SWEDCOMP 2026
Karlstad University
October 28–29, 2026

Program at a glance

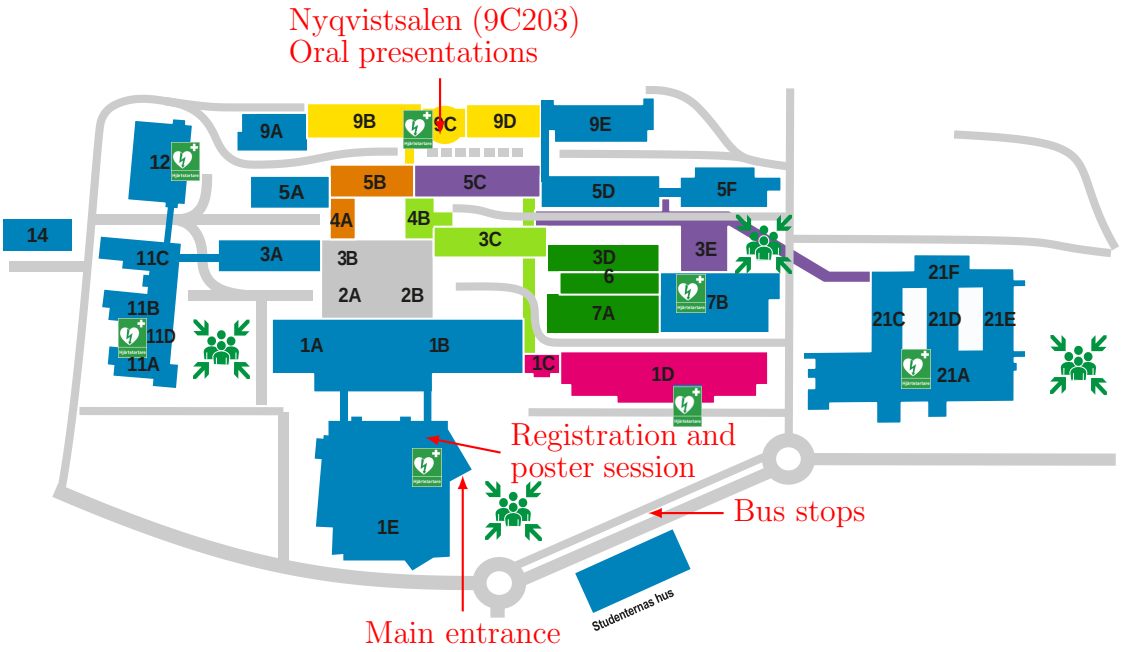
October 28

12:00–13:00	Registration and Lunch
13:00–13:10	Intro/Welcome
13:10–13:30	Davoud Mirzaei
13:30–13:50	Malin Mosquera
13:50–14:10	Philipp Birken
14:10–14:30	Morgan Görtz
14:30–15:00	Coffee break
15:00–15:20	Erik Boström
15:20–15:40	Shivangi Joshi
15:40–16:00	Stefan Engblom
16:00–16:30	Poster blitz
16:30–18:00	Conference photo and poster session
19:00–	Dinner

October 29

9:00– 9:20	Sergey Korotov
9:20– 9:40	Jimmy Kornelije Gunnarsson
9:40–10:00	Alexander Lewis
10:00–10:20	Andreas Granath
10:20–10:50	Coffee break
10:50–11:10	Carlos Jerez–Hanckes
11:10–11:30	Marvin Jans
11:30–11:50	Davide Pradovera
11:50–12:10	Joar Bagge
12:10–13:30	Lunch
13:30–13:50	Nikos Kavallaris
13:50–14:10	Elliot Backman
14:10–14:30	Ihsan Arharas
14:30–	Closing

The scientific parts of the program take place at Karlstad University (Universitetsgatan 2; 651 88 Karlstad); registration and the poster session will be held in Aula foajen (1E301) and the oral presentations will take place in Nyqvistsalen (9C203). The conference dinner will be held at Elite Stadshotellet. An overview map of the university campus is included below. The map indicates the locations of the conference venues, bus stops, CPR equipment (AEDs), and assembly points for use in the event of an emergency evacuation.



Oral presentations October 28, 13:10–14:30

Davoud Mirzaei Uppsala University
Inverse inequalities for scaled kernel spaces
Abstract: Direct and inverse inequalities play an important role in approximation theory for establishing stability and convergence of numerical discretizations. In this talk, we first illustrate these inequalities and discuss their role in the stability analysis of PDE solvers. We then focus on kernel approximation spaces, where the situation becomes more challenging when the kernel scale varies with the discretization level. We present recent results on scale-uniform inverse inequalities for scaled positive definite kernels with Sobolev native spaces.

Malin Mosquera Chalmers University of Technology/University of Gothenburg
A Localized Orthogonal Decomposition Method for Heterogeneous Mixed-Dimensional Problems
Abstract: In this talk, we present a model for solving mixed-dimensional problems with highly heterogeneous coefficients, a type of problem that commonly appears in e.g. modelling of fractured porous media but can be computationally challenging to solve numerically. Thin structures are often modelled as lower-dimensional interfaces embedded in a higher-dimensional bulk domain, leading to the mixed-dimensional model problem.

Our method is based on the Localised Orthogonal Decomposition (LOD) method and constructs locally supported basis functions on a coarse mesh that does not resolve the fine-scale variations of the coefficients. The basis functions are adapted to the problem at hand and thus carry the fine-scale information in order to ensure optimal convergence with respect to the coarse mesh, independent of the coefficient regularity. This method leads to an exponentially decaying localisation error. We present numerical experiments to validate the theoretical findings and demonstrate the computational viability of the method.

Philipp Birken Lund University
A high order method for numerical weather prediction on GPUs
Authors: Philipp Birken, Stéphane Gaudreault, Shoyon Panday, Carlos Pereira Frontado
Abstract: We consider numerical methods for the dynamical core in numerical weather prediction (NWP). Specifically, we are interested in schemes for the Euler equations in 3D at low Mach numbers with a gravity source term. As the trend in NWP is to increase the resolution, high order Discontinuous Galerkin (DG) methods are competitive, proving well suited for High Performance Computing due to their high arithmetic intensity. Due to stiffness, implicit discretizations are needed. The overall design goal is thus a suitable highly parallel stable and computational efficient DG implementation.

To deal with the gravitational source term, a well-balanced method is needed, suitable for large domains. Additionally, the scheme requires a numerical flux suitable for low Mach numbers, and some form of nonlinear stability such as entropy stability, suitable for large simulation times.

Environment and Climate Change Canada (ECCC) is currently redesigning its dynamical core along these lines within the WxFactory code. We present the implementation of a well-balanced DG method suitable for low Mach numbers. Specifically, we use a well-balanced Direct Flux Reconstruction implementation on GL nodes on quadrilateral meshes and a variant of the AUSM+up flux. For time integration, an exponential integrator is used. We provide numerical results showing the performance on atmospheric test cases in 2D and 3D.

Morgan Görtz Fraunhofer-Chalmers Centre
Beam network models, mathematical setting and application
Abstract: Beam network models describe the elasticity of slender, interconnected structures through one-dimensional equations coupled on a spatial graph. This talk presents the governing equations for the elastic wave equation on Timoshenko beam networks, together with the corresponding stationary problem.

Implicit time discretization of the elastic wave equation yields linear systems at each time step. These are solved by a two-level additive domain decomposition preconditioner combining local corrections with a global coarse space. We present a convergence analysis of the method and illustrate its convergence behavior through numerical examples.

Paper-based material provides a motivating application, where fiber arrangement, network connectivity, and inter-fiber contact strongly influence both in-plane and out-of-plane stiffness. Numerical results and comparisons with experimental data show how the mathematical formulation, network construction, and solution methods enable accurate, computationally efficient simulations of fibrous materials.

Oral presentations October 28, 15:00–16:00

Erik Boström Mälardalen University

Accelerating Brinkman flow computations using dual-space kernel splitting

Abstract: The Brinkman equations, $-(\Delta-\lambda^2)\mathbf{u}+\nabla p=\mathbf{f}$, $\nabla\cdot\mathbf{u}=0$, describe screened Stokes flow and are widely used to model flow in porous media; they also arise after implicit–explicit time discretization of the Navier–Stokes equations. Evaluating the velocity induced by N point forces through the Brinkmanlet requires $O(N^2)$ work if done directly. We present a kernel-splitting framework for the Brinkmanlet that applies both to the dual-space multilevel kernel-splitting framework (DMK) and to fast Ewald summation, which reduce the cost to $O(N)$ and $O(N\log N)$, respectively, for a fixed accuracy. The construction is based on the modified biharmonic Green's function, with Fourier transform $\hat{B}_\lambda(k)=1/(k^2(k^2+\lambda^2))$. We give conditions under which mollifiers used for Laplace kernel splitting can be converted into mollifiers that remove both the Laplace and the Yukawa singularity in Fourier space, and show that compactly supported mollifiers then give compactly supported residual kernels. The framework is applied to Gaussian mollifiers and to mollifiers based on prolate spheroidal wave functions. Both the Stokes limit $\lambda\to 0$ and the strongly screened regime $\lambda\to\infty$ require special numerical treatment. Numerical experiments in three dimensions show that parameters calibrated at a single value of λ give the prescribed accuracy over a wide range of Brinkman parameters and problem sizes, with DMK runtimes comparable to those of an existing, benchmarked Stokes implementation.

Shivangi Joshi Umeå University

Discontinuous Galerkin Galerkin Differences for Hyperbolic Conservation Laws

Authors: Shivangi Joshi (speaker, Umeå University), Gunilla Kreiss (Uppsala University), Peter Munch (Technical University of Berlin), Siyang Wang (Umeå University)

Abstract: Galerkin difference (GD) methods combine the efficiency of finite differences with the variational framework of finite elements. High-order approximations are built from neighbouring degrees of freedom, so there is only one unknown per grid point for any order. In the discontinuous Galerkin Galerkin difference (DGGD) method, the GD interpolant is built on a dual grid. This gives discontinuous basis functions, which can be coupled through numerical fluxes as in DG methods. The resulting schemes are high-order accurate and energy stable, and their time-step restrictions depend only mildly on the order.

For problems with discontinuities, however, high-order DGGD schemes still produce spurious oscillations. In this talk we introduce a DGGD method for hyperbolic conservation laws, implemented in deal.II, which adds the damping terms of oscillation-free DG methods to suppress these oscillations. We show results for linear advection and discuss extensions to Burgers' equation, the shallow water equations and cut-cell geometries.

Stefan Engblom Uppsala University

From single cells to tumors: computational modeling and analysis of cell populations

Abstract: This talk explores stochastic modeling approaches for spatial biological processes, motivated by phenomena such as wound healing, gradient sensing in migrating cells, and organoid formation. These systems pose various competing challenges: including large uncertainties, the need for analytical tractability, and modeling flexibility.

We begin with a short overview of our previous work in the reaction-diffusion master equation framework, which is well-suited for highly resolved models of individual cells. We then shift focus to the population level, introducing a computational framework designed to address the scale separation inherent in such systems.

As a case study, we examine a model of avascular tumor growth—usually described using fluid dynamics-style PDEs. We propose a discrete stochastic alternative and derive an approximate mean-field PDE, enabling analysis of the model's behavior and the influence of key parameters on system responses.

References:
[1] E. Blom, S. Engblom: DLCM: a versatile multi-level solver for heterogeneous multicellular systems. Preprint: https://arxiv.org/abs/2504.20565
[2] E. Blom, S. Engblom: Morphological stability for in silico models of avascular tumors In Bull. Math. Biol, 86 (2024)

Oral presentations October 29, 9:00–10:20

Sergey Korotov Mälardalen University, UKK
Longest-edge bisections for tetrahedral partitions: disproof of long-term conjecture on shape regularity
Abstract: Longest-edge bisection is a simple geometric refinement procedure for tetrahedral partitions. Its ability to preserve shape regularity (i.e. uniform nondegeneracy of the generated elements) in three dimensions has been conjectured for decades. We present an explicit counterexample consisting of a sequence of tetrahedra generated by successive longest-edge bisections, with admissible choices among tied longest edges. Although their diameters tend to zero, the tetrahedra degenerate: dihedral angles approach both zero and π. Consequently, both the minimum angle and maximum angle conditions, widely used in finite element analysis and mesh-quality assessment, fail. The construction disproves the general shape regularity conjecture and establishes a limitation of longest-edge bisection for producing uniformly regular finite element partitions [1]. The counterexample also extends to longest-edge n-section algorithms [2].
References
[1] S. Korotov, The longest-edge bisection algorithm may produce degenerating tetrahedra, arXiv:2608.23139, 2026.
[2] S. Korotov, On degeneration of tetrahedra under longest-edge n-section refinement, arXiv:2609.29153, 2026.

Jimmy Kornelije Gunnarsson Lund University
A Discontinuous Galerkin Scheme for the Cahn–Hilliard Equations
Abstract: Symmetric Weighted Interior Penalty (SWIP) discretization, was introduced by (Ern et al., 2008) and applied to the Cahn—Hilliard equations in (Gunnarsson & Klöfkorn, 2026a), where a specific weight option was proposed and compared to other schemes which numerically provide evidence of structure preservation. For the newly developed scheme in (Gunnarsson & Klöfkorn, 2026c) a discrete maximum principle and mass conservation is proven, and energy dissipation is observed. In this talk we present recent findings both on the theoretical level and on the numerical level. We further provide some generalizations which follow from coupling via advection – a similar context was studied in the hp-adaptive case in (Gunnarsson & Klöfkorn, 2026b).

Alexander Lewis Chalmers University of Technology
Stochastic surface evolution and its approximation
Abstract: This talk presents a framework for modelling and numerically approximating surfaces evolving under stochastic flows, where the flow is a solution to a Stratonovich stochastic differential equation. Under suitable regularity assumptions, this produces random deformations that preserve the surface's topology while allowing its shape and enclosed volume to evolve. We consider a one-parameter family of fully implicit schemes whose numerical maps, under suitable stepsize restrictions, are homeomorphisms and therefore preserve the topology of the transported surface. We investigate convergence of the surface to the approximate surface in Hausdorff distance, as well as measure the error in enclosed volume, including numerical volume growth when the underlying stochastic flow preserves volume exactly. Experiments using the stochastic midpoint method illustrate convergence for commuting and noncommuting noise.

Andreas Granath Umeå University
LR-WaveHolz: a low-rank Helmholz solver
Abstract: Solving the Helmholtz equation at high frequencies is notoriously difficult, especially in three dimensions. We present LR-WaveHoltz, a method that combines the time-domain WaveHoltz iteration with low-rank matrix and tensor representations to reduce computational cost. Discretizing with high-order summation-by-parts finite differences on Cartesian grids lets the method exploit low-rank structure in both two and three dimensions. Numerical experiments on free-space and half-space problems demonstrate convergence of the low-rank iteration together with substantial compression, leading to significant computational savings.

Oral presentations October 29, 10:50–12:10

Carlos Jerez–Hanckes KTH

When Geometry Moves: Boundary Integral Operators, Shape Holomorphy and Robust Solvers

Abstract: Wave scattering problems often need to be solved repeatedly over families of varying geometries. We will discuss recent results showing holomorphic dependence of Maxwell boundary integral operators and solutions on shape perturbations, providing a foundation for high-order approximation and uncertainty quantification. We will then show how this analytical structure can inform computation: a Calderón preconditioner built on a nominal geometry can be frozen and reused across perturbed scatterers while retaining robust iterative performance. The results illustrate how understanding operator dependence on geometry can lead simultaneously to approximation theory and faster many-query solvers.

Marvin Jans Lund University

Randomized Runge–Kutta methods

Abstract: Under low-regularity assumptions, numerical methods for ordinary differential equations can have a convergence order reduction. Randomized methods can guarantee a higher convergence order than deterministic methods under these low-regularity assumptions. In this presentation, we give an introduction to randomized methods and present our randomized singly diagonally implicit Runge–Kutta method. For this method, we have proven a convergence rate of 2.5 under low-regularity assumptions. The presentation is based on a joint work with Monika Eisenmann, Raphael Kruse and Helmut Podhainsky.

Davide Pradovera Stockholm University

Chasing resonances: adaptive rational approximation for Helmholtz problems

Abstract: Frequency-domain wave propagation and vibration phenomena often give rise to large-scale linear systems and nonlinear eigenvalue problems, where locating resonances is crucial for tasks like design optimization or uncertainty quantification. Because high-fidelity finite- or boundary-element simulations are too costly for direct use, surrogate modeling is essential. In this talk, I introduce frequency sweeps and resonance issues for Helmholtz problems across three distinct regimes: interior, exterior (with and without trapping), and transmission configurations. To efficiently solve these problems, I focus on adaptive rational approximation techniques. I present the "minimal rational interpolation" strategy, which adaptively selects frequency samples to construct accurate surrogates without oversampling. Combined with randomized sketching, this approach compresses the surrogate source problem associated with the eigenvalue problem, enabling reliable resonance approximation with substantial computational savings. This talk is based on [Pradovera, Hiptmair, and Perugia, J. Sci. Comput., 2025].

Joar Bagge KTH

Skeletonization and compression for Helmholtz and Stokes problems

Abstract: The Helmholtz equation can be used to describe acoustic scattering by a collection of obstacles. A well-known method for solving this problem is the method of fundamental solutions (MFS), which is based on the Green's function of the differential operator. MFS is simple to implement, but leads to ill-conditioned linear systems which can only be managed for small system sizes. The topic of this talk is a compression technique which both reduces the number of unknowns, and improves the conditioning of the resulting linear system significantly, while keeping the accuracy under control. The method is based on a compressed representation of the single-body scattering operator, can be combined with iterative solvers (such as GMRES) and fast summation algorithms (such as the FMM), and can be applied to both two- and three-dimensional problems. Numerical results are presented for systems of thousands of obstacles, including objects with sharp corners and cavities.

Oral presentations October 29, 13:30–14:30

Nikos Kavallaris Karlstad University
Nonlocal activator–inhibitor feedback in the Gierer–Meinhardt system: global continuation and Neumann Turing onset
Abstract: We study a nonlocal Gierer–Meinhardt activator–inhibitor system with distinct kernels for self-enhancement and inhibitor production. We establish local well-posedness and global continuation under a subcritical exponent condition and suitable kernel comparison assumptions. Linearisation in the Neumann eigenbasis shows that reflected kernels modify the Turing instability through mode-dependent multipliers, thereby shifting or suppressing the unstable range. A Neumann-compatible pseudospectral ETDRK4 method is developed, and one- and two-dimensional simulations illustrate how the interaction lengths affect growth, pattern amplitude and spatial localisation. The results show that finite-range feedback influences both global dynamics and pattern-forming instability.
This is a joint work with Marius Ghergu (University College Dublin, Ireland), Takashi Suzuki (Osaka University, Japan) and Eddie Wadbro (Karlstad University).

Elliot Backman Kungliga Tekniska Högskolan
Convergence of the WaveHolz Iteration on $\mathbb{R}^d$
Abstract: The WaveHoltz method is an iterative time-domain method for numerically solving the Helmholtz equation. Previous convergence analysis has focused on cases with bounded domains and various boundary conditions. In this talk we define and study the WaveHoltz iteration on the entirety of $\mathbb{R}^d$ in the constant-coefficient case. We present a frequency-explicit estimate of the error of the nth WaveHoltz iterate against the real part of the outgoing solution to the Helmholtz equation. We find that in a weighted L^2 norm the error in the nth WaveHoltz iterate decays in real part as $n^{-1/2}$.

Ihsan Arharas Linneaus University
Deep Learning for Energy Market Contracts: Dynkin Game with Doubly RBSDEs
Abstract: We formulate a Contract for Difference (CfD) with early exit options as a two-player zero-sum Dynkin game, reflecting the strategic interaction between an electricity producer and a regulatory entity. The game value is characterized through a doubly reflected backward stochastic differential equation DE. To compute the contract value and optimal stopping strategies, we develop a neural solver that approximates the DRBSDE solution using a sequence of neural networks trained on simulated trajectories. We establish a convergence result and test the method on two scenarios: a benchmark symmetric game in 20 dimensions, and a CfD model with 24-dimensional electricity prices representing multiple European zones.

Poster presentations

1. Andreas Langer
2. Anna Rockstroh
3. Arghya Kundu
4. Audrija Choudhury
5. Björn Müller
6. Christian Engström
7. Edith Frisk Gärtner
8. Fredrik Fryklund
9. Georg Kyhn
10. Isuru Kumarasiri
11. Jonatan Werpers and Vidar Stiernström
12. Jorge Solis
13. Mario Setta
14. Nicklas Jävergård
15. Qi Zhou
16. Roman Iakymchuk
17. Safdar Ali
18. Shantiram Mahata
19. Sofia Eriksson
20. Surendra Nepal
21. Tin Nwe Aye
22. Valentina Schüller
23. Vilhelm P. Lithell
24. Zunera Idrees

Andreas Langer Lund University

What Does a Physics-Informed Neural Network Loss Tell Us?

Abstract: Physics-informed neural networks (PINNs) approximate solutions of partial differential equations (PDEs) by minimizing losses that encode the governing equations and associated conditions [1]. A small, or even vanishing, physics-informed loss, however, does not in general guarantee that the represented neural function is close to the PDE solution. This is not merely a non-uniqueness phenomenon restricted to global minimizers. For sufficiently expressive neural-network classes, every attainable loss level of the discretized PINN functional is infinitely degenerate: infinitely many distinct neural functions attain exactly the same loss [2]. Moreover, these level sets are unbounded in function space, so that functions with identical loss can have arbitrarily large distance from the solution of the continuous PDE. Hence, the value of the discrete physics-informed loss alone need not control the approximation error.

We investigate this phenomenon for PINNs based on automatic differentiation (AD-PINNs) and their finite-difference counterparts (FD-PINNs). In both formulations, the degeneracy originates from the finite information entering the discrete loss: only finitely many values and derivatives, or finitely many sampled network values, are observed. This finite-information mechanism also underlies analogous non-uniqueness phenomena in neural variational methods such as the Deep Ritz method and weak PINNs [3].

Despite this common function-level degeneracy, AD- and FD-PINNs have a fundamentally different numerical structure. An AD-PINN evaluates the differential operator pointwise by automatic differentiation at finitely many collocation points, and no underlying discrete problem fixes the resulting neural representation. In contrast, an FD-PINN evaluates a finite-difference operator on sampled network values. Every FD-PINN minimizer therefore agrees on the computational grid with a solution of the corresponding finite-difference problem. In particular, whenever the discrete PDE has a unique solution, all zero-loss FD-PINN minimizers coincide with this solution on the finite-difference stencil [2]. Their remaining non-uniqueness is confined to the continuous extension away from the grid, where functions with the same loss may still differ arbitrarily. A related grid-level correspondence between neural and finite-difference formulations was previously established in a neural variational setting [4].

Numerical examples illustrate this contrast. The results show that function-level degeneracy and discrete numerical determinacy are distinct questions and clarify why identical physics-informed loss values can carry very different information in AD- and FD-based neural PDE solvers.

Keywords: Physics-informed neural networks; ill-posedness; theoretical machine learning.

References

[1] M. Raissi, P. Perdikaris, and G. E. Karniadakis, "Physics-informed neural networks: A deep learning framework for solving forward and inverse problems involving nonlinear partial differential equations," Journal of Computational Physics, vol. 378, pp. 686–707, 2019.
[2] A. Langer, "The Ill-Posed Foundations of Physics-Informed Neural Networks and Their Finite-Difference Variants," arXiv:2601.07017, 2026.
[3] A. Langer, "Non-Uniqueness of Solutions in Neural Variational Methods," arXiv:2605.08877, 2026.
[4] A. Langer and S. Behnamian, "DeepTV: A Neural Network Approach for Total Variation Minimization," arXiv:2409.05569, 2024.

Anna Rockstroh Lund University
Bayesian correction of model misspecification for partial differential equations
Abstract: Partial differential equations (PDEs) are often used to model physical phenomena. In practice, however, PDE models of real-world physics inevitably suffer from model misspecification. We present a data assimilation method for nonlinear PDEs to correct such misspecification by integrating observational data through a time-dependent correction functional applied to a computationally cheap linear low-fidelity model. At each discrete step of the time integration, Bayesian linear regression is used to correct the prediction of the low-fidelity model through the correction functional, where the training set is obtained via the adjoint method. In particular, the approach endows the predictions produced by the corrected model with uncertainty quantification. We illustrate the performance of the method for different types of PDEs.

Arghya Kundu Karlstad University
Derivation of a micro-meso-macro reaction-diffusion system using multiscale asymptotic analysis
Abstract: We use formal asymptotic arguments and three-scale periodic homogenization expansions to guess the correct scaling in terms of two distinct small parameters of a reaction-diffusion system arising in the modeling of self-healing in concrete due to the carbonation reaction. We then justify rigorously our asymptotic intuition using a suitable combination of two- and three-scale convergence concepts. The key ingredient is a suitable parameter-dependent energy estimate controlling the diffusive and boundary terms, which ensures this way the needed compactness. Finally, we report the structure of the wanted limit micro-meso-macro reaction-diffusion system and of the corresponding effective coefficients.
This is a joint work with Adrian Muntean (Karlstad) and Kota Kumazaki (Kyoto).

Audrija Choudhury Karlstad University
What Persists? Validating Topological and Network Features of Gene Co-expression
Abstract: Inflammatory and immune-related biomarkers in lung cancer form coordinated networks whose organisation may change during multimodal treatment. We developed an integrated multiscale framework combining persistent homology, community detection and network centrality to identify co-expression structures that remain robust across analytical scales and patient perturbations. Application to longitudinal qPCR data revealed phase-specific reorganisation of biomarker modules and cycles involving immune-checkpoint regulation, myeloid and inflammasome-associated inflammation, metabolic adaptation and lymphocyte signalling. The results indicate that connected components and higher-order cycles may evolve differently, thereby capturing complementary levels of network organisation. Although exploratory and non-causal, this framework provides a biologically interpretable strategy for prioritising robust multigene patterns for validation in larger, treatment-stratified cohorts.

This is a joint work with Ann Erladsson (Karlstad University), Nikos I. Kavallaris (Karlstad University) and Konstantinos Spiliotis (Democritus University of Thrace, Greece).

Björn Müller Chalmers University
Isotropic Q-fractional Brownian motion on the sphere: regularity and fast simulation
Abstract: As an extension of isotropic Gaussian random fields and Q-Wiener processes on d-dimensional spheres, isotropic Q-fractional Brownian motion is introduced and sample Hölder regularity in space-time is shown depending on the regularity of the spatial covariance operator Q and the Hurst parameter H. The processes are approximated by a spectral method in space for which strong and almost sure convergence are shown. The underlying sample paths of fractional Brownian motion are simulated by circulant embedding or conditionalized random midpoint displacement. Temporal convergence and computational complexity are numerically tested, the latter matching the complexity of simulating a Q-Wiener process if allowing for a temporal error.

Christian Engström Linneaus University
Computing Scattering Resonances in Open Dielectric Structures
Abstract: Scattering resonances characterize radiation losses and wave confinement in open systems. We present a finite-element framework for computing these resonances in two-dimensional dielectric structures. An exact circular Dirichlet-to-Neumann map eliminates the homogeneous exterior at the continuous level, reducing the open-domain problem to a bounded-domain formulation with a frequency-dependent boundary condition. Finite-element discretization and truncation of the boundary Fourier expansion yield a nonlinear eigenvalue problem, which is solved using Newton refinement and contour-integral methods. Numerical examples with piecewise-constant and smoothly graded refractive indices illustrate localized resonant fields, including whispering-gallery modes in a high-index annulus.

Edith Frisk Gärtner Lund University
Fast unified evaluation of layer and volume potentials for the 2D modified Helmholz equation
Abstract: We present a fast and accurate method for evaluating layer and volume potentials on smooth two-dimensional domains. Using heat-kernel representations, each potential is decomposed into a short-range local contribution and a smooth history contribution. The local part is evaluated through asymptotic expansions, while the history part is computed using non-uniform fast Fourier transforms. The volume potential is evaluated on triangular cut-cell meshes, where the mesh only enters the scheme as quadrature rule for smooth data over its support. This makes the method robust with respect to small and distorted mesh cells, without the need for stabilization or cell-merging techniques. We demonstrate the framework for the modified Helmholtz and incompressible Stokes equations, and observe the expected convergence rates. The approach provides a foundation for extensions to three dimensions and moving-interface problems.

Fredrik Fryklund KTH
Fourier-based potential theory without an explicit Green's function
Abstract: Integral equation methods typically rely on explicit Green's functions, which are often unavailable for coupled PDE systems arising in multiphysics applications. We introduce a Fourier-based potential theory that requires only the symbol of the governing operator. A matrix Ewald splitting decomposes the solution into a smooth, nonlocal component and a spatially localized correction. For the latter, we derive explicit asymptotic expansions for volume, single-layer, and double-layer potentials in terms of local geometry and source derivatives. The method avoids explicit Green's functions and singular quadrature, and numerical experiments demonstrate fifth-order convergence for a coupled system in a complex geometry.

Georg Kyhn University of Gothenburg
Adaptive optimization algorithms for reconstruction of dielectric properties of conductive objects
Abstract: The poster presents the performance of an adaptive domain decomposition finite element/finite difference method for reconstructing dielectric permittivity and conductivity functions in a 3D malignant melanoma model using measurements of the backscattered electric field at the boundary of the domain. The forward problem is a space and time dependent PDE of the electromagnetic field based on Maxwell's equations. The inverse problem is formulated as the minimization of a regularized Tikhonov functional, which is solved by constructing the corresponding Lagrangian. The domain decomposition finite element/finite difference method is formulated and explicit schemes for solving the forward and adjoint problems are also developed. We present both conjugate gradient and adaptive conjugate gradient reconstruction algorithms to compute a stationary point of the Lagrangian. Numerical experiments are conducted in both homogeneous skin settings and breast phantoms with adaptive refinement of the finite element mesh. The computational results demonstrate both qualitative and quantitative reconstruction of dielectric permittivity and conductivity using a realistic malignant melanoma model.

Isuru Kumarasiri Linneaus University
Numerical-range-aware Laplace inversion for multiterm time-fractional convection–diffusion PDEs
Authors: Christian Engström, Sofia Eriksson, **Isuru Kumarasiri**
Abstract: Multiterm time-fractional convection–diffusion partial differential equations can be solved without time stepping by numerical inversion of the Laplace transform. A quadrature rule on a contour reduces the problem to independent shifted problems with the operator function $T(\lambda) = m(\lambda)I - A$, where $m(\lambda) = \sum_k c_k \lambda^{\alpha_k}$. The accuracy depends on where the contour is placed. Convection can make A non-normal, motivating the use of numerical-range enclosures rather than spectral information alone. For the scalar Laplace symbol m, we derive explicit lower Lipschitz bounds on compact annular sectors. Under a localization condition, these bounds transfer numerical-range resolvent estimates to distances in the Laplace plane. We also establish localization-free bounds in the closed right half-plane. For a one-dimensional centered finite-difference approximation, we derive Laplace-domain consistency estimates and, under uniform contour and regularity assumptions, a combined spatial and contour-quadrature error bound. The analysis guides a parabolic contour construction adapted to the fractional symbol. Numerical experiments with smooth and boundary-layer solutions illustrate the influence of contour choice and spatial resolution.

Jonatan Werpers and Vidar Stiernström FOI
Applications and numerical methods in hydroacoustics at FOI
Abstract: The research unit for hydroacoustics at FOI studies how sea vessels can be detected using acoustic signals. Through simulations we work on modelling vessel signatures and predicting detection ranges in complex environments, such as the Baltic Sea. Simulation and modelling also offer significant opportunities for solving critical problems in port surveillance, underwater communication, sea mine clearance and the environmental impact of underwater noise. Models are regularly validated against data from lab experiments and sea trials.

Jorge Solis Karlstad University
Experimental-based Modelling of an on-grid Battery Energy Storage System
Abstract: Up to now, different kind of methods have been proposed to effectively control the Battery Energy Storage System (BESS) for energy efficiency and cost reduction. However, some of the conventional methods requires long-term forecasts (e.g., linear programming) and others may require a complete model of the whole system (e.g., dynamic programming). Therefore, it may not applicable for real complex systems having nonlinear dynamics and showing uncertainties due to the changing control conditions. More recently, alternative methods based on intelligent control strategies for on-grid battery energy storage system have been showing promising results in energy efficient and cost reduction. However, most of the methods doesn't take into account the effect of adapting the control parameters of the BESS due to the changing conditions in terms of the state-of-health (SOH) and the estimated state-of-charge (SOC). In this poster presentation, we proposed an experimental-based method to model an on-grid energy battery storage system in terms the state-of-charge based on the available data from a bi-directional inverter connected to the power grid, solar panels and a lithium ferro phosphate (LFP) battery at our campus.

Mario Setta Karlstad University
Minimum feature size control for binary topology optimization
Abstract: Topology optimization approaches that rely on binary (also known as discrete) design variables are currently limited by the absence of rigorous mathematical formulations that guarantee effective length scale control in their final designs. This lack of control often leads to non-physical designs or impractically fine structural features, limiting such methods. To address this gap, we investigate the applicability of a morphology-inspired filtering scheme specifically tailored for density-based topology optimization to impose a prescribed minimum feature size within binary design frameworks.

The analysis of the filtering strategy is implemented within the framework of the Topology Optimization of Binary Structures (TOBS) method. Thermal compliance test cases are examined, allowing for the assessment of the approach across different settings. The numerical experiments demonstrate that the morphology-mimicking filter consistently enforces the prescribed minimum feature size. Moreover, the optimized designs display a reduced sensitivity of the proposed scheme to filtering parameters compared to conventional density-based techniques that employ continuous variables.

Nicklas Jävergård Karlstad University
Morphology formation in three space dimensions: Exposition of a phase field model and its Blume-Capel lattice version
Abstract: Motivated by questions related to morphology formation in 3D involving interacting ternary mixtures, we propose a finite volume scheme to approximate numerically the unique weak solution to a coupled system of parabolic equations with nonlinear and nonlocal drift – a phase-field type model remotely resembling a nonlocal Cahn-Hilliard-type system. The special feature of our system is that the coupling takes place precisely via the structure of the drift terms. Using our phase-field model and its underlying stochastic description (a Blume-Capel type model with Kawasaki dynamics), we illustrate numerically in 3D the appearance of the wanted morphologies and explore their internal structure.

This is a joint work with Emilio N.M. Cirillo (La Sapienza Univ., Rome) and Adrian Muntean and Stela Andrea Muntean (Karlstad).

Qi Zhou KTH Royal Institute of Technology & Shanghai Jiao Tong University
SOG-TNN: Sum-of-Gaussians Tensor Neural Networks for solving many-electron Schrödinger equations with high precision
Abstract: We propose an accurate, efficient, and low-memory deterministic sum-of-Gaussians tensor neural network (SOG-TNN) for the solution of the high-dimensional Schrödinger equation. The SOG-TNN utilizes a low-rank tensor product representation with the approximation capability of neural networks to overcome the curse of dimensionality associated with high-dimensional integration. A standard Slater-determinant construction together with Löwdin-type biorthogonalization is employed to exactly enforce fermionic antisymmetry. To handle the Coulomb interaction, we develop an SOG-based decomposition to approximate the interaction kernel such that it is dimensionally separable, leading to a tensor representation with rapid convergence. We further develop a range-splitting scheme that partitions the Gaussian terms into short-, long-, and mid-range components. They are treated with the asymptotic expansion, the low-rank Chebyshev expansion, and the model reduction with singular-value decomposition, respectively, significantly reducing the number of two-dimensional integrals in computing electron-electron interactions. Together, these developments well resolves the computational challenge due to the singularity of the Coulomb interaction, leading to an efficient solver for the high-dimensional problem under the TNN framework. Numerical experiments are conducted on atomic systems from He to Be, demonstrating the high accuracy of the SOG-TNN while reducing the basis size by several orders of magnitude in comparison with basis-set methods. Furthermore, compared to the mainstream FermiNet method, the SOG-TNN achieves over a five-fold reduction in wall-clock time while securing higher accuracy. These results reveals that the SOG-TNN is a promising way for accurately tackling quantum many-body systems.

Roman Iakymchuk Uppsala University
Weighted Energy-Delay Product for Runtime Frequency Optimization in Homogeneous Workloads
Abstract: This poster proposes a kernel-agnostic lightweight optimization method for homogenous loads using a frequency sweep. We introduce the Weighted Energy-Delay Product (WEDP), an objective function derived for the classical Energy-Delay Product (EDP). Experimental results show that energy consumption scales with frequency following a Paretto Type II saturation function. Optimal runtime parameters can be inferred from the saturation function through the knee. Experimental tests showed that up to 24% of the energy can be recovered, in exchange for up to a 2% increase in runtime. We however recognize that the method does not take into consideration several important parameters such as NUMA domains, core counts or uncore frequency. Future outlooks do aim to investigate these settings, most importantly uncore frequency and core counts.

Safdar Ali Mälardalen University
Generalization of Strang-Fix Remark for Discrete Maximum Principles on Tetrahedral Meshes
Abstract: The discrete maximum principle (DMP) for finite element (FE) solutions is usually guaranteed by acute/non obtuse meshes – conditions that are hard to keep under refinement. For linear FEM applied to the Poisson equation on tetrahedra, we express the stiffness-matrix entries through edge lengths and cotangents of dihedral angles, give a new proof via Cayley–Menger determinants, and, following Strang & Fix, show that the DMP can still hold for tetrahedral configurations containing obtuse dihedral angles through cancellation of assembled edge-patch contributions.

Shantiram Mahata Linneaus University
Numerical Methods for Time-Fractional Evolution Equations with Exponential Tempering
Abstract: This poster presents numerical methods for time-fractional evolution equations with exponential tempering with nonsmooth initial data. We first use piecewise linear and continuous finite elements to approximate the space variable and the L1 scheme to discretize the fractional derivatives. Then, we design high-order methods in both space and time variables based on a splitting of the solution in a regular part and a singular part and using convolution quadrature in time. The convergence properties of these methods are established with illustrating numerical examples.

This is a joint work with Christian Engström (LNU) and Surendra Nepal (LNU).

Sofia Eriksson Linneaus University
Inverting the sum of two singular matrices
Abstract: Square matrices of the form $\widetilde{\mathbf{A}} = \mathbf{A} + \mathbf{e}D\mathbf{f}^*$ are considered. An explicit expression for the inverse is given, provided $\widetilde{\mathbf{A}}$ and D are invertible with $\operatorname{rank}(\widetilde{\mathbf{A}}) = \operatorname{rank}(\mathbf{A}) + \operatorname{rank}(\mathbf{e}D\mathbf{f}^*)$. The inverse is presented in two ways, one that uses singular value decomposition and another that depends directly on the components $\mathbf{A}$, $\mathbf{e}$, $\mathbf{f}$ and D. Additionally, a matrix determinant lemma for singular matrices follows from the derivations.

Surendra Nepal Linneaus University
A graded mesh L1 scheme for a time fractional reaction–diffusion equation on a growing domain
Abstract: We analyze a fully discrete scheme for a time-fractional reaction–diffusion equation on a growing domain. The reference domain problem includes a convection history term and is coupled to an unknown length through a bounded integral growth law. Our scheme combines continuous piecewise linear finite elements with a nonuniform L1 scheme on graded time meshes. We establish unique solvability, unconditional stability, and continuous dependence on the data for the fully discrete scheme. Under the initial temporal singularity assumption, we derive error estimates for the solution, and the domain length. We establish second-order spatial convergence and first-order temporal convergence under suitable mesh grading. Numerical experiments support the theoretical order of convergence and illustrate the evolution of the solution and the domain length.

Tin Nwe Aye Linneaus University
Analyzing Smoothness and Convergence in an SEIR^{T}R^{P}D Endemic Model with Distributed Delays
Abstract: This paper investigates the analytical properties and convergence of $\mathrm{SEIR^TR^PD}$ endemic model incorporating distributed delays to represent latency periods and temporary immunity. The delay structures are defined using continuous integral kernels with compact support and discrete terms represented by Dirac and Radon measures. Under mild assumptions on the system parameters, we establish the smoothing property, boundedness, and non-negativity of the solutions. Furthermore, numerical simulations demonstrate that continuous-delay models can be effectively approximated by discrete-lag models, with significantly reduced computational time compared to evaluating the exact solution. These results contribute to the mathematical analysis and numerical approximation of endemic models with different delay structures.

Valentina Schüller Lund University
Quantifying Coupling Errors in Atmosphere-Ice-Ocean Coupling
Abstract: The atmosphere, ocean, and sea ice components in Earth system models are coupled at the sea surface. There, boundary information is exchanged. Since this is inaccurate, a coupling error occurs. We quantified this error for a coupled single column model: the EC-Earth AOSCM, which uses the same coupling setup and model physics as the EC-Earth general circulation model (GCM). To this end, we used an iterative coupling algorithm to generate reference solutions where the coupling error is eliminated. We compare these to model results obtained with standard, non-iterative coupling algorithms. Understanding the size of the coupling error, as well as the convergence behaviour of the iteration, can inform model and algorithm development. We find that abrupt transitions between distinct physical regimes in certain parameterizations can lead to substantial coupling errors and even non-convergence of the iteration. We attribute discontinuities in the models for atmospheric vertical turbulence and sea ice albedo as sources for these problems. They can be mitigated by smoothing the discontinuity; we show how addressing this for the sea ice albedo affects EC-Earth GCM results.

Vilhelm P. Lithell KTH Royal Institute of Technology
Conditioning and backward errors for eigenvector nonlinearities
Abstract: We are interested in an eigenvector-nonlinear eigenvalue problem (NEPv), that is, an eigenvalue problem where the system matrix depends nonlinearly on the eigenvector. In this sense, this class of problems generalize the familiar linear eigenvalue problem. These problems arise in several important applications, perhaps most notably in the Gross-Pitaevskii equation (GPE) [E. Jarlebring and P. Henning. SIAM Review, 67:256-317, 2025] used to study Bose-Einstein condensation. Two central concepts in numerical analysis are the notions of conditioning and backward error. The conditioning of a problem reveals the sensitivity of the solution to perturbations in the data, and together with the backward error gives a first order estimate of the forward error of an approximate solution. These concepts have not previously been investigated for the NEPv class of eigenvalue problems, in spite of it appearing in important applications. We define these quantities for the NEPv, and subsequently completely characterize them, resulting in computable expressions for both for the conditioning of an eigenpair, and the backward error associated with an approximate eigenpair. We compare our results with the corresponding linear theory, and by means of numerical illustrations we demonstrate that problems incorporating eigenvector nonlinearities sometimes have to be approached with additional care.
This poster is based on joint work with Victors Janssens, Elias Jarlebring, Karl Meerbergen, and Wim Michiels.

Zunera Idrees Linneaus University
Computational Bifurcation Analysis of an Autotroph–Mixotroph System
Abstract: We investigate the nonlinear dynamics of a reduced autotroph–mixotroph chemostat model by varying the mixotrophic link parameter (a). Numerical equilibrium calculations, Jacobian-based stability analysis, and phase-plane simulations reveal changes in coexistence and oscillatory behaviour associated with transcritical, Hopf, and saddle-node bifurcations. We also examine saddle equilibria and their invariant manifolds to explore possible global connections. The results highlight the role of scientific computing in understanding parameter-dependent transitions in nonlinear ecological systems.