



## Thursday afternoon 9 October

- |                    |  |
|--------------------|--|
| 14:30 - 15:00 Hour | One-minute session (for presenting poster)<br>Line-up (alphabetic order, see booklet)<br><i>Room 27/28</i> |
| 15:00 - 16:30 Hour | Poster session, incl. coffee/tea<br><i>Vide (first floor), Foyer</i>                                       |

N.B. The posters boards will be available till **Friday** departure time!



# Numerical analysis of a nonlinear partial integro-differential equation

Samir Kumar Bhowmik, Department of Mathematics, University of Amsterdam, the Netherlands, e-mail: bhowmiksk@gmail.com

## Abstract

Piecewise collocation-finite element and Galerkin-finite element methods are proposed and analysed for an nonlinear partial integro-differential equation that arises in the modeling of phase transitions. We compute solutions in both methods using some standard quadrature rules. We present the order of accuracy of such semidiscrete time dependent problem with full integral and quadrature for the Galerkin inner product considering both the real solutions and the approximate solutions are sufficiently smooth in whole domain  $\Omega$ . We also find an upper bound considering the approximate solutions are  $L_2$  in  $\Omega$  and  $H^s$ ,  $s \geq 0$  in each subdomain  $\Omega_i$  such that  $\Omega = \cup_i \Omega_i$ .

# Geometric Multigrid for PDEs on Stretched Grids

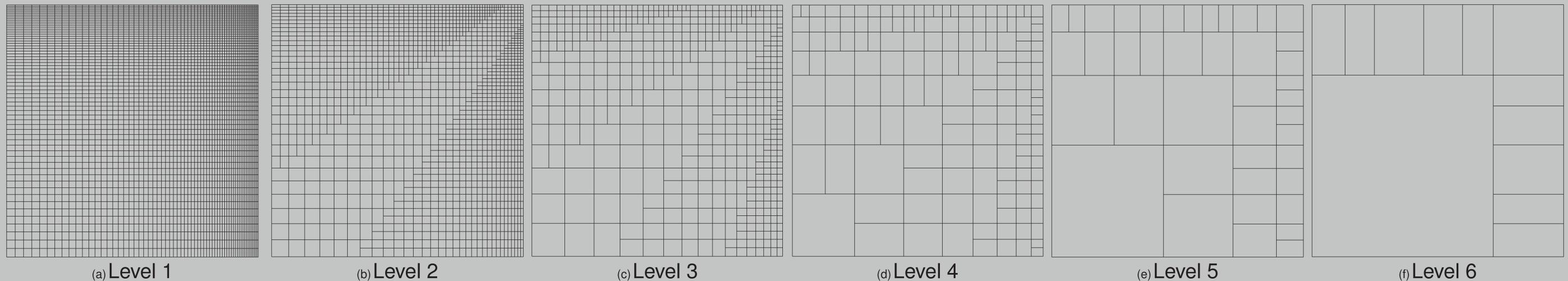
H. bin Zubair (TUDelft), S. P. Maclachlan (Tufts Univ.,US), C. W. Oosterlee (CWI Amsterdam)

Numerieke Wiskunde, DIAM, Delft University of Technology

## Current research objectives

Acquiring textbook multigrid convergence for elliptic model problems on rectangular domains, discretized on logarithmically stretched and locally refined grids. Exploiting the geometry for a priori coarse grid construction.

## Example of a predictable grid coarsening sequence



## Potential Target applications.

- ▶ Poisson-type equations (accomplished)
- ▶ Helmholtz equations (major work accomplished, completion underway)
- ▶ Maxwell equations for EM diffusion (near future)

# Numerical Integration of Damped Maxwell Equations



Mike Botchev (UTwente), Jan Verwer (CWI)

$$\partial_t B = -\nabla \times E$$

$$\varepsilon \partial_t E = \nabla \times (\mu^{-1}) B - \underbrace{\sigma E}_{\text{damping}} - J \quad \xrightarrow{\text{space discretization}}$$

$$\Rightarrow \begin{bmatrix} M_u & 0 \\ 0 & M_v \end{bmatrix} \begin{bmatrix} u' \\ v' \end{bmatrix} = \begin{bmatrix} 0 & -K \\ K^T & -S \end{bmatrix} \begin{bmatrix} u \\ v \end{bmatrix} + \begin{bmatrix} j_u \\ j_v \end{bmatrix} .$$

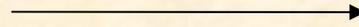
- How to build efficient higher-order integrators, such that
  - $(\nabla \times)$  wave terms are treated explicitly
  - damping terms are treated implicitly

# Solution of Darcy Flow by Density-Enthalpy Method

Ibrahim, C. Vuik, F. J. Vermolen, D. Hegen

Once we have computed

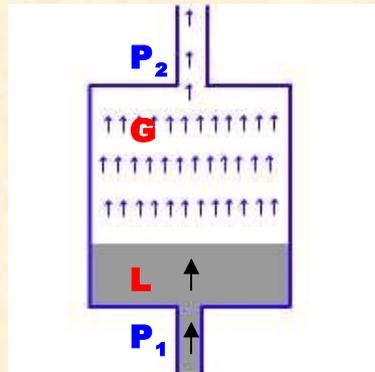
**Density & Enthalpy**



**Temperature, Pressure,  
Phase Fraction**

- **Energy Balance** and **Mass Balance** are used to solve the system.
- **Isolated** and **Open Systems** with respect to mass and energy are investigated in this work.
- System response for **Different Boundary Conditions** is computed.

**Boiler System**

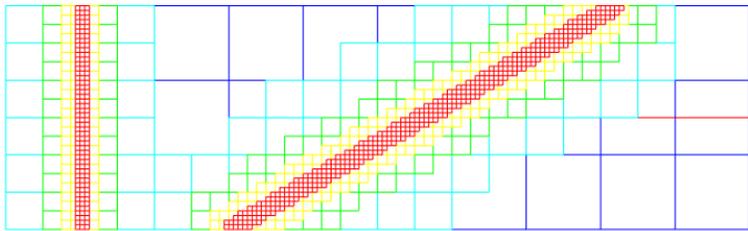


**Flow Through Porous Medium**

**References**

[1] Master Thesis of Abdelhaq Abouhafez "Finite Element Modeling of Thermal Processes With Phase Transitions", TUDelft, Netherlands.

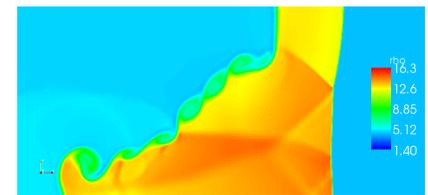
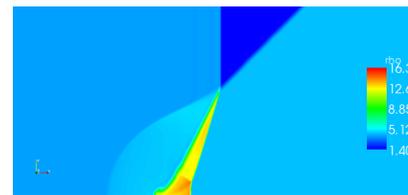
## AMRVAC



- Hybrid block-based AMR
- Richardson extrapolation
- Shock capturing algorithms
- Solving conservative equations:

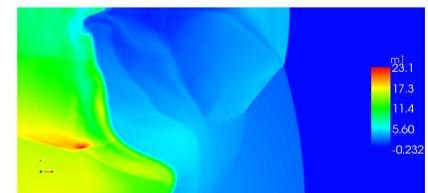
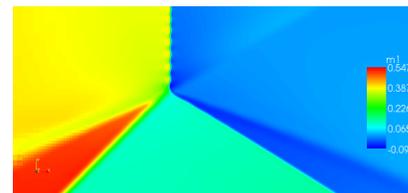
$$\partial_t \mathbf{U} + \nabla \cdot \mathbf{F}(\mathbf{U}) = \mathbf{S}(\mathbf{U}, \partial_i \mathbf{U}, \partial_i \partial_j \mathbf{U}, \mathbf{x}, t)$$

## 2D Hydrodynamics



- refraction in 3 waves
- instable contact

## 2.5D MHD

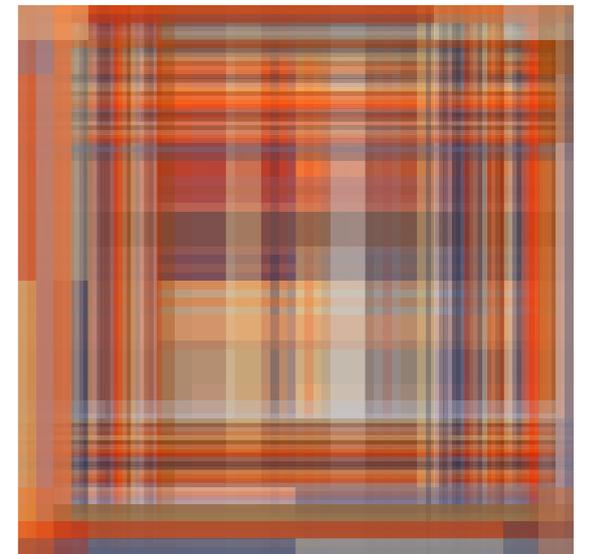


- refraction in 7 waves
- stable contact

# Approximation in high dimensional product domains

Tammo Jan Dijkema, UU

joint work with  
Rob Stevenson, UvA  
Christoph Schwab, ETH Zürich



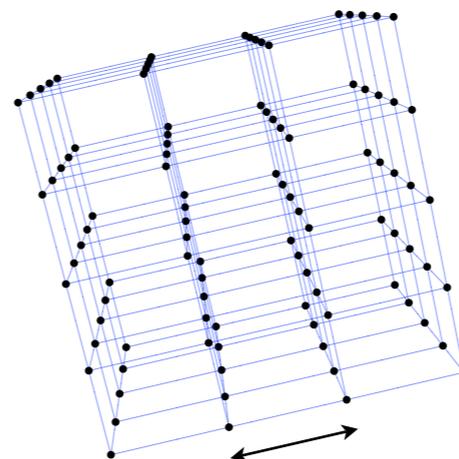
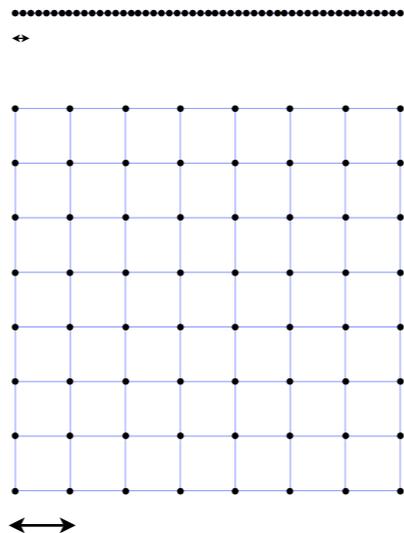
## THE CURSE OF DIMENSIONALITY

Approximate  $u \in L_2(\Omega^d)$   
by a piecewise constant  $u_h$ :

$$\|u - u_h\|_{L_2} \sim h$$

$$N \sim \frac{1}{h^d}$$

$$\|u - u_h\|_{L_2} \sim N^{-\frac{1}{d}}$$



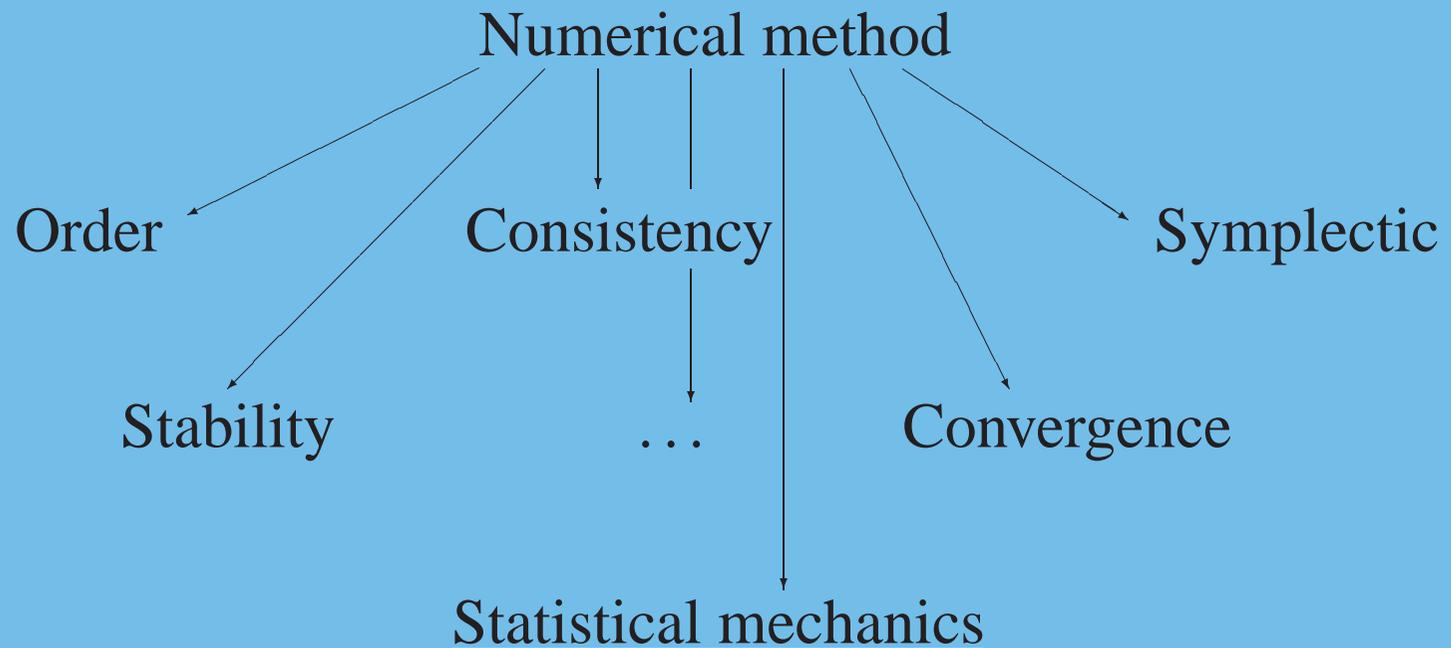
## Approaches:

- Sparse grids
- Adaptive wavelet method



# Statistical mechanics of a Hamiltonian particle-mesh method for incompressible flow over topography

Svetlana Dubinkina, Jason Frank  
CWI, Amsterdam, Netherlands



# Numerical Simulation of the Stirling-type pulse-tube refrigerator for 4 K

*M.A. Etaati*<sup>1</sup>

Supervisors:

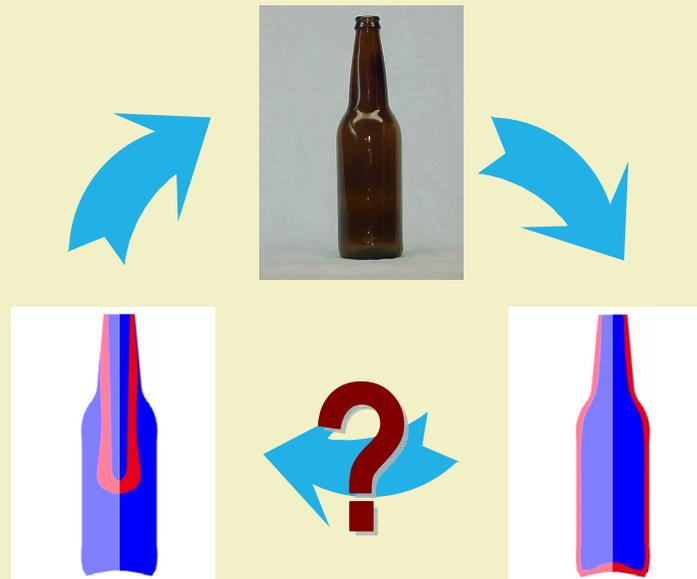
R.M.M. Mattheij<sup>1</sup>, A.S. Tijsseling<sup>1</sup>,  
A.T.A.M. de Waele<sup>2</sup>

<sup>1</sup>Mathematics & Computer Science Department - CASA

<sup>2</sup>Applied Physics Department

October 2008

# An Optimization Method for Blowing Glass Preform Shapes



**Hans Groot**

[j.a.w.m.groot@tue.nl](mailto:j.a.w.m.groot@tue.nl)

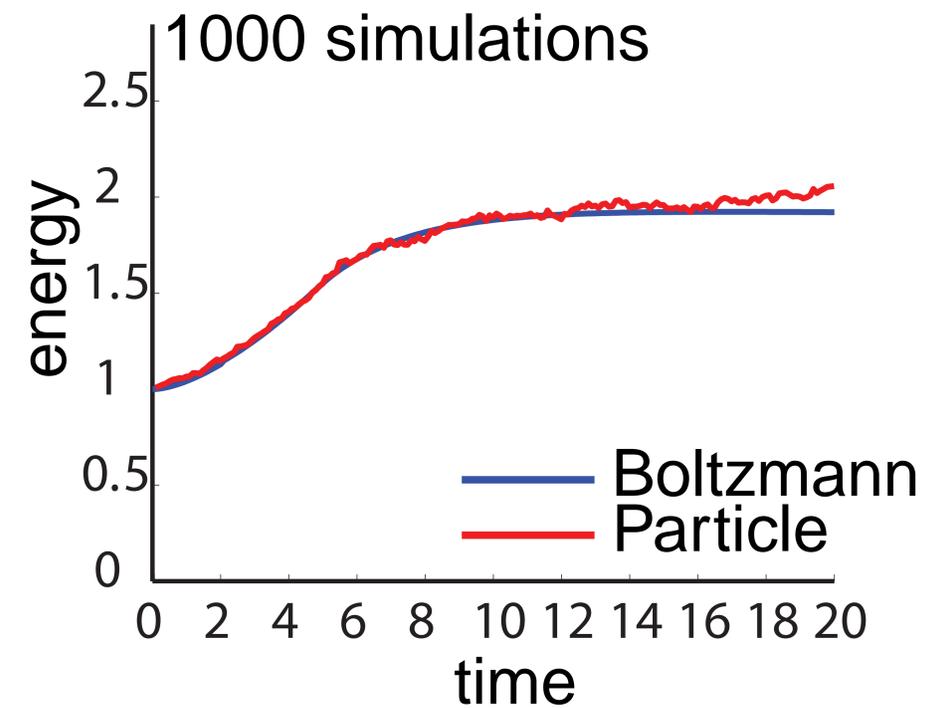
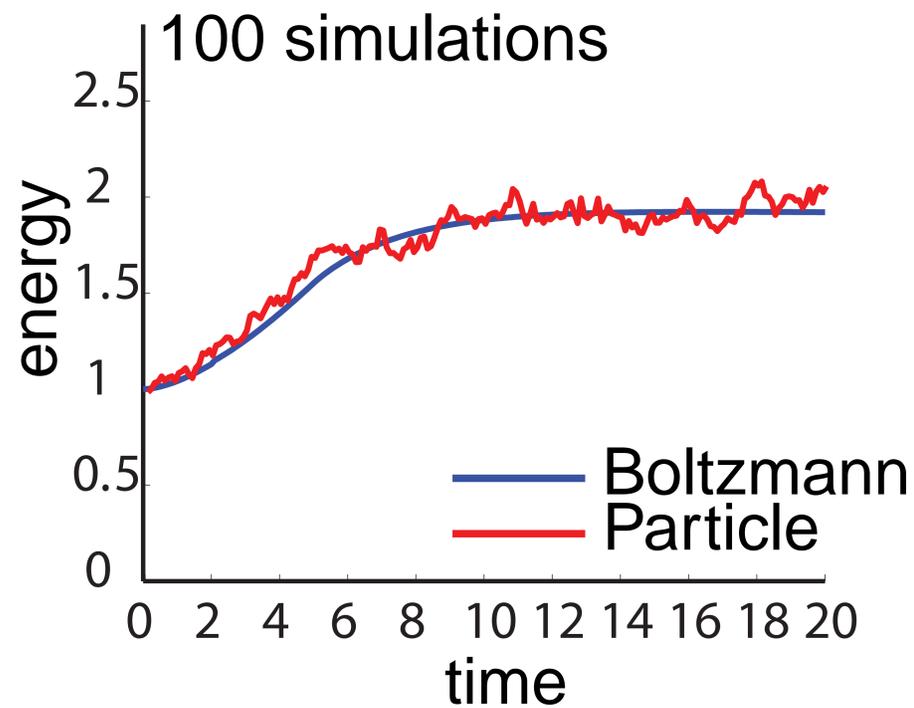
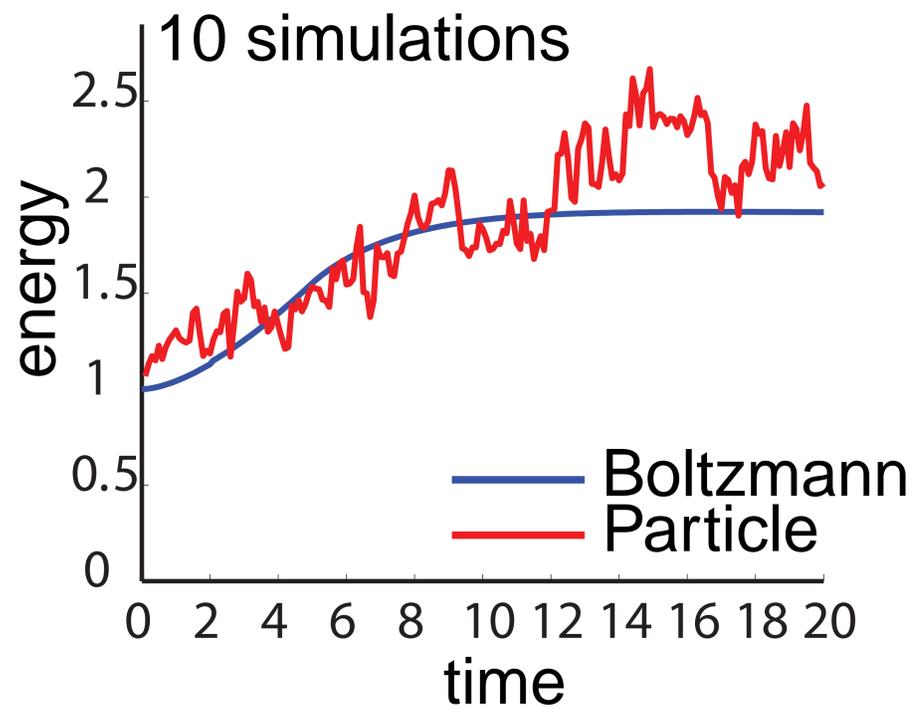
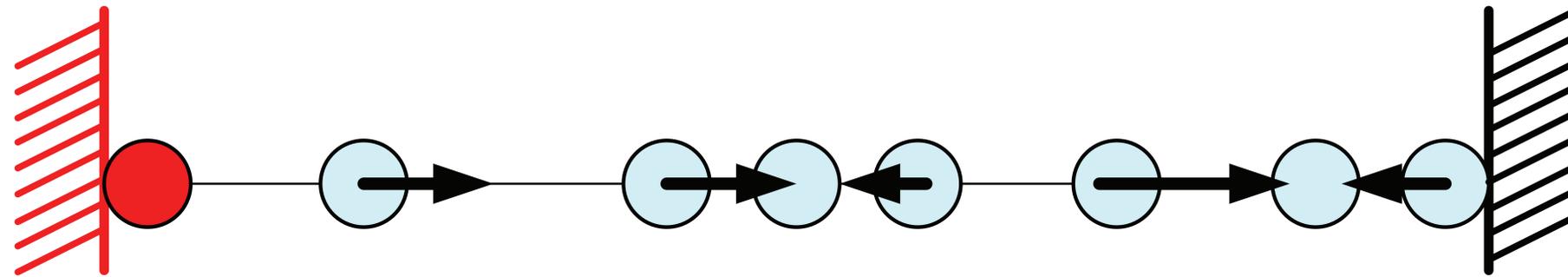
# Pricing Hybrid $\pi$ roducts

Ir. Lech A. Grzelak  
Project leader: Prof. C.W.Oosterlee  
Department: Applied Mathematics  
Mekelweg 4 2628 CD, Delft  
L.A.Grzelak@ewi.tudelft.nl



# Towards a DG method for the Boltzmann equation

Wijnand Hoitinga, Harald van Brummelen, René de Borst



The results of the Boltzmann model correspond with the results of many particle simulations!

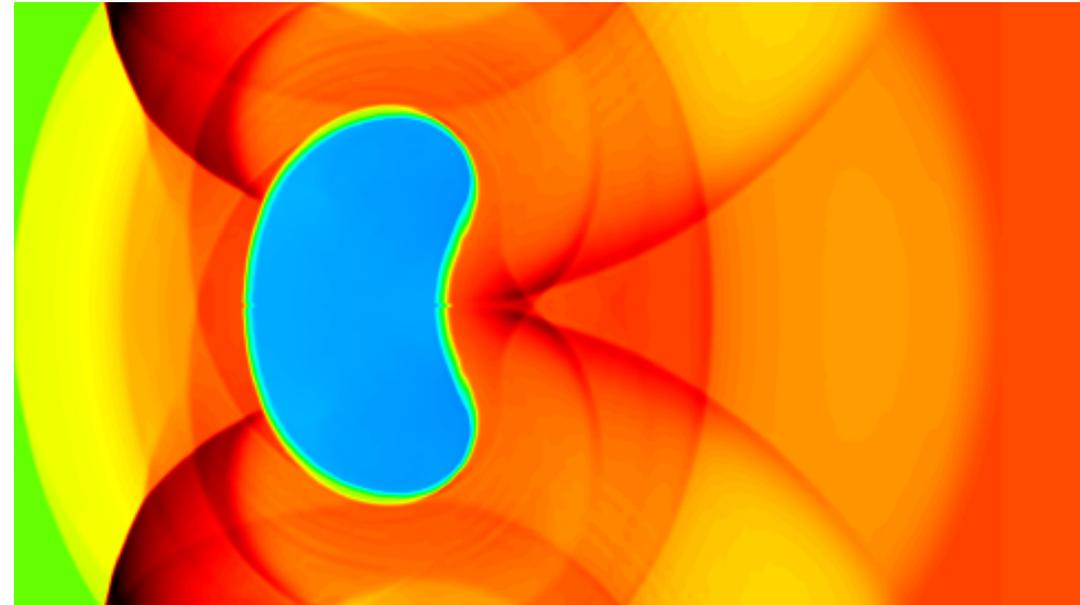
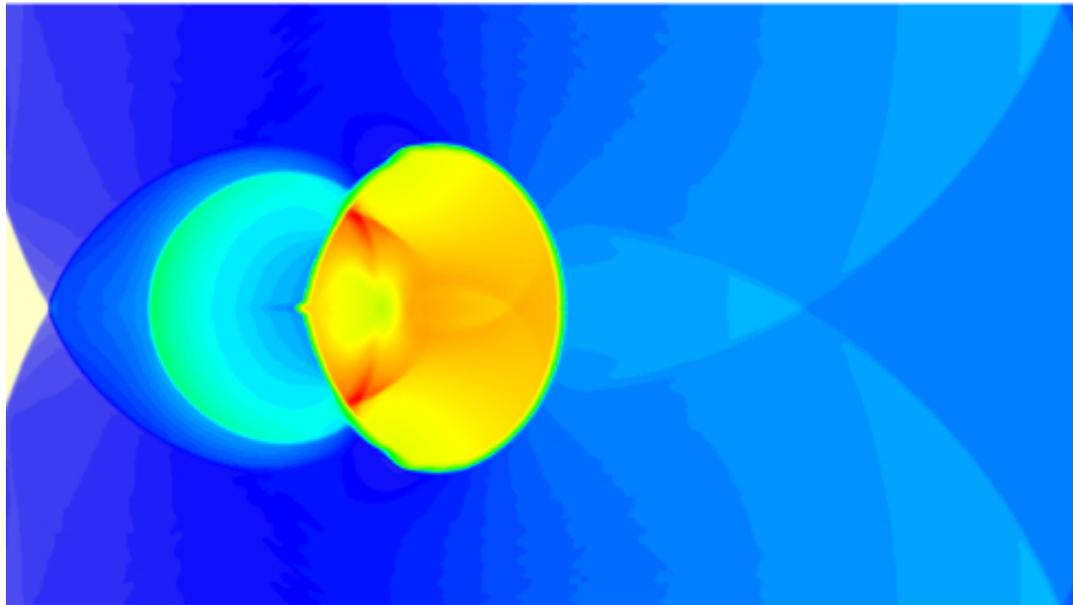
# Boundary Element Method: A survey of errors

Godwin Kakuba  
g.a.kakuba@tue.nl



# Compressible Two-Fluid Flow model for Interface Capturing

Jasper J. Kreeft



**Keywords: Two-Fluid Flow, Interface Capturing,  
Five-Equation model, Energy Exchange,  
Shock-Bubble Interaction**



# Robust Optimization of Thermal Aspects of Friction Stir Welding Using Manifold Mapping Techniques

Anders A. Larsen<sup>1</sup>, Domenico Lahaye<sup>2</sup>, Martin Bendsøe<sup>1</sup>, Jesper Hattel<sup>3</sup>, Henrik Schmidt<sup>3</sup>

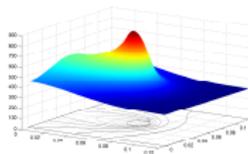
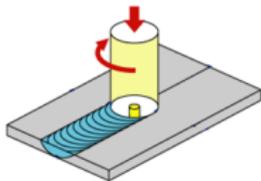
<sup>1</sup> Dept. of Mathematics, Tech. University of Denmark

<sup>2</sup> Delft Institute for Applied Mathematics, Tech. University of Delft

<sup>3</sup> Dept. of Mechanical Engineering, Tech. University of Denmark

## Friction stir welding

- ▶ Solid state welding process
- ▶ Good for aluminium welding
- ▶ Low residual stresses and distortions



## Robust optimization

- ▶ Include variations in material, machine and environmental parameters
- ▶ Statistical data computed using Taylor expansions

Manifold mapping allows efficient optimization

- ▶ No user-supplied gradients
- ▶ Fewer expensive function evaluations

# Efficient unsteady flow computations

Peter Lucas and Hester Bijl

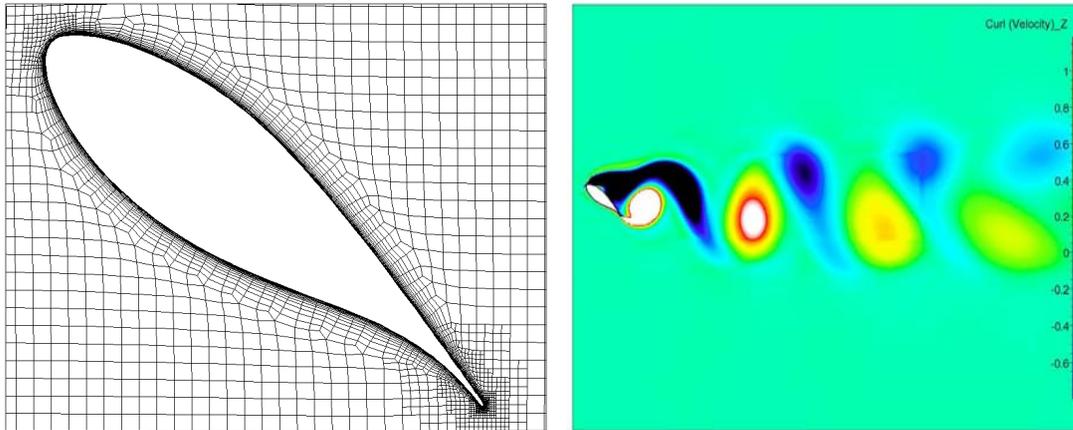


Fig. 1 Unsteady flow around wind turbine airfoil

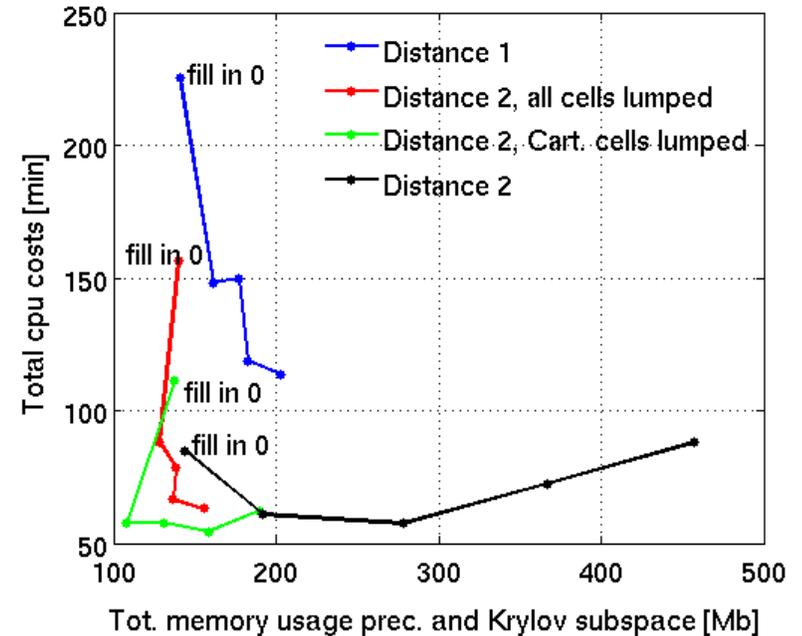


Fig. 2 Performance as function of numerical stencil Jacobian

Tab. 1 Comparison performance MG and JFNK

Flow topology converged	Iterative error < R-K error estim.	Two order res. reduction	Total costs / JFNK	MG
yes	no	no	4.3	
yes	yes	no	7.6	
yes	yes	yes	20	

# Model Reduction for Complex High-tech Systems

Agnieszka Lutowska  
a.lutowska@tue.nl



# Boundedness Properties of Time-stepping Methods

Anna Mozartova

CWI, Amsterdam, The Netherlands

Joint work with Willem Hundsdorfer and Marc Spijker.

- 
- General Linear Methods: RKMs and LMMs
  - Examples of boundedness properties:
    - ▷ TVB methods
    - ▷ Positivity properties

# One-way wave propagation through smoothly varying media

*Tim Op 't Root*

**One-way wave equation:** unidirectional waves through smooth models applied in **seismic imaging**

Improved wave **amplitudes** obtained by

- **symmetric** implementation of associate pseudo-differential operator
- wave field **normalization** with pseudo-differential operator

Theory and numerical simulation



**University of Twente**  
*Enschede - The Netherlands*

# A Hamiltonian Discretization for the Hydrostatic Euler Equations

Bob Peeters

UNIVERSITY OF TWENTE

## Key results:

1. Scheme is based on a (Lagrangian) particle method and (Eulerian) finite elements.
2. Numerical simulations,
3. Convergence & accuracy.

# Reconstruction of Non-periodic Structures from Scattered Light

Maxim Pisarenco, Robert Mattheij, Jos Maubach, Ronald Rook



**ASML**



**TU/e**

Technische Universiteit  
Eindhoven  
University of Technology

October 2008

# SIMPLE-type preconditioners for the incompressible Navier-Stokes problem

Mehfooz ur Rehman, Kees Vuik and Guus Segal  
Delft University of Technology, DIAM, Mekelweg 4, 2628 CD,  
Delft, The Netherlands

## Model Equations

The incompressible Navier-Stokes equations used to simulate the fluid flow, are given by

$$-\nu \nabla^2 \mathbf{u} + \mathbf{u} \cdot \nabla \mathbf{u} + \nabla p = \mathbf{f} \quad \text{in } \Omega$$

$$\nabla \cdot \mathbf{u} = 0 \quad \text{in } \Omega,$$

$\nu$  is the viscosity,  $\mathbf{u}$  is the velocity vector and  $p$  is the pressure.

## Finite element discretization and linearization

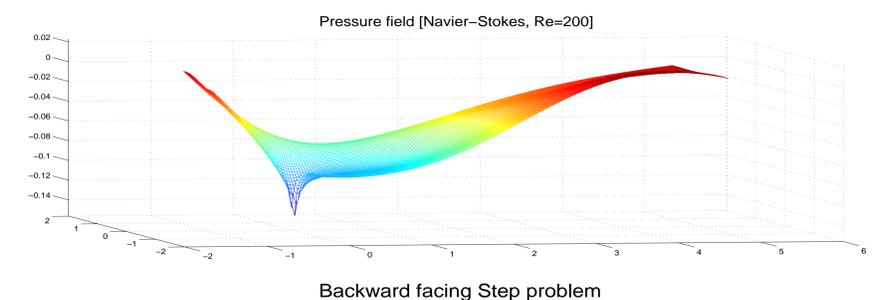
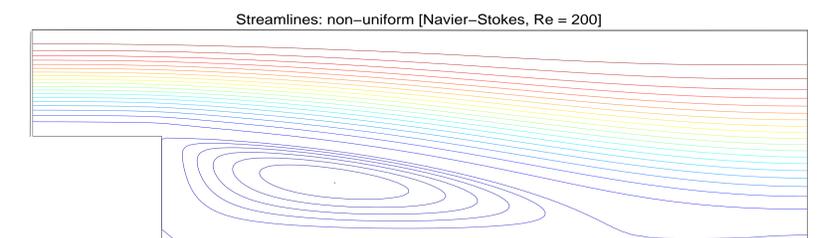
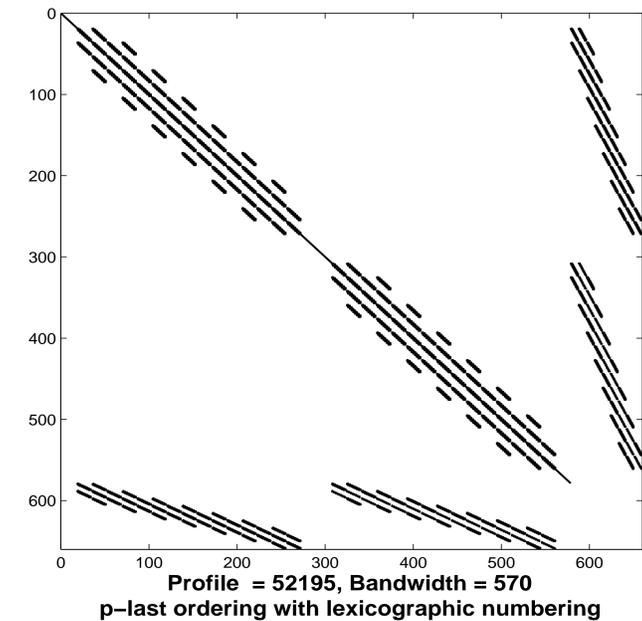
$$\begin{bmatrix} F & B^T \\ B & 0 \end{bmatrix} \begin{bmatrix} u \\ p \end{bmatrix} = \begin{bmatrix} f \\ 0 \end{bmatrix}.$$

The linear system is sparse, (Non-) symmetric.

## To solve

Preconditioned system :  $P^{-1}Ax = P^{-1}b$

SIMPLE-type preconditioners in combination with GCR



# Bounds for the lowest eigenvalue of rank-one perturbations of Hermitian matrices

Ricardo R. Silva  
joint work with Jan Brandts

Korteweg-de Vries Instituut voor Wiskunde

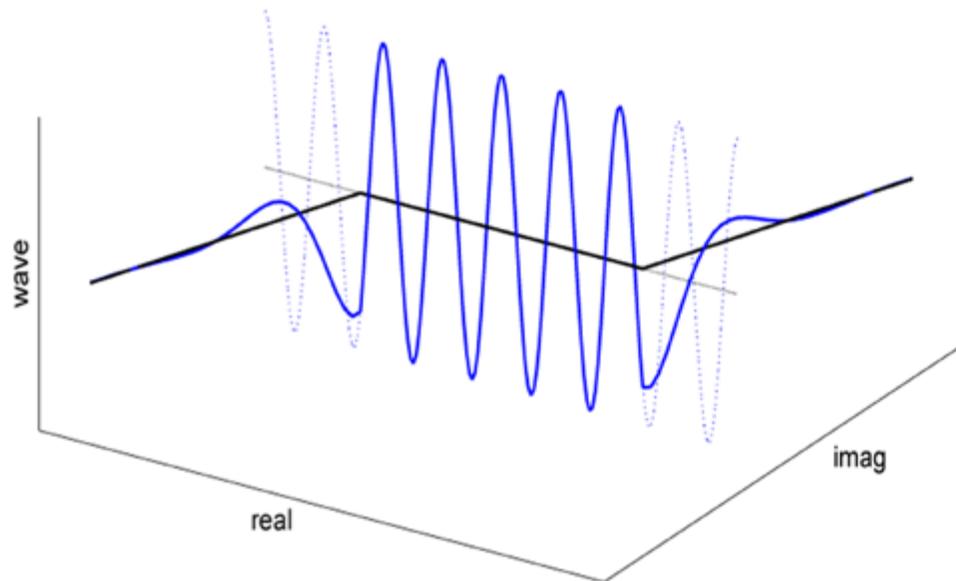
XXXIII Woudschoten Conference  
Oct 2008



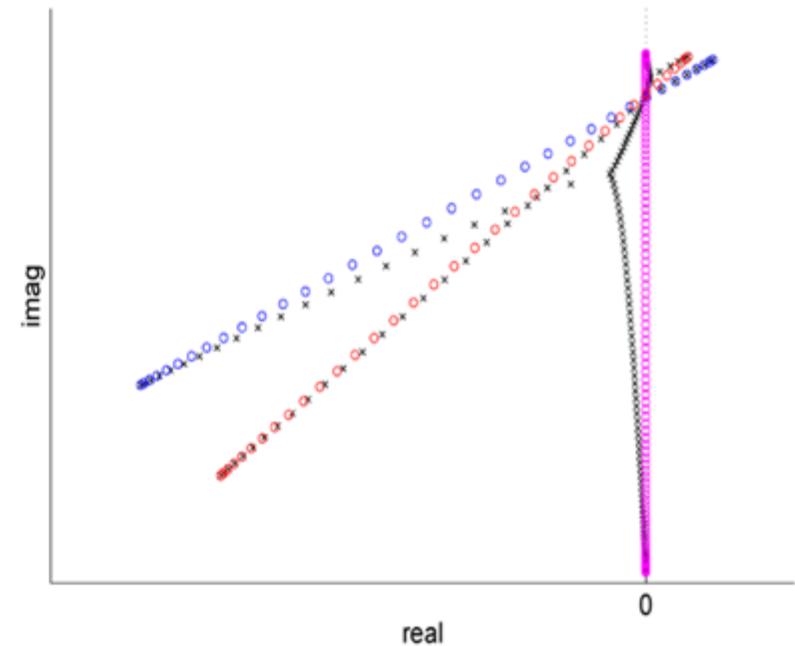
UNIVERSITEIT VAN AMSTERDAM

# Numerical solution of quantum systems in intense laser fields with absorbing boundary conditions

## Bram Reps

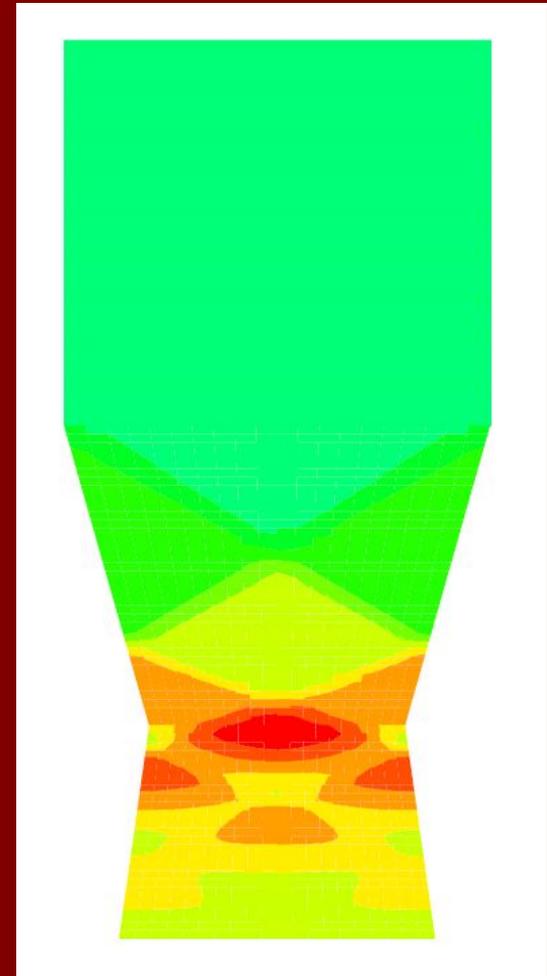


**Figuur:** Exterior complex scaling as an absorbing boundary condition



**Figuur:** Approximation of the complex spectrum

# DISCONTINUOUS GALERKIN METHOD FOR SHALLOW TWO PHASE FLOWS



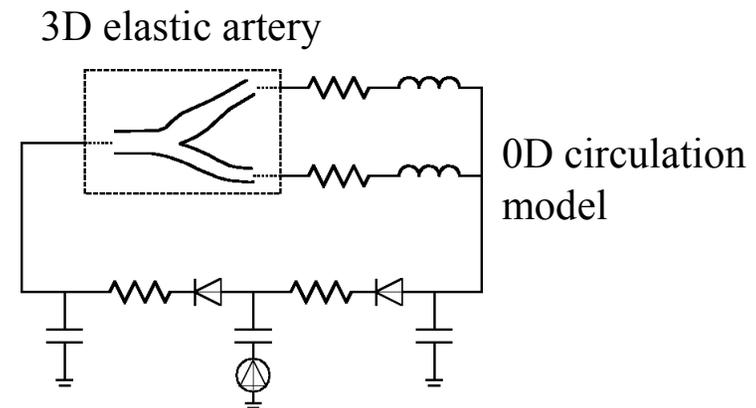
**SANDER RHEBERGEN - WOUDSCHOTEN 2008**



# The Quasi-Simultaneous Approach for Partitioned Systems in Hemodynamics

G. Rozema, A.E.P. Veldman, N.M. Maurits  
University of Groningen, University Medical Center Groningen

- *Problem:*  
Stability of weak coupling method depends on system parameters (limit on mass ratio).
- *Solution:*  
Quasi-simultaneous method: cheap approximation of strong coupling. Stability is achieved for all system parameters. No sub-iterations needed.
- *Applications:*
  - Fluid-Structure Interaction.
  - 0D-3D flow coupling.



# Autofocus algorithms in electron microscopy

Maria Rudnaya  
m.rudnaya@tue.nl

# Smoothness Increasing Accuracy Conserving Filtering for DGM

## Accuracy Enhancement:

- Existing Discontinuous Galerkin Approximation,

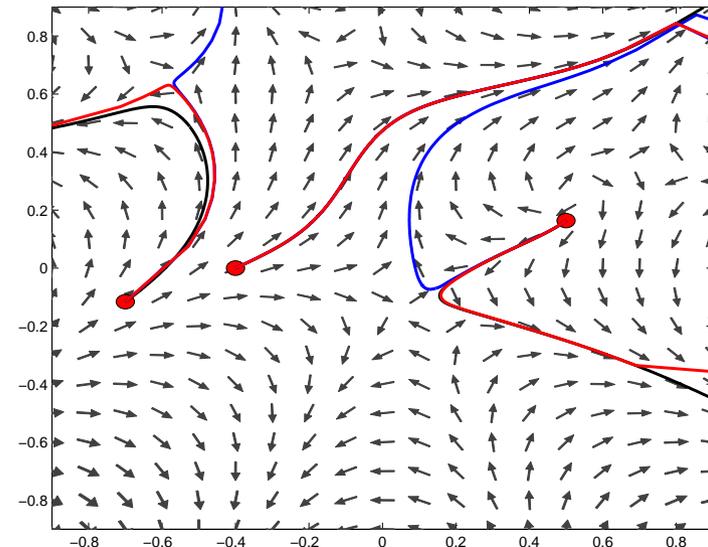
$$u_h(x, t) = \sum_{l=0}^k u_i^{(l)}(t) \phi_i^{(l)}(x),$$

is  $\mathcal{O}(h^{k+1})$ .

- We can improve the convergence rate to  $\mathcal{O}(h^{2k+1})$  and filter out the oscillations in the error by post-processing

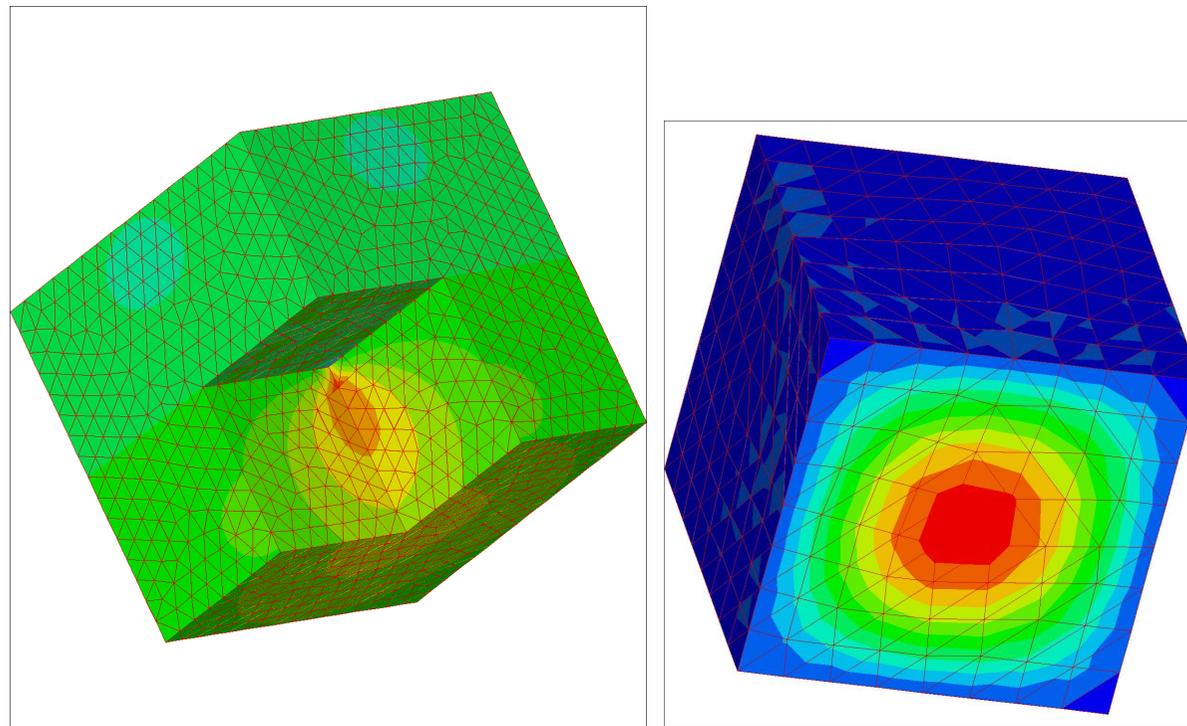
## Filtering for Visualization

- Can apply to entire field
- Can implement in a one-dimensional manner for multi-dimensional streamlines.





# High-order discontinuous Galerkin methods for the time-harmonic Maxwell equations in three dimensions





# Numerical Analysis of the Ginzburg–Landau equations

Nico Schlömer, Universiteit Antwerpen

## Problem

$$0 = (-i\nabla - \mathbf{A})^2\psi - \psi(1 - |\psi|^2)$$

$$0 = -\kappa^2\Delta\mathbf{A} - \frac{1}{2i}(\psi^*\nabla\psi - \psi\nabla\psi^*) + |\psi|^2\mathbf{A}$$

## Challenges

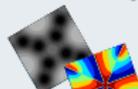
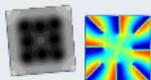
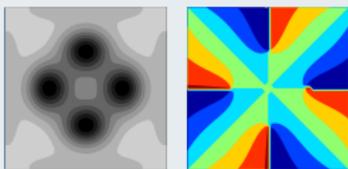
- ▶ complex values
- ▶ all solutions singular
- ▶ complicated solution landscape

## Numerical solution

## Methods

- ▶ Newton's method
- ▶ “customized” GMRES
- ▶ bordering
- ▶ continuation

solution  $\psi$



solution space

# Stability of the Super Node Algorithm for EM modelling of ICs

**Maria Ugryumova**

Technical University of Eindhoven  
Centre for Analysis, Scientific computing and Applications

# Implicit time integration methods in traffic flow modelling

Femke van Wageningen

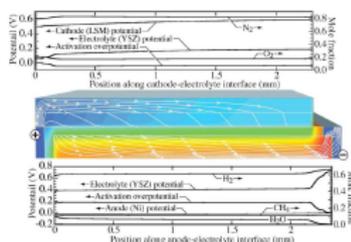
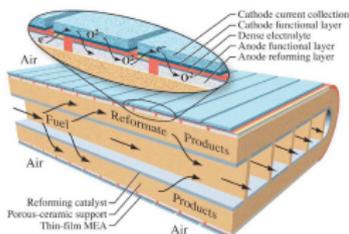
Continuum model: conservation of vehicles



stability  
large CPU-times  
nonlinearity  
phase errors  
numerical diffusion

# Instationary solvers for chemically reacting flow problems

Sander van Veldhuizen, Kees Vuik & Chris Kleijn

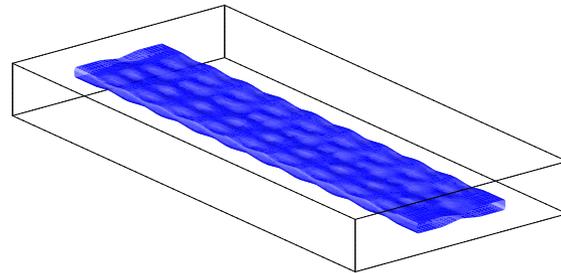


Delft Institute of Applied Mathematics and Multiscale Physics Department



# Analysis of a Vector Stefan Problem

Fred Vermolen & Etelvina Javierre & Kees Vuik



Woudschoten, 2008

Black-Scholes PDE:  $u_t = \frac{1}{2}\sigma^2 s^2 u_{ss} + rsu_s - ru$ .

FD schemes:

$$f'(s_i) \approx \frac{f(s_{i+1}) - f(s_{i-1}))}{h_i + h_{i+1}},$$

$$f'(s_i) \approx \frac{1}{h_i + h_{i+1}} \left[ -\frac{h_{i+1}}{h_i} f(s_{i-1}) + \left( \frac{h_{i+1}}{h_i} - \frac{h_i}{h_{i+1}} \right) f(s_i) + \frac{h_i}{h_{i+1}} f(s_{i+1}) \right],$$

$$f''(s_i) \approx \frac{2}{h_i(h_i + h_{i+1})} f(s_{i-1}) - \frac{2}{h_i h_{i+1}} f(s_i) + \frac{2}{h_{i+1}(h_i + h_{i+1})} f(s_{i+1}).$$

Results for the semi-discrete system  $U'(t) = AU(t) + b(t)$ :

- ▶ Upper bounds for  $\|e^{tA}\|_H$  (scaled Euclidean norm).
- ▶ Sufficient conditions for contractivity in the maximum norm.

# Cache-oblivious sparse matrix-vector multiplication by using sparse matrix partitioning methods

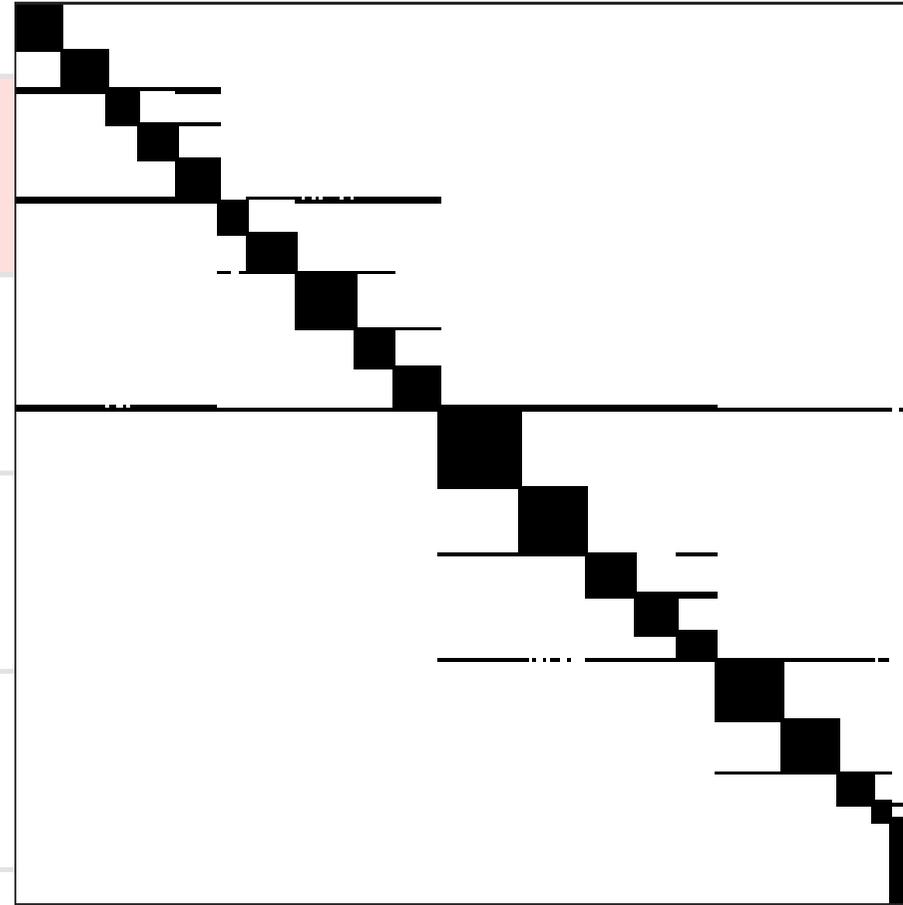
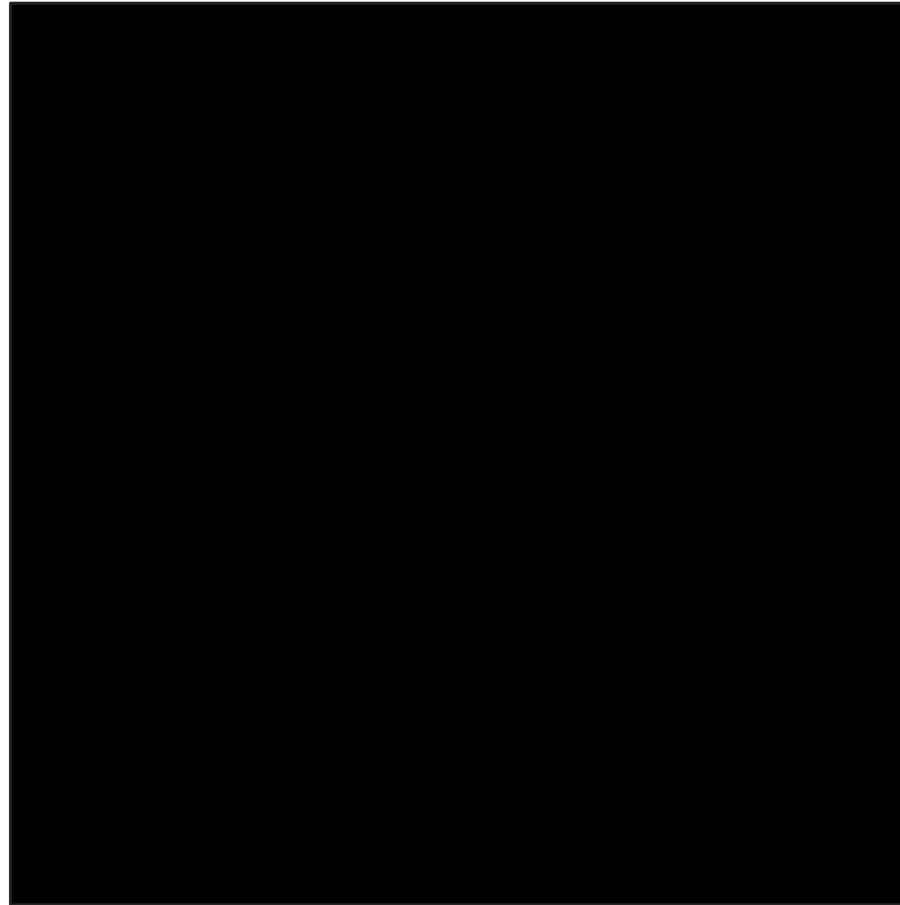
Stanford link matrix

32ms

Reordered Stanford link matrix

15ms

Gain: 53%

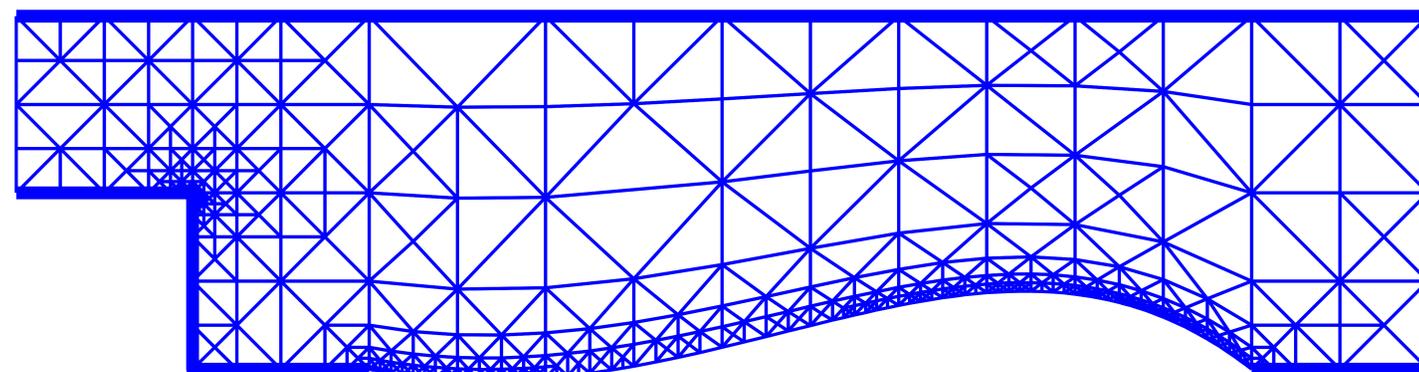
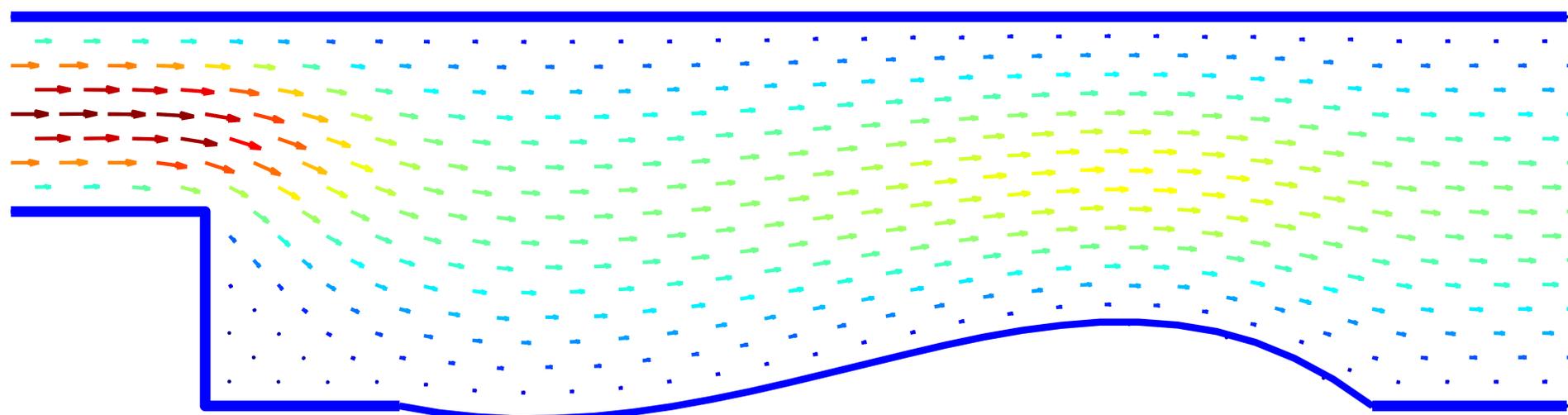


Universiteit Utrecht

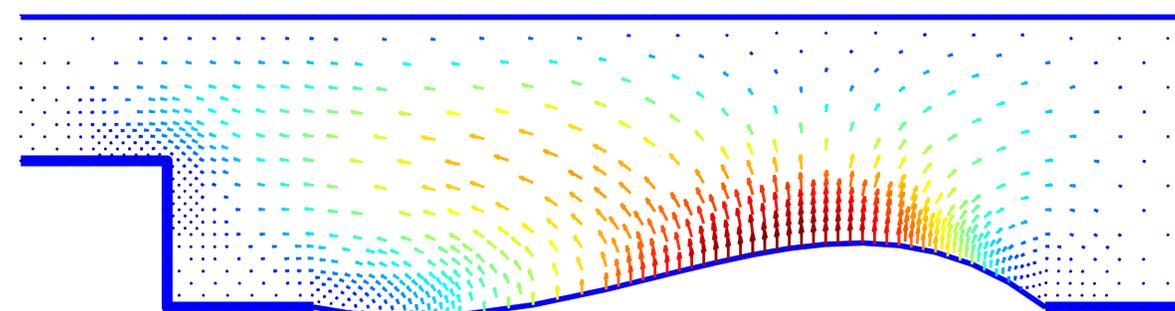
Albert-Jan Yzelman & Rob Bisseling  
Dept. of Mathematics, Utrecht University

# GOAL-ADAPTIVE DISCRETIZATION OF FLUID-STRUCTURE INTERACTION

Kris van der Zee, Harald van Brummelen, René de Borst



Adaptive Mesh



Dual Solution