First Year PhD report

Andrea Thomann

2017/2018

1 Attended Courses

1.1 PhD courses

1. *An introduction to networks* (Francesca Arrigo): Introduction to network science and graph theory, centrality measures and their connection to numerical linear algebra

2. *Generalized Locally Toeplitz Sequences: A Spectral Analysis Tool for Discretized Differential Equations* (Carlo Garoni): Introduction to GLT sequences, applications on different discretizations of Convection-Diffusion-Reaction equations in 1D

3. *Reconstruction methods for sparse-data tomography* (Samuli Siltanen): Introduction to sparse-data tomography, measurement and reconstruction of data, programming in Matlab

1.2 Schools

Intensive Program on Fluids an Waves: Numerics for Fluids and waves: summer school organized by the Gran Sasso Science Institute, L'Aquila, May 21-25 2018.
Courses: Review on Well-balanced schemes and path-conservative numerical methods (Manuel Castro), Fluids and waves error: control and adaptivity in computational partial differential equations (Omar Lakkis)

1.3 Attended conferences

Numerical Aspects of Hyperbolic Balance Laws and Related Problems, Ferrara, April 16-20 2018.
Giornata INdAM, Ferrara, April 18 2018: *Recent advances in multiscale modelling and numerics for hyperbolic and kinetic equations* - in honour of the 60th birthday of Prof. Giovanni Russo

1.4 Attended seminars

1. *An all-speed scheme for the simulation of compressible flows and multi-material interfaces* (Emanuela Abbate)
2. *From Brownian to pedestrian motion and Fokker-Planck Nash games* (Alfio Borzì)
3. *Hidden structures of stochastic numerical methods* (Raffaele D'Ambrosio)
4. *Well-posedness of a fluid-particle interaction model* (Jens Klotzky)
5. *Solar astronomical imaging* (Michele Piana)
6. *Coercivity estimates for kinetic equations* (Marlies Pirner)
7. *High order Finite Volume Schemes for Balance Laws with Stiff Sources* (Matteo Semplice)

2 Exams

1. Exam passed about networks including theory and numerical experiments of exponential and resolvent based centralities (based on *An Introduction to networks*)
2. Exam passed about the theory of well-balanced higher order path conservative schemes for hyperbolic non-conservative systems (based on the course of M. Castro held at the summer school organised by GSSI)
3. Exam planned about parallel programming based on the course *Introduction to Parallel Computing with MPI and OpenMP* organised by CINECA from 12.-14.11.2018
4. Exam planned about (low Mach) gas flows in pipeline networks

3 Research Activities

3.1 Present activities

1. *Development of well-balanced scheme for Euler equations with gravity*: The model is based on Suliciu relaxation. The potential is rewritten using the reference equilibrium to ensure the well-balancing of arbitrary hydrostatic equilibria. The scheme is based on an explicit finite volume Godunov-type Riemann solver. It is second order accurate. This is achieved by using a reconstruction in equilibrium variables at the interfaces. In addition it is preserving the positivity of internal energy and density which is important for physical applications.

This is joint work with Markus Zenk and Christian Klingenberg (both from University Würzburg) and was submitted to the International Journal for Numerical Methods in Fluids.

2. *Development of low Mach schemes for Euler equations*: The model is based on Suliciu relaxation and splitting of the pressure in a fast and a slow component. The finite volume scheme consists of an explicit part and an implicit part (IMEX schemes). Thereby the material waves are treated explicitly and the sound waves implicitly. The explicit part is based on a Godunov-type Riemann solver and the implicit part on an upwind scheme. I am also studying the stability, convergence and low Mach property of the scheme. The first order scheme is implemented in a 1D and 2D framework and the extension to second order is in progress. Numerical experiments give good results which are a SOD shock-tube test modified for low Mach flows in 1D and the Gresho vortex in 2D.

   This is joint work with Gabriella Puppo (University Insubria), Markus Zenk and Christian Klingenberg (both University Würzburg).

3.2 Future activities

1. Parallelization of the low Mach code for Euler equations. Therefore attending a programming course.

2. Well-balanced low Mach schemes for Euler equations with gravity.

3. Low Mach flows in gas networks.

4 Publications

1. Journal paper: A.Thomann, M. Zenk, C. Klingenberg, *A second order positivity preserving well-balanced FV scheme for Euler equations with gravity for arbitrary hydrostatic equilibria*, International Journal for Numerical Methods in Fluids, under revision

2. Poster presentation: *Second order well-balanced relaxation method for the Euler equations with gravity for hydrostatic equilibria*, Numerical Aspects of Hyperbolic Balance Laws and Related Problems, Ferrara