Induced Dimension Reduction method for solving linear matrix equations

Reinaldo Astudillo - Delft University of Technology

The fortieth Woudschoten Conference

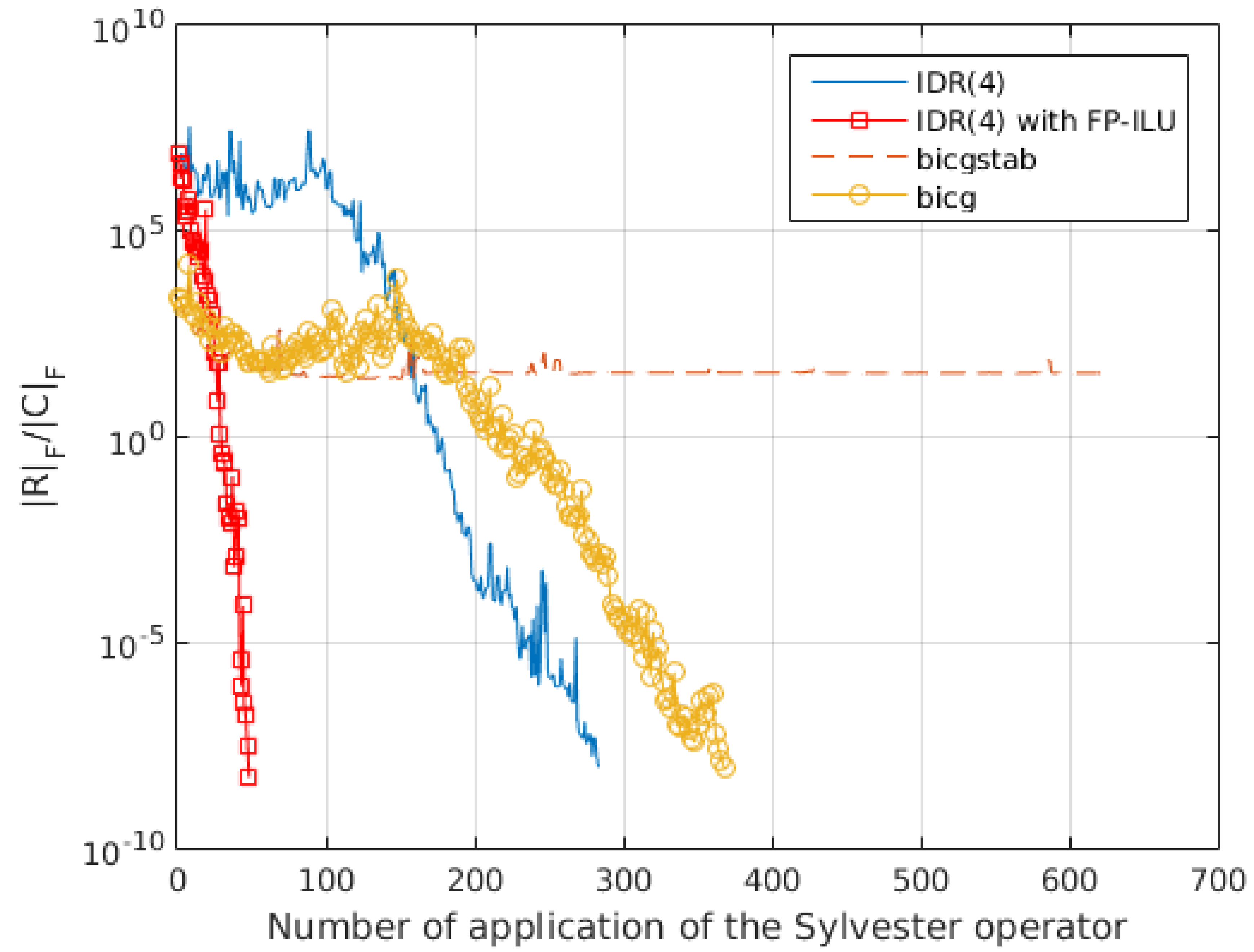
IDR(s) was originally develop for solving:

$$Ax = b.$$

We generalized the IDR(s) method to solve:

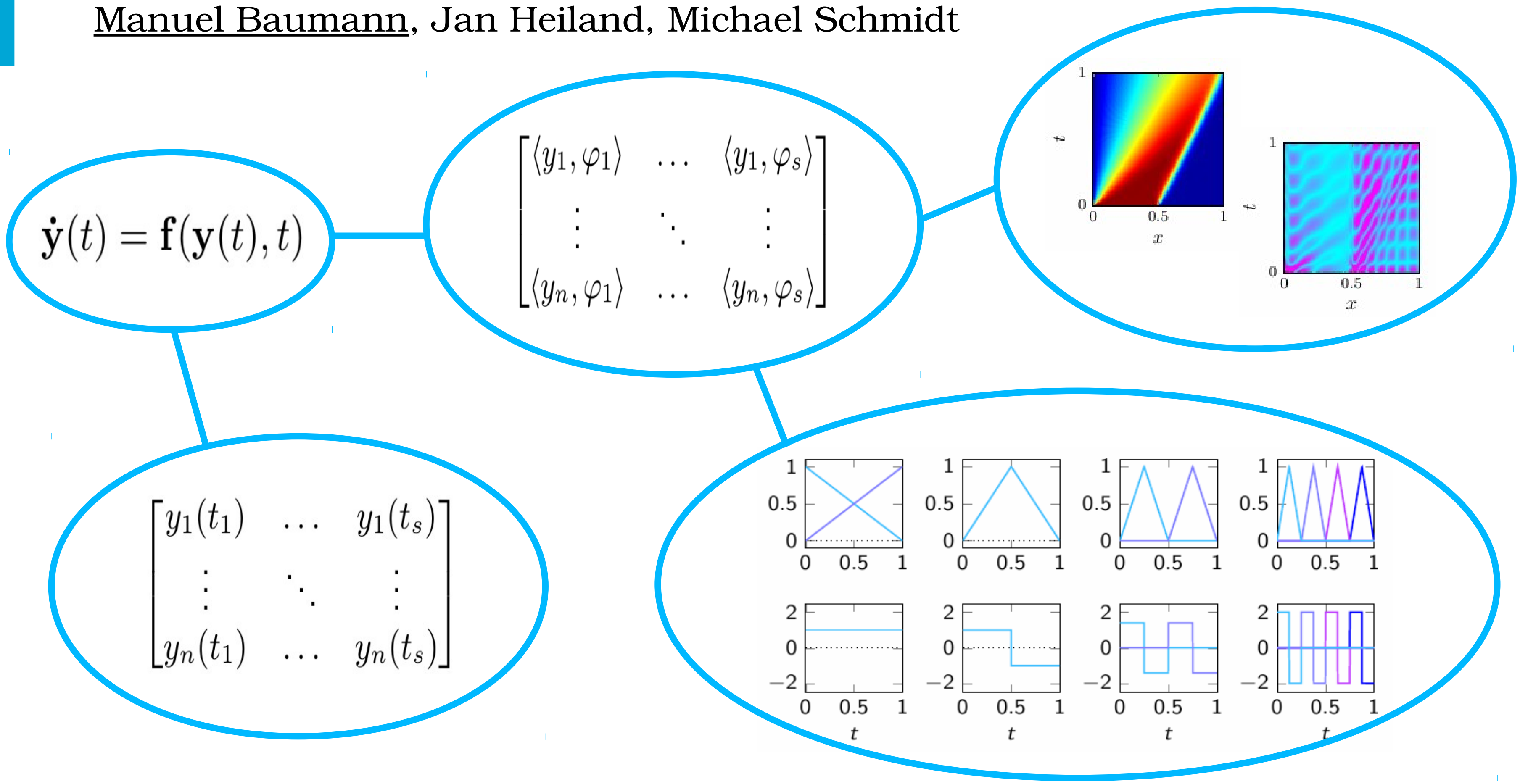
- $AX + XA^T = C$
- $Ax = b$ and $A^T\bar{x} = \bar{x}$
- $AXB = C$
- $AX + XB = C$
- $AX + BXD = C$
- "$u'' = f$"

- Including **preconditioning**.
- Examples from **CFD and Helmholtz equation**.
- Implementation in **Fortran, Matlab, Python, and Julia**.



A generalization of the Proper Orthogonal Decomposition method for nonlinear model-order reduction

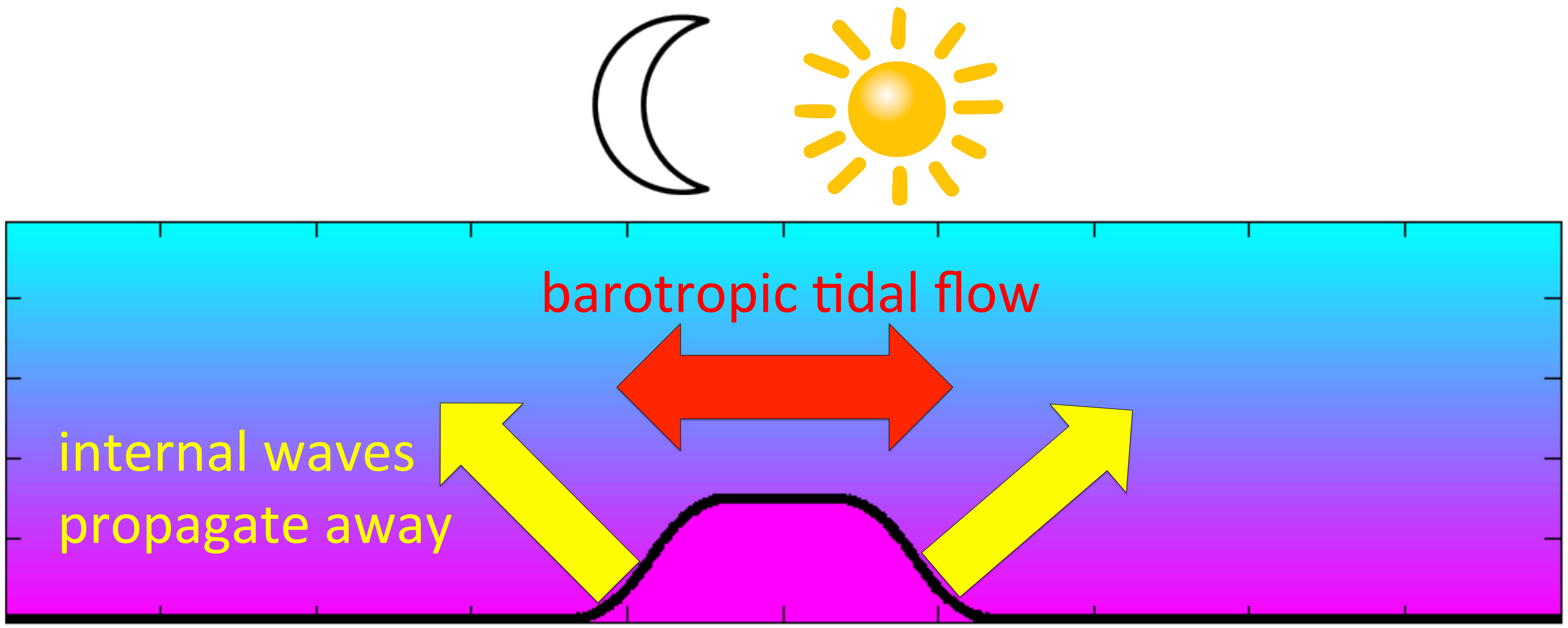
Manuel Baumann, Jan Heiland, Michael Schmidt



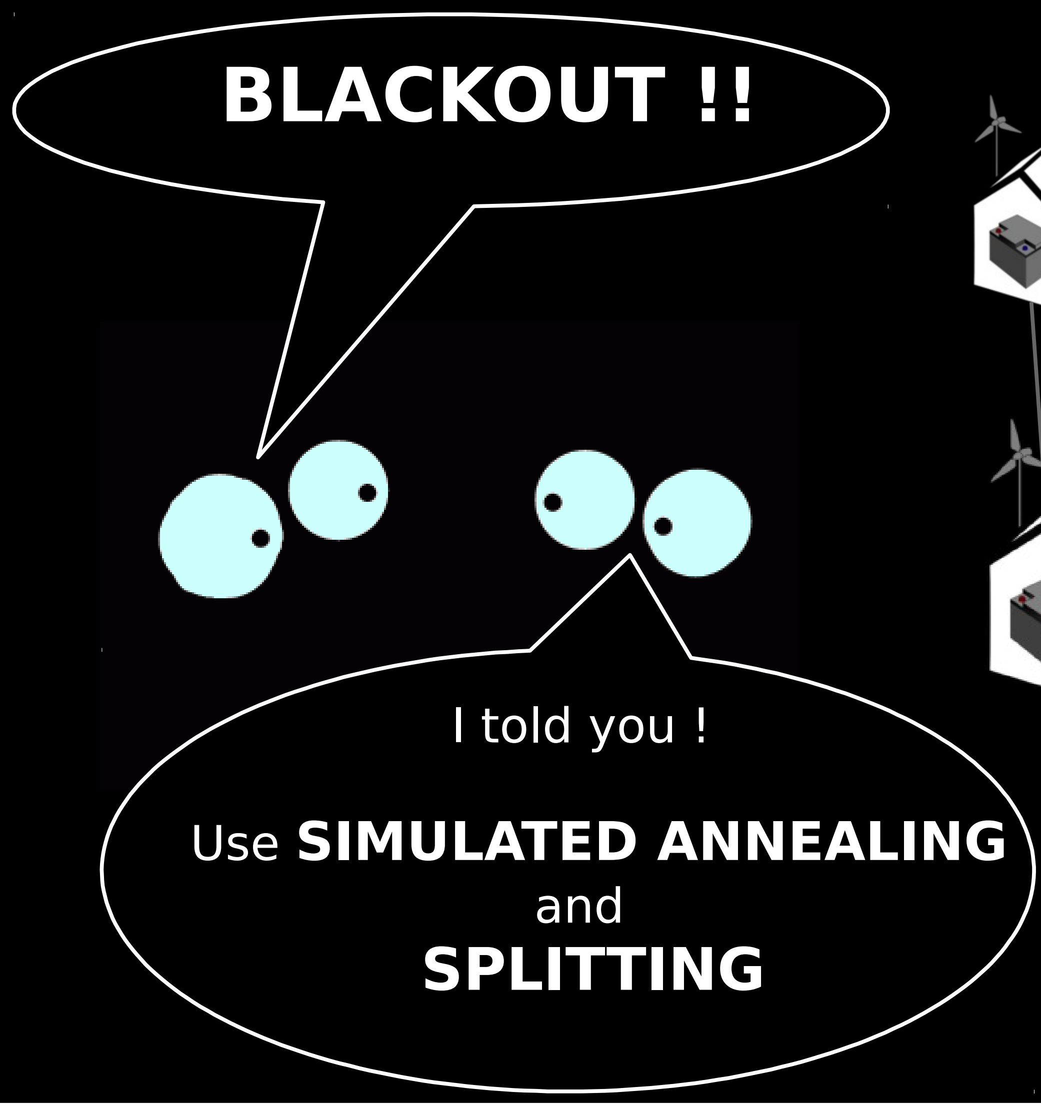
Universiteit Utrecht

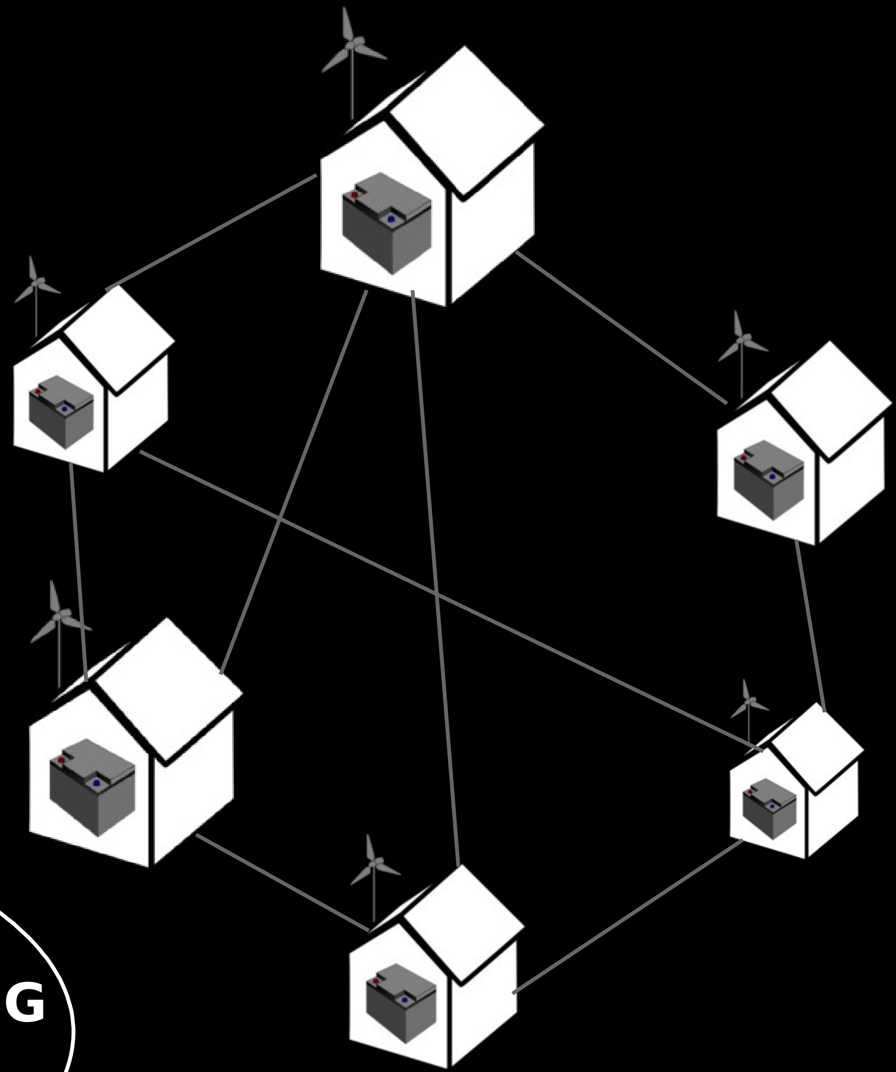
Analytical solutions describing tidal conversion over ocean ridges

Felix Beckebanze, Mathematical Institute, Utrecht University



Optimal Storage Placement in Power Network





Debarati Bhaumik
CWI Amsterdam

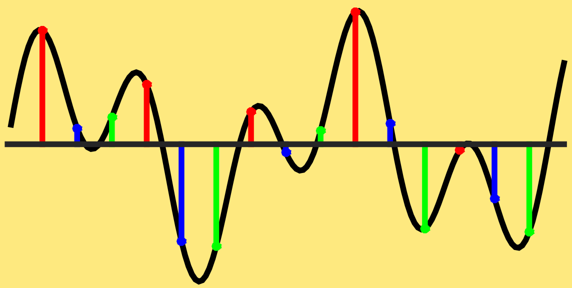
Fast solvers for fluid-structure interaction

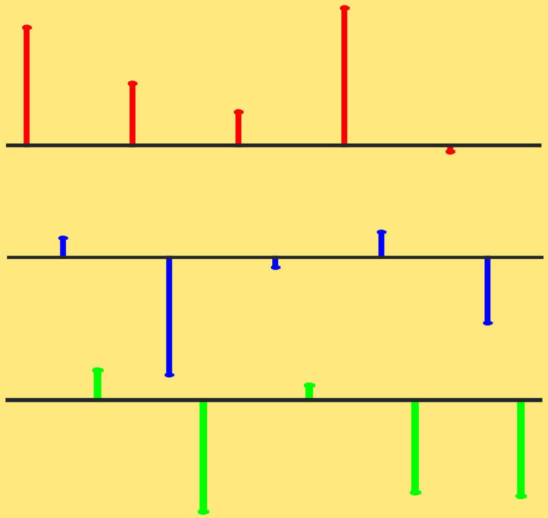
David Blom
Delft University of Technology

Universiteit Antwerpen

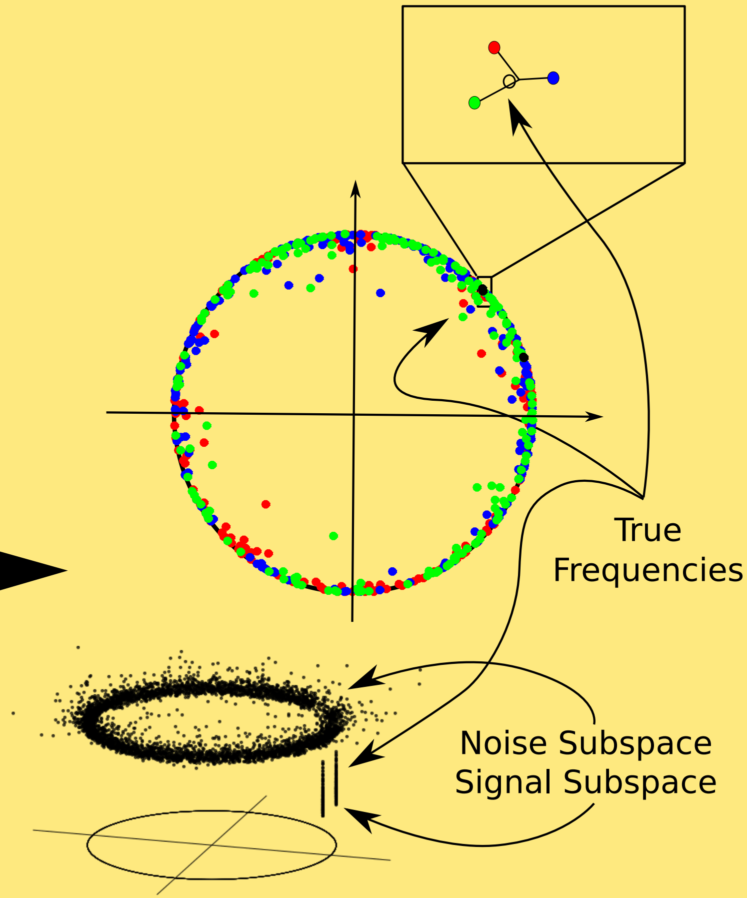
Validated Exponential Analysis

COMPUTATIONAL MATHEMATICS





Exploit Aliasing



Advantages:

- Smaller Parallel Systems
- Better Conditioning
- Frequency Validation
- Noise Subspace Separation

Some possible applications of Sub-Nyquist sampling:

- Nuclear Magnetic Resonance Spectroscopy
- Harmonics Separation in Audio Signal Processing
- Vibration Analysis

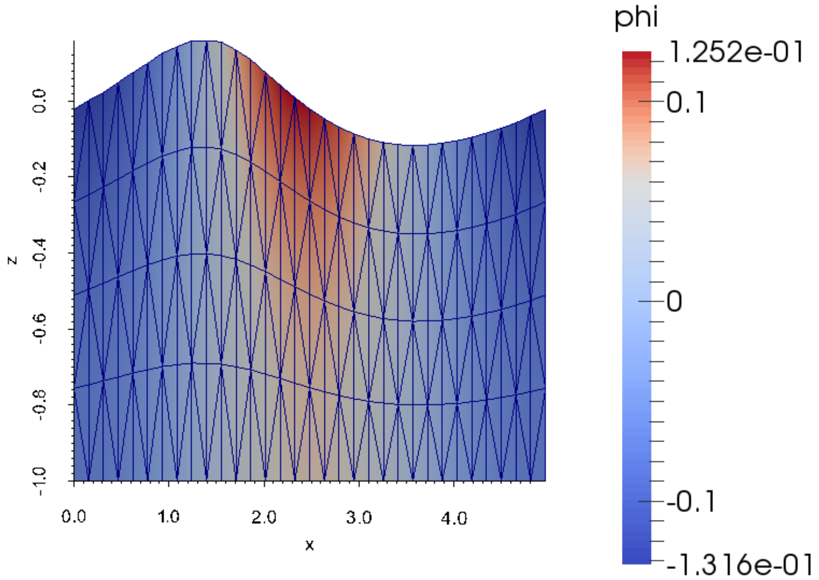
Matteo Briani
Annie Cuyt
Wen-Shin Lee
name.surname@uantwerpen.be

hpGEM: Software Library for Discontinuous and Conforming Finite Element Methods

Freekjan Brink, Anthony Thornton, Jaap van der Vegt
University of Twente

hpGEM offers:

- Fast and efficient implementation of finite element methods,
- Coupling with mesh generation and plotting software,
- Mixed mesh support,
- Applications: Water waves, Maxwell equations, granular flows, etc.



Source code, detailed information and full authors list available at hpGEM.org

Accurate Modeling of Light Propagation inside Photonic Crystals

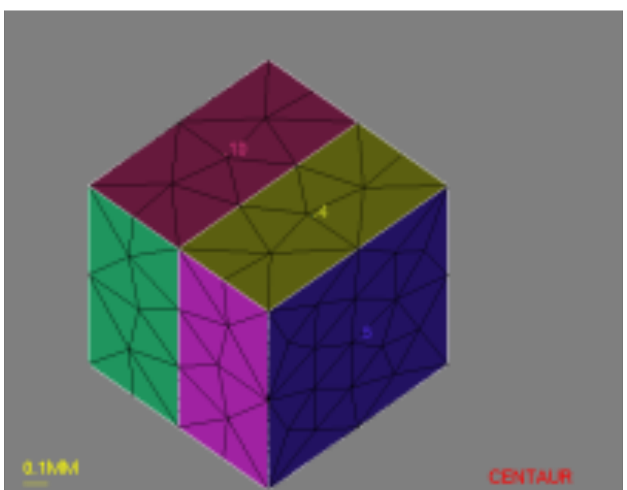
Devashish[1,2] , Freekjan Brink[1], Willem L. Vos[2], , Jaap van der Vegt[1]
[1] = Mathematics of Computational Science (MACS) , University of Twente
[2] = Complex Photonic Systems (COPS) , University of Twente

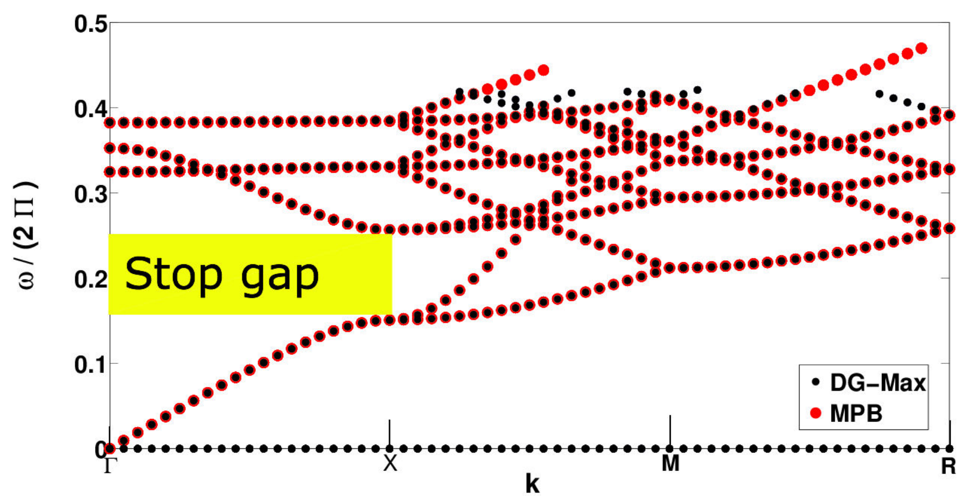
Aim

To develop a fast and parallelized discontinuous Galerkin finite-element (DGFEM) eigenvalue solver for the time-harmonic Maxwell equations.

Photonic Crystals

- Natural or artificial materials with spatial periodicity in the dielectric coefficient.
- Light propagation inside photonic crystals is described by the time-harmonic Maxwell equations.



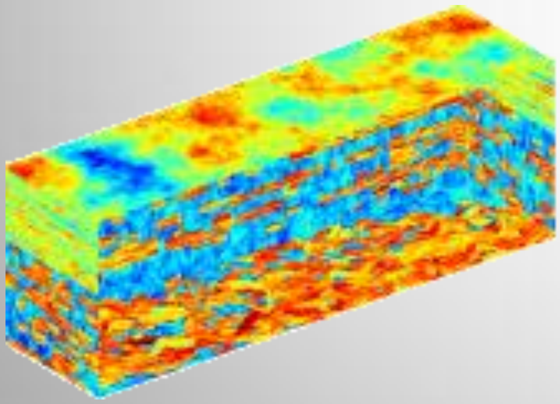


Physics-based preconditioners for large-scale subsurface flow simulation.

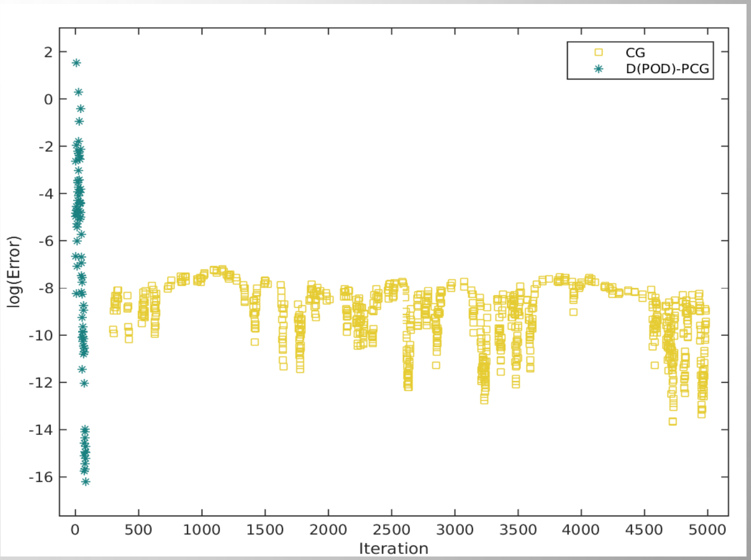
Gabriela Berenice Díaz Cortés

Prof. Kees Vuik
Prof J.D. Jansen

TU Delft



SPE 10



Optimization of Chaotic systems

$\Longrightarrow$ Calculate sensitivity of statistical averages of chaotic systems

Example: Lorenz system

$$\langle z \rangle \propto \rho$$

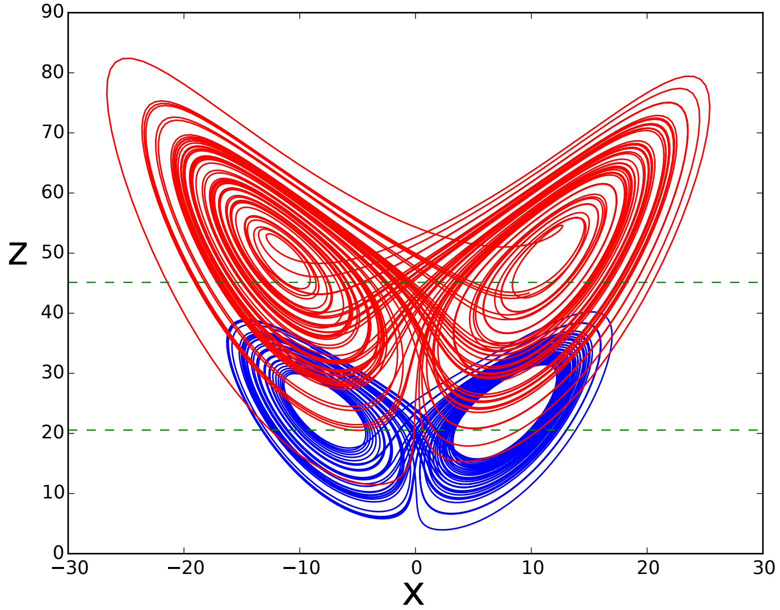
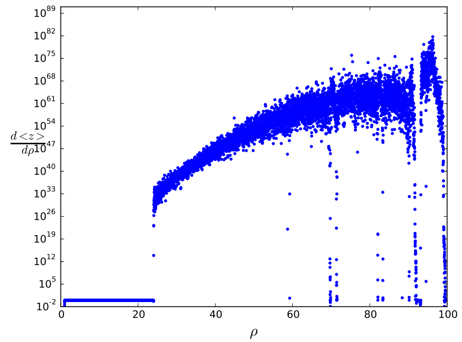
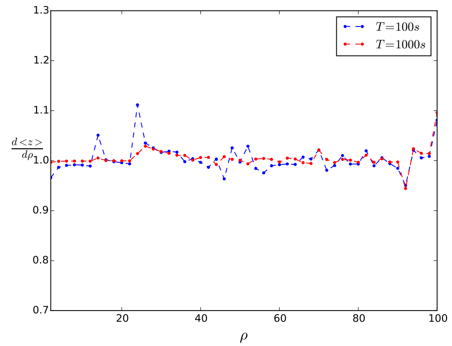


Figure: Average z-value

Using variational equations:



Using *least squares shadowing*:



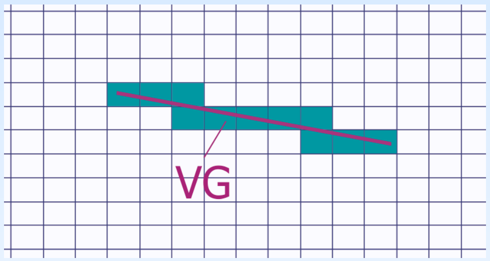
Efficient CFD simulations of vortex generator induced flow phenomena

ir. Liesbeth Florentie
Ph.D. Candidate
TU Delft - Aerospace Engineering
Supervisors: H. Bijl & A.H. van Zuijlen

Problem:

Body-fitted mesh simulations infeasible due to large scale difference

→ **Mimic effect of vortex generator on flow by source term in governing equations**



- ✓ Analysis of existing model
- ✓ Calculation of optimal source term with adjoint approach
- ✓ Turbulence models (RANS)

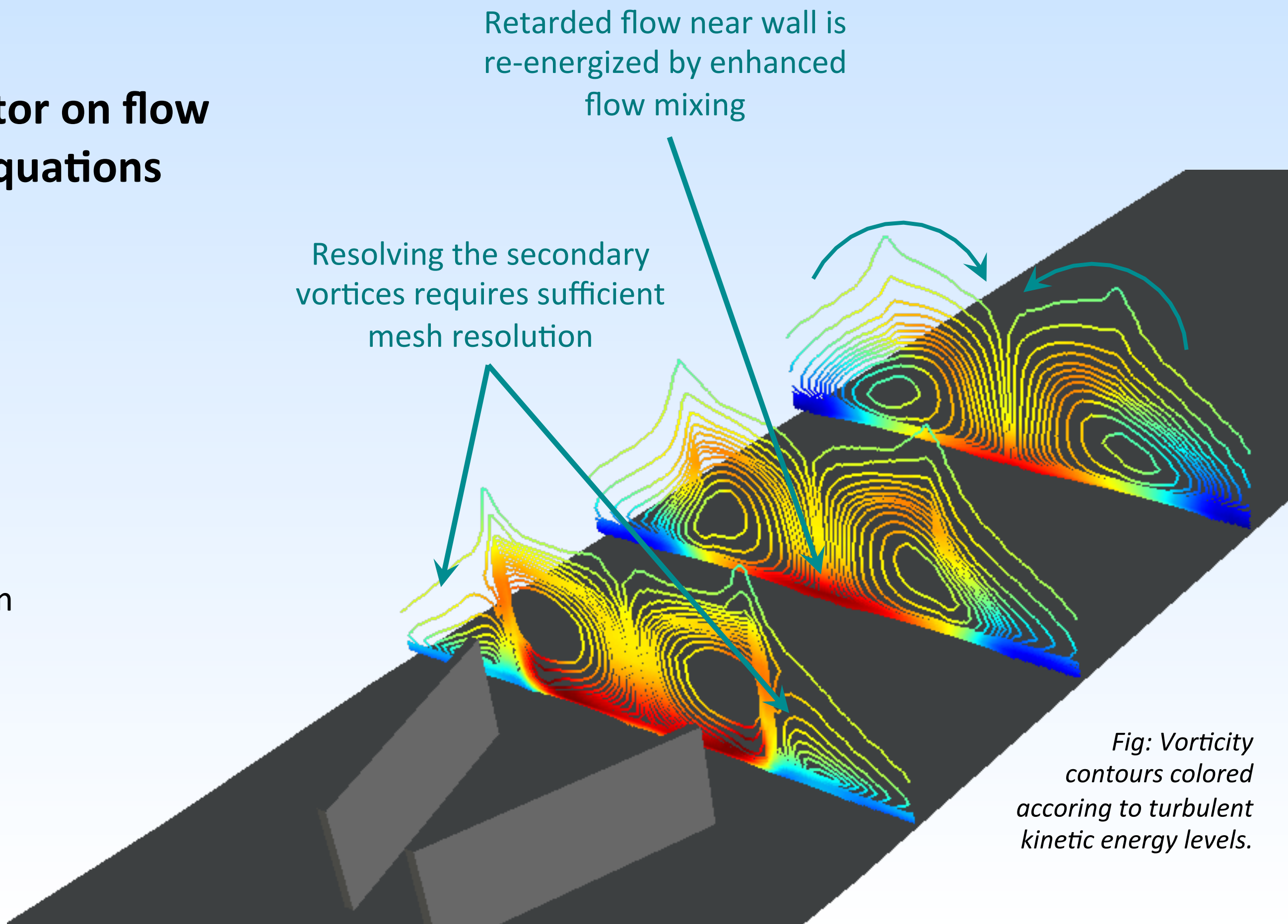
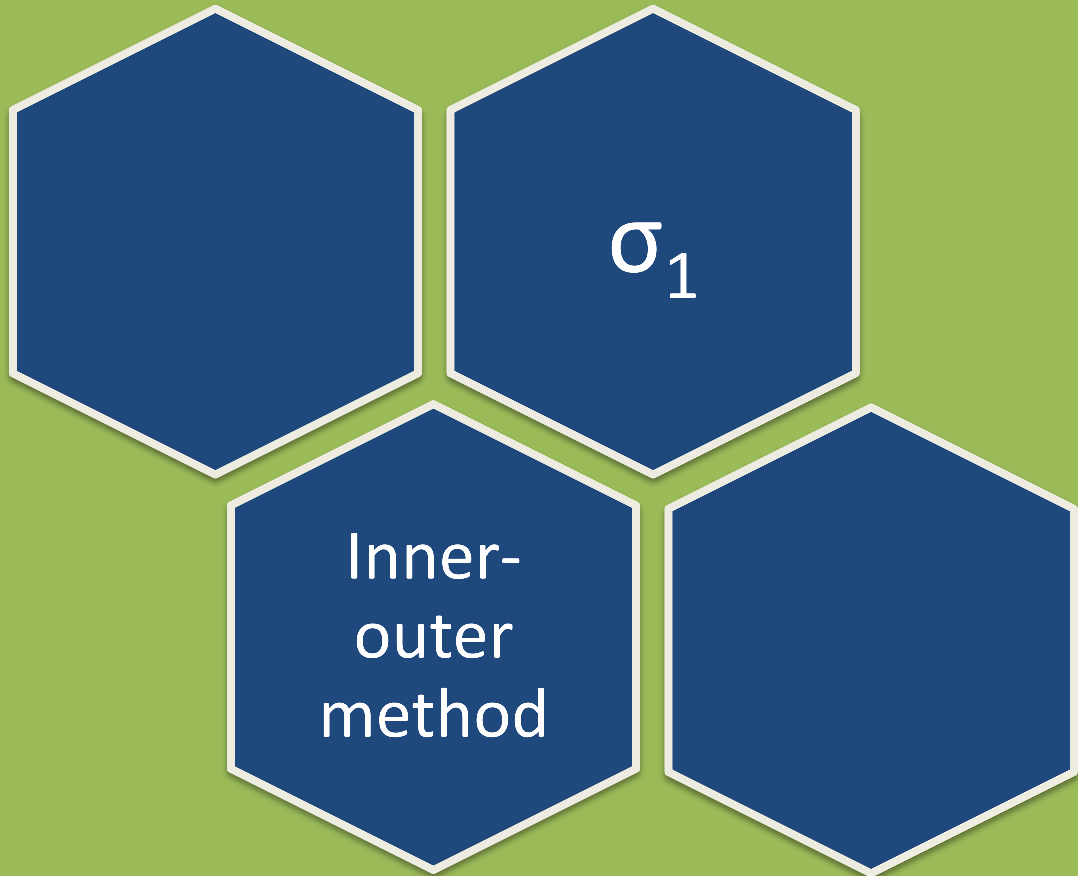


Fig: Vorticity contours colored accoring to turbulent kinetic energy levels.

TU Delft

Approximating $||f(A)||_2$

with inexact Lanczos bidiagonalization



Sarah W. Gaaf
TU/e

Numerical methods for decoupled forward-backward SDEs in finance

Z. van der Have C.W. Oosterlee

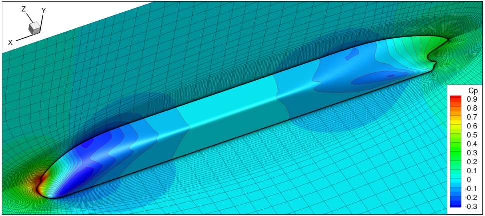
Delft University of Technology, Delft
Centrum Wiskunde & Informatica, Amsterdam

October 7-9, 2015

Block preconditioner for finite volume methods used in maritime CFD

Xin He and Kees Vuik

Delft Institute of Applied Mathematics,
Delft University of Technology, Netherlands

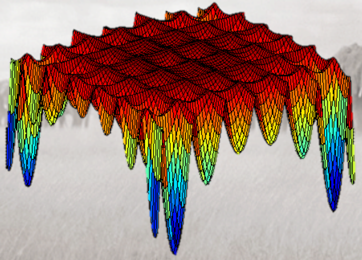


Pressure coefficient obtained on model scale tanker

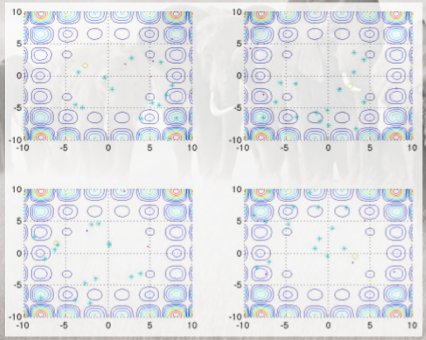
Elephant Herd Algorithm for multi-modal optimization

Ajinkya Kadu, Mritunjay Prasad, R. P. Shimpi

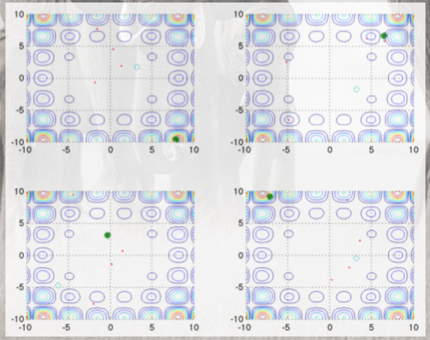
Holder Table Function



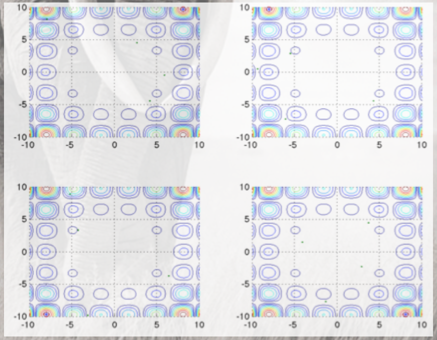
After 10 iterations



After 100 iterations



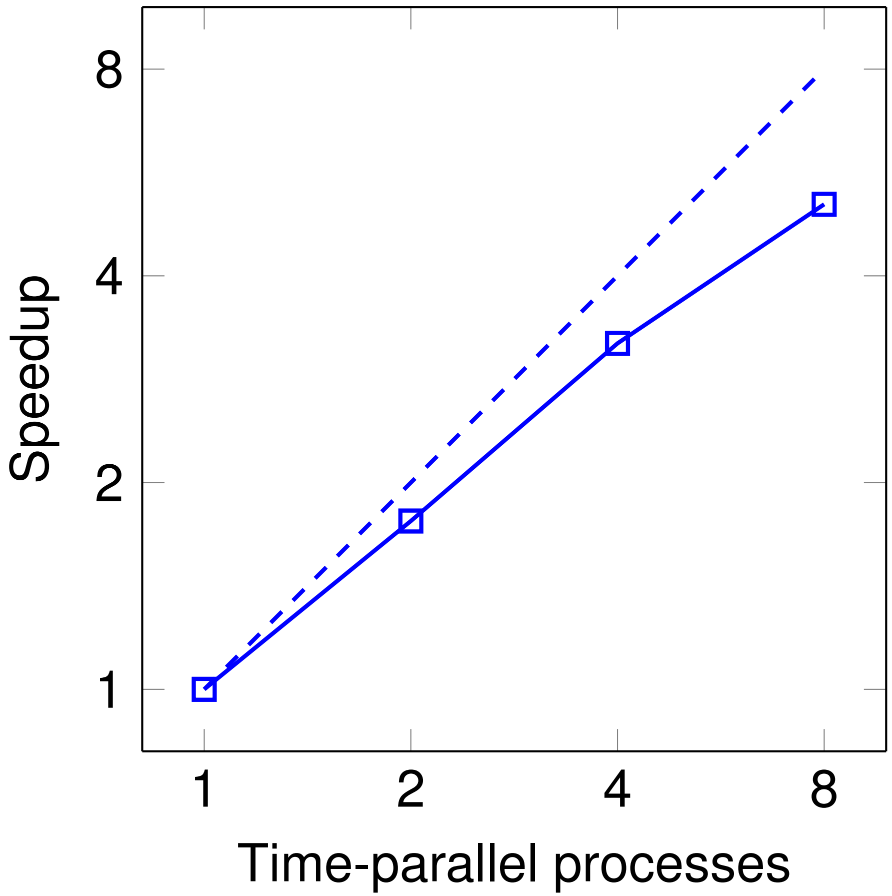
After 1000 iterations

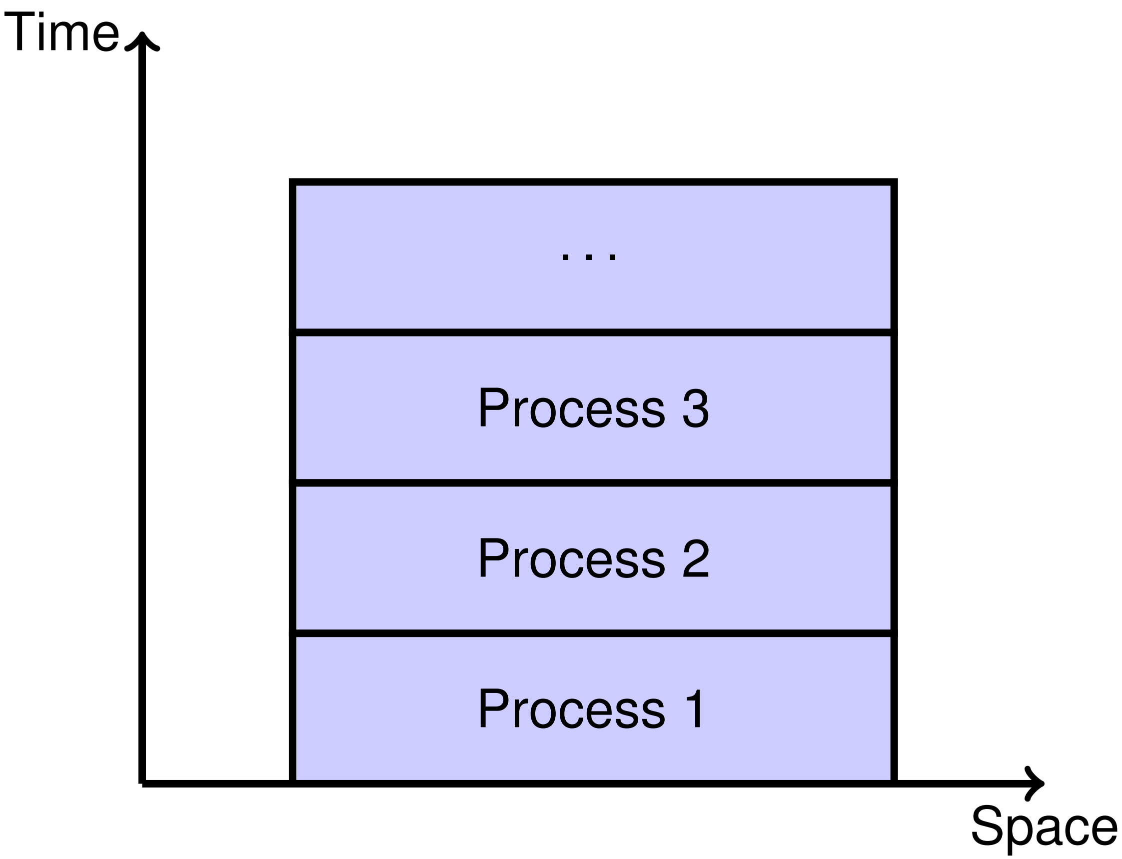


Parallel time integration of nonlinear partial differential equations

Gijs L. Kooij* Mike A. Botchev Bernard J. Geurts

Burgers' equation ($u_t + uu_x = \nu u_{xx}$)

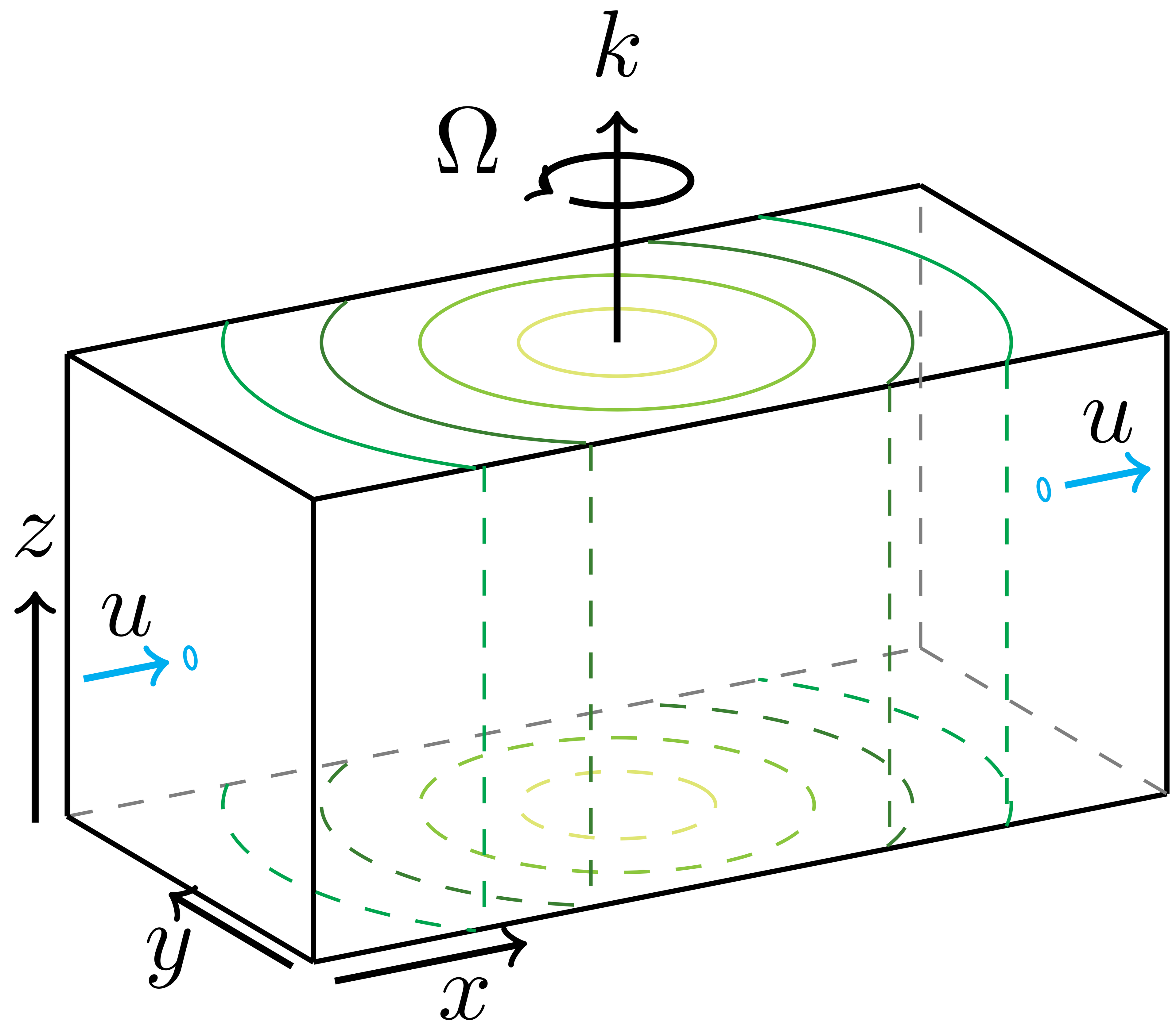


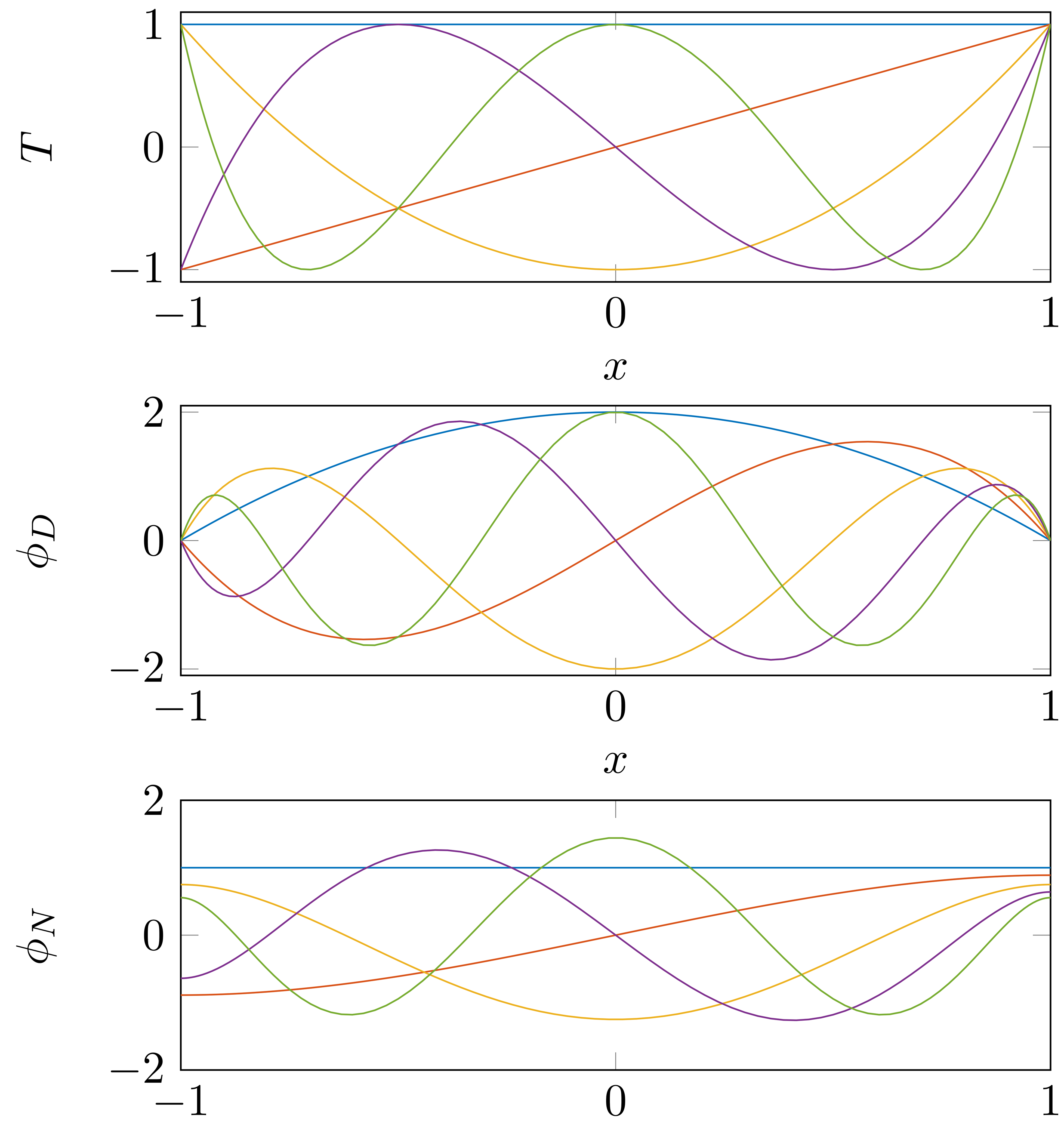


UNIVERSITY OF TWENTE. FOM

A nearly optimal Chebyshev method for inertial waves

Anna Kruseman, Utrecht University





Computation of Interface Velocities in the incompressible Navier-Stokes equations using Local BVPs

Nikhil Kumar, Jan ten Thije Boonkkamp, Barry Koren

Centre for Analysis, Scientific computing and Applications
Department of Mathematics and Computer Science
Eindhoven University of Technology

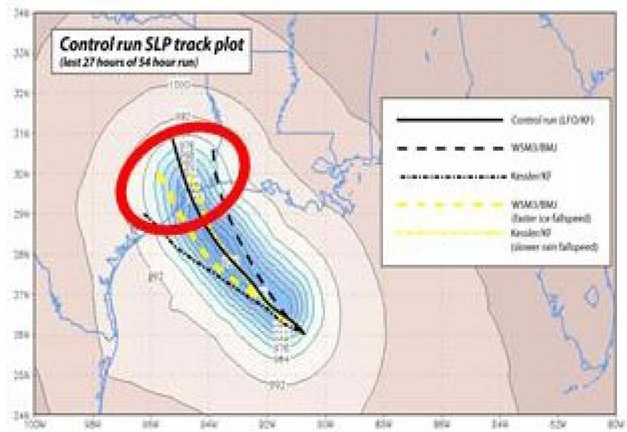
Universiteit Utrecht

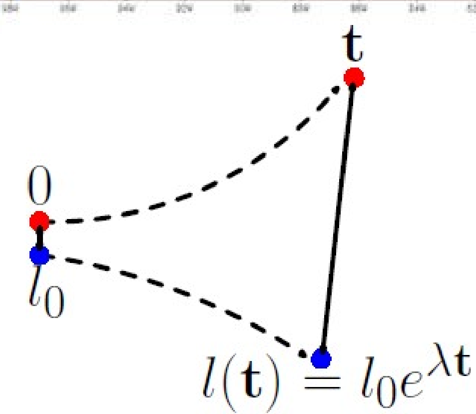
CWI
Centrum Wiskunde & Informatica

Geometric aspects of data assimilation

Bart de Leeuw, Svetlana Dubinkina, Jason Frank
Scientific Computing group, **Centrum Wiskunde & Informatica**, www.cwi.nl
Mathemetics Department, **Utrecht University**, www.math.uu.nl

- Data assimilation: finding a compromise between observations and current model state estimates
- Usually consists of cleverly weighted averaging
- However, model geometry influences statistics
- We want to improve data assimilation methods using model geometry, such as conservation laws and dynamical structure





Parallel Block Multilevel Incomplete LU Factorization Preconditioners

Jia Liao - University of Groningen (The Netherlands)

✗ We developed a Parallel Variable Block Algebraic Recursive Multilevel solver for distributed memory computers,.

✗ Excellent performance and strong parallel scalability of our solver were achieved from solving Computational Fluid Dynamics applications matrices.

Optics on phase space and Liouville's equation

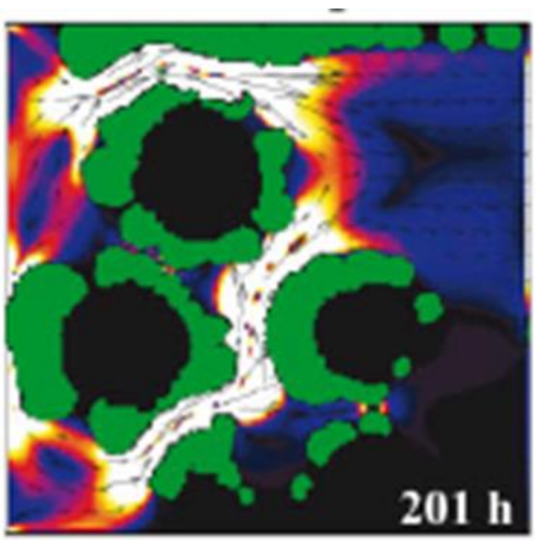
- Much light is wasted!
- Need better optics.
- Ray tracing is slow (and boring).
- Idea: use Liouville's equation.

Bart van Lith

Technische Universiteit Eindhoven University of Technology

PHILIPS

Modeling of Biofilm Growth in Porous Media



Luis Antonio López Peña

Dr. Ir. Fred Vermolen
Dr. Ir. Bernard Meulenbroek

EWI, TU DELFT

On an Uzawa Smoother in Multigrid for Poroelasticity Equations

P. Luo, C. Rodrigo, F.J. Gaspar, C.W. Oosterlee

- An Uzawa smoother for the multigrid method has been introduced.
- LFA analysis helps to determine each component of multigrid method.
- To improve the convergence performance, acceleration of multigrid by iterant recombination scheme is taken into account.

Temporal Oscillations in the simulation of Foam Enhanced Oil Recovery

Jakolien van der Meer[1], Matthias Möller[1], Hans Kraaijevanger[2], Hans Groot[2], Johan Romate[2], Jan Dirk Jansen[1],
[1]TU Delft, [2] Shell Rijswijk

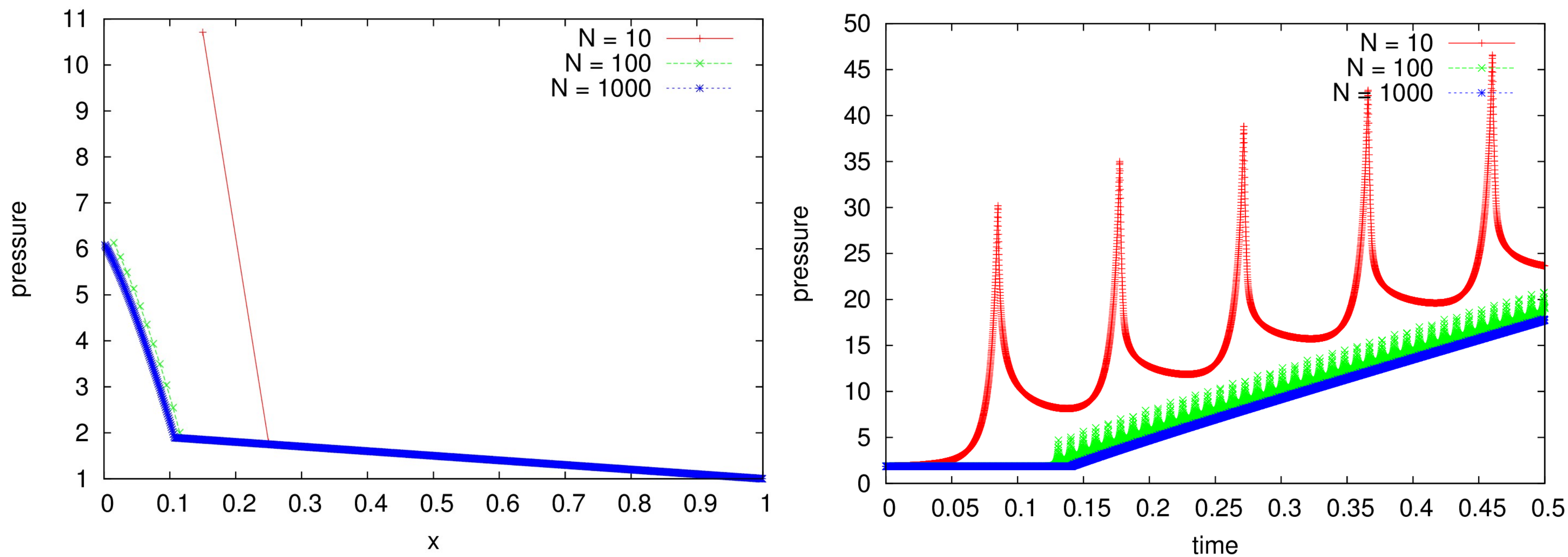
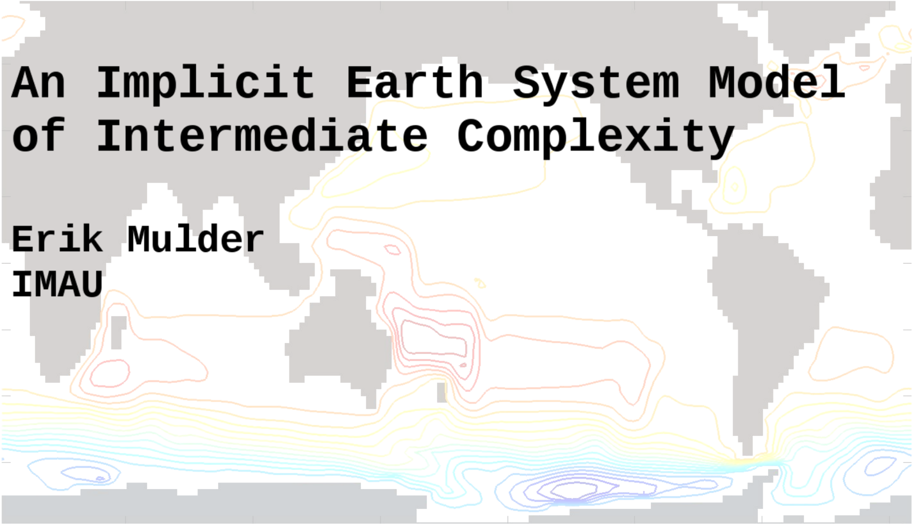
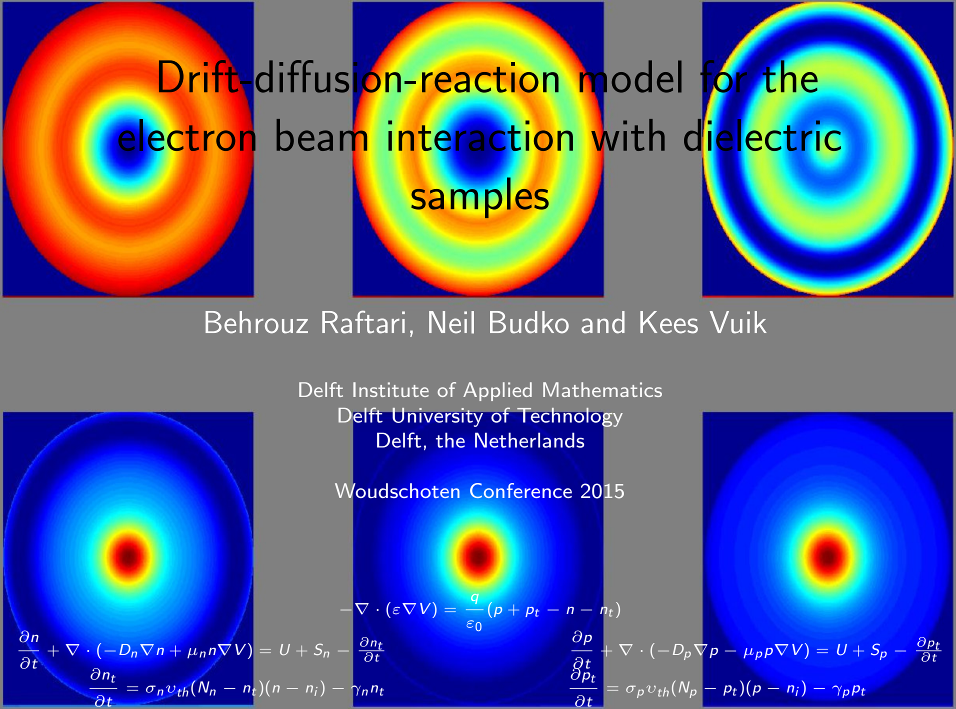


Figure: Oscillations due to generation of foam for different grid resolutions.

An Implicit Earth System Model of Intermediate Complexity

Erik Mulder
IMAU





Drift-diffusion-reaction model for the electron beam interaction with dielectric samples

Behrouz Raftari, Neil Budko and Kees Vuik

Delft Institute of Applied Mathematics
Delft University of Technology
Delft, the Netherlands

Woudschoten Conference 2015

$$-\nabla \cdot (\varepsilon \nabla V) = \frac{q}{\varepsilon_0}(p + p_t - n - n_t)$$

$$\frac{\partial n}{\partial t} + \nabla \cdot (-D_n \nabla n + \mu_n n \nabla V) = U + S_n - \frac{\partial n_t}{\partial t}$$

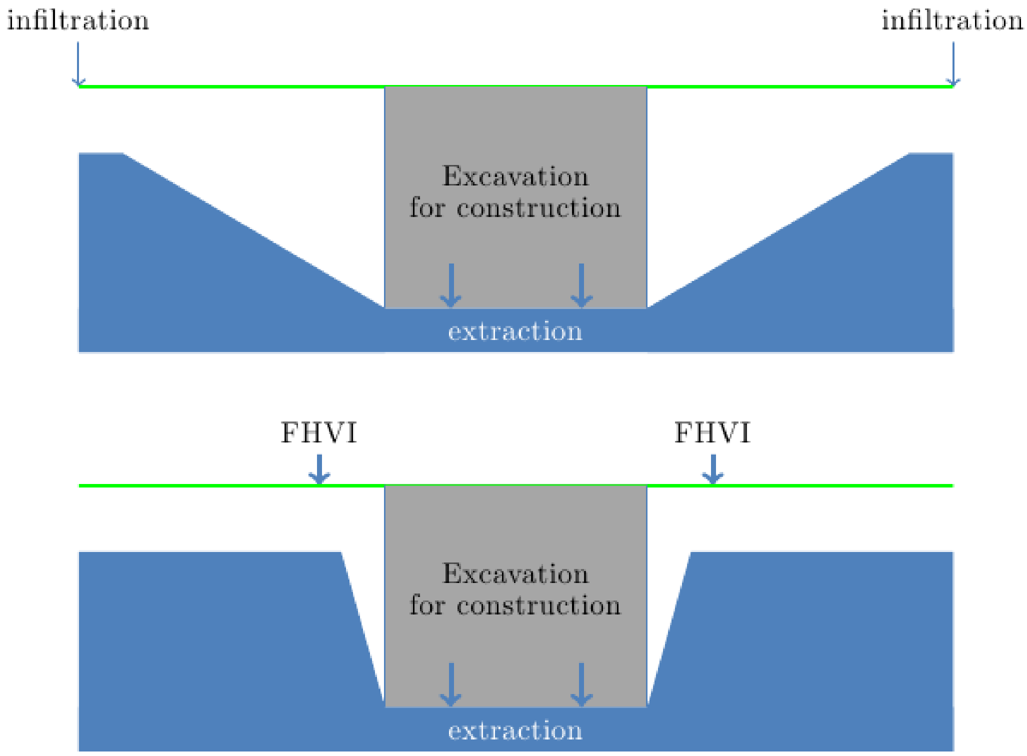
$$\frac{\partial n_t}{\partial t} = \sigma_n \upsilon_{th}(N_n - n_t)(n - n_i) - \gamma_n n_t$$

$$\frac{\partial p}{\partial t} + \nabla \cdot (-D_p \nabla p - \mu_p p \nabla V) = U + S_p - \frac{\partial p_t}{\partial t}$$

$$\frac{\partial p_t}{\partial t} = \sigma_p \upsilon_{th}(N_p - p_t)(p - n_i) - \gamma_p p_t$$

Fast, High Volume Infiltration

Menel Rahrah **Fred Vermolen** **Kees Vuik**



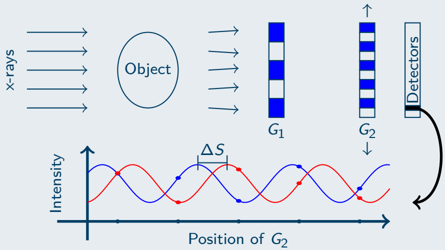
Multilevel Monte Carlo Methods for Problems in Uncertainty Quantification

Pieterjan Robbe

A Regularization Method For Phase Contrast Computed Tomograhpy

Nick Schenkels

Data acquisition through Phase Stepping



Can lead to higher contrast reconstructions in various applications.

We solve the resulting linear system via Tikhonov regularization:

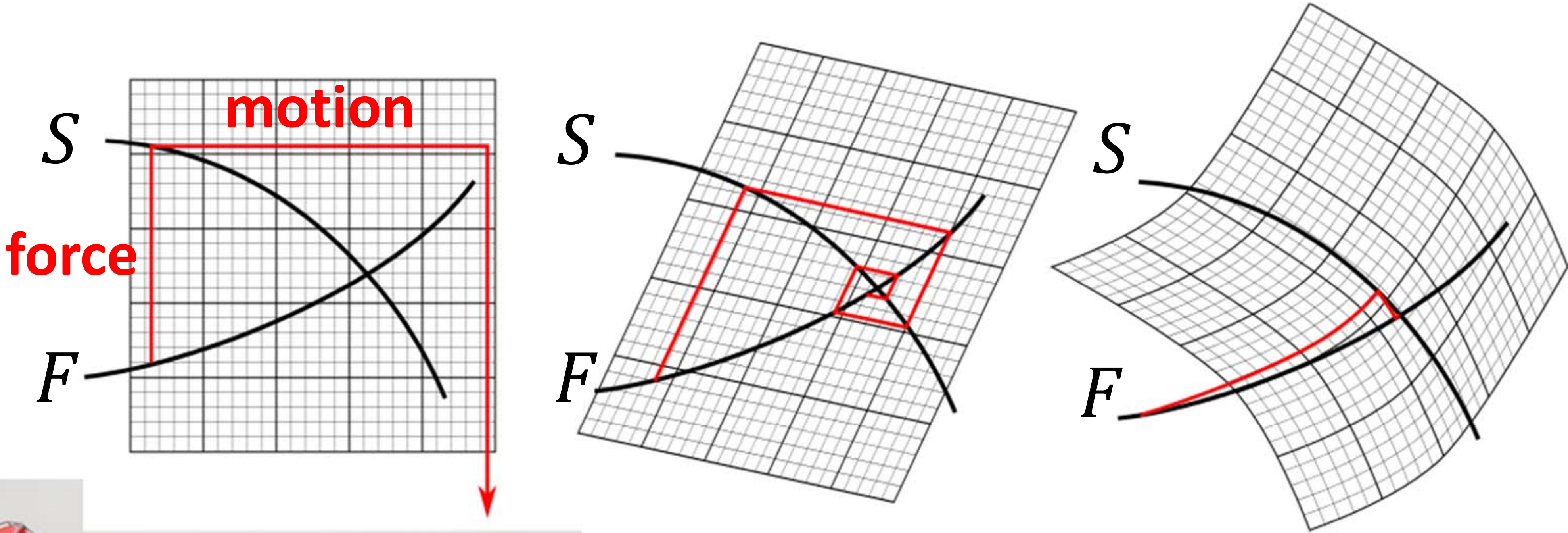
$$\min_x \|b - Ax\|_2^2 + \lambda \|x\|_2^2$$

λ is chosen iteratively based on the discrepancy principle.

A is the product of a finite difference operator & the original projection matrix for absorption contrast tomography.

Universiteit Antwerpen

Anticipatory interaction scheme for moving rigid bodies in free-surface flow



The response of the ship is *anticipated* in the boundary conditions of the fluid

ir. Henk Seubers
Johann Bernoulli Institute
rijksuniversiteit groningen

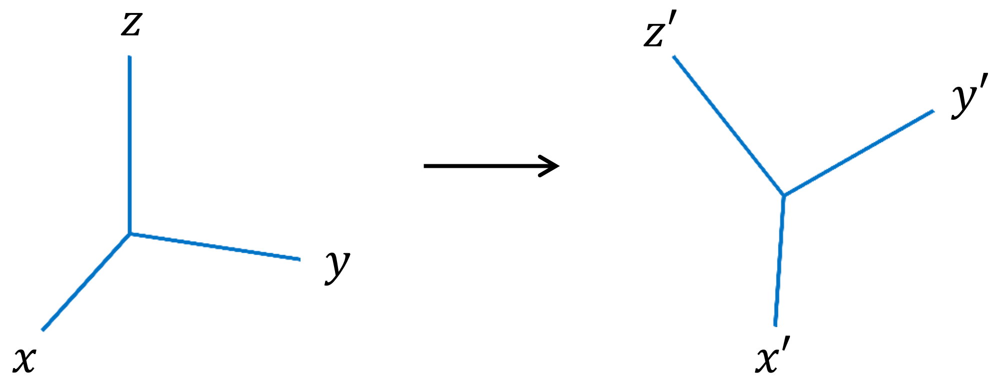
university of groningen
faculty of mathematics and natural sciences
johann bernoulli institute for mathematics and computer science

Maurits Silvis & Roel Verstappen

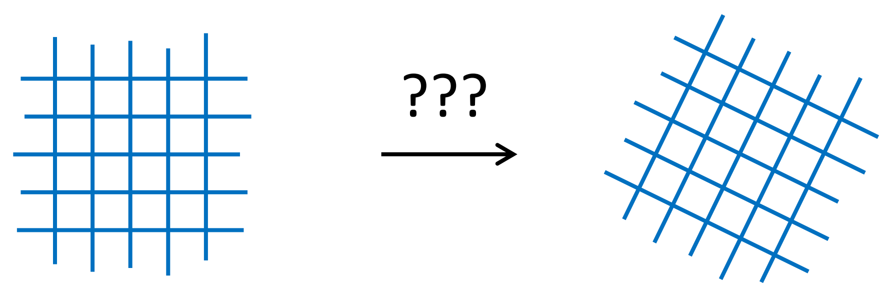
WSC 40th Woudschoten Conference | October 7-9, 2015

Symmetry-preserving subgrid-scale models for large-eddy simulation of turbulent flows

- Continuous level



- Discrete level



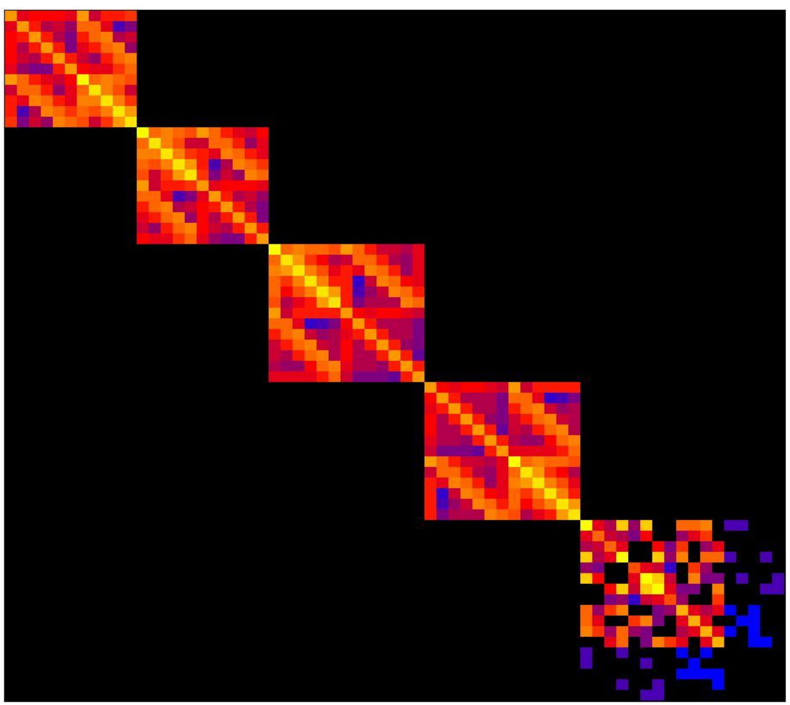
A Highly Parallel Code for Strongly Coupled Fluid-Transport Equations

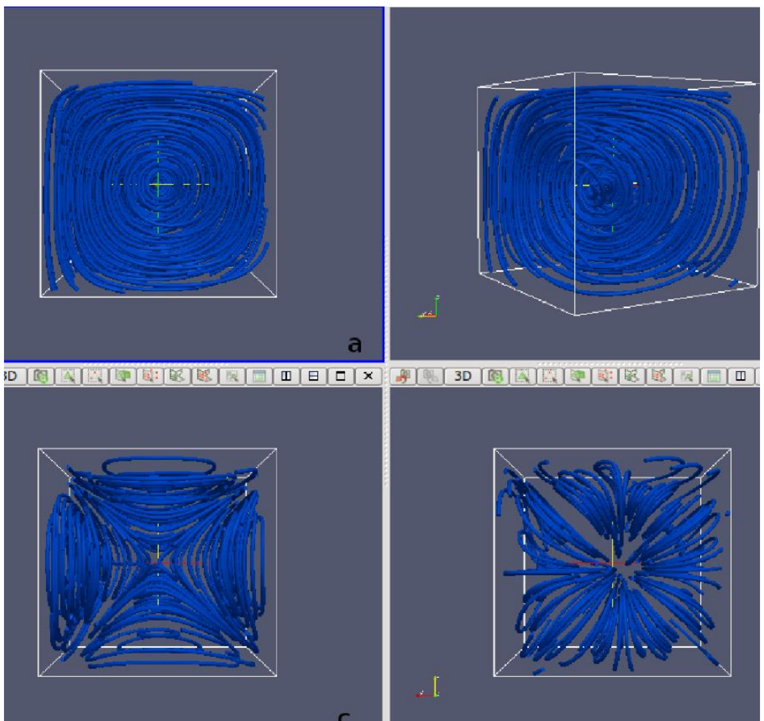
W. Song (RUG & DLR), F. W. Wubs (RUG), J. Thies (DLR)

Hybrid direct\iterative multi-level linear solver:
Parallel, scable, robust...

-Eigen pairs computation

-Bifurcation analysis





Block GMRES-DR method for linear systems with multiple shifts and multiple right-hand sides

Dong-Lin Sun (UESTC, RUG), Ting-Zhu Huang (UESTC), Yan-Fei Jing (UESTC), Bruno Carpentieri (RUG)

- We proposed a new shifted block GMRES method for solving linear systems with multiple shifts and multiple right-hand sides.

- In our method, we augment the space with directions associated with some approximations of selected eigenvalues and solve the multiple linear systems simultaneously.

- Moreover, the seed selection strategy is employed to improve the performance of our method.

Speeding Up Monte Carlo Simulation Using An Emulator

A.K. Tyagi, W.H.A. Schilders, X. Jonsson, T.G.J. Beelen

Center for Analysis, Scientific Computing and Applications (CASA),

Mentor Graphics®, Grenoble (FR)

Technische Universiteit
Eindhoven
University of Technology

October 7-9, 2015

Where innovation starts

Fitted SSP Schemes for Black-Scholes-Barenblatt

R. Valkov
Department of Mathematics and Computer Science, University of Antwerp
radoslav.valkov@uantwerpen.be

Let us consider the following controlled HJB PDE [Avellaneda et al. 1995]

$$\frac{\partial V}{\partial t} - \inf_{\sigma \in [\sigma_{\min}, \sigma_{\max}]} \left(\frac{\sigma^2}{2} S^2 \frac{\partial^2 V}{\partial S^2} + (r - D) S \frac{\partial V}{\partial S} \right) + rV = 0, (S,t) \in R_+ \times (0, T]$$

with butterfly payoff: $h(S) = \max(\mathrm{S} - \mathrm{K}_1, 0) - 2\max(\mathrm{S} - \mathrm{K}, 0) + \max(\mathrm{S} - \mathrm{K}_2, 0)$

Formally differentiate with respect to S and arrive at the BSB Delta PDE

$$\frac{\partial W}{\partial t} - \frac{\partial}{\partial S}\left(\inf_{\sigma \in [\sigma_{\min}, \sigma_{\max}]} \left(\frac{\sigma^2}{2} S^2 \frac{\partial W}{\partial S} + (r - D) S W \right) \right) + rW = 0, (S,t) \in R_+ \times (0, T]$$

with "digital" (disc.) payoff: $h(S) = H(\mathrm{S} - \mathrm{K}_1) - 2H(\mathrm{S} - \mathrm{K}) + H(\mathrm{S} - \mathrm{K}_2)$

where $W := V_S$ is the "Delta" Greek and $H(x)$ is the Heaviside function

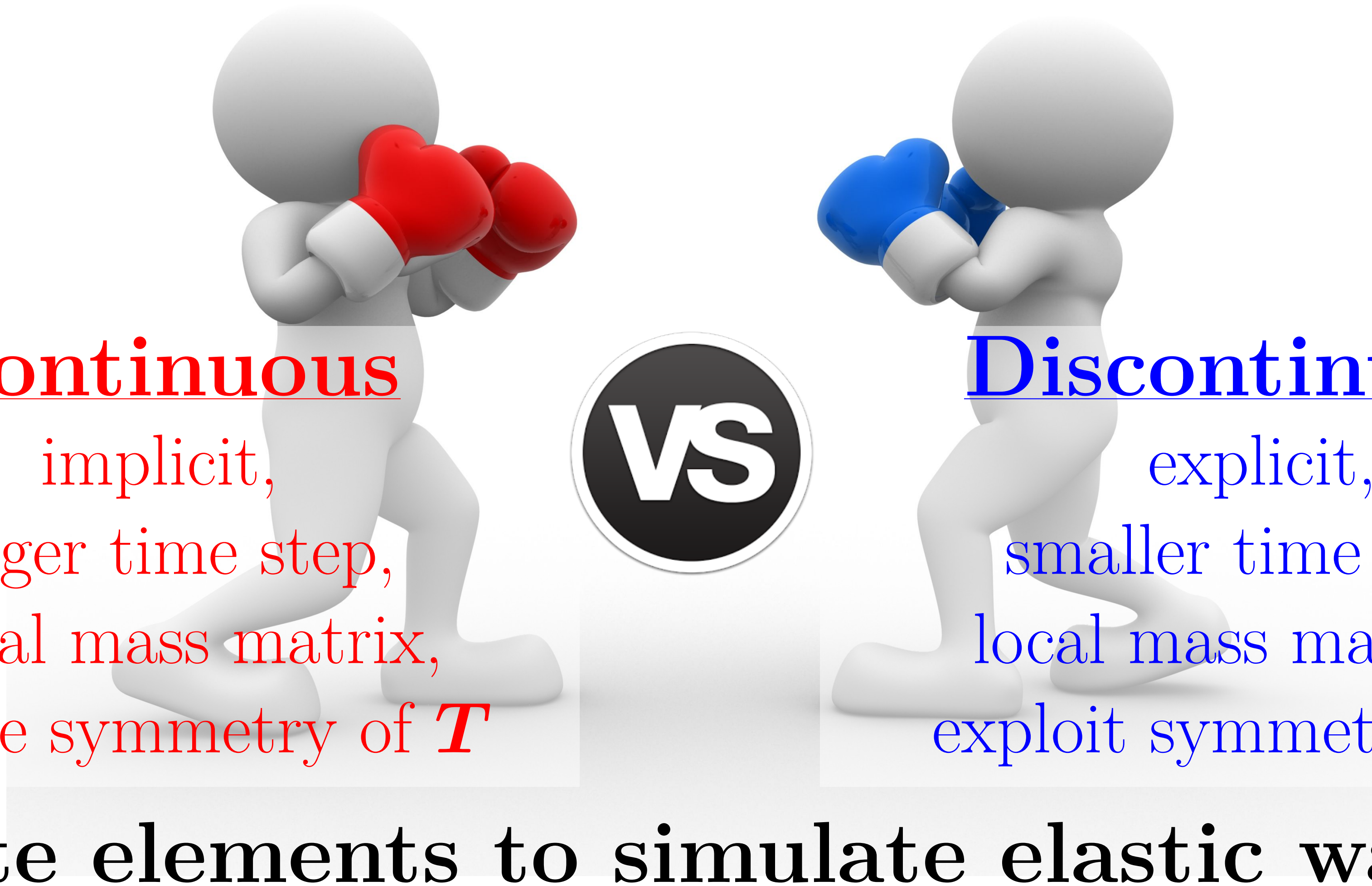
[1] R. Valkov, Fitted strong stability-preserving schemes for the Black-Scholes Barenblatt equation, IJCM (2015)
[2] R. Valkov, Predictor-corrector balance method for the worst-case 1D option pricing, CMAM (2015)

Numerical analysis
BSB "Delta" PDE

Fitted finite volume scheme
Strong-stability preserving [1]

- **Spatial discretization by fitted flux optimization**
- **Higher-order monotone Runge-Kutta time-marching**
- **Monotonicity and consistency analysis**
- **Generalized to the case of uncertain dividend yield and a general FVM [2]**
- **Comprehensive computational results**

The battle of



Continuous

implicit,
larger time step,
global mass matrix,
impose symmetry of $\boldsymbol{T}$

Discontinuous

explicit,
smaller time step,
local mass matrices,
exploit symmetry of $\boldsymbol{T}$

finite elements to simulate elastic waves

$$\boldsymbol{\mathcal{C}}^{-1} : \dot{\boldsymbol{T}} = 0.5\left(\nabla \boldsymbol{v} + (\nabla \boldsymbol{v})^T\right)$$

$$\rho \dot{\boldsymbol{v}} = \nabla \cdot \boldsymbol{T} + \boldsymbol{f}$$

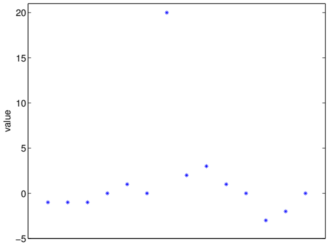
Steven Vandekerckhove, Hannes Vandecasteele

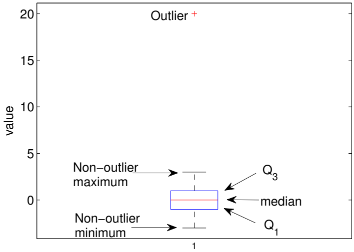
KU LEUVEN kulak

Automated parameters via outlier detection

Thea Vuik

Hyperbolic conservation, DG, Multiwavelets, Troubled cells, Limiting

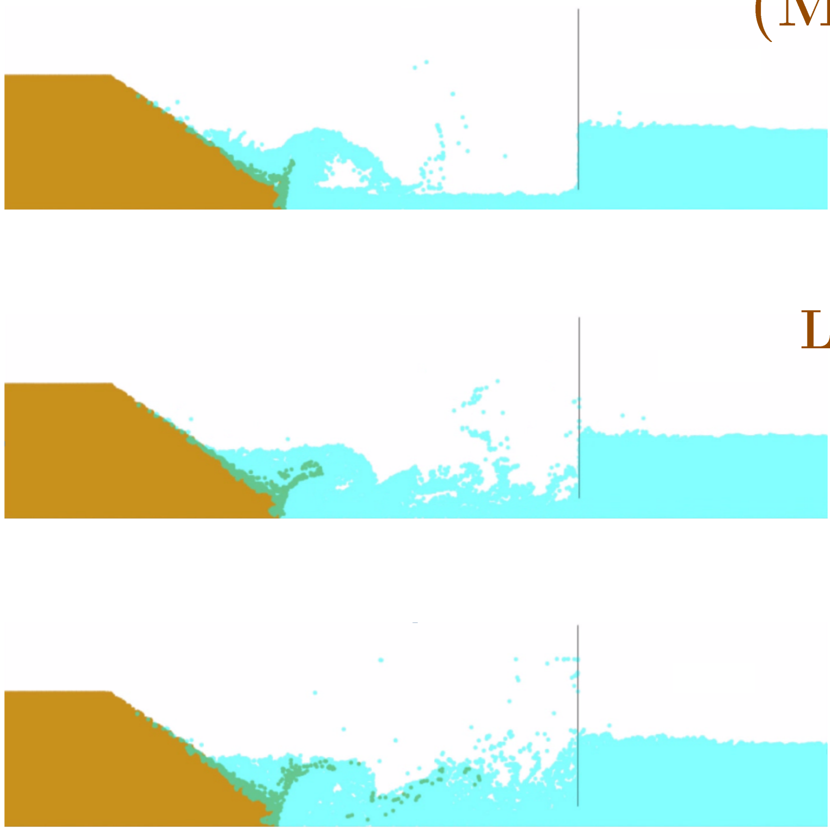


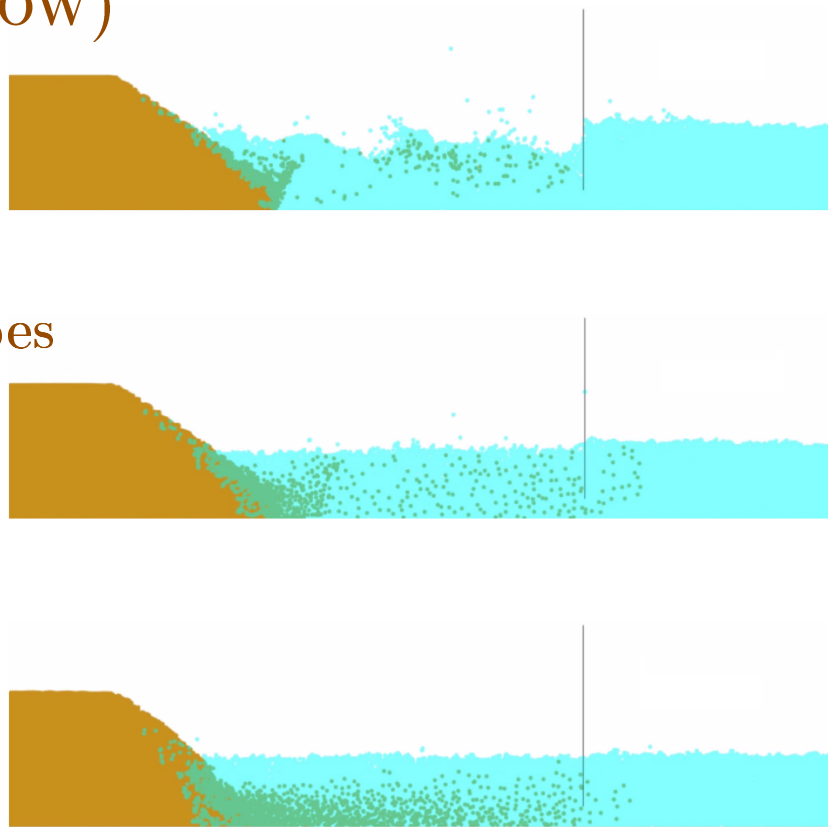


TU Delft Delft University of Technology

Deltares Enabling Delta Life

UNDERSTANDING FLOW SLIDES IN FLOOD DEFENCES (MPM-FLOW)



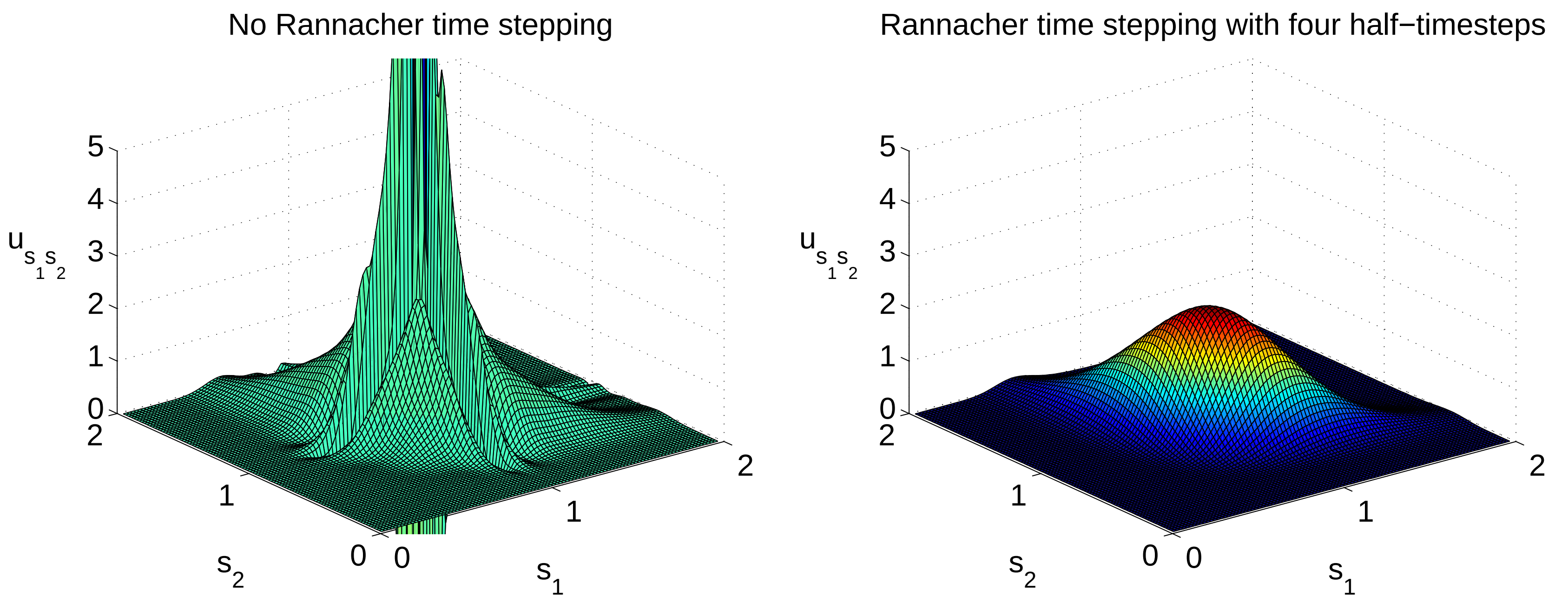


Lisa Wobbes

Więckowski (2013)

Convergence analysis of the Modified Craig–Sneyd scheme in 2 dimensions for nonsmooth initial data

40^{e} Woudschoten Conferentie, October 2015

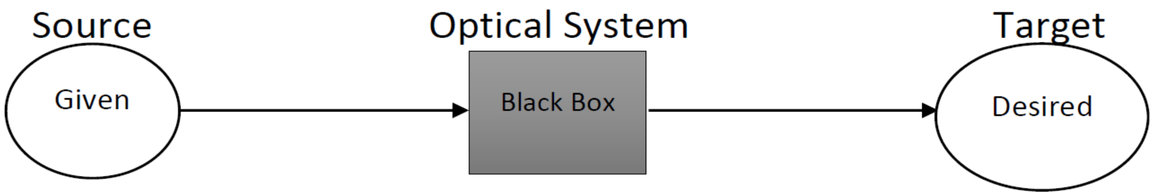


Universiteit Antwerpen

Maarten Wyns

Illumination Optics : Optimal Transport for Optical Design

N.K. Yadav, J.H.M. ten Thije Boonkkamp,
W.L. IJzerman



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