, S12
12:30	*Lunch*
14:00	P.5 Efstathia Bura (TU Wien)
15:00	
15:30	Sections S02, S03, S05, S07, S08, S09
17:00	*Break*
17:30	Sections S02, S03, S04, S05, S07, S09
19:00	

	Wednesday, September 18
08:30	P.6 Josef Hofbauer (UNI Wien)
09:30	P.7 ÖMG Award Winner: Christopher Frei (University of Manchester)
10:30	
11:00	M5. Inverse Problems for Partial Differential Equations & Sections S06, S09, S10
12:30	*Lunch*
14:00	*Excursions*
17:00	*Start guided walk or take the*
17:30	*Cable Car*
18:30	*Reception and Conference Dinner at Karren*

	Thursday, September 19
08:30	P.8 Susanna Terracini (Universitá di Torino)
09:30	
10:00	M2. Mathematical Finance in the age of Machine Learning, M4. Spectral Theory, M5. Inverse Problems for Partial Differential Equations
12:30	*Lunch*
14:00	P.9 Fritz Gesztesy (Baylor University)
15:00	
15:30	M2. Mathematical Finance, M4. Spectral Theory, M5. Inverse Problems for Partial Differential Equations
17:00	*Break*
17:30	M2. Mathematical Finance, M4. Spectral Theory, M5. Inverse Problems for Partial Differential Equations
19:00	Public lecture by Karl Sigmund (UNI Wien)

Friday, September 20	LehrerInnen-Tag Room W211/12	Hochschul-Tag Room W206
08:45	Registration	Registration
09:15	L.1 Tichy (TU Graz)	HT.1 Pickhardt (HS Albstadt Sigmaringen)
10:15		
10:45	L.2 Dorner (UNI Graz)	HT.2 Süss-Stepancik (PH NÖ)
11:45	*Lunch*	*Lunch*
13:30	L.3 Lindner (PH OÖ)	HT.3 Gröblinger (UNI Innsbruck)
14:30		
15:00	Discussion	Discussion
16:30	Closing	Closing

Monday, September 16, Afternoon Sessions

	Room W211/12	Room W205	Room W206
	Minisymposium M1: Industrial and Applied Mathematics	**Section S11: Probability, Statistics**	**Section S08: Functional Analysis, Real and Complex Analysis**
15:15	M1a.1 **C. Erath** Efficient solving of a time-dependent interface problem.	S11a.1 **T. Fetz** Computing upper probabilities of failure using Monte Carlo simulation, reweighting techniques…	S08a.1 **M. Kolář** Infinitesimal symmetries of weakly pseudoconvex manifolds.
15:45	M1a.2 **K. Frick** Using extended Kalman Filters for solving non-linear inverse problems.	S11a.2 **E. Sönmez** Random Walk on the Random Connection Model.	S08a.2 **M. Reiter** The reflection map of sphere mappings.
16:15	M1a.3 **R. Kowar** Iterative methods for PAT in dissipative media.	S11a.3 **C. Pfeifer** Embedding an empirically based decision strategy for backcountry skiers into a subjective probability…	S08a.3 **G. Racher** On Fourier multipliers.
16:45			

	Room U405	Room U406	Room U407
	Section S01: Logic, Set Theory, and Theoretical Computer Science	**Minisymposium M3: Parallel and Distributed Optimization and Simulation**	**Minisymposium M6: Enumerative and Algebraic Combinatorics**
15:15	S01a.1 **M. Koelbing** Distributivity of forcing notions.	M3a.1 **H. Shoukourian** Predicting the efficiency of LRZ's cooling infrastructure using machine learning.	M6a.1 **W. Fang** The Steep-Bounce Zeta Map in Parabolic Cataland.
15:45	S01a.2 **J. P. Schürz** Strong measure zero sets on 2^{κ}.	M3a.2 **P. Gschwandtner** Towards Multi-objective, Region-based Auto-tuning for Parallel Programs.	
16:00			M6a.2 **A. R. Miller** Some results on characters of symmetric groups.
16:15	S01a.3 **J. Schilhan** The tower spectrum.	M3a.3 **T. Feilhauer** Optimization with the Distributed Execution Framework.	
16:45			

Monday, September 16, Evening Sessions

Time	Room W211/12	Room W205	Room W206
	Minisymposium M1: Industrial and Applied Mathematics	**Section S11: Probability, Statistics**	**Section S08: Functional Analysis, Real and Complex Analysis**
17:15–17:45	M1b.1 **G. Zangerl** Full field inversion in photoacoustic tomography with variable sound speed.	S11b.1 **W. Woess** Recurrence of 2-dimensional queueing processes, and random walk exit times from the quadrant.	S08b.1 **C. Bargetz** On Generic Properties of Nonexpansive Mappings.
17:45–18:15	M1b.2 **B. Kaltenbacher** Parameter identification and uncertainty quantification in stochastic state space models and its application …	S11b.2 **A. Steinicke** BSDEs with Jumps in the L^p-setting: Existence, Uniqueness and Comparison.	S08b.2 **E. Nigsch** The geometrization of the theory of full Colombeau algebras.
18:15–18:45	M1b.3 **L. Neumann** Block coordinate descent method for ill-posed problems.		

Time	Room U405	Room U406	Room U407
	Section S01: Logic, Set Theory, and Theoretical Computer Science	**Minisymposium M3: Parallel and Distributed Optimization and Simulation**	**Minisymposium M6: Enumerative and Algebraic Combinatorics**
17:15	S01b.1 **L. Halbeisen** Formen des Auswahlaxioms in der Ringtheorie. (17:15–18:15)	M3b.1 **K. Rheinberger** Analyzing Autonomous Demand Side Algorithms with Parallel Computation Frameworks. (17:15–17:45)	M6b.1 **M. Schlosser** A weight-dependent inversion statistic and Catalan numbers. (17:15–18:00)
18:15	S01b.2 **V. Torres-Pérez** Diamonds, games and cardinal invariants. (18:15–18:45)		

Tuesday, September 17, Morning Sessions

Time	Room W211/12	Room W205	Room W206	Room U210
	Minisymposium M1: Industrial and Applied Mathematics	**Section S07: Partial Differential Equations and Calculus of Variations**	**Section S08: Functional Analysis, Real and Complex Analysis**	**Section S12: Financial and Actuarial Mathematics**
10:00	M1c.1 **M. Liebrecht** Process Model for the Industrial Plate Leveling Operation with Special Emphasis on Online…	S07a.1 **B. Schörkhuber** Nonlinear asymptotic stability of homothetically shrinking Yang-Mills solitons.	S08c.1 **M. Dymond** Highly irregular separated nets..	S12.1 **J. Sass** Utility Maximizing Strategies under Increasing Model Uncertainty in a Multivariate Black…
10:30	M1c.2 **D. Rothermel** Nonlinear inverse heat transfer problems in modelling the cooling process of heavy plates.		S08c.2 **I. Kossovskiy** Classification of homogeneous strictly pseudoconvex hypersurfaces in $\mathbb{C}^3$.	S12.2 **S. Desmettre** Severity Modeling of Extreme Insurance Claims for Tariffication.
11:00	M1c.3 **P. Sellars** Graph Based Methods for Hyperspectral Image Classification.	S07a.2 **R. Bürger** Two-locus clines maintained by diffusion and recombination in a heterogeneous environment.	S08c.3 **F. Haslinger** The ∂-complex on the Segal-Bargmann space.	S12.3 **J. A. Strini** Optimal dividends and funding in risk theory.
11:30	M1c.4 **J. Schwab** Regularizing Networks for Solving Inverse Problems.	S07a.3 **S. Blatt** The negative L^2 gradient flow for p-elastic energies.	S08c.4 **K. Gröchenig** Sampling, Marcinkiewicz-Zygmund sets, approximation, and quadrature rules.	S12.4 **S. Thonhauser** Optimal reinsurance for expected penalty functions in risk theory.
12:00	M1c.5 **A. Maier** Known Operator Learning – An Approach to unite Physics, Signal Processing, and Machine Learning.	S07a.4 **A. Kiesenhofer** Small data global regularity for half-wave maps in 4 dimensions.		
12:30				

Time	Room U405	Room U406	Room U407
	Section S01: Logic, Set Theory, and Theoretical Computer Science	**Section S05: Computational Geometry and Topology**	**Minisymposium M6: Enumerative and Algebraic Combinatorics**
10:00	S01c.1 **M. Müller** Automating Resolution is NP-Hard.	S05a.1 **R. Kwitt** Deep Homological Learning.	M6c.1 **M. Kauers** Making Many More Matrix Multiplication Methods.
10:30		S05a.2 **D. Egas Santander** Topological explorations in neuroscience.	
10:45			M6c.2 **B. Stufler** Local convergence of random planar graphs.
11:00	S01c.2 **S. Schumacher** The relation between two weak choice principles.	S05a.3 **A. Rolle** Spaces of clusterings.	
11:30	S01c.3 **V. Fischer** Independence and almost disjointness.	S05a.4 **A. Nikitenko** Stochastic applications of discrete topology.	M6c.3 **E. Y. Jin** Exact and asymptotic enumeration of ascent sequences and Fishburn matrices.
12:00	S01c.4 **W. Wohofsky** Cardinal characteristics and the Borel Conjecture.	S05a.5 **Ž. Virk** Detecting lengths of geodesics with higher-dimensional persistence.	
12:30			

Tuesday, September 17, Afternoon Sessions

	Room W211/12	Room W205	Room W206
	Section S09: **Numerical Analysis, Scientific Computing**	**Section S07:** **Partial Differential Equations and Calculus of Variations**	**Section S08:** **Functional Analysis, Real and Complex Analysis**
15:30–16:00	S09a.1 **O. Steinbach** Space-Time Finite Element Methods.	S07b.1 **I. Glogić** Threshold for blowup for the supercritical cubic wave equation.	S08d.1 **S. Haller** The heat kernel expansion of Rockland differential operators and applications to generic rank two…
16:00–16:30	S09a.2 **R. Eberle** Vibration of a beam under structural randomness.	S07b.2 **N. Vorderobermeier** On the analyticity of critical points of the Möbius energy.	S08d.2 **U. Grupel** Intersections with random geodesics in high dimensions.
16:30–17:00	S09a.3 **T. Cătinaş** On some interpolation operators on triangles with curved sides.	S07b.3 **L. Cossetti** Unique Continuation for the Zakharov Kuznetsov equation.	

	Room U405	Room U406	Room U407
	Section S03: **Number Theory**	**Section S05:** **Computational Geometry and Topology**	**Section S02:** **Algebra, Discrete Mathematics**
15:30–16:00	S03a.1 **K. Destagnol** Counting points of given degree and bounded height via the height zeta function.	S05b.1 **J. Liang** Topological Structures of Probabilistic Landscape of Stochastic Reaction Networks.	S02a.1 **A. Panholzer** Label-quantities in trees and mappings.
16:00–16:30		S05b.2 **L. L. Cristea** On fractal geometric and topologic properties of triangular labyrinth fractals.	S02a.2 **D. Krenn** Optimal Multi-Pivot Quicksort and its Asymptotic Analysis.
16:30–17:00	S03a.2 **N. Rome** On Serre's Problem for Conics.	S05b.3 **G. Leobacher** Necessary and sufficient conditions for the local unique nearest point property of a real…	S02a.3 **M. Wibmer** Galois groups of differential equations.

Tuesday, September 17, Evening Sessions

Time	Room W211/12	Room W205	Room W206
	Section S09: Numerical Analysis, Scientific Computing	**Section S07: Partial Differential Equations and Calculus of Variations**	
17:30	S09b.1 **J. M. Melenk** An adaptive algorithm for the fractional Laplacian.	S07c.1 **L. Forcella** Interpolation theory and regularity for incompressible fluid models.	
18:00	S09b.2 **S. Singh** A new approach of operational matrices for hyperbolic partial differential equations.	S07c.2 **D. S. Wallauch** Stable blowup for a nonlinear Klein-Gordon equation.	
18:30	S09b.3 **A. K. Yadav** Effect of Impedance on Reflection of Plane Waves in a Rotating Magneto-thermoelastic…	S07c.3 **A. Tumanyan** Fredholm property of regular hypoelliptic operators in multianisotropic Sobolev spaces.	
19:00			

Time	Room U405	Room U406	Room U407
	Section S03: Number Theory	**Section S05: Computational Geometry and Topology**	**S02: Algebra, Discrete Mathematics; S04: Algebraic Geometry, Convex and Discrete Geometry**
17:30	S03b.1 **C. Frei** Arithmetic progressions in binary quadratic forms and norm forms.	S05c.1 **A. Brown** Convergence and Stability of Random Mapper.	S02b.1 **A. Zastrow** Some observations on Archipelago-Groups.
18:00		S05c.2 **U. Bauer** Dualities and clearing for image persistence.	S04.1 **H. Al-Zoubi** Anchor rings of finite type Gauss map in the Euclidian 3-space.
18:30	S03b.2 **S. Yamagishi** Solving equations in many variables in primes.		
19:00			

Wednesday, September 18, Morning Sessions

	Room W211/12	Room W205	Room W206
	Minisymposium M5: Inverse Problems for Partial Differential Equations	**Section S06: Ordinary Differential Equations and Dynamical Systems**	**S09: Numerical Analysis, Scientific Computing; S10: Optimization**
11:00–11:30	M5a.1 **M. Haltmeier** NETT: Solving Inverse Problems with Deep Neural Networks.	S06.1 **P. Szmolyan** Periodic solutions and and switching behavior in a model of bipolar disorder.	S09c.1 **V. Devi** An operational matrix approach for two-dimensional hyperbolic telegraph equation.
11:30–12:00	M5a.2 **D. Obmann** Sparse synthesis regularization using deep neural networks.	S06.2 **Y. Halim** On a system of difference equations of second order solved in a closed from.	S09c.2 **R. K. Maurya** Multistep finite difference scheme for electromagnetic waves model arising from dielectric media.
12:00–12:30	M5a.3 **R. Ramlau** Singular Value Decomposition for Atmospheric Tomography.	S06.3 **C. E. Arroud** Optimality conditions of Moreau sweeping process.	S10.1 **I. A. R. Moghrabi** A Multi-step Hybrid Conjugate Gradient Method.

Thursday, September 19, Morning Sessions

	Room W211/12	Room W205	Room W206
	Minisymposium M5: Inverse Problems for Partial Differential Equations	**Minisymposium M2: Mathematical Finance in the age of Machine Learning**	**Minisymposium M4: Spectral Theory**
10:00–10:30	M5b.1 **W. Rundell** Determining nonlinear terms in a reaction-diffusion system.	M2a.1 **J. -P. Ortega** Dynamic and Control Theoretical Aspects of Reservoir Computing.	M4a.1 **T. Kappeler** On the integrability of the Benjamin-Ono equation with periodic boundary conditions.
10:30–11:00	M5b.2 **F. Hettlich** Identification and Design of EM-Chiral Scattering Obstacles.	M2a.2 **L. Grigoryeva** Forecasting of Realized (Co)Variances with Reservoir Computing.	M4a.2 **A. Sakhnovich** Discrete Dirac systems: spectral and scattering theories and Verblunsky-type…
11:00–11:30	M5b.3 **A. Agaltsov** Uniqueness and reconstruction in a passive inverse problem of helioseismology.	M2a.3 **L. Gonon** Error Bounds for Random Recurrent Neural Networks and General Reservoir Computing Systems.	M4a.3 **A. Kostenko** On the absolutely continuous spectrum of generalized indefinite strings.
11:30–12:00	M5b.4 **A. Wald** Parameter identification for the Landau-Lifshitz-Gilbert equation in Magnetic Particle Imaging.	M2a.4 **T. Krabichler** Deep ALM.	M4a.4 **R. Donninger** Strichartz estimates for the one-dimensional wave equation.
12:00–12:30	M5b.5 **G. Mercier** On convergence of Total Variation regularized inverse problems.	M2a.5 **A. Kratsios** Universal Approximation Theorems.	

Thursday, September 19, Afternoon Sessions

	Room W211/12	Room W205	Room W206
	Minisymposium M5: Inverse Problems for Partial Differential Equations	**Minisymposium M2: Mathematical Finance in the age of Machine Learning**	**Minisymposium M4: Spectral Theory**
15:30–16:00	M5c.1 **I. Piotrowska-Kurczewski** Generalized tolerance regularization.	M2b.1 **H. Wutte** Randomized shallow neural networks and their use in understanding gradient descent.	M4b.1 **G. Raikov** Threshold Singularities of the Spectral Shift Function for Geometric Perturbations of a Magnetic Hamiltonian.
16:00–16:30	M5c.2 **F. Romero Hinrichsen** Dynamical super-resolution with applications to Ultrafast ultrasound imaging.	M2b.2 **C. Cuchiero** Modeling rough covariance processes.	M4b.2 **J. Michor** Rarefaction and shock waves for the Toda equation.
16:30–17:00	M5c.3 **R. Klein** Regularizing sequential subspace optimization for the identification of the stored energy of a...	M2b.3 **W. Khosrawi** A Neural Network Approach to Local Stochastic Volatility Calibration.	M4b.3 **M. Piorkowski** Riemann-Hilbert approach to asymptotic analysis.

Thursday, September 19, Evening Sessions

	Room W211/12	Room W205	Room W206
	Minisymposium M5: Inverse Problems for Partial Differential Equations	**Minisymposium M2: Mathematical Finance in the age of Machine Learning**	**Minisymposium M4: Spectral Theory**
17:30–18:00	M5d.1 **S. Eberle** Solving the inverse problem of linear elasticity with monotonicity methods.	M2c.1 **J. Teichmann** Learning stochastic dynamics by random signatures with applications to mathematical Finance.	M4c.1 **R. Sousa** Product formulas and convolutions for solutions of Sturm-Liouville equations.
18:00–18:30		M2c.2 **S. Svaluto-Ferro** Infinite dimensional polynomial jump-diffusions.	M4c.2 **Z. Rao** Optimal Blowup Stability for the Energy Critical Wave Equation.
18:30–19:00		M2c.3 **S. Rigger** Interacting Particle Systems, Default Cascades and the M1-topology.	

ABSTRACTS OF PLENARY LECTURES, MINISYMPOSIA, SECTIONS, AND SIDE EVENTS

Plenary Speakers

Efstathia Bura (Technische Universität Wien)
Fritz Gesztesy (Baylor University)
Marlis Hochbruck (Karlsruher Institut für Technologie)
Josef Hofbauer (Universität Wien)
Özlem Imamoglu (ETH Zürich)
Helmut Pottmann (KAUST & Technische Universität Wien)
Wilhelm Schlag (Yale University)
Susanna Terracini (Universitá di Torino)

ÖMG Award Winner:
Christopher Frei (University of Manchester)

P.5
TUE
14:00
|
15:00
W211/12

Sufficient Dimension Reduction in high dimensional regression and classification

Efstathia Bura (Vienna University of Technology)

This talk will focus on model-based sufficient dimension reduction in regressions and classifications with predictor distributions in the elliptically contoured and exponential families. Model-based SDR stems from the connection between sufficient statistics in the inverse regression and the sufficient reduction in the forward regression. This leads to the exhaustive identification of the sufficient reductions, both linear and nonlinear, in the elliptically contoured and exponential families of distributions, which model most of the continuous, discrete and mixed predictors in high dimensional problems. The work associated with these developments will be presented.

P.9
THU
14:00
|
15:00
W211/12

The Birman sequence of integral inequalities and some of its refinements

Fritz Gesztesy (Department of Mathematics, Baylor University, Waco, Texas)

We review recent progress on the Birman sequence of integral inequalities in arbitrary dimension (the first two elements in this sequence being the celebrated inequalities of Hardy and Rellich).

Refinements of these inequalities that we will discuss include power weights as well as an arbitrary number of additional logarithmically weaker singular terms. In addition, we show that powers of the Laplacian can be replaced by the corresponding powers of the radial Laplacian.

This is based on joint work with L. L. Littlejohn, I. Michael, and M. M. H. Pang.

On leapfrog-Chebyshev schemes

Marlis Hochbruck (Karlsruhe Institute of Technology)

P.3
MON
13:45
|
14:45
W211/12

In this talk we consider variants of the leapfrog method for second order differential equations. In numerous situations the strict CFL condition of the standard leapfrog method is the main bottleneck that thwarts its performance. Based on Chebyshev polynomials new methods have been constructed that exhibit a much weaker CFL condition than the leapfrog method.

We will analyze the stability and the long-time behavior of leapfrog-Chebyshev methods in two-step formulation. This analysis indicates that on should modify the schemes proposed in the literature in two ways to improve their qualitative behavior:

For linear problems, we propose to use special starting values required for a two-step method instead of the standard choice obtained from Taylor approximation. For semilinear problems, we propose to introduce a stabilization parameter as it has been done for Runge-Kutta-Chebyshev methods before. For the stabilized methods we prove that they guarantee stability for a large class of problems.

While these results hold for quite general polynomials, we show that the polynomials used in the stabilized leapfrog Chebyshev methods satisfy all the necessary conditions. In fact, all constants in the error analysis can be given explicitly.

The talk concludes with numerical examples illustrating our theoretical findings.

This is joint work with Constantin Carle and Andreas Sturm, Karlsruhe Institute of Technology, funded by CRC 1173.

Permanence of biological systems

Josef Hofbauer (Universität Wien)

P.6
WED
08:30
|
09:30
W211/12

Given a mathematical model of a biological community [5, 6] (or a chemical reaction network [2]), can one find out whether the whole community will survive? Is there is a global attractor in which all species/types of the system coexist? If the state space is the nonnegative orthant $\mathbb{R}^n_+$ this means that its boundary (together with ∞) is a repeller for the dynamics. Important tools are *average Lyapunov functions* [1, 3, 5] and *Lyapunov exponents* [4]. I will give a survey of the methods and results obtained in the last decades about this problem.

[1] M. Benaïm, *Stochastic persistence*, https://arxiv.org/abs/1806.08450

[2] B. Boros, J. H., *Permanence of weakly reversible mass-action systems with a single linkage class*, https://arxiv.org/abs/1903.03071

[3] B. Garay, J. H., *Robust permanence for ecological differential equations, minimax, and discretizations*, SIAM J. Math. Anal. **34** (2003) 1007–1039.

[4] J. H., S. Schreiber, *To persist or not to persist*, Nonlinearity **17** (2004) 1393–1406.

[5] J. H., K. Sigmund, *Evolutionary Games and Population Dynamics*, Cambridge University Press (1998).

[6] H. L. Smith, H. R. Thieme, *Dynamical Systems and Population Persistence*, Amer. Math. Soc., 2011.

P.4
TUE
08:30
|
09:30
W211/12

Binary Quadratic Forms, Quadratic fields and Modular forms

Özlem Imamoglu (ETH Zürich)

There are numerous connections between binary quadratic forms, quadratic fields and modular forms. One of the most beautiful is provided by the theory of singular moduli, which are the values of the Klein's j-invariant

$$j(\tau) = q^{-1} + 744 + 196884\,q + 21493760\,q^2 + \cdots \qquad (q = e^{2\pi i\tau})$$

at imaginary quadratic irrationalities. In this talk I will give an overview of some of the old and new results and various applications of the connections between quadratic forms and modular forms.

P.2
MON
11:00
|
12:00
W211/12

Discrete geometric structures motivated by architecture and computational design

Helmut Pottmann (KAUST and TU Wien)

Discrete differential geometry is situated at the border between differential and discrete geometry and aims to develop discrete equivalents of notions and methods from smooth surface theory [1]. The current interest in discrete differential geometry is not only rooted in its importance in pure mathematics, but also in its relevance for other fields, including computer graphics and architectural geometry.

This talk will present recent results in discrete differential geometry whose development has been motivated by practical requirements on the fabrication of freeform shapes in modern architecture [3]. We will focus on various discretizations of principal curvature parameterizations [2]. The geometric properties of these principal nets facilitate the construction of architectural freeform skins from flat, nearly rectangular panels, associated with optimized support structures. Principal nets also appear in material-minimizing structures [4], and they are in a certain sense the smoothest polyhedral surfaces which approximate a given smooth surface [5]. Non-smooth representatives of certain principal nets are related to curved folding patterns and origami.

[1] A. Bobenko, Y. Suris, *Discrete differential geometry: Integrable Structure*, American Math. Soc., 2009.

[2] A. Bobenko, H. Pottmann, J. Wallner, *A curvature theory for discrete surfaces based on mesh parallelity*, Math. Annalen, 348 (2010), 1–24.

[3] H. Pottmann, M. Eigensatz, A. Vaxman, J. Wallner, *Architectural geometry*, Computers and Graphics, 47 (2015) 145–164.

[4] D. Pellis, M. Kilian, J. Wallner, H. Pottmann, *Material-minimizing forms and structures*, ACM. Trans. Graphics 36(6) (2017), 173:1–173:12.

[5] D. Pellis, M. Kilian, F. Dellinger, J. Wallner, H. Pottmann, *Visual smoothness of polyhedral surfaces*, ACM. Trans. Graphics 38(4) (2019), 31:1–31:11.

On no-return theorems in nonlinear dispersive PDEs

Wilhelm Schlag (Yale University)

P.1
MON
09:30
|
10:30
W211/12

In 2010 Nakanishi and the speaker introduced a "one-pass theorem" which precludes solutions to nonlinear wave equations starting from a small neighborhood of a ground state soliton and which return to another such neighborhood after some finite time. Such statements are non-perturbative and require global arguments. In the original setting invariant manifolds played an essential role, especially the one-dimensional unstable manifold associated with the steady-state solution. I will review these results, and discuss some of their ramifications over the past ten years.

P.8
THU
08:30
|
09:30
W211/12

Spiralling and other solutions in limiting profiles of competition-diffusion systems

Susanna Terracini (Università di Torino)

Reaction-diffusion systems with strong interaction terms appear in many multi-species physical problems as well as in population dynamics. The qualitative properties of the solutions and their limiting profiles in different regimes have been at the center of the community's attention in recent years. A prototypical example is the system of equations

$$\begin{cases} -\Delta u + a_1 u = b_1 |u|^{p+q-2} u + cp|u|^{p-2}|v|^q u, \\ -\Delta v + a_2 v = b_2 |v|^{p+q-2} v + cq|u|^p |v|^{q-2} v \end{cases}$$

in a domain $\Omega \subset \mathbb{R}^N$ which appears, for example, when looking for solitary wave solutions for Bose-Einstein condensates of two different hyperfine states which overlap in space. The sign of b_i reflects the interaction of the particles within each single state. If b_i is positive, the self interaction is attractive (focusing problems). The sign of c, on the other hand, reflects the interaction of particles in different states. This interaction is attractive if $c > 0$ and repulsive if $c < 0$. If the condensates repel, they eventually separate spatially giving rise to a free boundary. Similar phenomena occurs for many species systems. As a model problem, we consider the system of stationary equations:

$$\begin{cases} -\Delta u_i = f_i(u_i) - \beta u_i \sum_{j \neq i} g_{ij}(u_j) \\ u_i > 0 \ . \end{cases}$$

The cases $g_{ij}(s) = \beta_{ij} s$ (Lotka-Volterra competitive interactions) and $g_{ij}(s) = \beta_{ij} s^2$ (gradient system for Gross-Pitaevskii energies) are of particular interest in the applications to population dynamics and theoretical physics respectively.

Phase separation and has been described in the recent literature, both physical and mathematical. Relevant connections have been established with optimal partition problems involving spectral functionals. The classification of entire solutions and the geometric aspects of phase separation are of fundamental importance as well. We intend to focus on the most recent developments of the theory in connection with problems featuring anomalous diffusions, non-local and non symmetric interactions.

Average bounds for the ℓ-torsion in class groups of number fields

Christopher Frei⋆ (University of Manchester)
Martin Widmer (Royal Holloway, University of London)

P.7
WED
09:30
|
10:30
W211/12

The arithmetic of an algebraic number field K is determined in large parts by its class group Cl_K. For example, the ring of integers of K admits unique factorisation into irreducibles if and only if Cl_K is trivial. While it is known from classical algebraic number theory that Cl_K is always a finite abelian group, and the distribution of these groups is predicted by precise heuristics, precise provable information about their structure remains quite elusive. To emphasise our lack of knowledge, the question whether the class group is trivial for infinitely many number fields remains still open.

In this talk, we introduce class groups and survey classical and recent results (conditional and unconditional) bounding the cardinality of their ℓ-torsion subgroups, for a natural number ℓ. In the remaining time, we discuss joint work with Martin Widmer on average bounds for this ℓ-torsion in certain families of number fields, and applications thereof.

Minisymposium M1

Industrial and Applied Mathematics

Markus Haltmeier (Universität Innsbruck)

M1a.1
MON
15:15
|
15:45
W211/12

Efficient solving of a time-dependent interface problem

Christoph Erath (Technische Universität Darmstadt)

Modeling has been identified as an important tool to simulate phenomena and processes in natural sciences and engineering, which are often described by partial differential equations. Appropriate and effective numerical methods play a crucial role to solve these equations.

We consider a parabolic-elliptic interface problem in an unbounded domain. An application is, for instance, the modeling of eddy currents in the magneto-quasistatic regime. Due to different physical properties of the solution in different parts of the domain it makes sense to consider couplings of different methods to get the best possible numerical approximation.

Therefore, we introduce the coupling of the Finite Element Method and the Boundary Element Method to approximate such a solution in space without truncation of the unbounded domain [1]. This leads to a semi-discrete solution. For the subsequent time discretization we either use the classical backward Euler scheme or a variant of it to get a fully-discrete system. The model problem and its numerical discretization are well-posed also for Lipschitz interfaces [2]. Even more, we prove quasi-optimality, i.e., the best possible approximation of the solution, of our semi-discrete *and* fully-discrete solution under minimal regularity assumptions in the natural energy norm [2]. We remark that our analysis does not use duality arguments and corresponding estimates for an elliptic projection which are not available for our nonsymmetric coupling method. Instead, we use estimates in appropriate energy norms. Moreover, we discuss the extension of our model problem to a problem arising in fluid mechanics. However, since the conservation of fluxes is mandatory for such applications, we replace the Finite Element Method by the Finite Volume Method in our coupling approach [3]. Numerical examples illustrate the predicted (optimal) convergence rates and underline the potential for practical applications.

[1] R. C. MacCamy and M. Suri, *A time-dependent interface problem for two-dimensional eddy currents*, Quart. Appl. Math., 44 (1987) 675–690.

[2] H. Egger, C. Erath, and R. Schorr, *On the nonsymmetric coupling method for parabolic-elliptic interface problems*, SIAM J. Numer. Anal. 56(6) (2018) 3510–3533.

[3] C. Erath and R. Schorr, *Stable non-symmetric coupling of the finite volume method and the boundary element method for convection-domninated parabolic-elliptic interface problems*, Comput. Methods Appl. Math. published online (2019).

Using extended Kalman Filters for solving non-linear inverse problems

Klaus Frick⋆ (Interstaatliche Hochschule für Technik Buchs NTB)
Silvano Balemi (Zumbach Electronic AG)

M1a.2
MON
15:45
|
16:15
W211/12

Since decades the Kalman filter approach is widely used in numerous fields of applications ranging from inertial navigation to econometrics. Extended Kalman filters are used to estimate a time dependent state variable $x_k \in X$ from noisy observations $y_k \in Y$ according to the general non-linear dynamic model

$$\begin{aligned} x_{k+1} &= f(x_k) + v_k \\ y_k &= h(x_k) + w_k \end{aligned}$$

Here $f : X \to X$ defines the dynamics of the system, $h : X \to Y$ is the measurement mapping and v_k and w_k are noise terms. In this talk we consider the case when the measurement mapping is ill-posed and stress that in this case the Extended Kalman filter acts as a regularization method. We illustrate the performance of the method by means of a real-world example from industrial inline metrology, where the cross-section of moving tubular products such as steel-bars or cables is reconstructed at high precision from incomplete and noisy measurements.

Iterative methods for PAT in dissipative media

Richard Kowar⋆ (Department of Mathematics, University of Innsbruck)
Markus Haltmeier (Department of Mathematics, University of Innsbruck)
Linh V. Nguyen (Department of Mathematics, University of Idaho)

M1a.3
MON
16:15
|
16:45
W211/12

We present a convergence analysis of iterative methods for PAT in attenuating medium. An explicit expression for the adjoint problem is derived, which can efficiently be implemented. In contrast to time reversal, the adjoint wave equation is damping and, thus has a stable solution. Our numerical results demonstrate efficiency, stability and accuracy of the iterative method in various situations including the limited view case.

M1b.1
MON
17:15
|
17:45
W211/12

Full field inversion in photoacoustic tomography with variable sound speed

Gerhard Zangerl⋆ (Department of Mathematics, University Innsbruck)
Markus Haltmeier (Department of Mathematics, University Innsbruck)
Linh V. Nguyen (Department of Mathematics, University Idaho)
Robert Nuster (Department of Physics, University Graz)

Photoacoustic tomography (PAT) is a hybrid imaging technique, combining high contrast and resolution of optical and ultrasound tomography. Typically, data acquisition in PAT requires to record acoustic pressure that is emitted by an object by detectors surrounding it, which is typically time consuming. To address this problem, we consider a faster novel measurement setup for data acquisition in PAT where data in the form of projections of the full 3D acoustic pressure distribution at a certain time instant are collected. Existing imaging algorithms for this kind of data assume constant speed of sound. This assumption is not always met in practice and thus leads to erroneous reconstructions. We present a two-step reconstruction method for full field detection photoacoustic tomography that takes variable speed of sound into account. In the first step, by applying the inverse Radon transform, the pressure distribution at the measurement time is reconstructed point-wise from the projection data. In the second step, one solves a final time wave inversion problem where the initial pressure distribution is recovered from the known pressure distribution at the measurement time. For the latter problem, we derive an iterative solution approach, compute the required adjoint operator, and show its uniqueness and stability.

This talk is based on [1].

[1] G. Zangerl, M. Haltmeier, L. V. Nguyen, and R. Nuster 2019. *Full field inversion in photoacoustic tomography with variable sound speed.* Appl. Sci. 9 (8), pp. 1563.

Parameter identification and uncertainty quantification in stochastic state space models and its application to texture analysis

M1b.2
MON
17:45
|
18:15
W211/12

Barbara Kaltenbacher⋆ (Alpen-Adrai-Universität Klagenfurt)
Barbara Pedretscher (Kompetenzzentrum Automobil- & Industrie-Elektronik Villach)
Olivia Bluder (Kompetenzzentrum Automobil- & Industrie-Elektronik Villach)

In this talk, a computational framework, which enables efficient and robust parameter identification, as well as uncertainty quantification in state space models based on Itô stochastic processes, is presented. For optimization, a Maximum Likelihood approach based on the system's corresponding Fokker-Planck equation is followed. Gradient information is included by means of an adjoint approach, which is based on the Lagrangian of the optimization problem. To quantify the uncertainty of the Maximum a Posteriori estimates of the model parameters, a Bayesian inference approach based on Markov Chain Monte Carlo simulations, as well as profile likelihoods are implemented and compared in terms of runtime and accuracy. The framework is applied to experimental electron backscatter diffraction data of a fatigued metal film, where the aim is to develop a model, which consistently and physically meaningfully captures the metal's microstructural changes that are caused by external loading.

Block coordinate descent method for ill-posed problems

M1b.3
MON
18:15
|
18:45
W211/12

Lukas Neumann⋆ (Institut für Grundlagen der techn. Wissenschaften, Universität Innsbruck)
Simon Rabanser (Institut für Mathematik, Universität Innsbruck)
Markus Haltmeier (Institut für Mathematik, Universität Innsbruck)

Block coordinate descent methods are iterative schemes characterized by performing updates in the direction of subgroups of coordinates. Such methods proofed efficient in optimization problems and convergence in the objective function is known. However, convergence in the pre-image space, as typically needed in inverse problems, is not known and does not hold in general. We present a convergence analysis for linear ill-posed problems. Moreover we discuss numerical tests for a linear problem as well as a nonlinear example from one step inversion in multi-spectral X-ray tomography.

This talk is based on [1].

[1] S. Rabanser, L. Neumann, and M. Haltmeier, 2019. *Analysis of the Block Coordinate Descent Method for Linear Ill-Posed Problems*, Preprint available at `https://arxiv.org/abs/1902.04794`.

M1c.1
TUE
10:00
|
10:30
W211/12

Process Model for the Industrial Plate Leveling Operation with Special Emphasis on Online Control

Michael Liebrecht⋆ (RICAM, MathConsult GmbH)
Ann-Kristin Baum (RICAM)
Roman Wahl (uni software plus GmbH)
Michael Aichinger (uni software plus GmbH)
Erik Parteder (voestalpine Grobblech GmbH)

To produce high quality steel plates that meet the customers' requirements, physically based models are increasingly used in the automation systems of the production process. In this work, a 2D model to describe the leveling process of the heavy plate production is presented. The model is based on Euler beam theory and features isotropic hardening of the material and the elastic response of the leveling machine. It enables the computation of the full stress-strain history as well as all contact points and contact forces between the plate and the leveling rolls. The results are validated using the multi-purpose finite ele-ment software ABAQUS and compared to measured forces recorded during production. Changes of the mechanical properties of the plate caused by the leveling operation can be calculated from the stress-strain history. The implementation of the presented 2D model in C++ is dramatically faster compared to the multi-purpose finite element solution. Nevertheless, due to time constraints during the production process, it is not feasible to apply the 2D model in real time. For this purpose, a surrogate model based on vast pa-rameter studies has been developed.

M1c.2
TUE
10:30
|
11:00
W211/12

Nonlinear inverse heat transfer problems in modelling the cooling process of heavy plates

Dimitri Rothermel⋆ (Universität des Saarlandes)
Thomas Schuster (Universität des Saarlandes)

The goal of our project is the automation of the production of heavy plates from steel and the interest in adjusting the mechanical properties of those. For that reason, we want to model and control the cooling process depending on the water load and the speed of the cooling plate. Based on this, we get an optimal control problem with a nonlinear PDE (heat transfer equation) constraint, describing the heat (or temperature) distribution in the given region over time. This PDE however, is equipped with unknown functions which have to be characterized in different subproblems. In this talk we will give an overview of the project, present the experimental setup and show some numerical results.

Hyperspectral Image classification with Minimal Learning: A Graph Based Approach

M1c.3
TUE
11:00
|
11:30
W211/12

Philip Sellars⋆ (Department of Mathematics, University of Cambridge)
Angelica I. Aviles Rivero (Department of Mathematics, University of Cambridge)
Carola Bibiane Schönlieb (Department of Mathematics, University of Cambridge)

A central problem in hyperspectral image classification is obtaining high classification accuracy when using a *limited amount of labelled data*. In this talk I will present a novel graph-based semi-supervised framework to tackle this problem, highlighting the power of graph based learning. Our framework uses a superpixel approach, allowing it to define meaningful local regions in hyperspectral images, which with high probability share the same classification label. We then extract spectral and spatial features from these regions and use them to produce a contracted weighted graph-representation, where each node represents a region rather than a pixel. The graph is then fed into a graph-based semi-supervised classifier which gives the final classification. We show that using superpixels in a graph representation is an effective tool for speeding up graphical classifiers applied to hyperspectral images. We demonstrate through exhaustive quantitative and qualitative results that our proposed method produces accurate classifications when an incredibly small amount of labelled data is used.

Regularizing networks for soving inverse problems

M1c.4
TUE
11:30
|
12:00
W211/12

Johannes Schwab⋆ (Universität Innsbruck)
Markus Haltmeier (Universität Innsbruck)
Stephan Antholzer (Universität Innsbruck)

Recently, data driven methods for solving inverse problems have become very popular. With the help of deep neural networks, these methods empirically show outstanding performance but still lack of theoretical justification. In our work we analyze such trained neural networks combined with a classical regularization as a reconstruction method. We show, that for a particular type of networks, called regularizing networks, the proposed approach leads a convergent regularization method. Additionally we show convergence rates and illustrate the proposed method by the application of regularizing networks to limited view photoacoustic tomography.

M1c.5
TUE
12:00
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12:30
W211/12

Known Operator Learning — An Approach to unite Physics, Signal Processing, and Machine Learning

Andreas Maier (Friedrich-Alexander-Universität Erlangen-Nürnberg)

We describe an approach for incorporating prior knowledge into machine learning algorithms. We aim at applications in physics and signal processing in which we know that certain operations must be embedded into the algorithm. Any operation that allows computation of a gradient or sub-gradient towards its inputs is suited for our framework. We prove that the inclusion of such prior knowledge reduces maximal error bounds. Furthermore, we demonstrate experimentally that it reduces the number of free parameters. We apply this approach to various tasks ranging from CT image reconstruction over vessel segmentation to the derivation of previously unknown imaging algorithms. As such the concept is widely applicable for many researchers in physics, imaging, and signal processing. We assume that our analysis will support further investigation of known operators in other fields of physics, imaging, and signal processing.

[1] A. Maier, F. Schebesch, C. Syben, T. Würfl, S. Steidl, J.-H. Choi, and R. Fahrig, “Precision Learning: Towards Use of Known Operators in Neural Networks,” in *2018 24rd International Conference on Pattern Recognition (ICPR)*, J. K. T. Tan, Ed., 2018, pp. 183–188. [Online].

[2] C. Syben, B. Stimpel, J. Lommen, T. Würfl, A. Dörfler, and A. Maier, “Deriving neural network architectures using precision learning: Parallel-to-fan beam conversion,” in *German Conference on Pattern Recognition (GCPR)*, 2018.

Minisymposium M2

Mathematical Finance in the age of Machine Learning

Josef Teichmann (ETH Zürich)

M2a.1

THU
10:00
|
10:30
W205

Dynamic and Control Theoretical Aspects of Reservoir Computing

Juan-Pablo Ortega⋆ (Universität Sankt Gallen, Switzerland and CNRS, France)
Lukas Gonon (Universität Sankt Gallen, Switzerland)
Lyudmila Grigoryeva (Universität Konstanz, Germany)

Reservoir computing (RC) carries out the learning of input/output systems by using families of state space systems in which the training of a small portion of their parameters suffices for excellent generalization properties. In this talk we shall analyze in detail the connection between various dynamic and control theoretical features of widely used families of RC families and their impact in basic learning theoretical goals, in particular in the development of bounds for the approximation and estimation errors and in the design of dimension reduction techniques.

[1] Lukas Gonon and Juan-Pablo Ortega: Reservoir computing universality with stochastic inputs. *To appear in IEEE Transactions on Neural Networks and Learning Systems*, 2018.

[2] Lyudmila Grigoryeva and Juan-Pablo Ortega. Universal discrete-time reservoir computers with stochastic inputs and linear readouts using non-homogeneous state-affine systems. *Journal of Machine Learning Research*, 19 (24):1–40, 2018.

[3] Lyudmila Grigoryeva and Juan-Pablo Ortega. Echo state networks are universal. *Neural Networks*, 108: 495–508, 2018.

[4] Lyudmila Grigoryeva and Juan-Pablo Ortega. Differentiable reservoir computing. *Preprint*, 2019.

Forecasting of Realized (Co)Variances with Reservoir Computing

Lyudmila Grigoryeva⋆ (Universität Konstanz, Germany)
Lukas Gonon (Universität Sankt Gallen, Switzerland)
Oleksandra Kukharenko (Universität Konstanz, Germany)
Juan-Pablo Ortega (Universität Sankt Gallen, Switzerland and CNRS, France)

M2a.2
THU
10:30
|
11:00
W205

The problem of forecasting realized (co)variances (RV) computed out of intraday returns of the components of the S&P 500 market index is considered. The study focuses on a novel machine learning paradigm known as reservoir computing (RC) for producing multistep ahead forecasts for time series of realized (co)variances. Various families of reservoir computers have been recently proved to have universal approximation properties when processing stochastic discrete-time semi-infinite inputs [1, 2, 3]. We examine the empirical performance of RC in forecasting of realized (co)variances in comparison to many conventional state-of-the-art econometric models for various RV estimators, periods, and dimensions. We show that universal RC families consistently demonstrate superior predictive ability for various designs of empirical exercises.

[1] Lyudmila Grigoryeva and Juan-Pablo Ortega. Universal discrete-time reservoir computers with stochastic inputs and linear readouts using non-homogeneous state-affine systems. *Journal of Machine Learning Research*, 19 (24):1–40, 2018.

[2] Lyudmila Grigoryeva and Juan-Pablo Ortega. Echo state networks are universal. *Neural Networks*, 108: 495–508, 2018.

[3] Lukas Gonon and Juan-Pablo Ortega: Reservoir computing universality with stochastic inputs. *To appear in IEEE Transactions on Neural Networks and Learning Systems*, 2018.

Error Bounds for Random Recurrent Neural Networks and General Reservoir Computing Systems

Lukas Gonon⋆ (Universität St. Gallen)
Lyudmila Grigoryeva (Universität Konstanz)
Juan-Pablo Ortega (Universität St. Gallen and CNRS)

M2a.3
THU
11:00
|
11:30
W205

In this talk we present our recent mathematical results on universality and error bounds for reservoir computing. Motivated by the task of realized volatility forecasting, we study approximation and learning based on random neural networks and more general reservoir computing systems. For echo state networks with output feedback we obtain high-probability bounds on the approximation error in terms of the network parameters. For a more general class of reservoir computing systems and weakly dependent (possibly non-i.i.d.) input data, we then also derive generalization error bounds based on a Rademacher-type complexity.

M2a.4
THU
11:30
|
12:00
W205

Deep ALM

Thomas Krabichler⋆ (Hochschule Luzern)
Josef Teichmann (ETH Zürich)

There are very promising proofs-of-concept that reinforcement learning may revolutionise valuations and risk management strategies in the financial industry. A cornerstone in this regard is the concept "deep hedging". Accounting for transaction cost and liquidity constraints in the hedging of a multi-dimensional derivative exposure cannot be tackled at all with conventional methods from mathematical finance. Utilising techniques inspired from re-inforcement learning allows to overcome both the complexity and the curse of dimension. We aim at refining this approach for entire term structures in order to solve classical yet intractable problems from asset-liability-management (ALM).

M2a.5
THU
12:00
|
12:30
W205

Universal Approximation Theorems

Anastasis Kratsios (ETH Zürich)

The universal approximation theorem established the density of specific families of neural networks in the space of continuous functions and in various Bochner-Lebesgue spaces, defined between any two Euclidean spaces. We extend and refine their result and definitions by proving that there exist dense neural network architectures on a much larger class of function spaces and that these architectures may be written down using only a finite number of functions. Our results cover any function space which is homeomorphic either to a convex body in an infinite-dimensional Fréchet space, to a finite-dimensional compact Riemannian manifold, or to a metric space which is a retract of a Banach space. We prove that upon appropriately randomly selecting the neural networks architecture's activation function we may still obtain a dense set of neural networks, with positive probability.

Conversely, we show that given any neural network architecture on a set of continuous functions between two T0 topological spaces, there exists a unique finest topology on that set of functions which makes the neural network architecture into a universal approximator. Several examples are considered throughout.

Randomized shallow neural networks and their use in understanding gradient descent

Hanna Wutte⋆ (ETH Zürich)
Jakob Heiss (TU Wien)
Josef Teichmann (ETH Zürich)

M2b.1
THU
15:30
|
16:00
W205

Today, various forms of neural networks are trained to perform approximation tasks in many fields (including Mathematical Finance). However, the solutions obtained are not wholly understood. Empirical results suggest that the training favors regularized solutions. Moreover, it has been questioned how much training really matters, in the sense that randomly choosing subsets of the network's weights and training only a few leads to an almost equally good performance.

These observations motivate us to analyze properties of the solutions found by the gradient descent algorithm frequently employed to perform the training task. In particular, we consider one dimensional (shallow) neural networks in which weights are chosen randomly and only the last layer is trained. We show, that the resulting solution converges to the smooth spline interpolation of the training data as the number of hidden nodes tends to infinity. This might give valuable insight on the properties of the solutions obtained using gradient descent methods in general settings.

Modeling rough covariance processes

Christa Cuchiero⋆ (Wirtschaftsuniversität Wien)
Josef Teichmann (ETH Zürich)

M2b.2
THU
16:00
|
16:30
W205

The rough volatility paradigm asserts that the trajectories of assets' volatility are rougher than Brownian motion, a revolutionary perspective that has changed certain persistent views of volatility. It provides via stochastic Volterra processes a universal approach to capture important features of time series and option price data as well as microstructural foundations of markets. We provide an infinite dimensional point of view on stochastic Volterra processes, which allows to dissolve a generic non-Markovanity of the at first sight naturally low dimensional volatility process. This approach enables to go beyond the univariate case considered so far and to treat the challenging problem of multivariate rough covariance models, in particular of affine and Wishart type, for more than one asset.

M2b.3

THU
16:30
|
17:00
W205

A Neural Network Approach to Local Stochastic Volatility Calibration

Wahid Khosrawi⋆ (ETH Zurich)
Christa Cuchiero (Vienna University of Economics and Business)
Josef Teichmann (ETH Zurich)

A central task in modeling, which has to be performed each day in banks and financial institutions, is to calibrate models to market and historical data. So far the choice which models should be used was not only driven by their capacity of capturing empirically the observed market features well, but rather by computational tractability considerations. Due to recent work in the context of machine learning, this notion of tractability has changed significantly. In this work, we show how a neural network approach can be applied to the calibration of (multivariate) local stochastic volatility (LSV) models. In these models (assuming for simplicity zero interest rates), the price process $(S_t)_{t\geq 0}$ satisfies

$$dS_t = S_t L(t, S_t)\alpha_t dW_t,$$

where $(\alpha_t)_{t\geq 0}$ is some stochastic process taking values in $\mathbb{R}$. The function L is the so-called *leverage function* and the goal is to determine L such that option prices observed in the financial market are perfectly calibrated. Under strong assumptions on the observed prices - e.g. it is assumed that a continuum of prices are available which requires interpolation of observations - it is possible to perfectly calibrate the corresponding local volatility model by means of the Dupire-formula, see [1]. In practice, a McKean-Vlasov SDE type approach is then used to calibrate the corresponding SLV model, which by itself is a delicate task, compare [2]. We show how a direct calibration of the LSV model is possible by employing a neural network type approach without the need of interpolation methods for the financial data.

[1] B. Dupire, *Pricing With a Smile*, Risk **7**, (1994) 18 - 20.
[2] J. Guyon and P. Henry-Labordere, *The smile calibration problem solved*, Preprint , (2011).

Learning stochastic dynamics by random signatures with applications to Mathematical Finance

M2c.1
THU
17:30
|
18:00
W205

Josef Teichmann⋆ (ETH Zürich)
Christa Cuchiero (Wirtschaftsuniversität Wien)
Lukas Gonon (Universität St. Gallen)
Lyudmila Grigoryeva (Universität Konstanz)
Juan-Pablo Ortega (Universität St. Gallen, Switzerland and CNRS, France)

Stochastic dynamical systems can be approximated (or represented) as linear maps on the collections of iterated integrals of the (stochastic) input signal. We introduce random signatures of input signals and prove that they are similarly expressive as signature itself. This has several applications for (machine-) learning dynamics from training data and is another (provable) instance of reservoir computing.

Infinite dimensional polynomial jump-diffusions

M2c.2
THU
18:00
|
18:30
W205

Sara Svaluto-Ferro⋆ (University of Vienna)
Christa Cuchiero (University of Vienna)

We introduce polynomial jump-diffusions taking values in an arbitrary Banach space via their infinitesimal generator. We obtain two representations of the (conditional) moments in terms of solution of systems of ODEs. These representations generalize the well-known moment formulas for finite dimensional polynomial jump-diffusions. We illustrate the practical relevance of these formulas by several applications. In particular, we consider (potentially rough) forward variance polynomial models and we illustrate how to use the moment formulas to compute prices of VIX options.

Interacting Particle Systems, Default Cascades and the M1-topology

M2c.3
THU
18:30
|
19:00
W205

Stefan Rigger⋆ (Universität Wien)
Christa Cuchiero (Wirtschaftsuniversität Wien)
Sara Svaluto-Ferro (Universität Wien)

The M1-topology is one of the lesser-known topologies originally introduced by Skorokhod. An advantageous feature of this topology (in comparison to the more widely used J1-topology) is that it is particularly well-suited to deal with monotone functions. We prove a tightness result for processes that can be decomposed into a continuous and a monotone part and discuss its relevance for particle systems with singular interactions, which serve as models for networks with contagious effects. Applications include a variety of phenomena, such as neuronal synchronization in the brain, systemic risk of financial lending networks, and the supercooled Stefan problem.

Minisymposium M3

Parallel and Distributed Optimization and Simulation

Steffen Finck (Fachhochschule Vorarlberg)

M3a.1
MON
15:15
|
15:45
U406

Predicting the efficiency of LRZ's cooling infrastructure using machine learning

Hayk Shoukourian (Leibniz Supercomputing Centre (LRZ) of the Bavarian Academy of Sciences and Humanities; Ludwig-Maximilians-Universität München (LMU))

The power consumption of modern High Performance Computing (HPC) and cloud data centers increases hand-in-hand with their performance. The mentioned power consumption does not only translate to high operational costs but also to high carbon footprints, affecting the environment and limiting the further expansion of data centers, leading to an introduction of certain energy/power capping strategies. All these make it important to be preemptive in improving energy/power efficiency of HPC and cloud data centers that encompass the complete chain of power/energy consumers ranging from data center's building infrastructure over compute resource management and scheduling to application scaling.

The talk will give a brief overview on LRZ's newly deployed SuperMUC-NG flagship supercomputing system, outline its energy-efficiency characteristics as well as present a machine learning based approach used for modeling the efficiency of HPC data center's chiller-less hot water cooling loop. The talk will also highlight the applications of the developed model for the improvement of energy-efficiency in modern data centers.

M3a.2
MON
15:45
|
16:15
U406

Towards multi-objective, region-based auto-tuning for parallel programs

Philipp Gschwandtner (University of Innsbruck, Austria)

Efficient parallelization and optimization for modern parallel architectures is a time-consuming and error-prone task that requires numerous iterations of code transformations, tuning and performance analysis which in many cases have to be redone for each different architecture. In this talk we introduce a novel auto-tuning compiler named INSIEME which consists of a compiler component featuring a multi-objective optimizer and a runtime system. The multi-objective optimizer derives a set of non-dominated solutions, each of them expressing a trade-off among different conflicting objectives such as runtime, resource efficiency and energy consumption. This set is commonly known as Pareto set. Our search algorithm, which explores code transformations and their parameter settings, is based on differential evolution. Additionally, rough sets are employed to reduce the search space, and thus the number of evaluations required during compilation. We further examine global versus region-based tuning techniques and demonstrate our approach by tuning shared memory parallel programs for execution time, energy consumption and resource usage.

Optimization with the Distributed Execution Framework

Thomas Feilhauer⋆ (Fachhochschule Vorarlberg)
Steffen Finck (Fachhochschule Vorarlberg)

A central task of the Distributed Execution Framework (DEF) [1] is to supply efficient library routines across applications for simulation and optimization. The routines can then be included by the users in their applications and can be executed in parallel on the DEF. A key issue that is important for the acceptance of the DEF among users and routine developers is the independence of the programming language and the computer platform. Developers can implement their routines in any programming language, and the DEF users can also write their client applications in any programming language independent of the library routines used therein. The routines are called from the client application via an API developed for the DEF and the DEF, which is connected to the client application via a web service interface, takes care of the processing of the library routine calls.

The other important feature of the DEF is support for parallel processing of DEF applications. The DEF permits to create clusters with any number of worker nodes. For this purpose, the DEF relies on cloud technologies that enables the clusters to be operated both On- and Off-Premise. Finally, at runtime, the DEF distributes the invocation of library routines from the client application to the worker instances provided by the cluster.

The DEF's capabilities are exemplified on an expensive optimization problem. The aim is to perform a simulation-based optimization on a model of a bank's balance sheet to determine the worst case scenario [2]. The problem contains various bound constraints, a non-linear constraint, and is high-dimensional. Two approaches are used for the optimization, a simple random search approach and a Evolution Strategy. Next to the results obtained by these approaches, the respective run times and the scalability of the DEF are investigated.

[1] T. Feilhauer and M. Sobotka, *DEF-a programming language agnostic framework and execution environment for the parallel execution of library routines*, Journal of Cloud Computing, 5(1) (2016)

[2] S. Finck, *Worst Case Search over a Set of Forecasting Scenarios Applied to Financial Stress-Testing*, GECCO 19 Companion, ACM, (2019)

M3b.1

MON
17:15
|
17:45
U406

Analyzing Autonomous Demand Side Algorithms with Parallel Computation Frameworks

Klaus Rheinberger⋆ (Research Center Energy and Josef Ressel Centre for Applied Scientific Computing, FH Vorarlberg)
Ramona Rosskopf (Research Center Energy and Josef Ressel Centre for Applied Scientific Computing, FH Vorarlberg)
Markus Preißinger (Research Center Energy, FH Vorarlberg)
Peter Kepplinger (Research Center Energy and Josef Ressel Centre for Applied Scientific Computing, FH Vorarlberg)

In contrast to fossil energy sources, the supply by renewable energy sources like wind and photovoltaics can not be controlled. Therefore, flexibilities on the demand side of the electric power grid, like electro-chemical energy storage systems, are used increasingly to match electric supply and demand at all times. To control those flexibilities, we consider two algorithms that both lead to linear programming problems. These are solved autonomously on the demand side, i.e., by household computers.

In the classic approach, an energy price signal is sent by the electric utility to the households, which, in turn, optimize the cost of consumption within their constraints. Instead of an energy price signal, we claim that an appropriate power signal that is tracked in L1-norm as close as possible by the household has favorable characteristics. We argue that an interior point of the household's feasibility region is never an optimal price-based point but can result in a L1-norm optimal point. Thus, price signals can not parametrize the complete feasibility region which may not lead to an optimal allocation of consumption.

We compare the price and power tracking algorithms over a year on the base of one-day optimizations regarding different information settings and using a large data set of daily household load profiles. The computational task constitutes an embarrassingly parallel problem. To this end, the performance of the two parallel computation frameworks DEF [1] and Ray [2] are investigated. The Ray framework is used to run the Python applications locally on several cores. With the DEF framework we execute our Python routines parallelly in a cloud. All in all, the results provide an understanding of when which computation framework and autonomous algorithm will outperform the other.

[1] T. Feilhauer, M. Sobotka, *DEF-a programming language agnostic framework and execution environment for the parallel execution of library routines*, Journal of Cloud Computing (2016) 5: 20. https://doi.org/10.1186/s13677-016-0070-z
[2] P, Moritz, R. Nishihara et al., *Ray: A Distributed Framework for Emerging AI Applications*, arXiv:1712.05889v2 [cs.DC] (2017). https://arxiv.org/abs/1712.05889

Minisymposium M4

Spectral Theory

Gerald Teschl (Universität Wien)
Jussi Behrndt (Technische Universität Graz)

M4a.1
THU
10:00
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10:30
W206

On the integrability of the Benjamin-Ono equation with periodic boundary conditions

Thomas Kappeler (University of Zurich)

In this talk I report on joint work with Patrick Gérard (Université Paris-Sud) concerning the construction of global Birkhoff coordinates for the Benjamin-Ono equation. In these coordinates this equation can be solved by quadrature, meaning that it is an integrable (pseudo)differential equation in the strongest possible sense. The construction is based on the Lax pair formulation of this equation. I will present spectral properties of the Lax operator, discuss a generating function of the Benjamin-Ono hierarchy, which allows to establish various trace formulas, and introduce the Birkhoff coordinates. Furthermore, I will provide a characterization of finite gap solutions.

M4a.2
THU
10:30
|
11:00
W206

Discrete Dirac systems: spectral and scattering theories and Verblunsky-type coefficients

Alexander Sakhnovich (University of Vienna)

We consider discrete Dirac systems, give explicit expressions of rational Weyl functions and reflection coefficients, solve explicitly inverse problems and study stability of the procedure. We introduce also new Verblunsky-type coefficients and obtain Verblunsky-type results for Dirac systems and corresponding block Toeplitz matrices. The results were published in

[1] B. Fritzsche, B. Kirstein, I. Roitberg, A.L. Sakhnovich, *Discrete Dirac systems on the semiaxis: rational reflection coefficients and Weyl functions*, J. Difference Equ. Appl. 25 (2019) 294–304.

[2] I. Roitberg, A.L. Sakhnovich, *The discrete self-adjoint Dirac systems of general type: explicit solutions of direct and inverse problems, asymptotics of Verblunsky-type coefficients and the stability of solving of the inverse problem*, Zh. Mat. Fiz. Anal. Geom. 14 (2018) 532–548.

[3] A.L. Sakhnovich, *New "Verblunsky-type" coefficients of block Toeplitz and Hankel matrices and of corresponding Dirac and canonical systems*, J. Approx. Theory 237 (2019) 186–209.

On the absolutely continuous spectrum of generalized indefinite strings

Aleksey Kostenko (University of Ljubljana and University of Vienna)

M4a.3 THU 11:00 – 11:30 W206

Our main result is the stability of the absolutely continuous spectrum of two model examples of (Krein) strings under rather wide classes of perturbations. In particular, this enables us to prove that the absolutely continuous spectrum of the isospectral problem associated with the conservative Camassa–Holm flow in the dispersive regime is essentially supported on the interval $[1/4,\infty)$ for the entire natural phase space. If time permits, applications to quantum graphs and 1D Hamiltonians with δ'-interactions will be discussed as well.

The talk is based on joint work with J. Eckhardt (Loughborough, UK).

Strichartz estimates for the one-dimensional wave equation

Roland Donninger* (Universität Wien)
Irfan Glogić (Universität Wien)

M4a.4 THU 11:30 – 12:00 W206

We consider the hyperboloidal initial value problem for the one-dimensional wave equation, perturbed by a smooth potential. We show that the evolution decomposes into a finite-dimensional part that is controlled by spectral theory and an infinite-dimensional part that satisfies Strichartz estimates, provided a certain spectral assumption holds. As an application we consider the long-time asymptotics of Yang-Mills fields on a wormhole spacetime.

Threshold Singularities of the Spectral Shift Function for Geometric Perturbations of a Magnetic Hamiltonian

Georgi Raikov (Pontificia Universidad Católica de Chile)

M4b.1 THU 15:30 – 16:00 W206

I will consider the 3D Schrödinger operator H_0 with constant magnetic field, and its perturbations H_+ (resp., H_-) obtained from H_0 by imposing Dirichlet (resp., Neumann) conditions on an appropriate surface. I will introduce the Krein spectral shift function for the operator pairs (H_+,H_0) and (H_-,H_0), and will discuss its singularities at the Landau levels which play the role of thresholds in the spectrum of the unperturbed operator H_0.

The talk is based on a joint work with Vincent Bruneau (Bordeaux).

The financial support of the Chilean science fund Fondecyt under grant 1170816 is gratefully acknowledged.

M4b.2
THU
16:00
|
16:30
W206

Rarefaction and shock waves for the Toda equation

Johanna Michor⋆ (Universitat Wien)
Iryna Egorova (ILT Kharkiv)
Gerald Teschl (Universität Wien)

We give a survey of the long-time asymptotic of solutions of the Toda lattice equation with steplike constant initial data using the nonlinear steepest descent analysis for oscillatory Riemann–Hilbert factorization problems and its extension based on a suitably chosen g-function. Analytic formulas for the leading term of the asymptotic solutions of the Toda shock and rarefaction problems are given and complemented by numerical simulations. We provide an explicit formula for the modulated solution in terms of Abelian integrals on the underlying hyperelliptic Riemann surface and thus verify a conjecture from Venakides, Deift, and Oba from 1991. The corresponding results are published in [1, 2, 3].

[1] J. Michor, *Wave phenomena of the Toda lattice with steplike initial data*, Phys. Lett. A 380 (2016) 1110–1116.
[2] I. Egorova, J. Michor, and G. Teschl, *Rarefaction waves for the Toda equation via nonlinear steepest descent*, Discrete Contin. Dyn. Syst. 38(4) (2018) 2007–2028.
[3] I. Egorova, J. Michor, and G. Teschl, *Long-time asymptotics for the Toda shock problem: non-overlapping spectra*, Zh. Mat. Fiz. Anal. Geom. 14(4) (2018) 406–451.

M4b.3
THU
16:30
|
17:00
W206

Riemann–Hilbert problems in asymptotic analysis

Mateusz Piorkowski⋆ (University of Vienna)
Iryna Egorova (B. Verkin ILTPE, Kharkiv)
Gerald Teschl (University of Vienna)

Our research revolves around the applications of the Riemann–Hilbert (R-H) formalism to problems from asymptotic analysis. In particular, we have been analysing the long time behaviour of solutions to the KdV equation with step like initial data. We observed a previously unknown singular behaviour of the R-H solutions, which poses a new challenge to the usual approach. Our solution is based on a more careful analysis of the connection between R-H problems and singular integral equations. Similar ideas can be used in the long time asymptotics of orthogonal polynomials on a finite interval.

[1] P. Deift and X. Zhou, *A steepest descent method for oscillatory Riemann–Hilbert problems*, Ann. of Math. (2) **137**, 295–368 (1993).
[2] I. Egorova, Z. Gladka, V. Kotlyarov and G. Teschl, *Long-time asymptotics for the Korteweg–de Vries equation with step-like initial data*, Nonlinearity 26 (2013), no. 7, 1839-1864.

Product formulas and convolutions for solutions of Sturm-Liouville equations

Rúben Sousa⋆ (CMUP, Faculty of Sciences, University of Porto)
Manuel Guerra (CEMAPRE and ISEG, University of Lisbon)
Semyon Yakubovich (CMUP, Faculty of Sciences, University of Porto)

M4c.1
THU
17:30
|
18:00
W206

The Fourier transform, which lies at the heart of the classical theory of harmonic analysis, is generated by the eigenfunction expansion of the Sturm-Liouville operator $-\frac{d^2}{dx^2}$. This naturally raises a question: *is it possible to generalize the main facts of harmonic analysis to integral transforms of Sturm-Liouville type?*

In this talk we introduce a novel unified framework for the construction of product formulas and convolutions associated with a general class of regular and singular Sturm-Liouville boundary value problems. This unified approach is based on the application of the Sturm-Liouville spectral theory to the study of the associated hyperbolic equation. As a by-product, an existence and uniqueness theorem for degenerate hyperbolic Cauchy problems with initial data at a parabolic line is established.

We will show that each Sturm-Liouville convolution gives rise to a Banach algebra structure in the space of finite Borel measures in which various probabilistic concepts and properties can be developed in analogy with the classical theory. Examples will be given, showing that many known convolution-type operators — such as the Hankel, Jacobi and Whittaker convolutions — can be constructed using this general approach.

M4c.2
THU
18:00
|
18:30
W206

Optimal Blowup Stability for the Energy Critical Wave Equation

Ziping Rao⋆ (Universität Wien)
Roland Donninger (Universität Wien)

We study the stability of ODE blowup solutions of wave equations with power nonlinearity in the lightcone. Perturbing around the ODE blowup solution, we obtain a nonlinear wave equation with a time-dependent self-similar potential. In order to handle this potential, we introduce similarity coordinates, under which we rewrite the equation into an autonomous evolution equation. We first recall some stability results in higher regularity by Donninger and Schörkhuber. They use the Lumer–Phillips theorem to obtain a solution semigroup to the Cauchy problem. Then by the Gearhart–Prüss theorem they obtain enough decay of the semigroup to control the nonlinearity.

For the energy critical equation in the energy space, the semigroup does not have enough decay to control the nonlinearity. For this we need the help of Strichartz estimates. By constructing an explicit expression of the semigroup, we establish these estimates, and moreover improve the energy bound from the Gearhart–Prüss theorem. Following the pioneering work of the three dimensional case by Donninger in [1], we are able to obtain energy critical blowup stability in five dimensions in [2].

[1] R. Donninger, *Strichartz estimates in similarity coordinates and stable blowup for the critical wave equation*, Duke Math. J., Volume 166, Number 9 (2017), 1627-1683.

[2] R. Donninger, Z. Rao *Blowup stability at optimal regularity for the critical wave equation*, arXiv:1811.08130, 2018.

Minisymposium M5

Inverse Problems for Partial Differential Equations

William Rundell (Texas A&M University)
Barbara Kaltenbacher (Universität Klagenfurt)

M5a.1
WED
11:00
|
11:30
W211/12

NETT: Solving Inverse Problems with Deep Neural Networks

Markus Haltmeier⋆ (Department of Mathematics, University Innsbruck)
Johannes Schwab (Department of Mathematics, University Innsbruck)
Stephan Antholzer (Department of Mathematics, University Innsbruck)
Housen Li (Institut für Mathematische Stochastik, Universität Göttingen)

Recently, deep learning and neural network based algorithms appeared as new paradigm for solving inverse problems. In this talk we propose and analyze variational methods for inverse problems using a neural network as regularizer. We present a convergence analysis, derive convergence rates, and propose a possible training strategy. Numerical results are presented where the network approach demonstrates good performance even for unknowns very different from the training data.

This talk is based on [1].

[1] H. Li, J. Schwab, S. Antholzer, and M. Haltmeier, M., 2018. *NETT: Solving inverse problems with deep neural networks.* arXiv:1803.00092.

M5a.2
WED
11:30
|
12:00
W211/12

Sparse synthesis regularization using deep neural networks

Daniel Obmann⋆ (University of Innsbruck)
Markus Haltmeier (University of Innsbruck)
Johannes Schwab (University of Innsbruck)

We present a sparse synthesis regularization method for solving inverse problems. To achieve sparsity we use an encoder-decoder network which was trained with an added ℓ^1 regularization term. We demonstrate that images similar to the training data can be recovered from their thresholded synthesis coefficients using the trained decoder.

To solve inverse problems using this method we propose minimizing an ℓ^1-Tikhonov functional which is a sum of a data-fitting term and a weighted ℓ^1 regularization term which regularizes the synthesis coefficients.

M5a.3
WED
12:00
|
12:30
W211/12

Singular Value Decomposition for Atmospheric Tomography

Ronny Ramlau⋆ (Kepler University Linz and RICAM)
Simon Hubmer (RICAM)
Andreas Neubauer (Kepler University Linz)

In atmospheric tomography, light originating from guide stars travels through the atmosphere. Its recorded wavefronts are used to reconstruct the turbulence in the atmosphere. The information on the turbulence is then used to obtain sharp images from astronomical telescopes. Taking into account the layered structure of the turbulent atmosphere, the properties of the guide stars as well as the geometric structure of the telescope, we present singular value decompositions of the underlying tomography operators for different telescope settings.

Determining nonlinear terms in a reaction-diffusion system

William Rundell⋆ (Texas A&M University)
Barbara Kaltenbacher (Universität Klagenfurt)

Reaction-diffusion equations are one of the most common partial differential equations used to model physical phenomenon. They arise as the combination of two physical processes: a driving force $f(u)$ that depends on the state variable u and a diffusive mechanism that spreads this effect over a spatial domain. The canonical form is $u_t - \triangle u = f(u)$. Application areas include chemical processes, heat flow models and population dynamics. As part of the model building, assumptions are made about the form of $f(u)$ and these inevitably contain various physical constants. The direct or forwards problem for such equations is now very well-developed and understood, especially when the diffusive mechanism is governed by Brownian motion resulting in an equation of parabolic type.

However, our interest lies in the inverse problem of recovering the reaction term $f(u)$ not just at the level of determining a few parameters in a known functional form, but recovering the complete functional form itself. To achieve this we set up the usual paradigm for the parabolic equation where u is subject to both given initial and boundary data, then prescribe overposed data consisting of the solution at a later time T. We will transform the inverse problem into an equivalent nonlinear mapping from which we seek a fixed point. We will be able to prove important features of this map such as a self-mapping property and give conditions under which it is contractive.

Finally, we will indicate modifications required to incorporate more complex diffusion processes than that offered by classical Brownian motion.

M5b.2
THU
10:30
|
11:00
W211/12

Identification and Design of EM-Chiral Scattering Obstacles

Frank Hettlich (Karlsruhe Institute of Technology (KIT))

In scattering theory the far field operator includes to some extent geometrical and physical properties of the scattering object. Thus, inverse problems like recovering the shape of an obstacle from a far field pattern are of particular interest. As a first step a linearization of the far field pattern with respect to the shape of a penetrable obstacle in case of electromagnetic waves is discussed. Characterizing the corresponding domain derivative gives access to the linearization of the far field operator. Solving corresponding boundary integral equations with a sophisticated application of the boundary element platform Bempp illustrates the feasibility of regularized Newton type schemes in solving such highly ill-posed problems.

Furthermore, a geometry depending property of a scatterer is its chirality. The notion of electromagnetic chirality, recently introduced in the Physics literature, uses the correspondence of scatterer and far field pattern to define a quantifiable measure of chirality. We show that this measure can be given by the Hilbert-Schmidt norms of certain projections of the far field operator. An investigation of this splitting of the operator together with the above linearization with respect to geometry leads to the possibility in identifying and designing optimal chiral scattering obstacles, which are of special importance in chemistry and in physics. A first attempt to the challenging optimization problem in case of a fixed wave number is introduced and discussed.

M5b.3
THU
11:00
|
11:30
W211/12

Uniqueness and reconstruction in a passive inverse problem of helioseismology

Alexey Agaltsov (Max-Planck-Institut für Sonnensystemforschung, Göttingen)

We consider the inverse problem of recovering the radially symmetric sound speed, density and attenuation in the Sun from the measurements of the solar acoustic field at two heights above the photosphere and for a finite number of frequencies above the acoustic cutoff frequency. We show that this problem reduces to recovering a long range potential (with a Coulomb-type decay at infinity) in a Schrödinger equation from the measurements of the imaginary part of the radiation Green's function at two distances from zero. We demonstrate that generically this inverse problem for the Schrödinger equation admits a unique solution, and that the original inverse problem for the Sun admits a unique solution when measurements are performed at at least two different frequencies above the cutoff frequency. These uniqueness results are confirmed by numerical simulations.

This talk is based on a joint work in progress with T. Hohage and R. G. Novikov.

Parameter identification for the Landau-Lifshitz-Gilbert equation in Magnetic Particle Imaging

Anne Wald⋆ (Saarland University, Saarbrücken)
Tram Thi Ngoc Nguyen (Alpen-Adria-Universität Klagenfurt)
Barbara Kaltenbacher (Alpen-Adria-Universität Klagenfurt)
Thomas Schuster (Saarland University, Saarbrücken)

M5b.4
THU
11:30
|
12:00
W211/12

Magnetic particle imaging (MPI) is a relatively new tracer-based imaging technique suited for medical imaging of, e.g., blood vessels [1]. Magnetic nanoparticles are injected into the blood stream and serve as a tracer. In order to locate the particles, a time-varying external magnetic field with a field-free point (FFP) is applied to the object. More precisely, the FFP is moved through the object, causing a nonlinear response from the particles that are situated at the current position of the FFP. This response is measured as an induced voltage in the scanner's receive coils. The goal is to reconstruct the particle concentration from these measurements. Mathematically, the forward problem is formulated as an integral equation of the first kind, where the integration kernel is called the system function.

Prior to the actual imaging process, the scanner has to be calibrated, i.e., the system function has to be determined. This is currently done by a time-consuming pixel-wise scan of a known delta sample. Our goal now is a model-based approach for the calibration that incorporates the relaxation behaviour of the nanoparticles. The Landau-Lifshitz-Gilbert equation is used as a physical model to describe the magnetization of the particles [2], which then yields the system function. We thus consider a parameter identification problem for the Landau-Lifshitz-Gilbert equation, were the measured currents for known samples are used as data [3]. The problem is formulated and analyzed both in an all-at-once as well as in a reduced setting, see also [4, 5].

[1] T. Knopp, T. Buzug *Magnetic Particle Imaging: an Introduction to Imaging Principles and Scanner Instrumentation*, Springer Berlin Heidelberg, 2012.

[2] M. Kruzik, A. Prohl *Recent Developments in the Modeling, Analysis, and Numerics of Ferromagnetism*, SIAM Review, 48(3) (2006) 439–483.

[3] B. Kaltenbacher, T. T. N. Nguyen, T. Schuster, A. Wald *Parameter identification for the Landau-Lifshitz-Gilbert equation in Magnetic Particle Imaging*, in preparation.

[4] B. Kaltenbacher, *All-at-once versus reduced iterative methods for time dependent inverse problems*, Inverse Problems, 33(6) (2017) 064002.

[5] T. T. N. Nguyen, *Landweber–Kaczmarz for parameter identification in time-dependent inverse problems: all-at-once versus reduced version*, Inverse Problems, 35(3) (2019) 035009.

M5b.5
THU
12:00
|
12:30
W211/12

On convergence of Total Variation regularized inverse problems

Gwenael Mercier (Universität Wien)

We extend some recent results on the Hausdorff convergence of level-sets for total variation regularized linear inverse problems, as the noise and the regularization parameter simultaneously vanish. Such a mode of convergence, although seldom used, is of particular interest in the context of recovery of piecewise constant coefficients as well as in the processing of images composed mainly of objects separated by clear boundaries. In these situations, Hausdorff convergence of level-sets can be seen as uniform convergence of the geometrical objects appearing in the data. We will consider dimensions higher than two and measurements in Banach spaces and investigate the relation between the dimension and the assumed integrability of the solution that makes such a result hold. We also give some counterexamples of practical application scenarios where the natural choice of fidelity term makes such a convergence fail. Finally, we will shortly discuss the source condition assumption under which our result holds. This is a collaboration with J.A. Iglesias (RICAM, Linz).

Generalized tolerance regularization

Iwona Piotrowska-Kurczewski⋆ (Universität Bremen)
Georgia Sfakianaki (Universität Bremen)
Peter Maaß (Universität Bremen)

M5c.1
THU
15:30
|
16:00
W211/12

The Tikhonov regularization of inverse problems is based on minimizing functionals $\Phi(x) = \mathrm{dist}(F(x), y^\delta) + \alpha R(x)$, which balance a discrepancy term $\mathrm{dist}(F(x), y^\delta)$. It is obtained by measuring the mismatch between the data side and a regularization or penalty term $R(x)$, which encodes a-priori knowledge about the solution. Taking L_2 norm of both terms leads to the classical Tikhonov regularization case which is very well studied. A special case with sparsity constraints (L_1 norm) is also well established by now, see [1].

Motivated by applications in engineering we adjust the discrepancy and penalty terms by including a tolerance measure, so called ε distance function, which neglects deviations from the data within a prescribed ε tolerance. This way we take advantage of the experts knowledge about y and or x. In particular, for linear operators the transiton $\varepsilon \to 0$ and $p, q \to 1$ is equivalent to the transition from Tikhonov regularization to concept of support vector regression (SVR). This approach is of importance for applications where multiple measurements of the same object are available. It provides a confidence area for the true data. The parameter identification of (partial) differential equation is another application field for this technique. Additionally a smoothing property can be obtained for Tikhonov regularization containing the tolerances to the L_p-discrepancy term contains tolerances.

We present the analytical properties of $x^\delta_{\alpha,\varepsilon}$ for the Tikhonov regularization with tolerances in either the discrepancy $\mathrm{dist}_\varepsilon(F(x), y^\delta)$ or the penalty term $R_\varepsilon(x)$. We prove that in the limit point $\varepsilon = 0$ the classical Tikhonov minimizer is obtained. Numerical examples show a potential of this approach.

[1] M. Grasmair, M. Haltmeier, and O. Scherzer, *Sparse regularization with l_q penalty term*. Inverse Problems, 24:055020 (13pp), 2008

M5c.2
THU
16:00
|
16:30
W211/12

Dynamical super-resolution with applications to Ultrafast ultrasound imaging

Francisco Romero Hinrichsen⋆ (University of Graz)
Habib Ammari (ETH Zürich)
Giovanni Alberti (University of Genoa)
Timothée Wintz (ENS Paris)

There was a successful development in ultrasound imaging [1], that increased significantly its sampling rate and enhanced this imaging's capacities. In particular, for vessel imaging, the use of microbubble tracking allows us to super-resolve blood vessels, and by estimating the particles' speeds inside them, it is possible to calculate the vessels' diameters [2]. In this context, following the theory of super-resolution [3], we model the microbubble tracking problem, formulating it in terms of a sparse spike recovery problem in the phase space (the position and velocity space), that allows us to obtain simultaneously the speed of the microbubbles and their location. This leads to an L1 minimization algorithm for point source tracking, that promises to be faster than current alternatives.

[1] M. Tanter and M. Fink, *Ultrafast imaging in biomedical ultrasound*, IEEE transactions on ultrasonics, ferroelectrics, and frequency control, 2014.
[2] C. Errico et Al., *Ultrafast ultrasound localization microscopy for deep super-resolution vascular imaging*, Nature, 2015.
[3] E. Candès and C. Fernandez-Granda, *Towards a Mathematical theory of Super-resolution*, Communications on Pure and Applied Mathematics, 2014.

M5c.3
THU
16:30
|
17:00
W211/12

Regularizing sequential subspace optimization for the identification of the stored energy of a hyperelastic structure

Rebecca Klein⋆ (Saarland University)
Anne Wald (Saarland University)
Thomas Schuster (Saarland University)

We consider the nonlinear dynamic inverse problem of identifying the stored energy function of hyperelastic materials from surface sensor measurements. In connection with the detection of damages in structures consisting of such materials this task is highly interesting since all mechanical properties are hidden in the stored energy function. This problem has already been solved using the attenuated Landweber method. Since this process is extremely time-consuming, we use sequential subspace optimiziation as a regularization technique.

Solving the inverse problem of linear elasticity with monotonicity methods

Sarah Eberle⋆ (Goethe-University Frankfurt, Germany)
Bastian Harrach (Goethe-University Frankfurt, Germany)
Houcine Meftahi (ENIT of Tunisia, Tunisia)
Taher Rezgui (ENIT of Tunisia, Tunisia)

M5d.1
THU
17:30
|
18:00
W211/12

The main motivation of this problem is the non-destructive testing of elastic structures for material inclusions. We consider the inverse problem of recovering an isotropic elastic tensor from the Neumann-to-Dirichlet map. We show that the shape of a region where the elastic tensor differs from a known background elastic tensor can be detected by a simple monotonicity relation. In addition, we prove a Lipschitz stability. Our approach relies on the monotonicity of the Neumann-to-Dirichlet operator with respect to the elastic tensor and the techniques of localized potentials.

[1] S. Eberle, B. Harrach, H. Meftahi, and T. Rezgui. Lipschitz stability estimate and reconstruction of Lamé parameters in linear elasticity. *arXiv*:1906.02194v1, 2019.

Minisymposium M6

Enumerative and Algebraic Combinatorics

Michael Drmota (Technische Universität Wien)
Christian Krattenthaler (Universität Wien)

M6a.1
MON
15:15
|
16:00
U407

The Steep-Bounce Zeta Map in Parabolic Cataland

Wenjie Fang⋆ (Université Paris Est - Marne-la-Vallée)
Cesar Ceballos (Universität Wien)
Henri Mühle (Technische Universität Dresden)

As a classical object, the Tamari lattice has many generalizations, including ν-Tamari lattices and parabolic Tamari lattices. In this article, we unify these generalizations in a bijective fashion. We first prove that parabolic Tamari lattices are isomorphic to ν-Tamari lattices for bounce paths ν. We then introduce a new combinatorial object called “left-aligned colorable tree”, and show that it provides a bijective bridge between various parabolic Catalan objects and certain nested pairs of Dyck paths. As a consequence, we prove the Steep-Bounce Conjecture using a generalization of the famous zeta map in q,t-Catalan combinatorics. A generalization of the zeta map on parking functions, which arises in the theory of diagonal harmonics, is also obtained as a labeled version of our bijection.

[1] N. Bergeron, C. Ceballos, and V. Pilaud, *Hopf Dreams*, arXiv:1807.03044, 2018.
[2] C. Ceballos, W. Fang, and H. Mühle, *The Steep-Bounce Zeta Map in Parabolic Cataland*, arXiv:1903.08515, 2019.
[3] J. Haglund and N. A. Loehr, *A conjectured combinatorial formula for the Hilbert series fordiagonal harmonics*, Discrete Mathematics 298(2005), no. 1-3, 189–204.
[4] H. Mühle and N. Williams, *Tamari lattices for parabolic quotients of the symmetric group*, arXiv:1804.02761, 2018.

M6a.2
MON
16:00
|
16:45
U407

Some results on characters of symmetric groups

Alexander R. Miller (Universität Wien)

I will present some recent results and conjectures concerning vanishing and divisibility for character values of symmetric groups. The talk will focus on a portion of underlying combinatorics.

A weight-dependent inversion statistic and Catalan numbers

Shishuo Fu (Chongqing University)
Michael J. Schlosser⋆ (Universität Wien)

We introduce a weight-dependent extension of the inversion statistic, a classical Mahonian statistic on permutations. This immediately gives us a new weight-dependent extension of $n!$. When we restrict to 312-avoiding permutations, our extension gives rise to a weight-dependent family of Catalan numbers, which happen to coincide with the weighted Catalan numbers that were previously introduced by Postnikov and Sagan by weighted enumeration of Dyck paths [4]. While Postnikov and Sagan's main focus was on the modulo 2 divisibility of the weighted Catalan numbers, we worked out further properties of these numbers that extend those of the classical case, such as their recurrence relation, their continued fraction, and Hankel determinants. We also discovered an intriguing closed form evaluation of the weighted Catalan numbers for a specific choice of weights. We further present bi-weighted Catalan numbers that generalize Garsia and Haiman's q,t-Catalan numbers [2], and again satisfy remarkable properties. These are obtained by refining the weighted Catalan numbers by introducing an additional statistic, namely a weight-dependent extension of Haglund's bounce statistic [1, 3].

[1] A. Garsia and J.. Haglund, *A proof of the q,t-Catalan positivity conjecture*, Discrete Math. 256(3) (2002) 677–717.

[2] A. Garsia and M. Haiman, *A remarkable q,t-Catalan sequence and q-Lagrange inversion*, J. Alg. Combin. 5(3) (1996) 191–244.

[3] J. Haglund, *Conjectured statistics for the q,t-Catalan numbers*, Adv. Math. 175(2) (2003) 319–334.

[4] A. Postnikov and B.E. Sagan, *What power of two divides a weighted Catalan number?*, J. Combin. Theory Ser. A 114(5) (2007) 970–977.

M6c.1
TUE
10:00
|
10:45
U407

Making Many More Matrix Multiplication Methods

Manuel Kauers (Institute for Algebra, Johannes Kepler University)

Strassen's algorithm for matrix multiplication is based on the observation that the product of two 2×2 matrices can be computed with only 7 multiplications. It is known that there is no way to do it with fewer multiplications, and that Strassen's method is essentially the only way to do it with 7 multiplications. For 3×3-matrices, the situation is less clear. More than 40 years ago, Laderman gave a method that uses 23 multiplications, and still nobody knows whether there is a way to do it with fewer multiplications. Laderman's method is not unique. Several authors have later presented isolated additional methods that work for arbitrary coefficient rings, and there is even a family of methods with three free parameters but restricted to coefficient rings containing $\mathbb{Q}$. Using SAT solvers and Gröbner bases technology, we have found more than 10000 pairwise inequivalent new matrix multiplication methods with 23 multiplications. We were able to cluster them together into families with up to 16 parameters which apply without any restriction on the coefficient domain. In conclusion, the set of methods with 23 multiplications appears to be much larger than it seemed to be until now, and it is quite possible that the methods we found are still just the tip of the iceberg. Although our results have no immediate implications on the complexity of matrix multiplication, we do hope that the vast amount of new methods will eventually contribute to a better understanding of why these methods exist at all, and whether 23 is best possible for 3×3.

This is joint work with Marijn Heule and Martina Seidl.

M6c.2
TUE
10:45
|
11:30
U407

Local convergence of random planar graphs

Benedikt Stufler (Universität Zürich)

The present talk describes the asymptotic local shape of a graph drawn uniformly at random from all connected simple planar graphs with n labelled vertices. We establish a novel uniform infinite planar graph (UIPG) as quenched limit in the local topology as n tends to infinity. We also establish such limits for random 2-connected planar graphs and maps as their number of edges tends to infinity. Our approach encompasses a new probabilistic view on the Tutte decomposition. This allows us to follow the path along the decomposition of connectivity from planar maps to planar graphs in a uniformed way, basing each step on condensation phenomena for random walks under subexponentiality and Gibbs partitions. Using large deviation results for random walk, we recover the asymptotic formula by Giménez and Noy [1] for the number of planar graphs.

[1] Omer Giménez and Marc Noy. *Asymptotic enumeration and limit laws of planar graphs.* J. Amer. Math. Soc. 22 (2), 309–329 (2009)

Exact and asymptotic enumeration of ascent sequences and Fishburn matrices

Emma Yu Jin⋆ (Universität Wien)
Hsien-Kuei Hwang (Academia Sinica, Taiwan)
Michael Schlosser (Universität Wien)

M6c.3
TUE
11:30
|
12:15
U407

Ascent sequences were introduced by Bousquet-Mélou, Claesson, Dukes, Kitaev (2010) to unify three seemingly unrelated combinatorial structures: Fishburn matrices, (2 + 2)-free posets, a family of permutations avoiding a certain pattern, Stoimenow's involutions, (2-1)-avoiding inversion sequences and non-2-neighbor-nesting matchings.

We present a novel way to recursively decompose ascent sequences, which leads to a calculation of the Euler-Stirling distribution on ascent sequences, including the numbers of ascents (asc), repeated entries (rep), zeros (zero) and maximal entries (max). Together with the machinery of basic hypergeometric series, we are able to prove a bi-symmetry conjecture, which asserts that the quadruples (asc, rep, zero, max) and (rep, asc, max, zero) are equidistributed on ascent sequences.

Furthermore, a direct saddle-point analysis (without relying on any modular forms) is applied to establish the asymptotics of Fishburn numbers and a large number of others with a similar sum-of-finite-product form for their (formal) general functions. In addition to solving a conjecture by Jelínek, the application of our saddle-point approach to the distributional aspects is also examined, with many new limit theorems characterized, representing the first of their kind for such structures.

[1] G. Andrews and V. Jelínek, *On q-series identities related to interval orders*, Eur. J. Comb., **39** (2014), 178–187.

[2] M. Bousquet-Mélou, A. Claesson, M. Dukes and S. Kitaev, $(\mathbf{2}+\mathbf{2})$*-free posets, ascent sequences and pattern avoiding permutations*, J. Combin. Theory Ser. A, **117** (2010), 884–909.

[3] K. Bringmann, Y.K. Li and R.C. Rhoades, *Asymptotics for the number of row-Fishburn matrices*, Eur. J. Combin, **41** (2014), 183-196.

[4] P.C. Fishburn, *Interval orders and interval graphs: a study of partially ordered sets*, John Wiley & Sons, 1985.

[5] V. Jelínek, *Counting general and self-dual interval orders*, J. Combin. Theory Ser. A, **119** (2012), 599–614.

[6] D. Zagier, *Vassiliev invariants and a strange identity related to the Dedekind eta-function, Topology*, **40** (2001), 945–960.

Section S01

Logic, Set Theory, and Theoretical Computer Science

Vera Fischer (Universität Wien)
Martin Goldstern (Technische Universität Wien)

S01a.1
MON
15:15
|
15:45
U405

Distributivity of forcing notions

Marlene Koelbing⋆ (Kurt Gödel Research Center, Universität Wien)
Vera Fischer (Kurt Gödel Research Center, Universität Wien)
Wolfgang Wohofsky (Kurt Gödel Research Center, Universität Wien)

In my talk, I would like to discuss several aspects of the distributivity of forcing notions, concerning the combinatorial nature and purely forcing-theoretic properties.

S01a.2
MON
15:45
|
16:15
U405

Strong measure zero sets on 2^κ

Johannes Philipp Schürz (TU Wien)

The notion of **strong measure zero** for subsets of the reals $\mathbb{R}$ is due to Emil Borel. Call $X \subseteq \mathbb{R}$ **smz** iff

$$\forall (\varepsilon_n)_{n\in\mathbb{N}} \in \mathbb{R}_+^{\mathbb{N}}\, \exists (I_n)_{n\in\mathbb{N}}\, I_n \ldots \text{intervall}\colon \forall n \in \mathbb{N}\, \lambda(I_n) \leq \varepsilon_n \wedge X \subseteq \bigcup_{n\in\mathbb{N}} I_n.$$

As $\mathbb{R}$ can naturally be identified with $2^{\mathbb{N}}$, there is a canonical generalization for 2^κ, where κ is a large cardinal, e.g. inaccessible. We call a set $X \subseteq 2^\kappa$ **smz** iff

$$\forall f \in \kappa^\kappa\, \exists (\eta_i)_{i<\kappa}\colon \forall i < \kappa\, \eta_i \in 2^i \wedge X \subseteq \bigcup_{i<\kappa} [\eta_i],$$

where $[\eta] := \{x \in 2^\kappa\colon \eta \lhd x\}$.

I will present basic results about **smz** sets of $\mathbb{R}$ as well as of 2^κ, and I want to conclude with a Theorem showing the consistency of

$$\text{ZFC} + |2^\kappa| = \kappa^{++} \wedge (X \subseteq 2^\kappa \text{ is } \textbf{smz} \Leftrightarrow |X| \leq \kappa^+),$$

relative to the consistency of ZFC $+\ \kappa$ is inaccessible.

The tower spectrum

Jonathan Schilhan (KGRC, University of Vienna)

S01a.3 MON 16:15 – 16:45 U405

Let A, B be infinite sets of natural numbers. Then we say that A is *almost contained* in B, written as $A \subseteq^* B$, iff $A \setminus B$ is finite, i.e. all up to finitely many elements of A are also in B. A *tower* is a sequence $\langle A_\alpha : \alpha < \delta \rangle$ of infinite sets of naturals such that $A_\beta \subseteq^* A_\alpha$ for $\alpha < \beta$ and that is maximal with respect to this property.

Applying Zorn's lemma we see that towers always exist. But for what regular δ is there a tower of length δ? The *tower spectrum* is the set of such δ. We study what properties a set $\mathscr{C}$ of regular cardinals in a model of GCH has to satisfy to be realized as the tower spectrum in a forcing extension.

This is joint work with Vera Fischer. The authors would like to thank the Austrian Science Fund, FWF, for generous support through START-Project Y1012-N35.

Formen des Auswahlaxioms in der Ringtheorie

Lorenz Halbeisen (Department of Mathematics, ETH Zürich)

S01b.1 MON 17:15 – 18:15 U405

Zuerst wird gezeigt, dass das Auswahlaxiom äquivalent ist zur Aussage *Jeder Ring besitzt eine Wurzelfunktion*. Danach wird untersucht, welche Form des Auswahlaxioms äquivalent ist zur Aussage *Jeder Integritätsbereich hat eine Wurzelfunktion* bzw. zur Aussage *Jeder Integritätsbereich hat eine n-te Wurzelfunktion*. Im letzten Teil wird dann ein Permutationsmodell konstruiert, in dem gewisse dieser Formen des Auswahlaxioms gelten, andere aber nicht.

Diamonds, games and cardinal invariants

Víctor Torres-Pérez (TU Wien)

S01b.2 MON 18:15 – 18:45 U405

On one hand, we prove that WRP and saturation of the ideal NS_{ω_1} together imply $\Diamond\{a \in [\lambda]^{\omega_1} : \mathrm{cof}(\sup(a)) = \omega_1\}$, for all regular $\lambda \geq \aleph_2$.

On the other hand, in a joint work with J. Brendle and M. Hrusak, we consider a weak parametrized versions of the diamond principle which game versions of cardinal invariants $\mathfrak{t}$, $\mathfrak{u}$ and $\mathfrak{a}$. We show that the standard proof that parametrized diamond principles prove that the cardinal invariants are small actually show that their game counterparts are small. We show that $\mathfrak{t} < \mathfrak{t}_{game}$ and $\mathfrak{u} < \mathfrak{u}_{game}$ are both relatively consistent with the ZFC. The corresponding question for $\mathfrak{a}$ remains open.

S01c.1

TUE

10:00

|

11:00

U405

Automating Resolution is NP-Hard

Moritz Müller⋆ (Universitat Politècnica de Catalunya, Barcelona)
Albert Atserias (Universitat Politècnica de Catalunya, Barcelona)

We show that the problem of finding a Resolution refutation that is at most polynomially longer than a shortest one is NP-hard. In the parlance of proof complexity, Resolution is not automatizable unless P = NP. Indeed, we show it is NP-hard to distinguish between formulas that have Resolution refutations of polynomial length and those that do not have subexponential length refutations. This also implies that Resolution is not automatizable in subexponential time or quasi-polynomial time unless NP is included in SUBEXP or QP, respectively.

S01c.2

TUE

11:00

|

11:30

U405

The relation between two weak choice principles

Salome Schumacher (ETH Zürich)

After a brief introduction to permutation models, we will discuss the relationship between the following two weak choice principles:

ACF^{-}:= For every infinite family $\mathscr{F}$ of finite sets there is an infinite subfamily $\mathscr{G} \subseteq \mathscr{F}$ with a choice function.

KWF^{-}:= For every infinite family $\mathscr{F}$ of finite sets of size at least two there is an infinite subfamily $\mathscr{G} \subseteq \mathscr{F}$ with a Kinna-Wagner selection function. I.e. there is a function $g : \mathscr{G} \to \mathscr{P}\left(\bigcup \mathscr{G}\right)$ with $\emptyset \neq g(G) \subsetneq G$ for all $G \in \mathscr{G}$.

In particular it is shown that KWF^{-} does not imply ACF^{-}.

Independence and almost disjointness

Vera Fischer (University of Vienna)

The cardinal characteristics of the real line arise from various combinatorial properties of the reals. Their study has already a long history and is closely related to the development of major forcing techniques among which template iterations (see [9]), matrix iterations (see [2], [4]) and creature forcing (see [8]). An excellent introduction to the subject can be found in [1].

Two of classical combinatorial cardinal characteristics of the continuum are the *almost disjointness* and *independence numbers*. An infinite family $\mathscr{A}$ of infinite subsets of $\mathbb{N}$ whose elements have pairwise finite intersections and which is maximal under inclusion, is called a *maximal almost disjoint family*. The minimal size of such a family is denoted $\mathfrak{a}$ and is referred to as the *almost disjointness number*. A family $\mathscr{A}$ of infinite subsets of $\mathbb{N}$ with the property that for any two finite disjoint subfamilies $\mathscr{F}$ and $\mathscr{G}$, the set $\bigcap\mathscr{F}\setminus\bigcup\mathscr{G}$ is infinite is said to be *independent*. The minimal size of a maximal independent family is denoted $\mathfrak{i}$ and is referred to as the *independence number*. The characteristics $\mathfrak{a}$ and $\mathfrak{i}$ are among those for which there are no other known upper bounds apart from $\mathfrak{c}$, the cardinality of the continuum. It is well known that consistently $\mathfrak{a} < \mathfrak{i}$, however both the consistency of $\mathfrak{i} < \mathfrak{a}$ and the inequality $\mathfrak{a} \leq \mathfrak{i}$ remain open.

In this talk, we will outline some of the major properties of independence and almost disjointness, describe recent results (see for example [7, 5, 3, 6, 7]) and point out further interesting open problems.

[1] A. Blass, *Combinatorial Cardinal Characteristics of the Continuum*, Handbook of set theory, Springer, Dordrecht, (2010) 395–489.

[2] A. Blass, S. Shelah, *Ultrafilters with Small Generating Sets, Israel Journal of Mathematics, (1989) 395–465.*

[3] J. Brendle, V. Fischer, Y. Khomskii, Definable Independent Families*, Proceedings of the American Mathematical Society, to appear.*

[4] V. Fischer, S. Friedman, D. Mejía, D. Montoya, Coherent Systems of Finite Support Iterations*, Journal of Symbolic Logic, 83(1) (2018) 208–236.*

[5] V. Fischer, D. Mejía, Splitting, Bounding and Almost Disjointness Can be Quite Different*, Canadian Journal of Mathematics, 69(3) (2017) 502–531.*

[6] V. Fischer, D. Montoya, Ideals of Independence*, Archive for Mathematical Logic, to appear.*

[7] V. Fischer, S. Shelah, *The Spectrum of Independence*, Archive for Mathematical Logic, to appear.

[8] S. Shelah, *On Cardinal Cnvariants of the Continuum*, Contemp. Math., 31 (1984), 183–207.

[9] S. Shelah, *Two Cardinal Invariants of the Continuum ($\mathfrak{d} < \mathfrak{a}$) and FS Linearly Ordered Iterated Forcing*, Acta Math., 192(2) (2004), 187–223.

S01c.4
TUE
12:00
|
12:30
U405

Cardinal characteristics and the Borel Conjecture

Wolfgang Wohofsky⋆ (Kurt Gödel Research Center, Universität Wien)
Otmar Spinas (Universität Kiel)

In my talk, I would like to present some tentative considerations in connection with a survey article on the Borel Conjecture I recently wrote. I will provide some models in which the Borel Conjecture holds, and also models in which the Borel Conjecture fails, thereby discussing necessary (but not sufficient) conditions for the Borel Conjecture. I will argue that – given a model for some set-theoretical statement which is obtained by a countable support iteration of forcings adding dominating reals and satisfying the Laver property – it often seems to be easy to modify the construction in such a way that the resulting model additionally satisfies the Borel Conjecture, but it is not so clear how to make the Borel Conjecture fail in such a situation. As an example, I will mention the model from my joint work with Otmar Spinas in which $\mathfrak{h} = \mathrm{cov}(\mathscr{M}) < \mathfrak{b} = \mathfrak{s} = \mathrm{add}(s_0)$ holds (and which is obtained by such an iteration); in this case it is indeed easy to additionally obtain the Borel Conjecture but quite unclear how to make it fail.

[1] W. Wohofsky, *Borel Conjecture, dual Borel Conjecture, and other variants of the Borel Conjecture*, in preparation.
[2] O. Spinas, W. Wohofsky, *A Sacks amoeba preserving distributivity of $\mathscr{P}(\omega)/fin$*, 2019, submitted.

Section S02

Algebra, Discrete Mathematics

Clemens Heuberger (Universität Klagenfurt)
Clemens Fuchs (Universität Salzburg)

S02a.1
TUE
15:30
|
16:00
U407

Label-quantities in trees and mappings

Alois Panholzer (Technische Universität Wien)

We consider labelled trees and n-mappings, i.e., functions from the finite set $[n] := \{1,2,\ldots,n\}$ into itself, and study several problems related to the distribution of the labels along the paths in the tree or in the iteration orbit $(i, f(i), f^2(i), \ldots)$ of elements in a mapping, respectively.

In particular, we take a look at the occurrence and avoidance of certain permutation-patterns in trees and mappings as well as treat problems related to random sequential adsorption on trees. An analytic combinatorics treatment naturally yields a study of certain linear and quasi-linear PDEs.

S02a.2
TUE
16:00
|
16:30
U407

Optimal Multi-Pivot Quicksort and its Asymptotic Analysis

Daniel Krenn* (Alpen-Adria-Universität Klagenfurt$^\Psi$)
Clemens Heuberger (Alpen-Adria-Universität Klagenfurt)
Cecilia Holmgren (Uppsala Universitet)

This talk will be about the asymptotic analysis of the number of comparisons needed for sorting a list with multi-pivot quicksort. By the nature of the multi-pivot quicksort, there are many partitioning strategies possible (in contrast to the classical quicksort, where there is essentially one), and we will learn about the optimal strategy. We will focus on the strategy itself, the idea why this is the optimal strategy, and the asymptotic analysis of the number of key comparisons of the corresponding quicksort algorithm (as cost measure for the running time). In the spirit of analytic combinatorics, the algorithm is "‘translated” to discrete structures and generating functions. The analysis is computer assisted; the main ideas, tools and methods will be explained.

$^\Psi$Note on affiliation (by Sept. 2019): Uppsala Universitet (near past), Universität Salzburg (near future).

S02a.3
TUE
16:30
|
17:00
U407

Galois groups of differential equations

Michael Wibmer* (TU Graz)
Annette Bachmayr (Universität Bonn)
David Harbater (University of Pennsylvania)
Julia Hartmann (University of Pennsylvania)

The Galois theory of differential equations generalizes the classical Galois theory of polynomials. While the Galois group of a polynomial is a finite group acting on the roots, the Galois group of a homogeneous linear differential equation is a linear algebraic group that acts linearly on the vector space of solutions.

The absolute Galois group of the rational function field $\mathbb{C}(x)$ is known to be a free profinite group. In this talk I will explain progress towards understanding the absolute differential Galois group of $\mathbb{C}(x)$.

Some observations on Archipelago-Groups

Andreas Zastrow (University of Gdańsk)

The two prototype-examples of topological spaces, that in modern language are called “not homotopically Hausdorff" are Griffiths’ Space from the fifties, and the Harmonic Archipelago as constructed by Bogley and Sieradski in 1998. Both spaces have their reputation as well-known counter-examples. The fundamental group of the latter space has been investigated, been shown to be the universal countable locally free group [2], and given rise to the definition of Archipelago Groups [1]. At the beginning of this year K. Eda initiated a discussion, whether the results of [1] could be correct. In this talk I want to present the conclusions to which I came, having meditated about the assertions in the paper and of K. Eda.

Roughly speaking my conclusions were, that I could agree the K. Eda’s assertion that with the methods of the paper only much weaker universality properties of Archipelago Groups could be proven as asserted there. Contrary to what is asserted in the paper it is nor clear that the isomorphism type of an Archipelago group is already determined by vague cardinality data (no. of elements and of elements of order two) of the generating group, but the coincidence of these data only suffices to construct a surjective homomorphism between two Archipelago groups, also if generated by non-isomorphic groups with matching data.

In addition, when that way meditating about the paper, I also came to the conclusion that Thm. 5 of the paper, which asserts that Archipelago Groups are the fundamental groups of topological spaces that are constructed as a certain mapping cone, can only be correct, if one requires additional conditions that according to [1] are not required for those spaces that are used in the construction of the corresponding mapping cone. If time suffices I will outline a corresponding complexity-argument that shows that otherwise Thm.5 cannot be correct.

[1] G.R. Conner, W. Hojka & M. Meilstrup: *Archipelago groups*, Proc. Amer. Math. Soc. 143 (2015), no. 11, 4973–4988.

[2] Hojka, Wolfram: “The harmonic archipelago as a universal locally free group", J. Algebra 437 (2015), 44–51.

Section S03

Number Theory

Timothy Browning (IST Austria)

S03a.1

TUE
15:30
|
16:30
U405

Counting points of given degree and bounded height via the height zeta function

Kevin Destagnol (IST Austria)

Let $X = \mathrm{Sym}^d \mathbf{P}^n := \mathbf{P}^n \times \cdots \times \mathbf{P}^n / \mathfrak{S}_d$ where the symmetric d-group acts by permuting the d copies of $\mathbf{P}^n$. Manin's conjecture gives a precise prediction for the number of rational points on X of bounded height in terms of geometric invariants of a resolution of X and the study of Manin's conjecture for X can be derived from the geometry of numbers in the cases $n > d$ and for $n = d = 2$. In this talk, I will explain how one can use the fact that $\mathbf{P}^n$ is an equivariant compactification of an algebraic group and the height zeta function machinery in order to study the rational points of bounded height on X in new cases that are not covered by the geometry of numbers techniques. This might in particular be an interesting testing ground for the latest refinements of Manin's conjecture.

S03a.2

TUE
16:30
|
17:00
U405

On Serre's Problem for Conics

Nick Rome⋆ (IST Austria/University of Bristol)
Efthymios Sofos (Glasgow University)

We demonstrate an asymptotic formula for the number of ternary diagonal quadratic forms with coefficients of bounded size that have a rational point, thus improving upon a lower bound due to Hooley [2] and Guo [1], and an upper bound due to Serre [3]. We will discuss the connection between this result and the Loughran–Smeets conjecture on the number of everywhere locally soluble varieties in a family.

[1] C. R. Guo, *On solvability of ternary quadratic forms.* Proc. London Math. Soc., **70** , (1995), 241–263.
[2] C. Hooley, *On ternary quadratic forms that represent zero.* Glasgow Math. J., **35** , (1993), 13–23.
[3] J. P. Serre, *Spécialisation des éléments de* $Br_2(\mathbb{Q}(T_1, \cdots, T_n))$. C. R. Acad. Sci. Paris Sér. I Math., **311** , (1990), 397–402.

S03b.1

TUE
17:30
|
18:30
U405

Arithmetic progressions in binary quadratic forms and norm forms

Christopher Frei⋆ (University of Manchester)
Christian Elsholtz (TU Graz)

We discuss upper bounds for the length of arithmetic progressions represented by irreducible integral binary quadratic forms (or, more generally, arbitrary norm forms), which depend only on the form and the progression's common difference.

S03b.2
TUE
18:30
|
19:00
U405

Solving equations in many variables in primes

Shuntaro Yamagishi (University of Utrecht, Department of Mathematics)

Let $F \in \mathbb{Z}[x_1, \ldots, x_n]$ be a degree d homogeneous form. In 2014, Cook and Magyar proved the existence of prime solutions to the equation $F(x_1, \ldots, x_n) = 0$ under certain assumptions on F. In particular, their result requires the number of variables n to be an exponential tower in d. I will talk about a result related to this work of Cook and Magyar improving on the number of variables required.

Section S04

Algebraic Geometry, Convex and Discrete Geometry

Tim Netzer (Universität Innsbruck)

S04.1
TUE
18:00
|
18:30
U407

Anchor rings of finite type Gauss map in the Euclidean 3-space

Hassan Al-Zoubi (Al-Zaytoonah University of Jordan)

In 1983 B.-Y. Chen introduced the notion of Euclidean immersions of finite type [1]. A surface S is said to be of finite type corresponding to the first fundamental form I, or briefly of finite I-type, if the position vector x of S can be written as a finite sum of nonconstant eigenvectors of the Laplacian Δ^I, that is,

$$x = c + \sum_{i=1}^{k} x_i, \quad \Delta^I x_i = \lambda_i x_i, \quad i = 1, \ldots, k, \tag{1}$$

where c is a fixed vector and $\lambda_1, \lambda_2, \ldots, \lambda_k$ are eigenvalues of the operator Δ^I. In particular, if all eigenvalues $\lambda_1, \lambda_2, \ldots, \lambda_k$ are mutually distinct, then S is said to be of finite I-type k. When $\lambda_i = 0$ for some $i = 1, \ldots, k$, then S is said to be of finite null I-type k. Otherwise, S is said to be of infinite type.

Very little is known about surfaces of finite type in the Euclidean 3-space $\mathbb{E}^3$. Actually, so far, the only known surfaces of finite I-type in $\mathbb{E}^3$ are the minimal surfaces, the circular cylinders, and the spheres. So in [2] B.-Y. Chen mentions the following problem

Problem 1 *classify all surfaces of finite Chen I-type in* $\mathbb{E}^3$.

Many researchers start to solve this problem by investigating important classes of surfaces by proving that finite type ruled surfaces, finite type quadrics, finite type cyclides of Dupin and finite type spiral surfaces are surfaces of the only known examples in $\mathbb{E}^3$. However, for another classical families of surfaces, such as surfaces of revolution, finite type tubes, translation surfaces as well as helicoidal surfaces, the classification of its finite type surfaces is not known yet.In the present paper, we mainly focus on problem 1 by studying a subclass of tubes in $\mathbb{E}^3$, namely anchor rings.

[1] B-Y. Chen, *Total mean curvature and submanifolds of finite type*, Second edition, World Scientific Publisher, 2015.

[2] B-Y. Chen, *Some open problems and conjectures on submanifolds of finite type*, Soochow. J. Math., **17** (1991) 161–188.

Section S05

Computational Geometry and Topology

Herbert Edelsbrunner (IST Austria)
Michael Kerber (Technische Universität Graz)

S05a.1

TUE
10:00
|
10:30
U406

Deep Homological Learning

Roland Kwitt (Department of Computer Science, University of Salzburg)

Over the last couple of years, persistent homology, i.e., the prevalent tool in the growing field of topological data analysis (TDA), has found many applications in a wide variety of scientific areas, ranging from biology, chemistry or medicine to the analysis of social networks and images.

However, the adoption of concepts from TDA in the machine learning community is remarkably slow. This is surprising from multiple aspects: *First*, persistent homology, for instance, offers valuable topological information with potentially high discriminative power in supervised learning settings. *Second*, studying the topology of intermediate representations learned by today's neural networks, could offer novel insights into learning progress, "what is actually learned" and provide a better understanding of how representation spaces change as input data is sequentially transformed through multiple non-linear functions implemented by neural network components. *Third*, enforcing certain topological constraints during learning could help machine learning models to generalize better, or avoid highly irregular decision boundaries.

In the presentation, I will provide an overview of general strategies and prior work on (1) *passively* leveraging topological features obtained from persistent homology (mostly related to [1, 3]) for supervised learning and (2) present recent advances and challenges in *actively* controlling topological characteristics of data in the broader context of (unsupervised) learning with neural networks (mostly related to [3, 4]).

[1] C. Hofer, R. Kwitt, M. Niethammer, W. Lin and A. Uhl. *Deep Learning with Topological Signatures*, In *NIPS*, 2017.

[2] C. Hofer, R. Kwitt, M. Dixit and M. Niethammer. *Connectivity Optimized Representation Learning via Persistent Homology*, In *ICML*, 2019.

[3] C. Hofer, R. Kwitt and M. Niethammer. *Learning Representations of Persistence Barcodes*. J. Mach. Learn. Res., 2019 (in publication).

[4] C. Hofer, R. Kwitt and M. Niethammer. *Graph Filtration Learning*. `arXiv:1905.10996 [cs.LG]` (under peer-review), 2019.

S05a.2

TUE
10:30
|
11:00
U406

Topological explorations in neuroscience

Daniela Egas Santander (École polytechnique fédérale de Lausanne)

I will present some of the applications of topology and topological data analysis to neuroscience through an exploration of the collaboration between the applied topology group at EPFL and the Blue Brain Project. In particular, I will describe how we are using topology to further understand learning or simulations of voltage sensitive dye experiments.

Spaces of clusterings

Alexander Rolle⋆ (Technische Universität Graz)
Luis Scoccola (The University of Western Ontario)

S05a.3
TUE
11:00
|
11:30
U406

Cluster analysis is the task of finding clusters of points in a dataset; points belonging to the same cluster should be similar to one another in some sense, and points belonging to distinct clusters should be less so. In order to accomodate many applications, we use a very general definition: a clustering of a set is just a set of disjoint subsets.

Sometimes a clustering algorithm, rather than producing a single clustering of a dataset, produces a set of clusterings. For example, one gets a set of clusterings by running a clustering algorithm with a range of parameters. We present methods to give geometric structure to these sets of clusterings, which can be useful for parameter selection during cluster analysis.

Stochastic applications of discrete topology

Anton Nikitenko (IST Austria)

S05a.4
TUE
11:30
|
12:00
U406

Stochastic geometry studies geometric properties of random objects. Discrete topology provides a toolkit for implying topological properties of discrete point sets. A reference concept, which unites the two areas, is a subcomplex of the classic Poisson–Delaunay mosaic, the *Poisson–Delaunay complex*, which encodes the topology of the union of balls of fixed radius around a Poisson point process. The talk is intended to sketch the topological approach in stochastic geometry, and survey some of the recent developments, in particular deriving the sizes and the distribution of radii of the simplices in the Poisson–Delaunay mosaic using discrete Morse theory.

Detecting lengths of geodesics with higher-dimensional persistence

Žiga Virk (University of Ljubljana)

S05a.5
TUE
12:00
|
12:30
U406

Persistent homology is a variant of homology applied to a filtration of a space, the later often being obtained through the combinatorial construction of Rips or Čech complexes at different scales. The usual intuition behind this construction is that it measures sizes of holes in the space.

In this talk we will focus on geodesic spaces and describe how the combinatorial properties of the mentioned complexes allow us to extract relevant geometric information about the underlying space from higher-dimensional persistence. In particular, we can detect certain closed geodesics using higher-dimensional persistent homology even if geodesics themselves are contractible. We will discuss conditions on local properties of geodesics, which imply this kind of detections.

S05b.1

TUE
15:30
|
16:00
U406

Topological Structures of Probabilistic Landscape of Stochastic Reaction Networks

Wei Tian (University of Illinois at Chicago, Chicago, IL 60607, USA)
Hubert Wagner (Institute of Science and Technology, Austria, Klosterneuburg 3400, Austria)
Anna Terebus (University of Illinois at Chicago, Chicago, IL 60607, USA)
Farid Manuchehrfar (University of Illinois at Chicago, Chicago, IL 60607, USA)
Herbert Edelsbrunner (Institute of Science and Technology, Austria, Klosterneuburg 3400, Austria)
Jie Liang⋆ (University of Illinois at Chicago, Chicago, IL 60607, USA)

Stochasticity plays important roles in fundamental biology such as cellular fate determination. Stochasticity arise when small copy number of molecules participate in chemical reactions. The discrete Chemical Master Equation (dCME) provides a general framework for investigating stochasticity in reaction systems at mesoscopic scale. With recent advances in exact method (such as ACME) for computing time-evolving and steady state probability landscape by solving the dCMEs [1, 2], a full topological treatise [3, 4] of the probability landscapes of stochastic networks is now feasible. Such analysis has the promise in yielding new insight into the behavior of these stochastic networks. We discuss recent results in topological analysis of probabilistic landscape using model systems of Schlögl network, feed-forward loops, and toggle-switch systems, including computation of persistent homology [5], detection of topological changes, and topological sensitivity analysis. We also highlight key challenges in computing persistent homology of high-dimension probability landscape.

[1] Y. Cao, A. Terebus, and J. Liang. Accurate chemical master equation solution using multi-finite buffers. *SIAM Multiscale Modeling & Simulation*, 14(3):923–963, 2016.

[2] Y. Cao, A. Terebus, and J. Liang. State space truncation with quantified effects for accurate solution of discrete chemical master equation. *Bulletin Math Biology*, 78:617–661, 2016.

[3] H. Edelsbrunner, D. Letscher, and A. Zomorodian. Topological persistence and simplification. *Discrete and Computational Geometry*, 28:511–533, 2002.

[4] H. Edelsbrunner and J. Harer. *Computational Topology - An Introduction.* American Mathematical Society, 2010

[5] H. Wagner. `https://bitbucket.org/hubwag/cubicle/`.

On fractal geometric and topologic properties of triangular labyrinth fractals

Ligia L. Cristea⋆ (Karl Franzens Universität Graz)
Paul Surer (Universität für Bodenkultur, Wien)

Labyrinth fractals were introduced by Cristea and Steinsky [1] as special families of (self-similar) Sierpiński carpets. Based on that concept, we introduce triangular labyrinth fractals as the limit of an iterative process: we start with an equilateral triangle of side length one, divide it into $m \times m$ equilateral triangles of side-length $1/m$, and then colour some of them in black (indicating the sets that will be cut out throughout the iterative construction) and the rest in white, according to a given triangular pattern. Then we repeat the process with the remaining white triangles. The construction rule is determined by a triangular labyrinth patterns system that consists of a pattern (the white pattern) for the "upright" triangles , and one (the yellow pattern) for the "upside down" triangles. We study the topology and fractal geometry of triangular labyrinth fractals, with special focus on the arcs (length, dimension, tangents) in the dentrites, and construct, based on the choice of the generating patterns, and the properties induced on their arcs, three families of triangular labyrinth fractals. Some of these properties are proven by using GIFS as a tool.

[1] L. L. Cristea and B. Steinsky, *Curves of infinite length in* 4×4*-labyrinth fractals*, Geom. Dedicata, 141:1–17, 2009.

[2] L. L. Cristea and P. Surer, *Triangular labyrinth fractals*, accepted for publication in Fractals, 2019

S05b.3
TUE
16:30
|
17:00
U406

Necessary and sufficient conditions for the local unique nearest point property of a real sub-manifold

Gunther Leobacher⋆ (Universität Graz)
Alexander Steinicke (Montanuniversität Leoben)

We investigate the maximal open domain $\mathscr{E}(M)$ on which the orthogonal projection map p onto a subset $M \subseteq \mathbb{R}^d$ can be defined.

While [Dudek and Holly(1994)] showed that a sufficient condition for the inclusion $M \subseteq \mathscr{E}(M)$ is that M is a C^1 submanifold whose tangent spaces satisfy a local Lipschitz condition, we prove that this condition is also necessary. More precisely, if M is a topological submanifold with $M \subseteq \mathscr{E}(M)$, then M must be C^1 and its tangent spaces satisfy the same local Lipschitz condition.

The result is of general interest since cleary the above condition is also necessary for a topological submanifold to have *positive reach*, a by now well-known concept introduced in [Federer(1959)].

[Dudek and Holly(1994)] E. Dudek and K. Holly. Nonlinear orthogonal projection. *Annales Polonici Mathematici*, 59(1):1–31, 1994.

[Federer(1959)] Herbert Federer. Curvature measures. *Trans. Amer. Math. Soc.*, 93:418–491, 1959.

[Leobacher and Steinicke(2019)] R. L. Foote. Existence, Uniqueness and Regularity of the Projection onto Differentiable Manifolds. *Preprint, submitted*, 2019.

S05c.1
TUE
17:30
|
18:00
U406

Convergence and Stability of Random Mapper

Adam Brown (IST Austria)

In this talk I will discuss a probabilistic theory of convergence between a random mapper graph and the Reeb graph. I will outline the construction of an enhanced mapper graph associated to points randomly sampled from a probability density function concentrated on a constructible R-space. I will then explain how interleaving distances for constructible cosheaves and topological estimations via kernel density estimates can be used to show that the enhanced mapper graph approximates the Reeb graph in a precise way. The content of the talk is joint work with Omer Bobrowski, Elizabeth Munch, and Bei Wang.

Dualities and clearing for image persistence

Ulrich Bauer⋆ (Technical University of Munich (TUM))
Maximilian Schmahl (Technical University of Munich (TUM))

S05c.2
TUE
18:00
|
18:30
U406

Given a filtration of a simplicial complex by simplicial pairs, the inclusions of the pairs induce morphisms in persistent homology and cohomology. We show how to efficiently compute the barcode of the image of this morphism, employing the duality of persistent homology and cohomology and generalizing the clearing optimization introduced by Chen and Kerber. In order to provide the requisite algebraic foundations for this generalization, we establish correspondence results between the image barcodes for persistent absolute and relative (co)homology. We provide an implementation for Vietoris–Rips filtrations in the framework of the software Ripser.

Section S06

Ordinary Differential Equations and Dynamical Systems

Peter Szmolyan (Technische Universität Wien)

S06.1
WED
11:00
|
11:30
W205

Periodic solutions and and switching behavior in a model of bipolar disorder

Peter Szmolyan⋆ (Technische Universität Wien)
Ilona Kosiuk (Technische Universität Wien)
Ekatarina Kutafina (University Hospital RWTH Aachen)

We analyze a 4-dimensional system of ODEs which models the cyclic behavior observed in bipolar disorder. The phenomenological model is based on mutual inhibition and cross activation of two states related to mania and depression. The model appears to be a standard slow-fast system with two slow and two fast components depending on a small parameter ε. However, it turns out that the slow-fast structure is more complicated and several rescalings must be used to capture the global dynamics. An interesting feature of the problem is that some of the rescaled versions of the system are non-smooth in the limit $\varepsilon \to 0$. This complication is caused by the occurrence of powers of ε in Michaelis-Menten and Hill terms which model the interactions in the system. We show that repeated blow-ups are a convenient tool to overcome these difficulties and to prove the existence of a complicated relaxation oscillation.

On a system of difference equations of second order solved in a closed from

Yacine Halim⋆ (Mila University Center, Algeria)
Julius Fergy T. Rabago (University of the Philippines,Philippines)

The term difference equation refers to a specific type of recurrence relation, a mathematical relationship expressing x_n as some combination of x_i with $i < n$. These equations usually appear as discrete mathematical models of many biological and environmental phenomena such as population growth and predator-prey interactions, and so these equations are studied because of their rich and complex dynamics. Recently, the problem of finding closed-form solutions of rational difference equations and systems of rational of difference equations have gained considerable interest from many mathematicians.

This paper deals with the solution, stability character and asymptotic behavior of the rational difference equation

$$x_{n+1} = \frac{\alpha x_{n-1} + \beta}{\gamma x_n x_{n-1}}, \qquad n \in \mathbb{N}_0,$$

where $\mathbb{N}_0 = \mathbb{N} \cup \{0\}$, $\alpha, \beta, \gamma \in \mathbb{R}^+$, and the initial conditions x_{-1} and x_0 are non zero real numbers such that their solutions are associated to generalized Padovan numbers. Also, we investigate the two-dimensional case of the this equation given by

$$x_{n+1} = \frac{\alpha x_{n-1} + \beta}{\gamma y_n x_{n-1}}, \qquad y_{n+1} = \frac{\alpha y_{n-1} + \beta}{\gamma x_n y_{n-1}}, \qquad n \in \mathbb{N}_0.$$

[1] Y. Halim and J. F. T. Rabago. On the solutions of a second-order difference equations in terms of generalized Padovan sequences. *Math. Slovaca.*, 68: 625–638, 2018.
[2] Y. Halim and M. Bayram. On the solutions of a higher-order difference equation in terms of generalized Fibonacci sequences. *Math. Methods Appl. Sci.*, 39: 2974-2982, 2016.
[3] N. Touafek. On some fractional systems of difference equations. *Iranian J Math. Sci. Info.*, 9: 303–305, 2014.
[4] Y. Yazlik, D. T. Tollu and N. Taskara. On the solutions of difference equation systems with Padovan numbers. *Appl. Math.*, 12: 15–20, 2013.

S06.3
WED
12:00
|
12:30
W205

Optimality conditions of Moreau sweeping process

Chems Eddine Arroud⋆ (Department of Mathematics, Laboratory LMEPA, University of Jijel, Algeria)
Giovanni Colombo (Department of Mathematics, University of Padova, Italy)

We Consider the problem of free endpoint Bolza problem for the controlled Moreau process ;
Minimize $h(x(T))$ subject to

$$\begin{cases} \dot{x}(t) \in -N_{C(t)}(x(t)) + f(x(t), u(t))), \\ x(0) = x_0 \in C(0) , \quad u(t) \in U \end{cases} \tag{1}$$

Where $C(t)$ is a closed non-convex moving set, with normal cone $N_{C(t)}(x)$ at $x \in C(t)$, U being the control set and f being smooth.
We prove necessary optimality conditions in the form of Pontryagin maximum principle. We combine techniques from [2] and from [1], a kind of inward/outward pointing condition is assumed on the reference optimal trajectory at the times where the boundary of $C(t)$ is touched.
The adjoint equation is not the classical one, a signed vector measure appears and also the maximality condition is different.

[1] M. Brokate and P. Krejčí, *Optimal control of ODE systems involving a rate independent variational inequality*, Discrete and continous dynamical systems serie B. Volume 18 (2013), 331-348.
[2] M. Sene, L. Thibault, *Regularization of dynamical systems associated with prox-regular moving sets*, Journal of Nonlinear and Convex Analysis 15 (2014), 647-663.
[3] Ch. Arroud and G. Colombo. A Maximum Principle for the controlled Sweeping Process. Set-Valued Var. Anal (2017), 1-23.

Section S07

Partial Differential Equations and Calculus of Variations

Roland Donninger (Universität Wien)

S07a.1
TUE
10:00
|
11:00
W205

Nonlinear asymptotic stability of homothetically shrinking Yang-Mills solitons

Birgit Schörkhuber⋆ (Karlsruhe Institute of Technology)
Roland Donninger (University of Vienna)
Irfan Glogić (University of Vienna)

We consider the heat flow for Yang-Mills connections on $\mathbb{R}^d \times SO(d)$ in dimensions $5 \leq d \leq 9$. It is well known that for this model homothetically shrinking solitons, i.e. self-similar blowup solutions, exist. In this talk, we discuss the stability of the explicitly known Weinkove solution under small $SO(d)-$equivariant perturbations. The case $d = 5$ was resolved in [1] together with R. Donninger. The generalization to higher space dimensions is a recent joint work with I. Glogić.

[1] R. Donninger, B. Schörkhuber *Stable blowup for the supercritical Yang-Mills heat flow*, arXiv:1604.07737, to appear in Journal of Differential Geometry.

S07a.2
TUE
11:00
|
11:30
W205

Two-locus clines maintained by diffusion and recombination in a heterogeneous environment

Reinhard Bürger⋆ (Universität Wien)
King-Yeung Lam (The Ohio State University, Columbus, OH, USA)
Linlin Su (Southern University of Science and Technology, Shenzhen, China)

We study existence and stability of stationary solutions of a system of semilinear parabolic partial differential equations that occurs in population genetics. It describes the evolution of gamete frequencies in a geographically structured population of migrating individuals in a bounded habitat. Fitness of individuals is determined additively by two recombining, diallelic genetic loci that are subject to spatially varying selection. Migration is modeled by diffusion. Of most interest are spatially nonconstant stationary solutions, so-called clines. In a two-locus cline all four gametes are present in the population, i.e., it is an internal stationary solution. We provide conditions for existence and linear stability of a two-locus cline if recombination is either sufficiently weak or sufficiently strong relative to selection and diffusion. For strong recombination, we also prove uniqueness and global asymptotic stability. For arbitrary recombination, we determine the stability properties of the monomorphic equilibria, which represent fixation of a single gamete. Under specific assumptions on the environment, important characteristics of the cline, such as its slope in the center and its asymptotics, can be determined explicitly.

[1] R. Bürger, *Two-locus clines on the real line with a step environment*, Theor. Popul. Biol. 117 (2017) 1-22
[2] L. Su, K-Y. Lam, R. Bürger, *Two-locus clines maintained by diffusion and recombination in a heterogeneous environment*, J. Differential Equations 266 (2019) 7909–7947

The negative L^2 gradient flow for p-elastic energies

Simon Blatt⋆ (Universität Salzburg)
Christopher Hopper (Universität Salzburg)
Nicole Vorderobermeier (Universität Salzburg)

S07a.3
TUE
11:30
|
12:00
W205

This talk will be about ongoing work on the negative L^2 gradient flow of p-elastic energies for curves. After a quick overview over known results for this equation we will discuss two methods to get short- and longtime existence for these evolution equations, a regularization method and de Giorgi's method of minimizing movements. We will shortly discuss the pros and cons of both method and present some future directions of this research.

Small data global regularity for half-wave maps in 4 dimensions

Anna Kiesenhofer⋆ (EPFL)
Joachim Krieger (EPFL)

S07a.4
TUE
12:00
|
12:30
W205

We consider the half-wave maps problem

$$\partial_t u = u \times (-\triangle)^{\frac{1}{2}} u. \tag{1}$$

where $u : \mathbb{R}^{n+1} \longrightarrow S^2$. It was shown in [1] that for $n \geq 5$ this problem is globally well-posed for smooth initial data which are small in the critical l^1 based Besov space. We extend this result to dimension $n = 4$.

We can rewrite the half-wave maps equation (1) as a wave maps equation with additional non-local source terms. To treat these additional nonlinear terms we use an iteration scheme in a suitable space involving the scaling compatible Strichartz norms.

This is a formal analogue of the result by Tataru for wave maps [2].

[1] J. Krieger and Y. Sire *Small data global regularity for half-wave maps* Anal. PDE 11 (2018), no. 3, 661Ã-682.
[2] Tataru, D. *Local and global results for wave maps. I.* Comm. Partial Differential Equations 23 (1998), no. 9-10, 1781–1793.

S07b.1

TUE
15:30
|
16:00
W205

Threshold for blowup for the supercritical cubic wave equation

Irfan Glogić⋆ (University of Vienna)
Birgit Schörkhuber (Karlsruhe Institute of Technology)
Maciej Maliborski (University of Vienna)

We report on a recent work with B. Schörkhuber and M. Maliborski on the supercritical focusing cubic wave equation. In [1] we found an explicit, non-trivial self-similar blowup solution u_T^*, which is defined on the whole space and exists in all supercritical dimensions $d \geq 5$. Furthermore, for $d = 7$, we analyzed its stability properties without any symmetry assumptions and proved the existence of a co-dimension one Lipschitz manifold consisting of initial data whose solutions blowup in finite time and converge asymptotically to u_T^*. Furthermore, based on numerical simulations we subsequently performed [2], we conjecture that the stable manifold of u_T^* is in fact a threshold between finite time blowup and dispersion. This finding is especially interesting due to its striking similarity to the critical phenomena in gravitational collapse where threshold solutions are typically self-similar.

[1] I. Glogić, B. Schörkhuber, *Co-dimension one stable blowup for the supercritical cubic wave equation*. preprint, arXiv:1810.07681, October 2018.
[2] I. Glogić, M. Maliborski, and B. Schörkhuber. *Threshold for blowup for the supercritical cubic wave equation*. preprint, arXiv:1905.13739, May 2019.

S07b.2

TUE
16:00
|
16:30
W205

On the analyticity of critical points of the Möbius energy

Simon Blatt (Universität Salzburg)
Nicole Vorderobermeier⋆ (Universität Salzburg)

How nice are critical knots of knot energies? We already know that critical points of the so-called Möbius energy with merely bounded energy are smooth. This leads to the question whether smooth critical points of the Möbius energy are also real analytic. In this talk, we give a short introduction to geometric knot theory with focus on the Möbius energy and present the techniques, inter alia, Cauchy's method of majorants, with which the open question on the analyticity of smooth critical points of the Möbius energy was solved. To the best of the authors' knowledge, this is the first analyticity result in the context of non-local differential equations.

Unique Continuation for the Zakharov Kuznetsov equation

S07b.3 TUE 16:30 | 17:00 W205

Lucrezia Cossetti⋆ (Karlsruhe Institute of Technology, Karlsruhe, Germany)
Luca Fanelli (Università di Roma “La Sapienza”, Rome, Italy)
Felipe Linares (Instituto Matemática Pura e Aplicada (IMPA), Rio de Janeiro RJ, Brazil)

In this talk we analyze uniqueness properties of solutions to the Zakharov-Kuznetsov (ZK) equation

$$\partial_t u + \partial_x^3 u + \partial_x \partial_y^2 u + u\partial_x u = 0, \qquad (x,y) \in \mathbb{R}^2, \quad t \in [0,1].$$

Mainly motivated by the very well known PDE’s counterpart of the Hardy uncertainty principle, we provide a two times unique continuation result. More precisely, we prove that given u_1, u_2 two solutions to ZK, as soon as the difference $u1 - u2$ decays (spatially) fast enough at two different instants of time, then $u1 \equiv u2$. As expected, it turns out that the decay rate needed to get uniqueness reflects the asymptotic behavior of the fundamental solution of the associated linear problem. Encouraged by this fact we also prove optimality of the result.

Some recent results concerning the $(3+1)$- dimensional ZK equation will be also presented.

The seminar is based on a recent paper [1] in collaboration with L. Fanelli and F. Linares.

[1] L. Cossetti, L. Fanelli and F. Linares, *Uniqueness results for Zakharov-Kuznetsov equation*, Comm. Partial Differential Equations, DOI:10.1080/03605302.2019.1581803

Interpolation theory and regularity for incompressible fluid models

S07c.1 TUE 17:30 | 18:00 W205

Luigi Forcella⋆ (École Polytechnique Fédérale de Lausanne)
Maria Colombo (École Polytechnique Fédérale de Lausanne)
Luigi De Rosa (École Polytechnique Fédérale de Lausanne)

Motivated by the precise structure of the operator defining the pressure in an incompressible fluid model – as the Euler or the Navier-Stokes equations – we will give some abstract elliptic regularity results for this kind of operator by means of the Real Interpolation Method.

Once established linear and multilinear versions of such theorems, we will show how these abstract results imply an improvement of regularity in space and in time of rough solutions to the incompressible models.

S07c.2
TUE
18:00
|
18:30
W205

Stable Blow Up For A Nonlinear Klein-Gordon Equation

David Sebastian Wallauch (Universität Wien)

Informally speaking, a stable blow up of a partial differential equation, is a solution that blow ups and has the property that if we perturb the initial data slightly, we obtain a solution that exhibits the same behaviour. It was shown in [1] that there exists a stable blow up profile for the the (3+1) dimensional radial wave equation with a subcritical power nonlinearity in the lightcone. In the talk we will establish that this also applies to the (3+1) dimensional radial Klein-Gordon equation, with subcritical power nonlinearity in the backwards lightcone, provided the mass coefficient is chosen small enough. While the methods used to do so will be largely inspired by the ones in [2] and [1] we also admit complex valued solutions. This leads to a rotational symmetry, which in turn influences the spectrum of the linearised equation.

[1] 1 Roland Donninger, Birgit Schörkhuber. Stable self-similar blow up for energy subcritical wave equations. Dyn. Partial Differ. Equ. 9 (2012) no. 1, 63-87.

[2] 2 Roland Donninger, Birgit Schörkhuber. On blowup in supercritical wave equations Comm. Math. Phys. 346 (2016), no. 3, 907-943

Fredholm property of regular hypoelliptic operators in multianisotropic Sobolev spaces

Ani Tumanyan (Russian-Armenian University)

We study conditions under which hypoelliptic operators acting in multianisotropic Sobolev spaces in $\mathbb{R}^n$ satisfy the Fredholm property. The analysis of the Fredholm property of hypoelliptic operators in Sobolev spaces in $\mathbb{R}^n$ has certain difficulties - Fredholm theorems for compact manifolds cannot always be used in this case and characteristic polynomial of hypoelliptic operator is not homogeneous as in elliptic case. In this talk we give necessary and sufficient conditions for the Fredholm property of certain classes of regular hypoelliptic operators with variable coefficients acting in multianisotropic weighted Sobolev spaces in $\mathbb{R}^n$. Necessary conditions for fulfillment of a priori estimates for differential operators acting in multianisotropic spaces are obtained. The Fredholm property of semielliptic operators, which are the special subclass of hypoelliptic operators, is studied in the works [1, 2, 3, 4]. This work extends the previously obtained results described in the papers [3, 4] for differential operators acting in multianisotropic spaces.

[1] G. A. Karapetyan, A. A. Darbinyan, *Index of semielliptical operator in* $\mathbb{R}^n$. Proceedings of the NAS Armenia: Mathematics, 42(5) (2007) 33–50.

[2] G. V. Demidenko, *Quasielliptic operators and Sobolev type equations.* Siberian Mathematical Journal, 50(5) (2009) 1060–1069.

[3] A. G. Tumanyan, *On the invariance of index of semielliptical operator on the scale of anisotropic spaces.* Journal of Contemporary Mathematical Analysis. 51(4) (2016) 167–178.

[4] A. A. Darbinyan, A. G. Tumanyan, *On a priori estimates and Fredholm property of differential operators in anisotropic spaces.* Journal of Contemporary Mathematical Analysis. 53(2) (2018) 61–70.

Section S08

Functional Analysis, Real and Complex Analysis

Eva Kopecká (Universität Innsbruck)
Bernhard Lamel (Universität Wien)

S08a.1
MON
15:15
|
15:45
W206

Infinitesimal symmetries of weakly pseudoconvex manifolds

Martin Kolář (Masaryk University)

We classify the Lie algebras of infinitesimal CR automorphisms of weakly pseudoconvex hypersurfaces of finite multitype in $\mathbb{C}^N$. In particular, we prove that such manifolds admit neither nonlinear rigid automorphisms, nor real or nilpotent rotations. As a consequence, this leads to a proof of a sharp 2-jet determination result for local automorphisms. Moreover, for hypersurfaces which are not balanced, CR automorphisms are uniquely determined by their 1-jets. The same classification is derived also for special models, given by sums of squares of polynomials. In particular, in the case of homogeneous polynomials the Lie algebra of infinitesimal CR automorphisms is always three graded. The results also provide a necessary step for solving the local equivalence problem on weakly pseudoconvex manifolds. This is joint work with Shin Young Kim (Grenoble).

S08a.2
MON
15:45
|
16:15
W206

The reflection map of sphere mappings

Michael Reiter (University of Vienna)

In this talk we present some recent results about D'Angelo's reflection map. We show how the reflection map can be used to describe biholomorphic invariants of sphere mappings, such as finite or holomorphic nondegeneracy, and to study infinitesimal deformations of sphere mappings. In general, for $M \subset \mathbb{C}^N$ and $M' \subset \mathbb{C}^{N'}$ real submanifolds, an infinitesimal deformation of a mapping $H : M \to M'$ is a holomorphic mapping, defined in a neighborhood of M, whose real part is tangent to M' along the image of M under H.

S08a.3
MON
16:15
|
16:45
W206

On Fourier multipliers

Gerhard Racher (Paris Lodron Universität Salzburg)

We show that any locally compact group G containing an open abelian subgroup admits a nonzero bounded linear map from its von Neumann algebra into $L^2(G)$ which intertwines the respective actions by its Fourier algebra. This is a consequence of the Main Theorem in

T.S. Liu and A.C.M. van Rooij "Translation invariant maps $L_\infty(G) \to L_p(G)$". Indag. math. 36 (1974), 306-316.

On Generic Properties of Nonexpansive Mappings

Christian Bargetz (Universität Innsbruck)

S08b.1
MON
17:15
|
17:45
W206

We present a few recent results on the generic behaviour of nonexpansive mappings. The investigated properties include the (local) Lipschitz constant and the convergence behaviour of sequences of successive approximations for certain set-valued mappings.

Connections to the metric geometry of the underlying metric space are also discussed.

The geometrization of the theory of full Colombeau algebras

Eduard Nigsch (Universität Wien)

S08b.2
MON
17:45
|
18:15
W206

The theory of Colombeau algebras is an attempt to rigorously define a product of Schwartz distributions via general regularization methods while retaining as much compatibility as possible with distribution theory.

Motivated by applications in low-regularity differential geometry coming from general relativity, in particular the calculation of the curvature of singular metrics, a geometric (i.e., diffeomorphism invariant) version of the theory has been developed over the last years.

I will give a broad overview of the steps involved in obtaining a diffeomorphism invariant theory of nonlinear generalized functions and how it is extended to the case of nonlinear generalized tensor fields. Moreover, I will outline in which way this structure accomodates virtually all previous variants of Colombeau algebras and how it can be used to calculate the curvature of conical metrics.

Highly irregular separated nets.

Michael Dymond (Universität Innsbruck)

S08c.1
TUE
10:00
|
10:30
W206

In 1998 Burago and Kleiner and (independently) McMullen gave examples of separated nets in Euclidean space which are non-bilipschitz equivalent to the integer lattice. We discuss weaker notions of equivalence of separated nets and demonstrate that such notions also give rise to distinct equivalence classes. Put differently, we find occurrences of particularly strong divergence of separated nets from the integer lattice. Our approach generalises that of Burago and Kleiner and McMullen which takes place largely in a continuous setting. Existence of irregular separated nets is verified via the existence of non-realisable density functions $\rho\colon [0,1]^d \to (0,\infty)$. In the presented work, we obtain stronger types of non-realisable densities. This talk is based on joint work with Vojtěch Kaluža.

S08c.2
TUE
10:30
|
11:00
W206

Classification of homogeneous strictly pseudoconvex hypersurfaces in $\mathbb{C}^3$

Ilya Kossovskiy (University of Vienna)

Locally homogeneous strictly pseudoconvex hypersurfaces in $\mathbb{C}^2$ were classified by E. Cartan in 1932. In this joint work with A.Loboda, we complete the classification of locally homogeneous strictly pseudoconvex hypersurfaces in $\mathbb{C}^3$.

S08c.3
TUE
11:00
|
11:30
W206

The ∂-complex on the Segal-Bargmann space

Friedrich Haslinger (Universität Wien)

We use the powerful classical methods of the $\overline{\partial}$-complex based on the theory of unbounded densely defined operators on Hilbert spaces to study certain densely defined unbounded operators on the Segal-Bargmann space. These are the annihilation and creation operators of quantum mechanics. In several complex variables we have the ∂-operator and its adjoint ∂^* acting on $(p,0)$-forms with coefficients in the Segal-Bargmann space. We consider the corresponding ∂-complex and study spectral properties of the corresponding complex Laplacian $\tilde{\Box} = \partial\partial^* + \partial^*\partial$. In addition, we study a more general complex Laplacian $\tilde{\Box}_D = DD^* + D^*D$, where D is a differential operator of polynomial type, to find the canonical solutions to the inhomogeneous equations $Du = \alpha$ and $D^*v = \beta$.

We also study the ∂-complex on several models including the complex hyperbolic space, which turns out to have duality properties similar to the Segal-Bargmann space (which is common work with Duong Ngoc Son).

Sampling, Marcinkiewicz-Zygmund sets, approximation, and quadrature rules

Karlheinz Gröchenig (Universität Wien)

S08c.4
TUE
11:30
|
12:00
W206

Suppose you are given n samples of a function f on the torus. What can you say about f? How well can you approximate f or the integral $\int_0^1 f(x)dx$? The key notion to answer this question is the notion of Marcinkiewicz-Zygmund (MZ) sets [1, 2]. A MZ-set $X = (X_n)_{n\in\mathbb{N}}$ for the torus is a sequence of finite sets X_n such that

$$A\|p\|_2^2 \le \sum_{x\in X_n} |p(x)|^2 \le B\|p\|_2^2 \quad \forall p \in \mathscr{T}_n\,,$$

where $\mathscr{T}_n$ denotes the subspace of trigonometric polynomials of degree n and $A,B > 0$ are two constants *independent* of n.

To produce a good approximation of a smooth function f from its samples $f|_{X_n}$ on an MZ-set, one first constructs a trigonometric polynomial $p_n \in \mathscr{T}_n$ that approximates the given samples optimally. Numerically, this amounts to solving a least squares problem. For f in the Sobolev space H^σ, one can then prove a convergence rate

$$\|f - p_n\| = \mathscr{O}(n^{-\sigma+1/2})\,.$$

This also implies an error estimate for quadrature rule that is associated to every MZ-set.

Using the techniques from [3] one can prove similar results for functions on a bounded domain in $\mathbb{R}^d$, where the trigonometric system is replaced by the eigenfunctions of the Laplacian, or even more generally on compact Riemannian manifolds.

[1] A. Cohen and G. Migliorati. Optimal weighted least-squares methods. *SMAI J. Comput. Math.*, 3:181–203, 2017.

[2] F. Filbir and H. N. Mhaskar. Marcinkiewicz-Zygmund measures on manifolds. *J. Complexity*, 27(6):568–596, 2011.

[3] K. Gröchenig. Irregular sampling, Toeplitz matrices, and the approximation of entire functions of exponential type. *Math. Comp.*, 68(226):749–765, 1999.

S08d.1

TUE
15:30
|
16:00
W206

The heat kernel expansion of Rockland differential operators and applications to generic rank two distributions in dimension five

Stefan Haller (University of Vienna)

The short-time heat kernel expansion of elliptic operators provides a link between local and global features of classical geometries. Many geometric structures related to (non-)involutive distributions can be described in terms of an underlying filtered manifold. These include contact structures, Engel manifolds, and all regular parabolic geometries. Filtered analogues of classical (elliptic) operators tend to be Rockland, hence hypoelliptic. Remarkably, the heat kernel expansion of Rockland differential operators on general filtered manifolds has the same structure as the one for elliptic operators. These results have been obtained using a recently introduced calculus of pseudodifferential operators generalizing the Heisenberg calculus.

In this talk we will illustrate the aforementioned analysis by applying it to an intriguing five dimensional geometry related to the exceptional Lie group G_2. This geometry has many names: generic rank two distribution in dimension five, filtered manifolds of type $(2,3,5)$, or rank two distributions of Cartan type.

[1] Shantanu Dave and Stefan Haller, *Graded hypoellipticity of BGG sequences.* Preprint available at `arXiv:1705.01659`

[2] Shantanu Dave and Stefan Haller, *The heat asymptotics on filtered manifolds.* J. Geom. Anal. https://doi.org/10.1007/s12220-018-00137-4 electronically published in January 2019 (to appear in print). Preprint available at `arXiv:1712.07104`

[3] Shantanu Dave and Stefan Haller, *On 5-manifolds admitting rank two distributions of Cartan type.* Trans. Amer. Math. Soc. **371**(2019), 4911–4929. Preprint available at `arXiv:1603.09700`

Intersections with random geodesics in high dimensions

Uri Grupel (Universität Innsbruck)

S08d.2
TUE
16:00
|
16:30
W206

Given a large subset of the sphere $A \subseteq S^{n-1}$ does the ratio of lengths between a random geodesic Γ and the intersection $\Gamma \cap A$ represent the size of A or does it tend to a zero-one law (as the dimension grows)? We will show that for any large set A we have a distribution that is not concentrated around neither zero nor one.

In contrast to the case of the sphere, for any convex body in high dimensions, we can find a subset, of half the volume, such that the ratio of lengths between the intersection of the random geodesic with the convex body and the intersection of the subset with the random geodesic will be close to zero-one law.

The analysis of the two cases has different flavors. For the sphere we analyze the singular values of the Radon transform, in order to bound the variance of the length of the random intersection. For convex bodies, we use concentration of measure phenomena.

The results on the sphere can be generalized to the discrete torus or to intersection on the sphere with higher dimensional subspaces.

Section S09

Numerical Analysis, Scientific Computing

Jens Markus Melenk (Technische Universität Wien)
Olaf Steinbach (Technische Universität Graz)

S09a.1
TUE
15:30
|
16:00
W211/12

Space–Time Finite Element Methods

Olaf Steinbach (TU Graz)

In this talk we will review some recent developments of space–time finite element methods for the numerical solution of time–dependent partial differential equations such as the heat equation. Here, the variational formulation is considered in the space–time domain Q, which allows the use of adaptive finite element spaces simultaneously in space and time, and the use of parallel solution strategies. The first and more standard approach is based on variational formulations in Bochner spaces where unique solvability is based on suitable inf–sup stability conditions. As an alternative we may consider the weak solution of the heat equation in anisotropic Sobolev spaces which requires the use of appropriate test and ansatz spaces. Here we introduce a modified Hilbert transformation to end up with a positive definite and symmetric approximation of the first order time derivative. Several numerical examples will indicate the potential of the proposed methods.

Vibration of a beam under structural randomness

Eberle Robert[⋆] (Universität Innsbruck)
Michael Oberguggenberger (Universität Innsbruck)

S09a.2
TUE
16:00
|
16:30
W211/12

In engineering, the study of vibrations in structures is essential. Some structures such as bridges or skis can be modelled as an Euler-Bernoulli beam. The damped vibrations of an Euler-Bernoulli beam is described by the partial differential equation [1]

$$(EI(x)w_{xx})_{xx} + \rho A(x)w_{tt} + \beta\,(EI(x)(w_t)_{xx})_{xx} + \alpha\rho A(x)w_t = f. \tag{1}$$

Here, x denotes the longitudinal coordinate, t the time, $EI(x)$ the flexural stiffness, $w(x,t)$ the deflection of the structure in vertical direction, ρ the mass density, $A(x)$ the cross sectional area of the beam, and f the line forces acting on the beam. The coefficients β and α stand for the damping coefficients.

The main characterisation of a beam is its bending stiffness $EI(x)$, which can be determined by measurements. Such measurements usually yield variations in the bending stiffness $EI(x)$. These variations can be taken into account by adding a random field $r(x)$ [2] to a mean bending stiffness $EI_0(x)$ in the beam equation (1)

$$EI(x) = EI_0(x) + r(x). \tag{2}$$

We investigate the vibrations of a ski in the following situation. The ski is clamped in the centre, the ski tip is deflected and released. This experiment accords with the vibration of a deflected cantilever beam and is modelled by equation (1) with boundary conditions (clamped - free)

$$w(0,t) = 0, \quad w_x(0,t) = 0, \quad w_{xx}(L,t) = 0, \quad w_{xxx}(L,t) = 0 \tag{3}$$

and initial deflection and velocity:

$$w(x,0) = w_0(x), \quad w_t(x,0) = 0. \tag{4}$$

The initial deflection $w_0(x)$ is calculated by the static beam equation. The differential equation is solved by the spectral method [3]. A sequence of simulations is performed (Monte Carlo simulation) and the vibrations are analysed.

In the future, the presented approach will be applied on other structural problems, such as the vibrations of a composite bridge under traffic load.

[1] R. Eberle, P. Kaps, and M. Oberguggenberger *A multibody simulation study of alpine ski vibrations caused by random slope roughness*, Journal of Sound and Vibration, 446 (2019) 225–237.

[2] R.G. Ghanem and P.D. Spanos, *Stochastic finite elements: a spectral approach*. Springer, New York, 2003.

[3] C.D. Munz and T. Westermann, *Numerische Behandlung gewöhnlicher und partieller Differenzialgleichungen*, Springer, Berlin, 2006.

S09a.3
TUE
16:30
|
17:00
W211/12

On some interpolation operators on triangles with curved sides

Teodora Cătinaş (Babeş-Bolyai University, Cluj-Napoca, Romania)

We present some results regarding interpolation operators and linear, positive operators defined on triangles having one curved side. They are extensions of the corresponding operators for functions defined on triangles with straight sides.

The operators defined on domains with curved sides permit essential boundary conditions to be satisfied exactly and they have important applications in: finite element methods for differential equations with given boundary conditions, the piecewise generation of surfaces in CAGD, in obtaining Bezier curves/surfaces in CAGD and in construction of surfaces that satisfy some given conditions.

We consider some Lagrange, Hermite and Birkhoff type interpolation operators and Bernstein, Cheney-Sharma and Nielson type operators on triangles with one curved side. We construct their product and Boolean sum and study their interpolation properties.

We study three main aspects of the constructed operators: the interpolation properties, the orders of accuracy and the remainders of the corresponding interpolation formulas.

We use some of the interpolation operators and some of the Bernstein type operators for construction of surfaces that satisfy some given conditions, such as the roofs of the halls.

Finally, we give some numerical examples and we study the approximation errors for the operators presented here.

[1] P. Blaga, T. Cătinaş, G. Coman, *Bernstein-type operators on triangle with all curved sides,* Appl. Math. Comput., 218 (2011), 3072–3082.

[2] P. Blaga, T. Cătinaş, G. Coman, *Bernstein-type operators on triangle with one curved side*, Mediterr. J. Math., 9 (2012), No. 4, 843-855.

[3] T. Cătinaş, P. Blaga, G. Coman, G., *Surfaces generation by blending interpolation on a triangle with one curved side*, Res. Math., 64 (2013) nos. 3-4, 343-355.

[4] T. Cătinaş, *Extension of some particular interpolation operators to a triangle with one curved side*, Appl. Math. Comput. 315 (2017) 286–297.

[5] G. Coman, T. Cătinaş, *Interpolation operators on a tetrahedron with three curved sides*, Calcolo, 47 (2010), no. 2, 113-128.

[6] G. Coman, T. Cătinaş, *Interpolation operators on a triangle with one curved side,* BIT Numer. Math., 50 (2010), no. 2, 243-267.

An adaptive algorithm for the fractional Laplacian

Jens Markus Melenk⋆ (TU Wien)
Markus Faustmann (TU Wien)
Dirk Praetorius (TU Wien)

S09b.1
TUE
17:30
|
18:00
W211/12

For the discretization of the integral fractional Laplacian $(-\Delta)^s$, $0 < s < 1$, based on piecewise linear functions, we present and analyze a reliable weighted residual *a posteriori* error estimator. In order to compensate for a lack of L^2-regularity of the residual in the regime $3/4 < s < 1$, this weighted residual error estimator includes as an additional weight a power of the distance from the mesh skeleton. We prove optimal convergence rates for an h-adaptive algorithm driven by this error estimator in the framework of [CFPP14]. Key to the analysis of the adaptive algorithm are novel local inverse estimates for the fractional Laplacian. These local inverse estimates have further applications. For example, they underlie the proof that multilevel diagonal scaling leads to uniformly bounded condition numbers even in the presence of locally refined meshes.

[CFPP14] C. Carstensen, M. Feischl, M. Page, and D. Praetorius, *Axioms of adaptivity*, Comput. Math. Appl. **67** (2014), no. 6, 1195–1253.

A new approach of operational matrices for hyperbolic partial differential equations

Somveer Singh⋆ (Department of Mathematics, Indian Institute of Technology Delhi, India)
Vineet Kumar Singh (Department of Mathematical Sciences, Indian Institute of Technology, Banaras Hindu University(IIT BHU), Varanasi, India)

S09b.2
TUE
18:00
|
18:30
W211/12

A new approach based on operational matrices of Legendre wavelets is introduced for the class of first order hyperbolic partial differential equations with the given initial conditions. Operational matrices of integration of Legendre wavelets are derived and utilized to transform the given PDE into the linear system of equations by combining collocation method. Convergence analysis and error estimation the presented technique are also investigated. Some numerical experiments are performed to demonstrate accuracy and efficiency of the proposed method.

S09b.3
TUE
18:30
|
19:00
W211/12

Effect of Impedance on Reflection of Plane Waves in a Rotating Magneto-thermoelastic Solid Half-Space with Diffusion

Dr. Anand Kumar Yadav ((1) Department of Mathematics, M. M. Deemed To Be University Mullana Ambala, India, (2) Shishu Niketan Model Senior Secondary School, Sector 22-D, Chandigarh, India)

In this paper, the governing equations of rotating magneto-thermoelasticity with diffusion are formulated in context of Lord-Shulman theory of generalized thermoelasticity. The plane wave solutions of these equations indicate the existence of four plane waves. The speed of these plane waves are computed for a particular material and plotted against the diffusion parameter, thermal parameter and frequency. The plane surface of the half-space is subjected to impedance boundary conditions, where normal and tangential tractions are proportional to normal and tangential displacement components time frequency, respectively. Reflection of these plane waves from a stress-free thermally insulated surface is studied to obtain the reflection coefficients and energy ratios of reflected waves. The reflection coefficients and energy ratios of reflected waves are computed for a particular material and effect of diffusion and angle of incidence is observed graphically on energy ratios.

S09c.1
WED
11:00
|
11:30
W206

An operational matrix approach for two-dimensional hyperbolic telegraph equation

Vinita Devi⋆ (Department of Mathematical Sciences, Indian Institute of Technology, Banaras Hindu University(IIT BHU), Varanasi, India)
Vineet Kumar Singh (Department of Mathematical Sciences, Indian Institute of Technology, Banaras Hindu University(IIT BHU), Varanasi, India.)

In this work, an efficient method is proposed to find the numerical solution of two dimensional hyperbolic telegraph equation. In this method, the roots of Legendre's polynomial are taken as the node points for the Lagrange's polynomial. First, we convert the main equation in to partial integro-differential equations(PIDEs) with the help of initial and boundary conditions. The operational matrices of differentiation and integration are then used to transform the PIDEs in to algebraic generalized Sylvester equations. We compared the results obtained by the proposed method with Bernoulli matrix method which shows that the proposed method is accurate for small number of basis function.

Multistep finite difference scheme for electromagnetic waves model arising from dielectric media

Rahul Kumar Maurya⋆ (Department of Mathematical Sciences, Indian Institute of Technology, Banaras Hindu University(IIT BHU), Varanasi, India)
Vineet Kumar Singh (Department of Mathematical Sciences, Indian Institute of Technology, Banaras Hindu University(IIT BHU), Varanasi, India)

S09c.2
WED
11:30
|
12:00
W206

In this work, we developed a finite difference scheme for solving two dimensional (2D) fractional differential models of electromagnetic waves (FDMEWs) arising from dielectric media. The Caputo's fractional derivative in time is discretized by a difference scheme of $\mathscr{O}(t^{3-\alpha})$, $1<\alpha<2$, and the Laplacian operator is approximated by central difference discretization. Unconditional stability for the proposed scheme is established and convergence analysis is done through optimal error bounds. For 2D FDMEWs, accuracy of $\mathscr{O}(\tau^{2-\alpha}+\tau^{2-\beta}+h_1^2+h_2^2)$ are proved for the discrete numerical scheme, where $1<\beta<\alpha<2$. Several examples are included to verify the reliability and computational efficiency of the proposed scheme which support our theoretical findings.

Section S10

Optimization

Radu Bot (Universität Wien)

S10.1

WED
12:00
|
12:30
W206

A Multi-step Hybrid Conjugate Gradient Method

Issam A.R. Moghrabi (Gulf University for Science and Technology, Kuwait)

A multi-step hybrid Conjugate Gradient (CG) algorithm is introduced in this research that generates weighted search directions. The algorithm employs a weighting matrix that is is a two-step quasi-Newton inverse Hessian update matrix that utilizes data from the two most recent iterations. Multi-step methods have proven to be serious contenders when it comes to the implementation of quasi-Newton methods, as opposed to the standard class of the quasi-Newton type that use updates satisfying the standard one-step Secant equation. Our implementation requires a few additional vectors that need to be updated at each iteration without requiring storing, coding and updating the Hessian or inverse Hessian matrix approximations. The numerical performance of the new algorithm is evaluated by comparing it to other well known methods developed in a similar context. The new method is tested on a set of 1941 standard unconstrained optimization problems. Our results reveal encouraging improvements over other successful methods at a reasonable extra computational as well as storage costs. The gains are specifically appreciated as the dimension of the problem increases, thus justifying the extra cost incurred in the implementation of the new method.

Section S11

Probability, Statistics

Evelyn Buckwar (Universität Linz)
Michaela Szölgyenyi (Universität Klagenfurt)

S11a.1
MON
15:15
|
15:45
W205

Computing upper probabilities of failure using Monte Carlo simulation, reweighting techniques and fixed point iteration

Thomas Fetz⋆ (Universität Innsbruck)
Matthias C. M. Troffaes (Durham University)
Michael Oberguggenberger (Universität Innsbruck)

In many engineering problems, it can be difficult to specify full probability density functions for all parameters, due to a lack of data and expert information. In such cases, we estimate the upper probability $\overline{p}$ of failure with respect to a parametrized family of probability density functions f_t with t in a parameter set $\mathscr{T}$. The upper probability $\overline{p}$ is the solution of the optimization problem $\overline{p} = \max_{t\in\mathscr{T}} p(t)$ where $p(t)$ is the failure probability for a parameter value t in $\mathscr{T}$.

In our approach, we estimate $p(s)$ for fixed $s \in \mathscr{T}$ using Monte Carlo simulation. The algorithm for solving the optimization problem needs values $p(t)$ at many different t which are computed using importance sampling and reweighting techniques to avoid expensive function evaluations of the performance function (finite element computations). The accuracy may not be very high if the optimal parameter value t^* obtained by the optimization procedure is far from the starting value s. In this case, we iterate which means to simulate again, but now with $s = t^*$ as fixed parameter value. The presentation is devoted to such fixed point iterations and in particular to the reuse and combination of former iteration steps to improve the convergence of the fixed point iteration, the estimate of the function p and the upper probability $\overline{p}$ of failure.

[1] Fetz, T. *Efficient computation of upper probabilities of failure. In 12th International Conference on Structural Safety & Reliability*, pages 493–502, 2017.

[2] Fetz T. and M. Oberguggenberger. *Imprecise random variables, random sets, and Monte Carlo simulation.* In ISIPTA'15: Proceedings of the Ninth International Symposium on Imprecise Probability: Theories and Applications, pages 137–146, 2015.

[3] Troffaes, M. C. M. *A note on imprecise Monte Carlo over credal sets via importance sampling.* In Proceedings of the Tenth International Symposium on Imprecise Probability: Theories and Applications, volume 62 of Proceedings of Machine Learning Research, pages 325–332. PMLR, July 2017.

[4] Troffaes, M. C. M., Fetz, T. and Oberguggenberger, M. *Iterative importance sampling for estimating expectation bounds under partial probability specifications.* In: Proceedings of the 8th International Workshop on Reliable Engineering Computing. Digital Repository of the University of Liverpool, pages 139–146, 2018.

Random walk on the random connection model

Ercan Sönmez (University of Klagenfurt)

S11a.2

MON
15:45
|
16:15
W205

We study the behavior of the random walk in a continuum independent long-range percolation model, in which two given vertices x and y are connected with probability that asymptotically behaves like $|x-y|^{-\alpha}$ with $\alpha > d$, where d denotes the dimension of the underlying Euclidean space. Focus is on the random connection model in which the vertex set is given by the realization of a homogeneous Poisson point process. We show that this random graph exhibits the same properties as classical discrete long-range percolation models with regard to recurrence and transience of the random walk. We fully characterize recurrence and give sufficient conditions for transience.

S11a.3
MON
16:15
|
16:45
W205

Embedding an empirically based decision strategy for backcountry skiers into a subjective probability framework.

Christian Pfeifer⋆ (Universität Innsbruck)
Thomas Fetz (Universität Innsbruck)

In the Alps, most fatal snow avalanche accidents are caused by skiers or snowboarders. As a consequence several decision strategies for backcountry skiers have been established in the last two decades in order to prevent avalanche accidents or avalanche fatalities. The most important among them are: Munter's method of reduction, Snowcard method (DAV), Stop or Go (OeAV) and an empirically driven decision strategy [1].

In these strategies the fundamental input variables are

- x = "danger level of avalanche",
- y = "incline of the slope",
- z = "aspect of the slope".
- (skiers behaviour)

To put them into a meaningful mathematical/statistical framework, the strategies above could be understood as a "subjective degree of belief" (or subjective risk) causing an avalanche event. Additionally, the skier's or expert's perception of danger level (e.g. perception of danger level "considerable/3") , incline/aspect of the slope is more or less imprecise or fuzzy.

In 2009, Pfeifer [2] published an empirical based decision and prediction model, which is based on probabilities of a logistic regression model using variables mentioned above. We will give a brief intro into this model.

In this application, we use the fuzzy logic framework [3] fuzzifying the empirical based method of Pfeifer [2] which is resulting in a decision model within a consistent probability framework that takes (among others) the subjective human perception into account.

[1] P. Plattner, *Werner Munter's Tafelrunde. Strategische Lawinenkunde auf dem Prüfstand*, Berg&Steigen 4/2001.

[2] C. Pfeifer, *On probabilities of avalanches triggered by alpine skiers. An empirically driven decision strategy for backcountry skiers based on these probabilities*, Natural Hazards, 48(3):425-438, 2009.

[3] L. A. Zadeh, *Fuzzy sets*, Information and Control, 8(3): 338–353, 2009.

Recurrence of 2-dimensional queueing processes, and random walk exit times from the quadrant

Wolfgang Woess⋆ (TU Graz)
Marc Peigné (Université de Tours)

S11b.1
MON
17:15
|
17:45
W205

Let $X = (X_1, X_2)$ be a 2-dimensional random variable and $X(n), n \in \mathbb{N}$ a sequence of i.i.d. copies of X. The associated random walk is $S(n) = X(1) + X(n)$. The corresponding absorbed-reflected walk $W(n), n \in \mathbb{N}$ in the first quadrant is given by $W(0) = x \in \mathbb{R}^2_+$ and $W(n) = \max\{0, W(n-1) - X(n)\}$, where the maximum is taken coordinate-wise. This is often called the Lindley process and models the waiting times in a two-server queue. We are characterize recurrence of this process, assuming suitable, rather mild moment conditions on X. It turns out that this is directly related with the tail asymptotics of the exit time of the random walk $x + S(n)$ from the quadrant, so that the main part of this paper is devoted to an analysis of that exit time in relation with the drift vector, i.e., the expectation of X.

BSDEs with Jumps in the L^p-setting: Existence, Uniqueness and Comparison

Alexander Steinicke⋆ (Department of Mathematics and Information Technology, Montanuniversität Leoben)
S. Kremsner (Department of Mathematics and Scientific Computing, KFU Graz)

S11b.2
MON
17:45
|
18:15
W205

We study the existence and uniqueness of solutions to backward stochastic differential equations driven by a Lévy process. In the L^p-setting, $p \geq 2$, we find a positive answer, assuming generators that satisfy an extended monotonicity condition and which are not restricted to linear growth in the y-variable. In the delicate case $1 < p < 2$, we show existence and uniqueness of a solution as well, however, the same assumptions on the generator demand new and different proof techniques. In both cases, in dimension 1, if the behavior of the generator's jump variable meets an additional, natural condition, then a comparison theorem holds.

Section S12

Financial and Actuarial Mathematics

Gunther Leobacher (Universität Graz),
Stefan Thonhauser (Technische Universität Graz)

S12.1
TUE
10:00
|
10:30
U210

Utility Maximizing Strategies under Increasing Model Uncertainty in a Multivariate Black Scholes Type Market

Jörn Sass⋆ (University of Kaiserslautern)
Dorothee Westphal (University of Kaiserslautern)

When modeling financial markets one is often confronted with model uncertainty in the sense that parameters of the model or the distributions of some factors in the model are only known up to a certain degree. We look at a multivariate continuous-time financial market driven by a Brownian motion.

In an extreme setting, we investigate how optimal trading strategies for a utility maximization problem behave when we have Knightian uncertainty on the drift, meaning that the only information is that the drift parameter lies in a certain set. This is a robust portfolio optimization setting in which we aim at the best performance given that the true drift parameter is the worst possible parameter for our chosen strategy within this set. If the model uncertainty exceeds a certain threshold, simple strategies such as uniform portfolio diversification outperform more sophisticated ones due to being more robust, see [1] in discrete time. We extend these results to continuous time, provide quite explicit strategies and convergence results, and discuss these in terms of different performance measures.

Another approach to deal with uncertainty is the use of expert opinions in a parametric model. In such a market model with with Gaussian drift, the underlying drift can be estimated by the Kalman filter from the observed stock returns and expert opinions can lead to an improvement of the basic filter. So the expert opinions reduce parameter uncertainty in this setting. In [2] bounds on the performance are derived. We relate and compare the two approaches.

[1] G. Ch. Pflug, A. Pichler, D. Wozabel, *The 1/N investments strategy is optimal under high model ambiguity*, Journal of Banking & Finance 36 (2012) 410–417.

[2] J. Sass, D. Westphal, R. Wunderlich, *Expert opinions and logarithmic utility maximization for multivariate stock returns with Gaussian drift*, International Journal of Theoretical and Apllied Finance 20 (2017) 41 pages.

Severity Modeling of Extreme Insurance Claims for Tariffication

Sascha Desmettre⋆ (Karl-Franzens-Universität Graz)
Christian Laudagé (Fraunhofer Institut für Techno- und Wirtschaftsmathematik)
Jörg Wenzel (Fraunhofer Institut für Techno- und Wirtschaftsmathematik)

S12.2
TUE
10:30
|
11:00
U210

Generalized linear models (GLMs) are common instruments for the pricing of non-life insurance contracts. Among other things, they are used to estimate the expected severity of insurance claims. However, these models do not work adequately for extreme claim sizes. To accomodate for these, we develop the threshold severity model in [1], that splits the claim size distribution in areas below and above a given threshold. More specifically, the extreme insurance claims above the threshold are modeled in the sense of the peaks-over-threshold (POT) methodology from extreme value theory using the generalized Pareto distribution for the excess distribution, and the claims below the threshold are captured by a generalized linear model based on the truncated gamma distribution. The threshold severity model for the first time combines the POT modeling for extreme claim sizes with GLMs based on the truncated gamma distribution. Based on this framework, we develop the corresponding log-likelihood function w.r.t. right-censored claim sizes, which is a typical issue that arises for instance in private or car liability insurance contracts. Finally, we demonstrate the behavior of the threshold severity model compared to the commonly used generalized linear model based on the gamma distribution in the presence of simulated extreme claim sizes following a log-normal as well as Burr Type XII distribution.

[1] C. Laudagé, S. Desmettre & J. Wenzel, *Severity modeling of extreme insurance claims for tariffication*, Insurance: Mathematics and Economics, Volume 88, Pages 77-92, https://doi.org/10.1016/j.insmatheco.2019.06.002, (2019).

S12.3
TUE
11:00
|
11:30
U210

Optimal dividends and funding in risk theory

Josef Anton Strini⋆ (Graz University of Technology)
Stefan Thonhauser (Graz University of Technology)

We extend the classical dividend maximization problem from ruin theory by introducing a funding opportunity in addition to the existing dividend control. This new control is, in contrast to the dividend payments, able to increase the reserve process. Our goal is to reveal a suitable control strategy which maximizes the difference of expected cumulated discounted dividends and total expected discounted additional funding (subject to some proportional transaction costs). As presented in [1], dividends are modelled using the common approach, whereas for the funding opportunity we use the jump times of another independent Poisson process at which we choose an appropriate funding height, contrary to classical capital injection strategies, see [2]. In case of exponentially distributed claims we are able to determine an explicit solution to the problem and derive an optimal strategy whose nature heavily depends on the size of the transaction costs. On top of this, the optimal strategy identifies unfavourable surplus positions prior to ruin at which refunding is highly recommended. Some numerical illustrations conclude our contribution, where we depict the optimal strategy as a function of the transaction cost parameter.

[1] P. Azcue, N. Muler, *Stochastic optimization in insurance*, Springer Briefs in Quantitative Finance, Springer, New York, 2014.
[2] N. Kulenko, H. Schmidli, *Optimal dividend strategies in a Cramér-Lundberg model with capital injections*, Insurance Math. Econom., 43(2), (2008) 270–278.

S12.4
TUE
11:30
|
12:00
U210

Optimal reinsurance for expected penalty functions in risk theory

Stefan Thonhauser⋆ (Technische Universität Graz)
Michael Preischl (Technische Universität Graz)

Complementing existing results on minimal ruin probabilities, we minimize expected discounted penalty functions (or Gerber-Shiu functions) in a Cramér-Lundberg model by choosing optimal reinsurance. Reinsurance strategies are modeled as time dependent control functions, which lead to a setting from the theory of optimal stochastic control and ultimately to the problem's Hamilton-Jacobi-Bellman equation. We show existence and uniqueness of the solution found by this method and provide numerical examples involving light and heavy tailed claims and also give a remark on the asymptotics.

LehrerInnen-Tag

Bernd Thaller (Universität Graz)
András Bátkai (Pädagogische Hochschule Vorarlberg)

L.1
FRI
09:15
|
10:15
W211/12

Mathematatik an der Brücke von Schule zur Universität im Wandel der Zeit

Robert Tichy (Technische Universität Graz)

In diesem Vortrag berichte ich über meine mehr als 30-jährige Erfahrungen bei der Abhaltung von Grundvorlesungen für Studierende der Mathematik und Physik sowie für Studierende aller technischen Studienrichtungen. Im Fokus stehen Aspekte der Digitalisierung im Unterricht, Lehrmethodik, Vorkenntnisse und Fähigkeiten (die im Gymnasium vermittelt werden sollten) sowie mögliche Auswirkungen der Zentralmatura. Im Speziellen wird auf folgende Probleme eingegangen:

- Was ist Mathematik?
- Welche mathematische Fähigkeiten können zu Beginn des Studiums erwartet werden?
- Welche Vorkenntnisse können die Universitäten erwarten?
- Wie soll man StudienanfängerInnen in heutiger Zeit unterrichten?

L.2
FRI
10:45
|
11:45
W211/12

Computereinsatz im Mathematikunterricht aus fachdidaktischer Sicht – ein Überblick

Christian Dorner (Universität Graz)

Am Beginn des Vortrags werden (altbekannte) Hoffnungen, Forderungen und Zielsetzungen im Hinblick auf einen digitalen Technologieeinsatz im Mathematikunterricht erläutert. Aufschluss über den tatsächlichen Nutzen bestimmter Verwendungen digitaler Werkzeuge beim Mathematiklernen soll eine Auswahl an empirischen Studien geben. Der Fokus wird sich dabei auf Untersuchungen zum Einsatz von Computeralgebrasystemen richten. Abschließend werden weiterhin offene Fragestellungen bezüglich eines Einsatzes digitaler Technologien im Mathematikunterricht diskutiert.

Mathematik mit GeoGebra: Schneller, höher, stärker oder weniger ist mehr?

Andreas Lindner (Pädagogische Hochschule Oberösterreich)

Seit mehr als 25 Jahren wird Technologie in Form von verschiedenen Mathematikprogrammen im Unterricht verwendet. Aber noch immer scheint kein Konsens über das Ausmaß und die speziellen Anwendungsbereiche für einen sinnvollen Technologieeinsatz zu herrschen, während gleichzeitig der Verlust der elementaren Rechentechniken beklagt wird. Das Programm GeoGebra, das von einer überwiegenden Mehrzahl der Maturantinnen und Maturanten in der Sekundarstufe 2 und bei der schriftlichen Reifeprüfung verwendet wird, unterliegt einem ständigen Entwicklungsprozess und bietet immer bessere Möglichkeiten für einen technologiegestützten Unterricht. Anhand von ausgewählten Beispielen werden die Neuerungen von GeoGebra vorgestellt und kritisch hinterfragt.

Hochschul-Tag

Karl Unterkofler (Fachhochschule Vorarlberg)
Susanne Teschl (Fachhochschule Technikum Wien)

HT.1
FRI
09:15
|
10:15
W206

Von der inhaltsbezogenen zur kompetenzorientierten Mathematiklehre unter Berücksichtigung von Seamless Learning

Carola Pickhardt (Hochschule Albstadt Sigmaringen, Fakultät Life Sciences, Sigmaringen)

Am Beispiel des Moduls *Mathematische Grundlagen und mathematisches Modellieren in den Life Sciences* wird aufgezeigt wie der systemische Veränderungsprozess von einer inhaltsbezogenen zu einer kompetenzorientierten Lehre unter Berücksichtigung von Seamless Learning gestaltet werden kann – mit dem Ziel die Lernende auf ein kontextübergreifendes Arbeiten und lebenslange Lernen in einer digitalisierten Wissensgesellschaft vorzubereiten. Anhand der realisierten Seamless Learning-Konzeption wird vorgestellt, wie Reibungsverluste zwischen unterschiedlichen Bildungskontexten – u.a. durch integrativen Einsatz digitaler Technologien - minimiert werden können. Ein Beispiel ist der durchgängige (*seamless*) Kompetenzaufbau vom mathematischen Modellieren zum Simulieren, wofür im Projekt *MoSeL – Modellieren und Visualisieren als Seamless Learning* des IBH-Lab Seamless Learning eine Konzeption entwickelt wurde. Die Themen Visualisierung und Simulation von Prozessen führen zu einem interessanten Ausblick auf die Bedeutung von Digitalisierung und Nachhaltigkeit in der Lehre.

HT.2
FRI
10:45
|
11:45
W206

Digitalisierung im Mathematikunterricht

Evelyn Süss-Stepancik (Pädagogische Hochschule Niederösterreich)

Die Lehre an Pädagogischen Hochschulen, Fachhochschulen und Universitäten ist eine höchst anspruchsvolle und komplexe Aufgabe. Die Vorstellung, dass Dozentinnen und Dozenten als Fachexpertinnen und -experten ihr Wissen durch bloße Instruktion an Studierende “übertragen” und diese die vorgetragenen Lerninhalte konsumieren, ist einem anderen, zeitgemäßen Verständnis von Lehren und Lernen gewichen. Diese zeitgemäße Form der Lehre rückt die Interaktion als wichtigen Faktor für Lernerfolg ins Zentrum der Aktivitäten. Dabei wird auf die Interaktion der Lernenden mit den Inhalten, mit den anderen Lernenden, aber auch mit den Lehrenden abgezielt. Digitale Medien können hier einen wesentlichen Beitrag leisten. Allerdings ist der Einsatz digitaler Medien in der Lehre nicht ausgehend von den vorhandenen technischen Möglichkeiten, sondern von den didaktischen Konzepten der Lehrveranstaltungen zu planen. Wie solche Konzepte für Vorlesungen, Seminare und Übungen im Bereich der Mathematik umgesetzt und das Potenzial digitaler Medien in der Lehre lernwirksam genützt werden kann, wird im Vortrag exemplarisch aufgezeigt.

Trends im eLearning-Bereich

Ortrun Gröblinger (Universität Innsbruck, Abteilung Digitale Medien und Lerntechnologien)

HT.3
FRI
13:30
|
14:30
W206

Hat sich eLearning neu eingekleidet und läuft nun als Digitalisierung der Lehre durch die Gänge der Hochschulen? Das Berufsbild des Influencers war bis vor wenigen Jahren noch nicht einmal erfunden – jetzt ist es in aller Munde. Werden wir an Hochschulen mit den gleichen Mitteln arbeiten müssen, um die Aufmerksamkeit unserer Studierenden halten zu können? Wie begegnen wir Fragen nach Qualität, Motivation und Demotivation derjenigen, die letztendlich die Verantwortung für die Ausbildung der sogenannten nächsten Generation tatsächlich tragen: den Lehrpersonen? Open Educational Resources (OER) sind einer der Trends der letzten Jahre. Das Mindset, das hinter der Anwendung und Produktion von OER liegt, trägt das Potential in sich, die vorab aufgeworfenen Fragen zumindest teilweise zu beantworten. Im Rahmen des Vortrags wird auf die aktuelle Lage in Österreich sowohl von einem akademischen Standpunkt, als auch anhand von Praxisbeispielen eingegangen.

List of Participants

Agaltsov Alexey (Göttingen)	M5	THU	11:00-11:30	W211/12
Al-Zoubi Hassan (Amman)	S04	TUE	18:00-18:30	U407
Arroud Chems Eddine (Jijel)	S06	WED	12:00-12:30	W205
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