Program of **Living the DREAM** seminar

To be held on **Monday, 11 May 2026**
in **Jyväskylä**, Agora building, room Ag A102 (Martti Ahtisaari)
and on **Zoom** at `https://jyufi.zoom.us/j/65389553933`

Session 1:

09:00 - Welcome speech *(G. Covi)*
09:05 - Talk 1: Trudinger's parabolic equation *(R. Anttila)*
09:20 - Talk 2: Discrete exterior calculus for phonon propagation in layered periodic structures *(M. Myyrä)*
09:35 - Talk 3: Tensor tomography in gas giant geometry *(E. Satukangas)*
09:50 - Talk 4: Quantitative discrete time hedging under initial insider information *(O. Hinkkanen)*

Coffee break

Session 2:

10:30 - Talk 5: Bio-optical inversion of satellite imagery of inland waters *(P. Naik)*
10:45 - Talk 6: Computational methods for analyzing layered paintings in hyperspectral images *(J. Riihimäki)*
11:00 - Talk 7: Horizontal and vertical regularity of elastic wave geometry *(P. Kirkkopelto)*
11:15 - Talk 8: Regularity for the geodesic X-ray transform in non-smooth geometry *(M. Manu)*

TRUDINGER'S PARABOLIC EQUATION

RIKU ANTTILA

Abstract

Trudinger's equation is a non-linear parabolic PDE that generalizes the classical heat equation. In this talk, I present some of our recent development related to this equation and discuss a few open problems related to our ongoing work.

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Discrete exterior calculus for phonon propagation in layered periodic structures

Mikael Myyrä

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Abstract

Discrete exterior calculus (DEC) is a modern method for discretizing differential equations, drawing inspiration from differential geometry. In this presentation, I briefly introduce the most important ideas of DEC and showcase an application in the simulation of elastic waves. Specifically, linear elastic waves are propagated in layered structures with piecewise constant isotropic material parameters and horizontal translational symmetry. The structure is illuminated with plane waves at varying frequencies, angles of incidence, and polarizations, measuring outgoing energy to obtain transmission coefficients for the corresponding phonon modes. Results can be applied e.g. to the estimation of heat conductivity in low-temperature nanostructures.

Tensor tomography in gas giant geometry

Joonas Ilmavirta[1], Antti Kykkänen[2], Eetu Satukangas[3]

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Abstract

Gas giant geometry is a special type of Riemannian manifold with boundary that describes acoustic wave propagation in gas giant planets. In this talk I will present recent and ongoing progress on solving the tensor tomography problem in the setting of gas giant geometry.

In practice the data of interest for the tensor tomography problem is given by travel times of seismic waves that travel through a planet from boundary to boundary. The goal is then to recover a physical property, e.g. the sound speed within the planet, from the data. In a geometric setting the data corresponds to integrals of a symmetric tensor field over maximal geodesics. The tensor tomography problem asks if one can uniquely recover a symmetric tensor field from its integrals over maximal geodesics. In certain seismological models the sound speed within a planet is given by a Riemannian metric which connects the geometry with physics.

On gas giants the sound speed goes to zero up to the boundary according to previous equation of state type of models of gas giants. The Riemannian metric that physically corresponds to the propagation of acoustic waves has the inverse of this property: The Riemannian metric in gas giant geometry is singular up to the boundary of the manifold. The singularity in the metric is tame enough so that for example all maximal geodesics have finite length. All results regarding the tensor tomography problem on gas giants so far can be found in the two pre-prints Arxiv:2602.10322 and Arxiv:2403.05475.

Abstract title

Hannah Geiss[1], Stefan Geiss[2], Onni Hinkkanen[3]

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Quantitative discrete time hedging under initial insider information

The problem of quantitative discrete time hedging within the Black-Scholes model has been intensively studied for many years. In this presentation we study this problem under initial insider information. To include non-smooth terminal conditions, which induce a blow-up of trading strategies, we use adapted, i.e. not equidistant, deterministic time-nets. It is well known that the best possible rate of the L_2-hedging error in the setting without insider information is $n^{-1/2}$, when the number n of trading dates tends to infinity.

We investigate the question to what extent this convergence improves in the presence of insider information. Moreover, we compute the limit of the re-scaled L_2-hedging error. Because of the insider information, the underlying stochastic analysis in order to treat this models changes, for example Skorohod integration has to be used.

This is joint work with Hannah Geiss and Stefan Geiss

Bio-optical Inversion of Satellite Imagery of Inland Waters

Pritish Naik[1]*, Pauliina Salmi*[2]*, Anna-Maria Raita-Hakola*[1]*, Ilkka Pölönen*[1]

[1] University of Jyväskylä, [2] Norwegian University of Science and Technology, Norway,

The inverse problem of resolving bio-optical variables from satellite data of inland waters is an ill-posed and active area of research[1] . The atmospherically corrected and processed reflectance spectra from ENMAP[2] and PRISMA[3] has low signal-to-noise ratio and additionally, the background components such as bottom surface reflectance in shallow water, anthropogenic effect, Colored Dissolved Organic Matter (CDOM) and suspended sediments make it difficult to account for their individual contributions. This project addresses the inverse problem in optically complex inland waters. Specifically, given reflectance spectra from hyperspectral satellites, can we infer the inherent optical properties and bio-optical parameters, and can we distinguish phytoplankton groups such as cyanobacteria from other phytoplankton?

The key questions that this project seeks to answer are as follows.

- How can we extract representative lake spectrum from hyperspectral satellite images from inland water bodies under varying cloud cover that contain sufficient features to resolve the bio-optical variables?
- How can the inversion model account for the different optical signals from different types of background spectra such as suspended solids and CDOM ?
- How can the inversion model account for natural variation introduced by different bottom types in shallow waters and the corresponding variations in their optical properties?

In 2024, we acquired 24 EnMAP[2] and 13 PRISMA[3] hyperspectral satellite images from Scottish and Finnish inland waters of anthropogenic significance and collected the ground truth measurements using multiparameter buoy sensors. This project includes building a data pipeline to filter and identify representative inland water spectra under varying cloud cover, identifying the appropriate priors for the inversion model and training the inversion model to resolve bio-optical variables from the satellite data.

References

[1] Morel, Anclré, and Louis Prieur. "Analysis of variations in ocean color 1." *Limnology and oceanography* 22.4 (1977): 709-722

[2] EnMAP (The Environmental Mapping and Analysis Program). Earth Observation Center EOC of DLR.

[3] PRISMA (Hyperspectral Precursor of the Application Mission). Agenzia Spaziale Italiana (ASI).

Computational Methods for Analyzing Layered Paintings in Hyperspectral Images

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[1] Information Technology, University of Jyväskylä, Finland

Abstract

Hyperspectral (HS) imaging combines imaging with spectroscopy, capturing tens or hundreds of wavelength channels. Each pixel is a spectrum, often a complex mixture of the materials present in the scene. Because materials have unique spectral signatures, it is possible to extract the pure materials' spectra and their fractional proportions from the mixed spectra using methods such as spectral unmixing. Since many pigments behave transparently at certain wavelengths (especially within the infrared range), HS imaging can "see beneath" the surface layer of paint and reveal subsurface features, such as underdrawings or earlier compositions. However, traditional spectral unmixing algorithms do not take into account the presence of multiple paint layers. In this work, we develop a neural-network–based model that not only performs unmixing but also disentangles the hyperspectral image into two separate reconstructions: one of the visible paint layer and one of the hidden layer. This supports tasks such as art authentication and conservation, but is also applicable to other domains.

HORIZONTAL AND VERTICAL REGULARITY OF ELASTIC WAVE GEOMETRY

JOONAS ILMAVIRTA, PIETI KIRKKOPELTO AND ANTTI KYKKÄNEN

Abstract. The elastic properties of a material are encoded in a stiffness tensor field and the propagation of elastic waves is modeled by the elastic wave equation. We characterize analytic and algebraic properties a general anisotropic stiffness tensor field has to satisfy in order for Finsler-geometric methods to be applicable in studying inverse problems related to imaging with elastic waves.

Regularity for the geodesic X-ray transform in non-smooth geometry

Pieti Kirkkopelto[1], Miika Manu[2], Mikko Salo[3]

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Abstract

In this talk we study the geodesic X-ray transform If, which encodes the integrals of f over all maximal geodesics, on Riemannian manifolds with low regularity metrics. When metric is smooth, it is known that normal operator $N = I^*I$, where I^* is a formal adjoint of I, is an elliptic pseudodifferential operator. Hence there exists an approximative inverse operator Q such that

$$QNf(x) = f(x) + Rf(x),$$

where R is smoothing operator. Now $If = 0$ implies $f = -Rf$ i.e functions f in the kernel of I are smoother than assumed a priori. In order to prove injectivity of the geodesic X-ray transform, one needs to prove injectivity only for smooth functions.

In non-smooth case we use similar approach. We decompose normal operator

$$N = P + R,$$

where P is pseudodifferential operator in suitable non-smooth calculus and R is smoothing operator. Moreover, we use symbol smoothing arguments to reduce matters to an elliptic operator in the smooth calculus.