Programme

International Workshop

Mathematical and Numerical Modelling in Science and Technology

November 18–20, 2010
University of Jyväskylä, Finland

Workshop dedicated to the memory of Prof. V. Rivkind

Timetable Thursday 18th November Agora Aud 2

9:30	**Registration and coffee**	**Agora**
10:00	*Pekka Neittaanmäki, Jyväskylä* **Welcome Address**	**Agora Aud 2**

Session 1: 10:15–12:00 *Chairman Pekka Neittaanmäki*

10:15	*Leonid Rukhovets, St.-Petersburg* **Construction and Application the Mathematical Models for Great European Lakes Ladoga and Onego**
10:50	*Vladislav Pukhnachev, Novosibirsk* **Modeling of Three Dimensional Convective Motions in Long Tubes on the Base of Two Dimensional Initial Boundary Value Problems**
11:25	*Nikita Morozov, St.-Petersburg* **The Surface Effects and Nanotechnology**
12:00	**Lunch break**

Session 2: 13:30–15:15 *Chairman Leonid Rukhovets*

13:30	*Roland Glowinski, Houston* **A Least-Squares/Finite Element Method for the Numerical Solution of the Navier-Stokes-Cahn-Hilliard System Modeling the Motion of the Contact Line**
14:05	*Sergey Repin, Jyväskylä / St.-Petersburg* **Mathematical Problems with Linear Growth Energy Functionals: Numerical Methods, A Priori and A Posteriori Estimates**
14:40	*Jacques Periaux, Jyväskylä* **Multi Objective Design Optimization of High lift systems using fast Evolutionary Algorithms coupled with Games coalition**
15:15	**Coffee break**

Session 3: 15:45–17:30 *Chairman Roland Glowinski*

15:45	*E. L. Tarunin, Perm* **The Model of Convective Vortex in Rotating Vessel**	
16:20	*Olli Mali, Pekka Neittaanmäki, Sergey Repin, Jyväskylä* **Indeterminant Data in Problems of Continuum Mechanics**	
16:55	*Albert L. Stasenko, Moscow* **Icing of a Body Moving in a Supercooled Cloud (World Experience in Physics and Numerical Modeling and Some New Conceptions)**	
17:30	**Cocktail**	**Lea Pulkkinen Hall, 4th floor**

Timetable — Friday 19th November — Agora Beeta

Session 4: 9:00–10:45 — *Chairman Sergey Repin* — **Agora Beeta**

9:00 — *Galina Levina, Perm and Moscow, Michael T. Montgomery, USA*
How a Concept of Helicity can be Applied to Tropical Cyclone Investigations

9:35 — *Olga Lavrenteva, Haifa*
Simulation of Motion and Deformation of Viscoplastic Drops and Shells in a Viscous Fluid

10:10 — *Jari Hämäläinen, Lappeenranta*
Depth-averaged CFD Models in Industrial Optimization Tools

10:45 — **Coffee break**

Session 5: 11:15–13:00 — *Chairman Boris Chetverushkin*

11:15 — *Dmitri Kuzmin, Erlangen*
High-resolution Finite Element Schemes for Convection-dominated Flows

11:50 — *Alexei Heintz, Gothenburg*
On Generalised Curvature and Willmore Flows by a Convolution - Thresholding Method

12:25 — *Boris Epstein, Tel Aviv-Yafo*
Multi-Accuracy Approach to Large-Scale Aerodynamic Simulations

13:00 — **Lunch break**

Session 6: 14:30–17:20 — *Chairman Jacques Periaux*

14:30 — *Boris Chetverushkin, Moscow*
Hybrid Computing System and Its Applications

15:05 — *Mikhail Anolik, St. Petersburg*
Calculation of Rarefied Gas Flow around Rough Bodies

15:40 — **Coffee break**

16:10 — *Heikki Haario, Lappeenranta*
Closure Parameters of Large Scale Models

16:45 — *Pekka Neittaanmäki, Jyväskylä*
Impact of Valery Rivkind's Researh in University of Jyväskylä

17:20 — End of the presentations

19:00 — **Dinner** — **Restaurant Ylistö (Survontie 9)**

Minisymposium -
Analytical-numerical Methods for Investigation of Oscillations

Timetable | Saturday 20th November | Agora Beeta

10:00	**Opening words**	**Agora Beeta**

Session 7: 10:10–12:30 — *Chairmen Pekka Neittaanmäki, Gennady Leonov and Nikolay Kuznetsov*

10:10 — *V.O. Bragin, Nikolay Kuznetsov, Jyväskylä, Gennady Leonov, St.-Petersburg, V.I. Vagaitsev*
Analytical-numerical Methods for Hidden Oscillations Localization: Aizerman and Kalman Conjectures, Hidden Attractor in Chua Circuits

10:30 — *Nikolay Kuznetsov, Gennady Leonov, Pekka Neittaanmäki, Svetlana Seledzhi, Marat Yuldashev, Jyväskylä, Renat Yuldashev, Jyväskylä*
Nonlinear Analysis of Phase-locked Loop

10:50 — *Olga Kuznetsova, Jyväskylä, Gennady Leonov, Pekka Neittaanmäki*
Computational Methods of Limit Cycles Investigation of Two-dimensional Dynamical Systems

11:10 — **Coffee break**

11.50 — *Gennady Leonov, Elena Solov'eva, Jyväskylä, Alexandr Zarezky, Jyväskylä*
Estimation of a Limit Load for Synchronous Machines

12:10 — *Maria Kiseleva, Jyväskylä, Gennady Leonov*
Mathematical Problem for Drilling System

12:30 — End of the workshop

List of Lecturers

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Short abstracts for Thursday 18th November

Construction and Application the Mathematical Models for Great European Lakes Ladoga and Onego

L.A. Rukhovets

Presentation is devoted to construction and application 3D hydrothermodynamics model and ecosystem model for large stratified lakes. The results of numerical experiments devoted to estimation of potential changes in the ecosystems of Lakes Ladoga and Onego in the 21st century under the impact of anthropogenic and climatic factors are presented. For these aims the year-round regime of functioning of the lakes ecosystems are reproduced by ecosystem models. The determinant factor controlling the state of the ecosystem of the large stratified Lake Ladoga is the level of anthropogenic load. The same situation takes place for Lake Onego.

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Modeling of Three Dimensional Convective Motions in Long Tubes on the Base of Two Dimensional Initial Boundary Value Problems

R.V. Birikh[1] *and V.V. Pukhnachev*[2]

It is well known the solution of Oberbeck-Boussinesq equations describing the two dimensional flow in a horizontal strip under joint action of longitudinal heat flux and transversal gravity field (Birikh, 1966). Asymptotical character of this exact solution was confirmed by experimental and numerical methods (Kirdyashkin, Polezhaev & Fedyushkin, 1983). Its generalization for the case of motion in a cylindrical tube of an arbitrary cross-section was proposed by Pukhnachev (2000). Let z is coordinate along the tube and x, y are coordinates in its cross-section. It is characteristic that the velocity field in solutions under consideration has three nonzero components depending of x, y and time t only while dependence of temperature θ and pressure on z is linear, and also $\partial\theta/\partial z = const$. As a result, the original three dimensional problems can be reduced to two dimensional ones. This reduction has a group-theoretical nature: it is provided by the presence of the wide Lie pseudogroup admitted by Oberbeck-Boussinesq equations. The global unique solvability of non-stationary problem and local solvability of stationary problem are established. The similar results are obtained in the problem of thermal convection in a rotating circular tube with temperature gradient to be a linear function of z. We underline that both angular velocity of tube and gravity acceleration can be arbitrary functions of t. If the gravity is absent, the latter problem has axially symmetric solution determined from a linear system of equations. Moreover, in this case $\partial\theta/\partial z$ can be function of time and polar radius. This problem admits an effective solution if the longitudinal gradient of pressure is given function of t. If the liquid flux over a tube cross-section is prescribed, we get an inverse problem, for which the existence and uniqueness theorems are proved. The case of zero flux is of a special interest from the point of view of the solution physical interpretation. A similar inverse problem for the Poiseuille flow was studied by Pileckas & Keblikas (2005). Stationary solutions of this type can be expressed via elementary functions. Besides, we construct solutions of the axially symmetric problems describing the flow of two immiscible liquids with a cylindrical interface. Formally speaking, obtained results deal with motions in infinite tubes. To apply them to description of convection in finite long tubes, it is desirable to have some analogue of the Saint-Venant principle in the classical elasticity theory. We believe that this principle is valid at least for small Rayleigh numbers. It would be interesting to verify our conjecture by numerical experiments.

This work was supported by grants of Russian Foundation for Basic Research No. 09-01-00484 (R.V. Birikh), No. 10-01-00007 (V.V. Pukhnachev) and Joint project of Siberian, Ural and Far Eastern Branches of the Russian Academy of Sciences.

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The Surface Effects and Nanotechnology

Nikita Morozov

The modern nanoindustry requires the consideration of different problems: strength, fracture, stability, delamination, defects etc. It is possible for solution of such problems to use the continuum mechanics methods. Of course, the problems of nanomechanics have specific character. At first, it is necessary to take into account the surface effect. In presented report is demonstrated the different some particular problems of nanomechanics and methods of its solution.

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A Least-Squares/Finite Element Method for the Numerical Solution of the Navier-Stokes-Cahn-Hilliard System Modeling the Motion of the Contact Line

Roland Glowinski

In this lecture, we will discuss the numerical solution of the Navier-Stokes-Cahn-Hilliard system modeling the motion of the contact line separating two immiscible incompressible fluids near a solid wall. The method we employ combines a finite element space approximation with a time discretization by operator-splitting. To solve the Cahn-Hilliard part of the problem, we use a least-squares/conjugate gradient method. Our approach is validated by the results of numerical experiments.

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Mathematical Problems with Linear Growth Energy Functionals: Numerical Methods, A Priori and A Posteriori Estimates

Sergey Repin

Variational problems associated with linear growth functionals arise in the theory of minimal and capillary surfaces, plasticity, and other models that include saturation type constitutive relations. From the mathematical and computational points of view, these problems are essentially different with respect to problems with superlinear growth (e.g., those related to quadratic energy functionals).

In the talk, a concise historical overview is given. Then, approximation methods are discussed. Finally, new results related to a posteriori analysis are presented.

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Multi Objective Design Optimization of High lift systems using fast Evolutionary Algorithms coupled with Games coalition

Jacques Periaux

With the increasing complexity of digital aircraft design problems, Multi-Objective optimization (MOO) using Evolutionary Algorithms (EAs) requires innovative approaches to improve both efficiency and design quality.

Road maps to speed up evolutionary optimization algorithms include Game Strategies with coalition concepts of Nash, Pareto and Stackelberg games.

In that direction, EAs can be dynamically coupled with hybridized Pareto – Nash Games to reduce computational time efforts and produce higher quality design solutions due to increased diversity of the selection pool.

In this lecture numerical experiments focused on efficiency and design quality obtained with two multi objective optimization methods are presented and discussed for the design of multi element airfoils configurations.

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The Model of Convective Vortex in Rotating Vessel

D. A. Vinokurov, E. L. Tarunin

G.P. Bogatyrev and his colleagues studied the laboratory model of typhoon-like vortex in Perm from 1990 [1]. This research was focused on formation and evolution of an intensive cyclonic vortex in rotating cylindrical vessel with local heating from a bottom. According to the experiments velocity of the vortex exceeded a solid-state rotation in 8-9 times. After the laboratory experiments several articles devoted to numerical modeling of similar phenomenon were published.

In this work we also use resources of numerical modeling to define dependencies which were not obtained earlier. Our research focuses on conditions of intensive vortex formation and flow restructuring with emerging of “typhoon eye”. The axysimmetric problem, described by the heat convection equations (Boussinesq approximation), was solved using finite differences in the variables of two-field method. Geometrical parameters corresponded to the laboratory experiments [1]. Except geometrical parameters problem had three dimensionless numbers - Grashof, Prandtl and Reynolds. Flow pictures and integral characteristics dependencies on Grashof and Reynolds numbers were obtained. Also boundaries of intensive vortex formation and "typhoon eye" emerging were determined.

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[3] Sukhanovsky A.N. Differential Rotation Formation in Cylindrical Fluid Layer // Computational Mechanics of Continuous Media, 2010, Vol. 3, Num. 2, pp. 103-115.

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Indeterminant Data in Problems of Continuum Mechanics

Olli Mali, Pekka Neittaanmäki, Sergey Repin

We discuss the sensitivity of various models with respect to their data. Of our special interest is the accuracy limit created by data indeterminacy. The main tool of our analysis are functional a posteriori error estimates. Full exposition of the theory can be found from [2] and [3]. They are derived on a functional level and are not associated to any particular numerical method. Moreover, they provide guaranteed bounds for the error and depend explicitly on the problem data. The latter property is essential. We address various elliptic problems including linear elasticity and diffusion problem.

The goal of our analysis is to find relations between the set of admissible data and the set of solutions related to these data values. Motivated by engineering practise, we consider data given in the following form: mean value and variations. The relation between the magnitude of variations and radius of the resulting solution set is of particular interest. This approach was first presented in [1]. Estimates of the radius of the solution set gives us the desired accuracy limit. It gives us the stopping criteria for any meaningful simulations dedicated to improve tha accuracy of approximative solution and it enables us to investigate the reliability of any quantitative results obtained from the simulation.

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Icing of a Body Moving in a Supercooled Cloud (World Experience in Physics and Numerical Modeling and Some New Conceptions)

Albert L. Stasenko

A multitude of investigations were undertaken to predict icing of a solid body in the metastable air\ droplets medium, but up to the date, the physical cause of discrepancies between numerous results obtained with different codes(and also with experimental data) cannot be explained, see for example [1].

In the present Report, several paths of investigation of this phenomenon are pointed out to take into consideration some essential physical processes: non-spherical shape of the supercooled droplets approaching a body; Saffman force in the boundary layer; thermal stresses into the ice slab due to release the latent heat of crystallization.

Note that a serious contribution in the understanding of the drop hydrodynamics was made by V. Rivkind. The present Report is the further development of results reported at the previous meeting devoted to His memory [2], and also discussed in [3,4]. The author's participation at the present workshop is friendly supported by University of Jyväskylä.

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[3] Kudrov M.A., Stasenko A.L., Zdor A.G. Icing modeling of an airfoil in a supercooled cloud. Seminar ONERA-TsAGI., Nov. 17-22. 2009. Lille, France.
[4] Kashevarov A.V., Stasenko A.L. Forced crystallization of drops in front of a body moving in a supercooled cloud. Mathematical Models and Computer Simulations. 2010. Vol. 2, No. 5, pp. 614-620. Pleyades Publishing. Ltd., 2010.

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Short abstracts for Friday 19th November

How a Concept of Helicity can be Applied to Tropical Cyclone Investigations

Galina Levina[1),2)] and Michael T. Montgomery[3),4)]

There exists a fundamental theoretical hypothesis about a small-scale helical turbulence that may result in a large-scale instability governing the structure formation. A numerical approach was developed and applied by Levina (2006, Doklady Earth Sciences) to simulate helical-vortex effects under developed thermal convection. Resulting findings showed the threshold for larger scale structure generation as well as a way of development of large-scale helical instability by merging of cells and consequent intensification of newly forming helical vortices. At the same time a paper by Montgomery and co-authors (2006, Journal of Atmospheric Sciences) appeared which proposed a new scenario of tropical cyclogenesis and showed by near cloud resolving simulations (2-3 km grid spacing) how a mesoscale tropical depression vortex could develop from cumulonimbus convection as a result of the growth of flow scales occurred by multiple mergers of small-scale convective structures. Results of these two works were brought in together under collaborative efforts with Montgomery Research Group (NPS, Monterey, CA, USA). That gave a start for introducing the analysis of helical characteristics of the velocity field in numerical investigations of tropical cyclones by use of atmospheric modeling systems (2010, Doklady Earth Sciences).

Results of our recent numerical simulation on helicity role in tropical cyclogenesis will be discussed. A short presentation of a wide-ranging NSF-NOAA PREDICT (Pre-Depression Investigation of Cloud-systems in the Tropics http://catalog.eol.ucar.edu/predict/index.html) Experiment leaded by Professor M.T. Montgomery and currently August-September 2010 underway in the Caribbean Sea, will also be given.

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Simulation of Motion and Deformation of Viscoplastic Drops and Shells in a Viscous Fluid

Olga M. Lavrenteva, Irina Smagin, Avinoam Nir

The slow sedimentation of deformable viscoplastic drops and shells in a Newtonian fluid is studied making use of a variation of integral equation method. The Green function for the Stokes equation is used and the non-Newtonian stress is treated as a source term. Integration over the outer unbounded domain occupied by the Newtonian liquid, is eliminated by satisfying the boundary condition at using the integral expressions for the adjoined domains. Thus, the problem is reduced to an integral equation in a bounded domain, which reduction is the main advantage of this method.

The computations carried out for a range of physical parameters of the system revealed that increasing in the yield stress magnitude (the Bingham number, *Bn*) stabilizes both oblate and prolate drops. This is in contrast to the effect of the viscosity of Newtonian drop that is known to destabilize oblate drops. This strong stabilization effect can be explained by the presence of unyielded zones inside falling drops. An interesting observation is that the growth of the limiting viscosity of the Bingham fluid destabilize oblate deformations at low *Bn* and have stabilizing effect at higher *Bn*.

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Depth-averaged CFD Models in Industrial Optimization Tools

Jari Hämäläinen

Computational Fluid Dynamics (CFD) is a mature science. Optimization has also a long history. However, combining computationally expensive CFD with optimization is still a challenge. In CFD-based optimization, a CFD model needs to be solved hundreds or thousands of times. If one CFD simulation requires hours to be completed, an optimization task would last weeks, months, or even years, which is not reasonable. Therefore, simplifications must be done. Instead of a full 3D model, lower dimensional equations can be derived by integrating original equations in the direction of one coordinate axis, e.g. in the depth direction of a channel when it is order of magnitude smaller than the other dimensions.

Already in early 1990's the approach was utilized for a contracting channel of a paper machine headbox when Professor Valeri Rivkind worked as a supervisor of the doctoral thesis which was finalized in 1993 [1]. Similar approach was also used in [2] where equations for open channels were derived. The work that was started with Professor Rivkind has led to several industrial software tools [3]. The first one was developed for shape optimization of the tapered header in 1995; still in use in industry [4]. The second one, HOCS Fibre software [5], has been developed more recently by Numerola and Metso Paper for trouble-shooting and control of fibre orientation in the paper sheet based on the equations derived in [1]. The same approach has also proven its strength in multi-objective optimization of heat exchangers [6, 7] and line-level paper making decision support [8]. The approach which made CFD possible in 1990's makes CFD-based optimization possible today.

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[7] Marko Lyytikäinen: Modelling and Optimization of Chevron-type Plate Heat Exchangers, Doctoral thesis, University of Kuopio, 2009.
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High-resolution Finite Element Schemes for Convection-dominated Flows

Dmitri Kuzmin

The talk is concerned with the design of high-resolution finite element schemes satisfying the maximum principle for transport equations. Continuous Galerkin approximations are constrained within the framework of algebraic flux correction. An extension to hp-FEM and a failsafe control mechanism are discussed. A new slope limiter is introduced in the context of discontinuous Galerkin methods. The coefficients of a local Taylor series are constrained so that vertex-based degrees of freedom are bounded by cell averages. The hierarchical limiting strategy is designed to maintain high accuracy at smooth extrema. A numerical study is performed for 2D benchmark problems discretized with linear and quadratic finite elements.

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On Generalised Curvature and Willmore Flows by a Convolution - Thresholding Method

Alexei Heintz

We consider geometric flow of the boundary ∂C of a domain $C \subset R^3$ by a function of mean curvature H and by the gradient operator Delta(H)+2H(H^2-K) of the Willmore energy Int(H^2)dS, where H is the mean curvature, K is the Gauss curvature and Delta is the Laplace-Beltrami operator on ∂C. In connection with these problems we consider the convolution of an indicator function of $C \subset R^3$ with an isotropic and fast decreasing normalised kernel r(|x|). The main technical result is that the third term in the asymptotic expansion of this convolution when the support of r(|x|) shrinks to zero, is proportional to Delta(H)+2H(H^2-K) on ∂C and the second one is proportional to H. This result is used to approximate the geometric flows above by the level sets of the linear combinations of such convolutions. Willmore flows are of interest because they model for biological membranes and are used in image processing.

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Multi-Accuracy Approach to Large-Scale Aerodynamic Simulations

Boris Epstein and Sergey Peigin

The paper deals with the following problem. Industrial CFD tools are required to provide accurate Navier-Stokes solutions for complex high-Reynolds turbulent flows around complex configurations. This prompts the requirements of geometrical flexibility, high accuracy (in particular, in order to get realistic estimates of sensitive aerodynamic characteristics such as drag and moments), realistic turn-around times and the high robustness. These demands are greatly amplified in the case of CFD driven shape optimization where a single optimization may require hundreds or even thousands of consistent CFD evaluations.

The requirements of high robustness and accuracy tend become contradictory since robust numerical schemes use to possess relatively low accuracy, and higher-order schemes use to exhibit low robustness.

We have developed a numerical technique which employs multi-accuracy approach. In the framework of this approach, most of computational work is performed by low-accuracy methods on relatively coarse meshes while higher-order numerical operators provide corrections for low-accuracy discretizations through residual estimation on high-resolution meshes.

The current approach uses a defect-correction/multi-grid framework where the target approximation is different from that used in the relaxation process. A higher-order scheme employed for the estimation of defect correction represents a modified variant of Essentially non-Oscillatory (ENO) method of Harten et al. It is applied only a very limited number of times (roughly equal to the number of multi-grid cycles on the finest level), and the relaxations are driven by easy-to-invert one-point upwind-biased characteristic operator.

The above described approach proved to be reliable and consistent tool of aerodynamic analysis. This allowed employing it as a CFD driver for aerodynamic shape optimization for minimum drag. Here we use Genetic Algorithms (GAs) in conjunction with a special technique developed by the authors which allows incorporating of multiple non-linear constraints. Within the framework of this method, we use the genetic properties of infeasible solutions by extending the objective function into the infeasible region. This allows attaining optimal solutions which lie exactly on the boundary between feasible and infeasible regions which greatly improves the accuracy of optimal search.

Since the main drawback of GAs consists in poor computational efficiency, the multi-accuracy approach was extended to include a specially designed variant of Reduced Order Models – Local Approximation Method. The computation was also facilitated by employing Hierarchical Grid Consistency principle which makes use of the topological similarity of tested geometries.

In order to enhance the global nature of genetic search we also use a prediction-correction approach. In the prediction stage, the genetic search is performed is concurrently performed on a number of search domains. Then the whole set of suboptimal points is verified through exact Navier-Stokes computations which yields the starting point for the next optimization step.

To illustrate the ability of the method to provide accurate flow simulations, the computational results include a number of industrial-strength applications including complete aircrafts. In the field of shape optimization, the presented results prove the ability of the method to significantly reduce the total drag of complex aerodynamic configurations in the presence of multiple aerodynamic and geometric constraints.

These results together with previously published applications (see, e.g. Epstein et al., 2009) show the ability of the approach to perform accurate and robust flow simulations and shape optimization in the demanding industrial environment.

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Hybrid Computing System and Its Applications

B.N. Chetverushkin

The need for new HPC architectures became urgent during the past few years. The reason of this is well known – the traditional architectures suffer from the increasing number of system bottlenecks. The new HPC architectures are potentially very efficient, but good programming for them is often not easy for the application developers. The partial solution of this problem can be found by making the new HPC systems hybrid. Possible solutions of the problems mentioned above are demonstrated on MVS-Express supercomputer designed in Keldysh Institute of Applied Mathematics (KIAM). The compute nodes of the system are hybrid, each node consisting of the 8-core commodity server and an GPGPU as a coprocessor. The inter-node communication system is also designed in KIAM. It is a direct PCI-Express switch, highly optimized for latency to make hybrid applications development as easy as possible.

The results of the numerical simulation of some CFD problems are presented. A good speedup in comparison with the universal processors was achieved. The technique of modeling of gamma radiation transport in non-homogeneous structures on HPC is also presented.

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Calculation of Rarefied Gas Flow around Rough Bodies

Mikhail Anolik

Surface roughness is one of essential factors which bring influence on aerodynamical characteristics of bodies in rarefied gas flow [1–4]. A rough surface is simulated by homogeneous isotropic differentiable Gaussian random field with given statistical characteristics. The problem of rarefied gas reflection from a rough surface is reduced to evaluation of some continual integrals [5–7]. The approximation of these path integrals by multiple ones allows us to obtain their upper bounds. Arising multiple integrals are evaluated by the Monte Carlo method using dependent samples and also some other technique for reducing the storage size and run time. The results are compared with lower bounds obtained by means of the Rice series [4–7]. In case of single and both single and twofold reflections the calculation is carried out for specular and diffuse scattering function in a small area. The exchange and aerodynamical resistance coefficients for rough bodies of the simplest shape (sphere, cylinder, cone) are calculated in a free molecular flow under different normalization of numerically found scattering function on a rough surface [8–9].

In present time two methods are used for the calculation of aerodynamical characteristics of bodies of complicated shape in transitional flow regime: the local method [10–12] and Direct Simulation Monte Carlo (DSMC) [13]. The local method is applied on the stage of preliminary designing of flying vehicles, DSMC is applied on detailed investigation. The local method allows us to determine the aerodynamical characteristics for any convex axisymmetrical rough bodies in transitional flow regime [14]. In case of DSMC it is recommended to use the scattering function on a rough surface, numerically founded in [9].

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Closure Parameters of Large Scale Models

Heikki Haario

Large scale models typically include 'closure' parameters. These parameters appear in physical parameterization schemes where some unresolved variables are expressed by predefined parameters, rather than being explicitly modeled. Naturally, they provide a source for uncertainty for the model predictions. For climate models, for instance, expert knowledge is used to define the optimal closure parameter values, based on observations, process studies, etc. Here, instead, we study the option of employing Markov chain Monte Carlo (MCMC) methods for such numerically demanding simulations. Especially, we study the posterior probability density of a number of closure parameters appearing in the ECHAM5 climate model. The main conclusion is that under certain restrictions the approach is a viable option for the analysis of even large-scale computational models.

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Impact of Valery Rivkind's Researh in University of Jyväskylä

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Short abstracts for

Minisymposium -

Analytical-numerical Methods for Investigation of Oscillations

Saturday 20th November

Analytical-numerical Methods for Hidden Oscillations Localization: Aizerman and Kalman Conjectures, Hidden Attractor in Chua Circuits

V. Bragin N. Kuznetsov, G. Leonov, V. Vagaitsev

The method of harmonic linearization, numerical methods, and the applied bifurcation theory together discover new opportunities for analysis of oscillations of dynamical systems.

In this presentation new analytical-numerical algorithm for localization of hidden oscillation is discussed. Examples of hidden attractor localization in Chua's circuit and counterexamples construction to Aizerman's conjecture and Kalman's conjecture are considered.

Nonlinear Analysis of Phase-locked Loop

N. Kuznetsov, G. Leonov, P. Neittaanmäki, S. Seledzhi, M. Yuldashev, R. Yuldashev

To design PLL systems an important task is to determine characteristics of system providing required characteristics of operation of PLL. To solve this problem, it is used real experiments with concrete realization of PLL as well as the analytical and numerical methods of analysis of mathematical models of PLL.

Remark, however, that for the strict mathematical analysis of PLL it should be taken into account the fact that the above principles of operation of PLL result in the substantial requirements:

- construction of adequate nonlinear mathematical models in signal space and in phase-frequency space (since PLL contains nonlinear elements) and
- justification of the passage between these models (since PLL translates the problem from signal response to phase response and back again).

Despite this, as noted by Danny Abramovitch in his keynote talk at ACC'2002, the main tendency in a modern literature on analysis of stability and design of PLL is the use of simplified ''linearized'' models and the application of the methods of linear analysis, a rule of thumb, and simulation.

In the present work, on the examples of classical PLL, it is described the approaches to nonlinear analysis and design of PLL, which are based on the construction of adequate nonlinear mathematical models and applying the methods of nonlinear analysis of high-frequency oscillations.

Computational Methods of Limit Cycles Investigation of Two-dimensional Dynamical Systems

O. Kuznetsova, G. Leonov, P. Neittaanmäki

In the present work the methods of computation of Lyapunov quantities and localization of limit cycles of two dimensional dynamical systems are demonstrated. These methods are applied to investigation of quadratic systems with small and large limit cycles. By the transformation of quadratic system to Lienard system and the method of asymptotical integration, quadratic systems with large limit cycles are investigated. The domain of parameters of quadratic systems, for which four limit cycles can be obtained, is determined.

Estimation of a Limit Load for Synchronous Machines

G. Leonov, N. Kondrateva, E. Solovyeva, A. Zaretskiy

In the work the electromechanical models of synchronous machines, namely model with quadrupole rotor and two damper windings and model with smooth rotor and two damper windings at different commutations with two exciting currents, are considered. Parallel and serial commutations in exciting system are investigated.

For this purpose the rotating coordinate system, rigidly bound with rotating magnetic field, is introduced. The classical laws of mechanics and electrical engineering make it possible to pass from these electromechanical models to their mathematical description. Mathematical models – systems of differential equations fourth order in case of parallel commutation and differential equations third order in case of serial commutation – are derived. Limit load problem is considered.

Mathematical Problem for Drilling System

M. Kiseleva, G. Leonov

Drill string failure is today one of the most common non-routine events the drilling industry faces, which increases drilling costs and provokes the loss of valuable drilling time. In the present work a model of a drilling system is considered. This model includes equations of an asynchronous motor and a flexible shaft. Numerical analysis of the system is carried out and obtained results are investigated.

General Information

Wireless Internet

Our wireless network, called *agora-open*, is open to everyone. In case of technical problems please contact our registration desk.

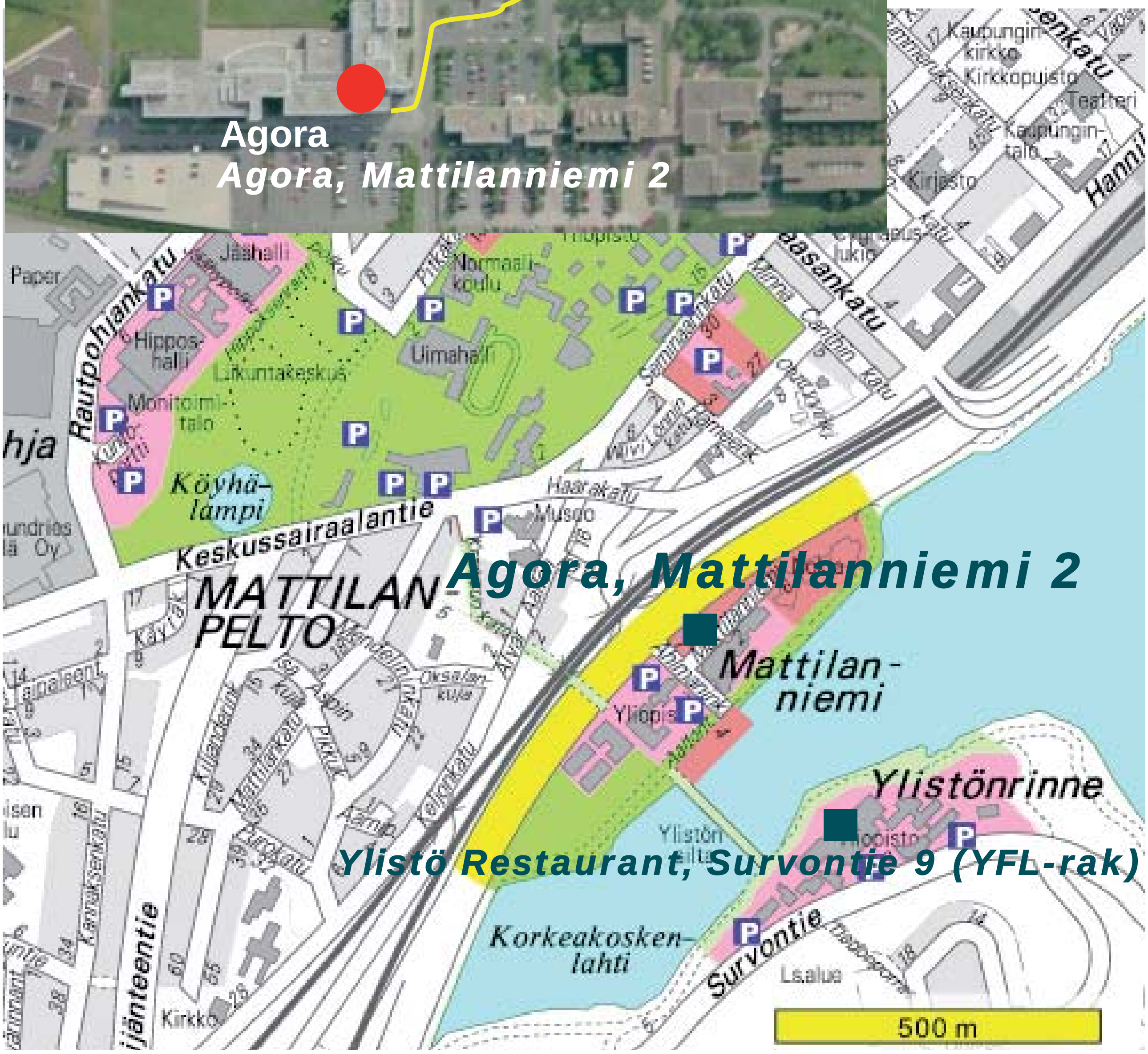
Cocktail

Cocktail is on Thursday, November 18, at 17:30. It is in Agora building at Lea Pulkkinen Hall, 4th floor.

Dinner

Dinner is on Friday, November 19, at 19:00. It will be held at restaurant Ylistö (Survontie 9, near the Agora building), please see the maps.

Ylistö Restaurant, Survontie 9 (YFL-rak)
Agora
Agora, Mattilanniemi 2



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Monitoimi-
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