CENS
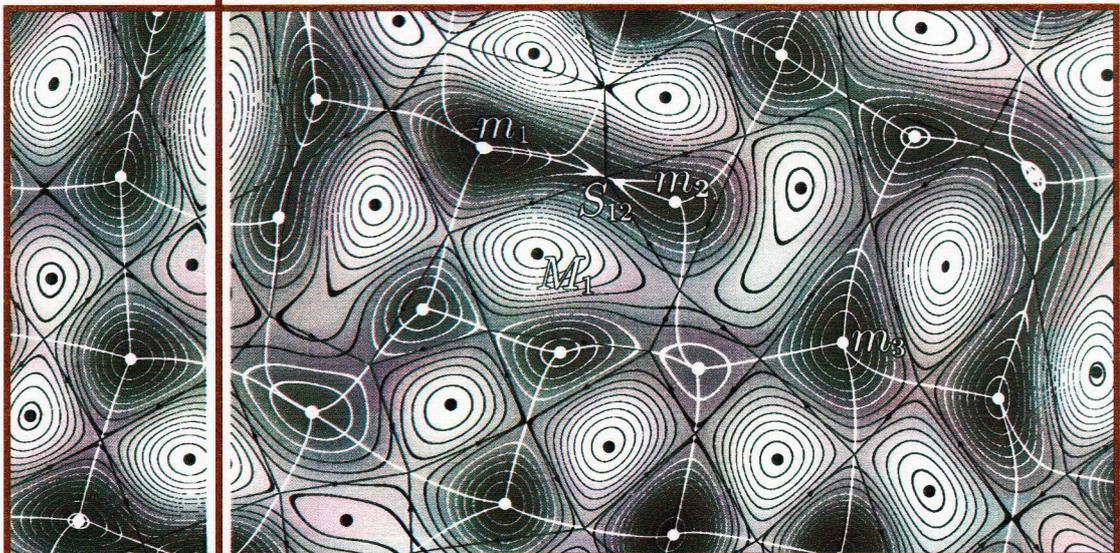
cENTRE FOR NONLINEAR STUDIES

2012 ANNUAL REPORT

Tallinn

Institute of Cybernetics at Tallinn University of Technology

Institute of Physics, University of Tartu

CENS

Centre for Nonlinear Studies

Estonian Centre of Excellence in Research

Annual Report

Tallinn 2012

Contents

Abstract

This Report gives a brief overview on activities of CENS in 2012. From August 2011, CENS is an Estonian Centre of Excellence in Research, supported by the European Regional Development Fund. Described are studies and results in: (i) dynamics of microstructured materials and solitons; (ii) general nonlinear wave theory; (iii) fractality and econophysics; (iv) nonlinear photoelasticity; (v) systems biology and cell energetics; (vi) water waves and coastal engineering; (vii) nonlinear control theory; (viii) nonlinear optics and localised waves.

The full records of papers, reports, conference talks, teaching activities, promotions, etc are all included. A separate section lists the highlights of research. The Annex includes some additional information on activities and further challenges.

Keywords: nonlinear dynamics, soft matter physics, microstructured solids, solitons, acoustodiagnostics, photoelasticity, cell energetics, water waves, extreme waves, coastal engineering, differential equations, control theory, wave optics and localised waves.

Sisukord

Lühikokkuvõte

Aruanne sisaldab ülevaadet CENSi (Mittelineaarsete Protsesside Analüüsi Keskuse) tegevusest 2012.a. Alates augustist 2011, on CENS Eesti tippkeskus, millega kaasneb toetus Euroopa Regionaalarengu Fondilt. Põhitulemused on kirjeldatud järgmiste alateemade kaupa:
(i) lainelevi mikrostruktuursetes materjalides ja solitonid; (ii) üldine mittelineaarne laineleviteooria; (iii) fraktaalsus ja ökonofüüsika; (iv) mittelineaarne fotoelastsus; (v) süsteemibioloogia ja rakuenergeetika; (vi) lained veepinnal ja rannikutehnika; (vii) mittelineaarne juhtimisteooria; (viii) mittelineaarne optika ja lokaliseeritud lained.

On esitatud publikatsioonide, konverentsiettekannete, seminaride ja õppekursuste jm. nimekirjad. Eraldi on välja toodud olulised teadustulemused. Lisas on täiendav informatsioon üksikutest tegevustest.

Võtmesõnad:

mittelineaarne dünaamika, pehmisefüüsika, mikrostruktuuriga materjalid, solitonid, akustodiagnostika, fotoelastsus, rakuenergeetika, pinnalained, hiidlained, rannikutehnika, diferentsiaalvõrrandid, juhtimisteooria, laineoptika, lokaliseeritud lained.

1. Introduction

The underlying idea for founding Centre for Nonlinear Studies (CENS) in 1999 was to bring together the scientific potential of Estonia engaged in interdisciplinary studies of complex nonlinear processes. In 2002–2007 CENS was included into the first Estonian National Programme for Centres of Excellence in Research. The results from this period are described in "CENS Highlights, 2007" (see also Annual Reports).

In 2009 CENS was awarded with the title "Centre of Excellence in Research" of Tallinn University of Technology for years 2009–2011.

In 2011, CENS was included into the second Estonian National Programme for Centres of Excellence in Research (2011–2015).

This Report covers, like the previous ones, all the activities carried on by the staff of CENS including students. Section 2 is a short summary on the structure of CENS and on highlights in 2012. In Section 3, current research results in 2012 are briefly described. Next Sections describe funding (Section 4), publications, conferences, etc. (Section 5) and other activities of CENS (Section 6). Finally, in Section 7 conclusions are presented. Some additional materials describing the activities of CENS are given in the Annex.

According to the views of the International Advisory Board, this Report is made more attractive: beside the traditional short abstracts of results, several illustrations are included. Also included is a Table with data on funding.

2. Overview on CENS and highlights in 2012

CENS is the Estonian hub of competence, research and training in nonlinear phenomena – the intrinsic component of real world that brings in universal phenomena (solitons, coherence, chaos, hierarchies, self-emergence, etc.) which need specific tools for their analysis and control. The research is interdisciplinary and cross-disciplinary.

The present CENS from 2011 on includes the following research groups from the Institute of Cybernetics at Tallinn UT (IoC at TUT) and the University of Tartu (UT):

> *Nonlinear Dynamics* (IoC at TUT) — Prof J.Engelbrecht;
>
> *Wave Engineering* (IoC at TUT) — Prof T.Soomere;
>
> *Systems Biology* (IoC at TUT) — Dr M.Vendelin;
>
> *Optics* (UT) — Prof P.Saari;
>
> *Nonlinear Control Theory* (IoC at TUT) — Dr Ü.Kotta.

Nonlinear Dynamics group deals with (i) nonlinear wave motion in solids; (ii) soft matter physics; (iii) photoelasticity. Attention is on hierarchical behaviour of microstructured solids under dynamical loads, including impact and corresponding inverse problems; solitons and solitary waves; turbulent mixing; processes with power laws; nonlinear photoelastic tomography.

Wave Engineering group has competence in nonlinear wave theory and modelling of fluids with the focus on applications in the marine and coastal environments. Attention is to wave excitation and propagation over the sea surface; impact of waves in coastal regions; unified framework for wave-driven phenomena, and Lagrangian transport.

Systems Biology group is focused on unravelling the intricacies behind regulation of intracellular processes in cardiac muscle cells. Efforts are mostly concentrated on studying regulatory mechanisms of metabolic processes in the heart, expanding our knowledge of cardiac energetics and contractile function, and shedding light on novel aspects of excitation-contraction coupling in rat, trout and mouse hearts. Both experimental and computational approaches are applied in investigating these topics.

Optics group has competence in ultrafast optics, optical and nonlinear spectroscopy and localized waves. Attention is to application of localized waves in femtosecond optics and nonlinear spectroscopy as well as extending operational characteristics of laser-based optical tomography.

Nonlinear Control Theory group deals with in dynamical control systems on time scales. Attention is focused on novel algebraic methods and symbolic software tools for solving fundamental problems for nonlinear control systems towards unification of discrete- and continuous-time control.

Synergy and added value is created in understanding universal nonlinear phenomena: mathematical models and methods of analysis; interaction of waves in a wide range of scales; solitons; solitary and localised waves; emerging features; nonlinear feedback; irreversibility; control over physical phenomena. Such studies are in the forefront of science, more specifically in studies of complex systems. There are many practical applications in materials science, environmental protection, health care, and information technology. Research is supported by several international agencies and programmes: Wellcome Trust, BONUS+, Roboswarm, Humboldt Foundation, etc.

CENS has personnel of 67, of whom 27 are PhD students (see Annex 1).

Highlights of research in 2012

Nonlinear Dynamics

- It is shown that the concept of dual internal variables can provide hyperbolic governing equations for processes in the microscale of microstructured materials concerning also temperature fluctuations which can be treated as microtemperature.

- The accuracy of wave models for microstructured solids is analysed in case of different internal structures for a large range of material parameters and wavelengths.

- The novel methods for measuring the orientation of fibres in short fibre reinforced concrete are proposed and applied.

- An analysis of phase plots and parametric plots is carried out in order to enhance accuracy of Nondestructive Testing for functionally graded materials.

- The mechanism for anomalously fast nucleation of droplets is explained by highly inhomogeneous and intermittent widening of the droplet-size distribution spectra.

- A multivariable method for determining scaling exponents (developed earlier at CENS) is used to analyse the classical percolation problems.

Wave Engineering

- The basic features of the wave climate in the South-Western Baltic Sea are established based on the second longest instrumentally recorded wave time series in the Baltic Sea at the Darss Sill in 1991–2010.

- Using the concept of finite-time compressibility, the patch formation efficiency is explained in compressible flows on the example of the analysis of the surface velocity field in the Gulf of Finland.

- The preventive technique for the optimisation of fairways based on environmental considerations has been expanded to cover the south-western Baltic Sea and the Kattegat.

- A catalogue of rogue wave accidents reported in mass media during 2006–2010 has been created.

Optics

- For the first time temporal focusing of ultrashort pulsed Bessel beams into Airy-Bessel light bullets by a circular diffraction grating was verified.

- For the experiments an ultra-broadband version of spectral interferometer was constructed which allows to record impulse responses with ultrahigh (single-cycle) temporal and micrometer-range spatial resolution.

Systems Biology

- An efficient and accurate method for determining sarcomere lengths of cardiomyocyte has been developed and implemented in open-source software.

- It has been shown that the dynamic method provides a measure of total flux, and not net flux as presumed previously, making the fluxes predicted from both methods consistent.

- Results obtained from experiments indicate that diffusion of a smaller molecule (1127 MW fluorescently labeled ATTO633-ATP) is restricted more than that of a larger one (10,000 MW Alexa647-dextran), when comparing diffusion in cardiomyocytes to that in solution. The presence of periodic intracellular barriers has been suggested.

- An integrated method to quantify calcium fluxes in cardiac excitation-contraction coupling has been developed which can be applied to all species – including genetically modifiable mice and zebrafish – to study the cardiac functional phenotype under a range of physiological conditions.

Nonlinear Control Theory

- The simple necessary and sufficient conditions, allowing to transform the nonlinear discrete-time control system into the extended observer form, were provided. The solvability conditions are formulated in terms of certain partial derivatives and due to the matrix representation they can be checked almost by direct inspection.

- The application of Neural Networks based Additive Nonlinear Auto Regressive eXogenous (NN-ANARX) models as a computational tool of the supervision system for therapeutic exercises was proposed.

Applications

- A semi-immersive 3 D visualization system has been designed and installed aiming to have a tool for computer graphics and research on complex microstructured materials.

- The photoelastic scattered light polariscope SCALP is designed and applied.

- IOCBio Sarcomere length and fundamental period software is developed:
  http://code.google.com/p/iocbio/wiki/IOCBioSarcomereLength.

3. Current results 2012

3.1 Institute of Cybernetics, Department of Mechanics and Applied Mathematics, Tallinn University of Technology

3.1.1 Dynamics of microstructured materials and solitons

Waves in microstructured solids.
A mathematical model describing 1D wave propagation in Mindlin-type microstructured solids with nonlinearities in the macro- and microscale is used for studying propagation of solitary waves in such media. Corresponding full system of equations (FSE) is derived in terms of macro-displacement and micro-deformation. Making use of slaving principle a hierarchical Boussinesq-type equation (HE), which includes only macro-displacement related terms, is derived from the FSE in early studies. Both model equations, the FSE and the HE, are solved numerically under localized initial conditions and periodic boundary conditions by the pseudospectral method. It is demonstrated how the values of the model parameters influence the wave propagation, the evolution and the interaction of waves under the framework of considered models. For this reason the solutions of the model equations are compared under different parameter combinations against one fixed combination of material parameters which is called 'the reference case'. The results could be used for the stress analysis as well as for the nondestructive testing of material properties. (A.Salupere, K.Tamm, J.Engelbrecht).
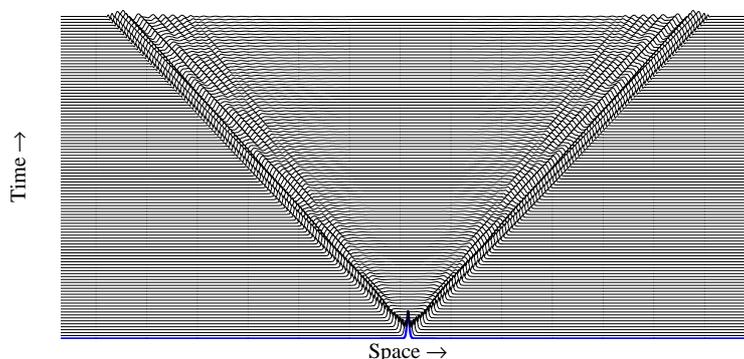

Figure 1: The typical solution for the model equations.

Soliton ensembles and solitonic structures.
Several case studies have revealed the role of complicated non-integrable evolution equations in supporting complicated steady solutions which generalize the concept of single solitons. The cases studied include: (i) martensitic-austenitic alloys; (ii) hyperelastic rod and (iii) granular materials. The corresponding non-integrable evolution equations include higher order nonlinear and dispersive terms and represent the generalisations of the celebrated Korteweg-de Vries equation. The numerical simulation is carried out by the pseudospectral method. It has been demonstrated that several combinations of steady solutions may exist. One group of solutions called soliton ensembles involves plaited solitons, the second group, called solitonic structures includes solitons with non-vanishing oscillatory tails and wave packets. The results are analysed in terms of the energy of an initial excitation (J.Engelbrecht, A.Salupere).

Waves in microstructured solids, general theory.

The response of many materials (metals, alloys, composites, etc) to external loading may be essentially influenced by an existing or emerging internal structure at smaller scales which must be taken into account. For this purpose the concept of dual internal variables can be used in order to describe the effect of internal fields. It is shown that the dual internal variable theory is sufficiently general to model cases like the micromorphic elasticity and the influence of microtemperature. Based on the material (canonical) balance equations for material momentum and energy, this approach extends the single internal variable theory. The resulting governing equations are not limited by first-order reaction-diffusion equations, as it is typical for the single internal variable theory. Hyperbolic governing equations for internal variables provide the description of the interaction of waves at macro- and micro-levels (J.Engelbrecht, A.Berezovski).

The mathematical structure and properties of a micromorphic-type microstructure model is studied. The model is based on material formulation of continuum mechanics and dual internal variables concept. It is shown that the governing wave equations derived in such a way reflect the influence of the internal structure on the macromotion of solids in a sufficiently general way. Actually this model describes the internal fields in solids under external loading and the interaction of these fields results in various physical effects. The emphasis is on wave motion and dispersion analysis (A.Berezovski, J.Engelbrecht, A.Salupere, K.Tamm, T.Peets, M.Berezovski).

Wave propagation in materials with embedded two different microstructures is also considered. Each microstructure is characterized by its own length scale. The main working hypothesis, i. e. the dual internal variables approach is adopted yielding in a Mindlin-type model including both microstructures. Equations of motion for microstructures are coupled with the balance of linear momentum for the macromotion. The solution of the evolution equations is non-zero even for zero initial and boundary conditions for internal variables due to the coupling with the macromotion equation. The influence of a microstructure depends on the values of material parameters characterizing the microstructure (A.Berezovski, J.Engelbrecht, M.Berezovski).

The asymptotic stability of solutions of the Mindlin-type microstructure model for solids is analyzed. It is shown that short waves are asymptotically stable even in the case of a weakly non-convex free energy dependence on microdeformation. This result enlarges the classical requirement about the convexity of the free energy as a natural requirement providing stability conditions in homogeneous solids. Inhomogeneous solids may have, in principle, more weak requirements for the free energy convexity (A.Berezovski, M.Berezovski).

Waves in microstructured solids, numerics.

Numerical simulations of the thermoelastic response of a microstructured material on a thermal loading are performed in the one-dimensional setting to examine the influence of temperature gradient effects at the microstructure level predicted by the thermoelastic description of microstructured solids. The system of a hyperbolic evolution equation for the microtemperature, a parabolic macroscopic heat conduction equation, and a hyperbolic equation of motion is solved by a finite-volume numerical scheme. Effects of microtemperature gradients exhibit themselves on the macrolevel due to the coupling of equations of the macromotion and evolution equations for macro- and microtemperatures (A.Berezovski, M.Berezovski).

A series of numerical simulations is carried on in order to understand the accuracy of dispersive wave models for microstructured solids. The computations are performed by means of the finite-volume numerical scheme, which belongs to the class of wave-propagation algorithms. The dispersion effects are analyzed in materials with different internal structures: microstructure described by micromorphic theory, regular laminates, laminates with substructures, etc., for a large range of material parameters and wavelengths (A.Berezovski, J.Engelbrecht, M.Berezovski).

The accuracy of two-dimensional wave propagation algorithm is examined on the example of an elastic impact of two thick solid plates (see Fig. 2). The results of numerical computations are compared with the known analytical solution. The comparison shows a good agreement between analytical and numerical solutions (A.Berezovski).
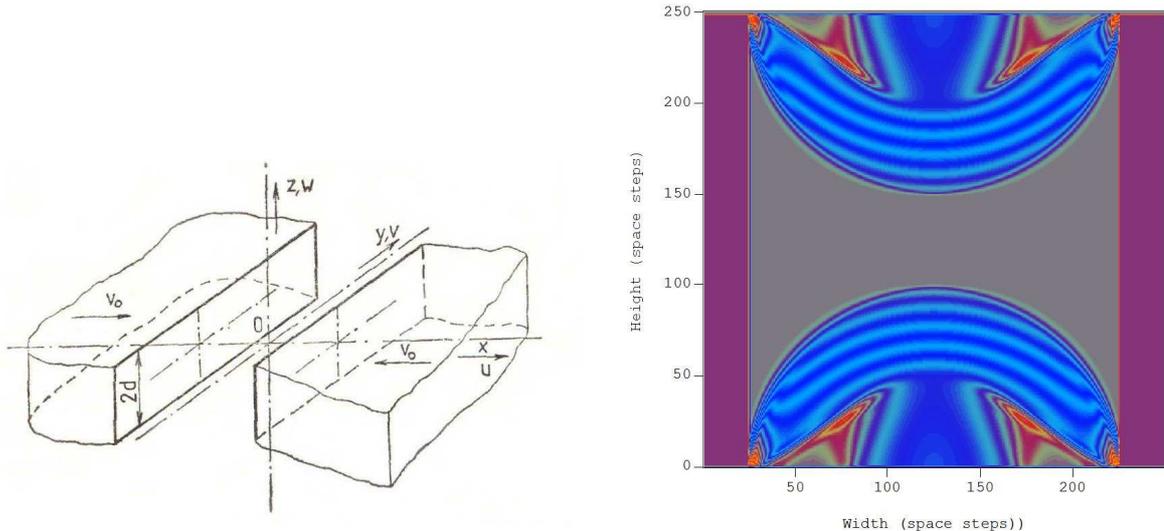
Figure 2: Geometry of impact (left) and longitudinal stress colour contours at 100 time steps after impact (right).

Analysis of concepts of mesoscopic physics for microstructured materials.
Different scenarios of the usage of the distribution function with its evolution equation together with different versions of the balance of mass are described and virtually disconnected mesoscopic domains are studied. The problem that continuous three-dimensional domains may become discontinuous when using the mesoscopic space is discussed. It means that under certain circumstances, i.e. when the mesoscopic domain becomes non-connected, mesoscopic continuum physics requires a strongly non-local formulation of constitutive function. A weakly non-local formulation containing gradients is not sufficient any more. The next step is to find suitable numerical methods for determining virtual boundary conditions (H.Herrmann, J.Engelbrecht).

Measurement of fibre orientation distributions.
Two modern methods for measuring the orientation of short metal fibres in short fibre reinforced concrete (SFRC) have been used, one of them a new method that was developed together with members of the centre for biorobotics of TUT. These methods are

- (micro) computed tomography

- robotic DC-conductivity testing (see Fig. 3)

where the latter one is the newly developed method. Both methods are capable of measuring the orientation of individual fibres with high accuracy.
By use of these methods the fibre orientations in SFRC slabs have been analysed, the results show a strong locality of the fibre orientation distribution (OD) – see Fig. 4. This points out the connection between fibre OD and the casting/production method. Future research in this direction is envisaged (H.Herrmann, M.Eik).

Constitutive theory and simulation of short fibre reinforced materials.
A phenomenological constitutive mapping for short fibre reinforced materials has been formulated, which takes the orientation distribution of fibres into account. First FEM (finite element method) simulations for example configurations have been performed, these show that the constitutive model is promising. Further, first simulations on the fracture of short fibre reinforced materials have been done using DEM (discrete element method), a particle based method. The target was to model tension tests in combination with a single fibre pullout (H.Herrmann, M.Eik, V.Berg).
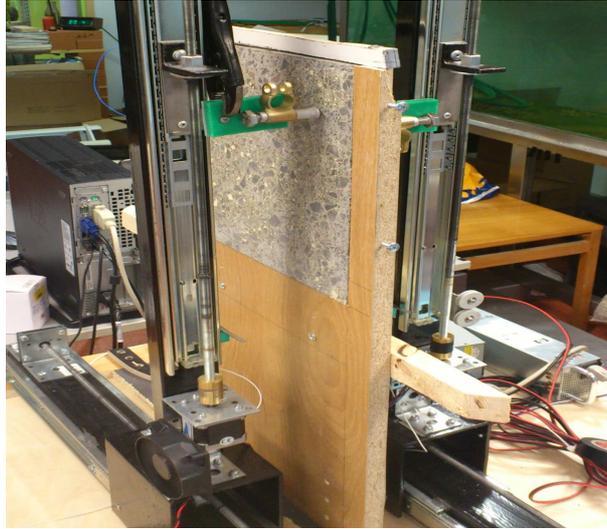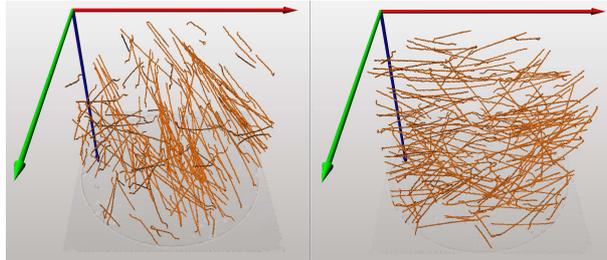
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Figure 3: DC-conductivity testing

Figure 4: Skeletons of steel fibres in SFRC, obtained by CT measurements.

3.1.2 General nonlinear wave theory

Acoustodiagnostics of inhomogeneous solids.
The theoretical investigation of inverse problems to characterize the strongly variable properties of functionally graded materials (FGMs) on the basis of direct solutions to the problems of ultrasonic wave propagation is carried on (see Fig 5). We aimed at solving the problem resorting to the response of FGMs to the dynamic excitation evoked in the material by the propagation and reflection of the ultrasonic harmonic burst. The response is analyzed using the phase plots and their generalizations into parametric plots composed on the basis of different profiles of boundary oscillations. Comparisons between the composed plots enable one to determine the character of material properties variation and to distinguish the most relevant property of the material responsible for inhomogeneity. These results may be used as the basis for elaboration of the method for qualitative nondestructive characterization of FGMs with essentially changing continuous properties (A.Ravasoo).
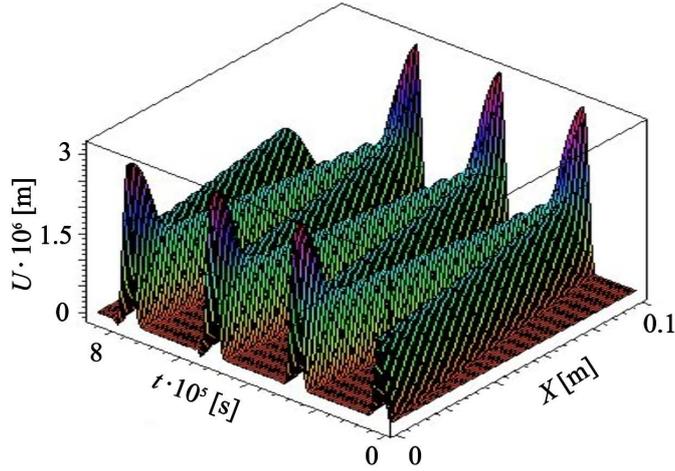
Figure 5: Tone burst in inhomogeneous material.

Nonlinear phenomena of the piano string vibrations.

The main goal is the physics-based modeling of the piano string vibrations in case of its nonlinear amplitude limitation caused by the capo bar and the damper. It was shown that the proposed approach is suitable for simulation of the nonlinear effects induced by the contact nonlinearity. The schemes of string-damper interaction and reflection of a single wave are shown in Fig. 6. The developed theoretical model was compared with experimental results, and it was concluded that the proposed technique is able to produce the main effect of the energy transfer from the lower harmonics to higher partials, which can excite missing modes during the nonlinear string vibrations (A.Stulov, D.Kartofelev) `http://www.cs.ioc.ee/~dima/results.html`).
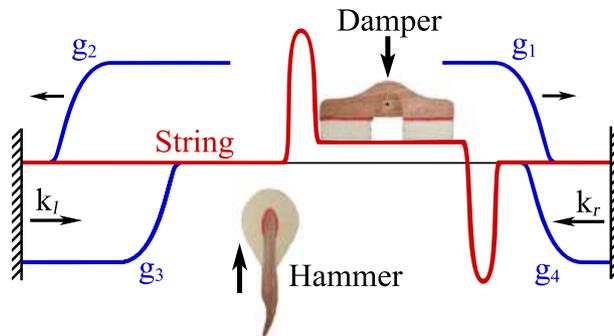

Figure 6: Scheme of string-damper interaction. Functions g are the traveling waves; k_l and k_r are the reflection coefficients.

3.1.3 Fractality and econophysics

Understanding the mechanisms responsible for anomalously fast nucleation of droplets (as compared with the existing theories) has been a long-standing challenge for the physicists. The studies performed at CENS suggest that the anomalously fast nucleation rate can be explained by a highly inhomogeneous and intermittent widening of the droplet-size distribution spectra spectra. This hypothesis was tested using the stochastic triplet-map model of turbulent mixing. Strong fluctuations of the spectral width can be clearly seen in Fig. 7, which represents numerically obtained droplet-width-spectra for different altitudes (scales are with arbitrary units). The nucleation time was estimated as a function of the Kolmogorov scale and the density of nucleation centres. The effect has been studied both numerically and analytically, the results are in a reasonable agreement.
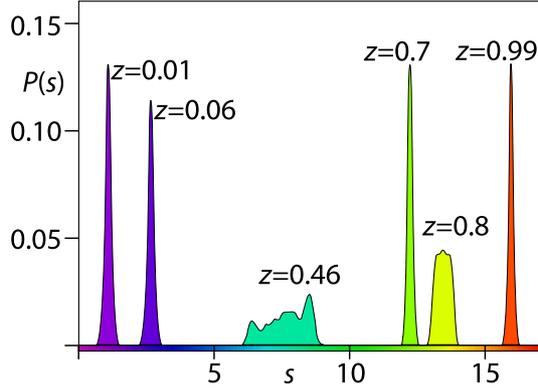
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Figure 7: General structure of spectra.

The stochastic triplet-map model of turbulent mixing has been also used to analyse the two-dimensional turbulent mixing of a tracer injected from a localised point source. The structure function scaling exponents have been derived as a function of the Hurst exponent of the stream function; the results are verified numerically.

It has been well known that in compressible flows, tracer particles tend to gather into patches. Earlier studies at CENS revealed that classically defined compressibility of velocity fields is not sufficient to describe the patch-formation-efficiency of real (i.e. time-correlated) flows. The alternative measure of finite-time compressibility (FTC) has been introduced to study time effects on the evolution of tracer particles. Using the concept of FTC, extended analysis of the surface-velocity-field of the Gulf of Finland has been performed in collaboration with the Laboratory of Wave Engineering. While the FTC describes the patch-formation-efficiency of real flows more reliably than the classical compressibility, it has still certain flaws. In order to describe the patch-formation-efficiency by a single number, the concept of *asymptotic compressibility* has been introduced.

In collaboration with the Department of Materials Engineering, TUT, and Institute of Physics, UT, the mixing of nano-fibres into composite materials has been studied. In order to provide homogeneous and efficient mixing without excessive entanglement of nano-fibres, a novel architecture of the mixing apparatus has been devised.

A multivariate method of determining scaling exponents from finite-size Monte-Carlo simulation data (developed earlier at CENS) has been used to determine the asymptotic correction exponents of the classical percolation problem. Unrivalled numerical accuracy has been achieved by defining and analysing nine different fractal sets with equal fractal dimension, five of which ("bonds", "ends", "hull", "lines", and "sides") are depicted in Fig. 8 below.

A simple model for the nonlinear oscillations of tunnel diodes has been developed which explains the shape of the effective (time-averaged) V-I curve in the region of negative differential resistance; the analytical results are in a good agreement with the experimental measurement data.

Based on the scaling analysis of the competition protocol of the 43rd International Physics Olympiad, it has been shown that in the case of "creative" problems (which cannot be solved by a straightforward application of the formulae and techniques taught during physics courses), the score distribution is characterised by certain power laws. Meanwhile, in the case of "non-creative" problems, such a scale-free behaviour is not observed. This scaling analysis can be used as a nonsubjective problem classification tool.
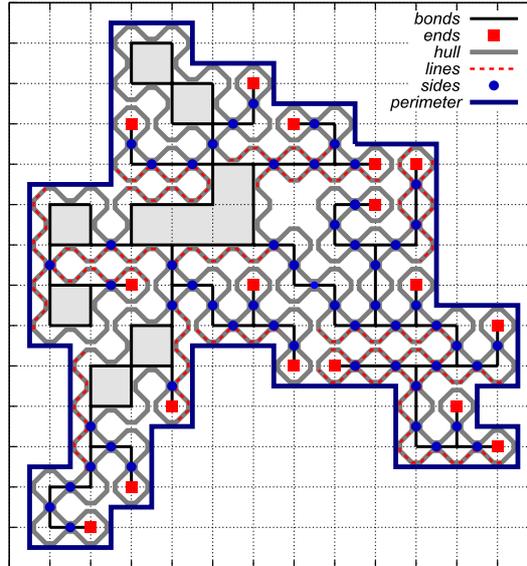
Figure 8: General structure of fractal sets.

Complex systems have been discussed in the context of economic and business policy and decision making. In particular, it has been argued that small economies have good prospects to gain from the global processes underway, if they can demonstrate flexible production, reliable business ethics and good risk management. Regarding the challenges in decision making under complexity from macro and micro economic perspective, it has been concluded that the main task for corporate managements is finding and continuously maintaining the balance between short term noise and long term chaos whose attractor includes customers, shareholders and employees (J.Kalda, R.Kitt, I.Mandre, M.Kree, et al.).

3.1.4 Laboratory of Wave Engineering

Lagrangian trajectory methods are increasingly being used for transport studies due to ocean currents. Particle motion can be computed as a superposition of transport by (i) modelled velocities of water particles (advection) and (ii) basically random fluctuations due to processes that cannot yet be adequately replicated by existing models (often called simply diffusion). We have investigated the implementation of particle diffusion, specifically comparing a standard constant-coefficient model with a model where the diffusion coefficient varies in time and space. The different model implementations have a clear impact on individual particle trajectories and residence time of particles within a bay. However, analysis of coastal impact from offshore pollution in the Gulf of Finland showed remarkably little impact of particle diffusion on several features of large sets of trajectories, including typical areas hit by the pollution (within 2–3% of non-diffusive reference simulations). The impact of particle diffusion is thus closely linked with the particular process that is investigated.

The basic features of the *wave climate in the South-Western Baltic Sea* are established based on the second longest instrumentally recorded wave time series – waverider measurements at the Darss Sill in 1991–2010 — and two series of numerical simulations. The wave climate in this region is typical for semi-enclosed basins of the Baltic Sea, with the maximum wave heights (measured maximum significant wave height 4.46 m on 03.11.1995) about half of those in the Baltic Proper, a very small role of remote swell, substantial seasonal and decadal variation but with almost no long-term trend. The wave periods, estimated using the standard waverider and the usual setup of wave models are mostly concentrated in a narrow range of 2.6–4 s.
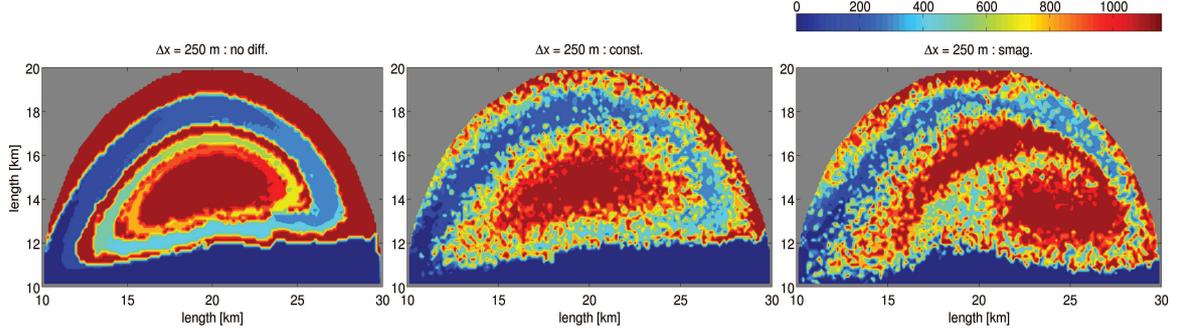
Figure 9: Spatial variation of residence time for particles seeded within a semicircular bay. Motion is driven by a constant current from left to right at the bottom boundary. The color scale range is from 0 to 1152 hours. The figure panels show results for non-diffusive, constant diffusion coefficient and variable diffusion coefficient test cases, respectively (Torsvik T., 2012).

Their distribution is almost constant over decades. The use of wave models with an extended frequency range (periods down to 0.5 s) revealed that both the standard waverider and the classical set-up of wave models overlook a substantial part of shorter waves, with periods about 2–2.8 s.
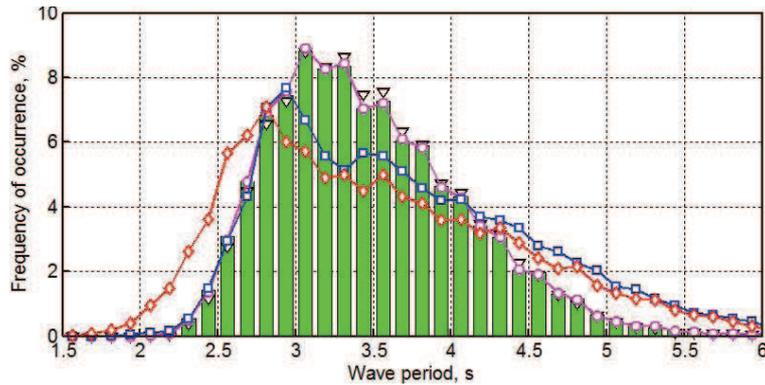
Figure 10: Frequency of occurrence of different mean wave periods in the overlapping data set of waverider measurements (bars) and two simulations (blue squares and red diamonds) at the Darss Sill in 1991–2002. Triangles show the distribution of all recorded wave data in 1991–2010 (Soomere T., Weisse R., Behrens, A., 2012).

Nonlinear effects at the bottom profile of convex shape (non-reflecting beach) are studied using an asymptotic approach (nonlinear WKB approximation) and the direct perturbation theory. A basically well-known effect of the presence nonlinearity is the generation of high-order harmonics in the propagating wave, which results in wave breaking at some location. Using the perturbation theory, we demonstrate that nonlinearity also leads to certain variations in the mean sea level (that is, set-down and set-up of water level). Differently from linear wave propagation (when wave energy is not reflected from certain profiles), nonlinear effects lead to wave reflection from these profiles. For the wave propagating shoreward the nonlinear correction (the second harmonic) is smaller than the one predicted by the asymptotic approach, while for the offshore propagating wave they have a similar magnitude. In both cases the nonlinear corrections are oscillatory.

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Figure 11: Comparison of amplitudes of the second harmonics found from the nonlinear WKB approximation (solid line) and nonlinear term (dashed line) for the wave propagating shoreward (top) and seaward (bottom) (Didenkulova I., Pelinovsky E., 2012).
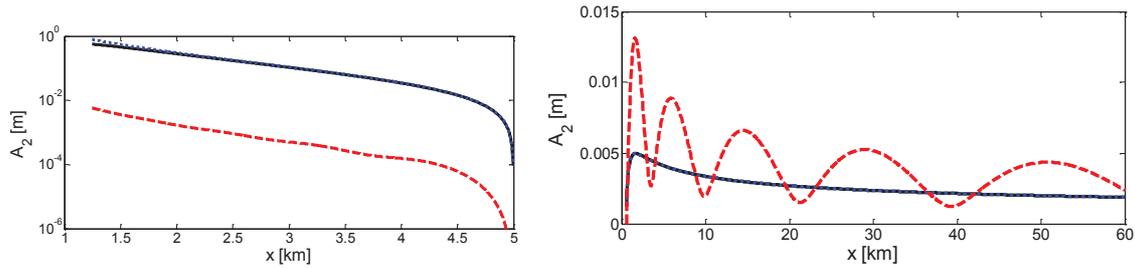
Standard models of internal waves fail to properly describe the evolution of internal waves *in a three-layer fluid with so-called symmetric stratification* (that often occurs in the Baltic Sea and in the Gulf of Finland). This situation requires the use of the extended modified Korteweg-de Vries [(2 + 4)KdV] equation that apparently is non-integrable. Its small-amplitude solitary wave solutions behave similarly to solitons of the modified Korteweg-de Vries equation. Their large-amplitude sisters acquire a plateau-like shape similar to solitons of the Gardner equation. The collision of solutions of the (2+4)KdV equation is weakly inelastic.
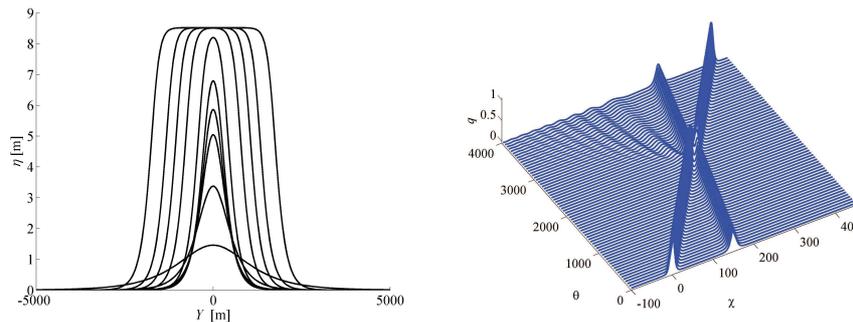
Figure 12: The shape of solitary wave solutions to the (2+4)KdV equation for increasing solitary wave speeds (left; the lowest speed correspond to the wave with the smallest amplitude) and interaction of solitary wave solutions of elevation in nondimensional coordinates (Kurkina O.E., Kurkin A.A., Ruvinskaya E.A., Pelinovsky E.N., Soomere T., 2012).

The *preventive technique for the optimisation of fairways based on environmental considerations* (Soomere et al., 2011) has been expanded to cover the South-Western Baltic Sea and the Kattegat. The technique relies on the quantification of the offshore domains (the points of release of adverse impacts) in terms of their ability to serve as a source of remote, current-driven danger to the nearshore. The optimum fairways are identified from the spatial distributions of the probability of hitting the coast and for the time (particle age) it takes for the pollution to reach the coast. In general, the northern side of the Darss Sill area and the western domains of the Kattegat are safer to travel. The gain from the use of the optimum fairways is in the range of 10–30% in terms of the decrease in the probability of coastal hit or an increase by about 1–2 days of the time it takes for the hit to occur.

Figure 13: Examples of optimum fairways in the western Baltic Sea based on the distribution of the probability for coastal hit (red) and the time it takes for the pollution to reach the coast (white) for the period of 1990–1994 (Lu X., Soomere T., Stanev E., Murawski I., 2012).

Rogue wave accidents include 106 events reported in mass media during 2006–2010. They are classified as either true (78 events) or possible (28), and by the location of their occurrence: deep, shallow 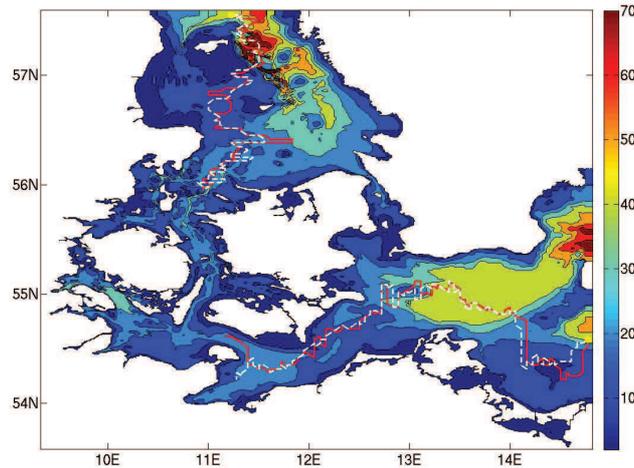and coastal conditions. The "validity" of the event has been estimated either by the rogue wave height, which should be twice larger than the significant wave height (taken from satellite data), and/or by the associated hazard. A surprisingly large number of rogue wave observations occurred in shallow waters (51% for all observed events and 38.5% for the true events) or at the coast (40% for all observed events and 50% for the true events). This predominance of nearshore and coastal events can be explained by the presence of dense population in these areas and/or a heavy marine traffic in coastal waters where rogue waves cause especially high damage.
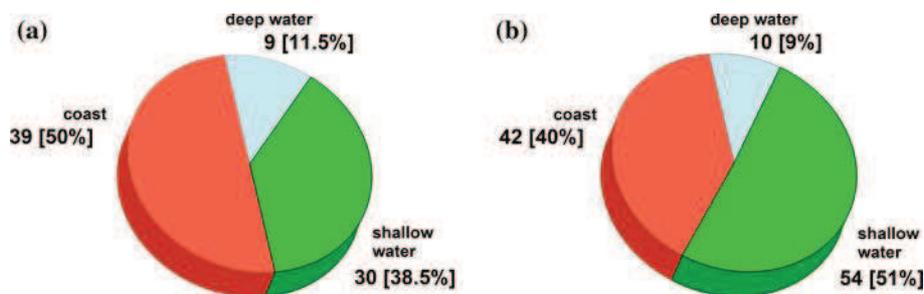
Figure 14: The number and proportion of rogue wave occurrence in deep and shallow waters and at the coast in 2006–2010 based on a) true events b) all observed events (Nikolkina I., Didenkulova I., 2012).

Other results of the Wave Engineering Laboratory team include: analysis of decadal-scale impacts of a segmented, shore-parallel breakwater system (T.Dolphin, A.Terentjeva with colleagues from the UK), establishing the properties of transformation and interactions of strongly non-linear (Riemann) waves in a shallow-water basin (optionally of variable cross-section), resonant generation of tsunami waves by submarine landslides, formation of shallow-water rogue waves and their statistics in Tallinn Bay (I.Didenkulova, A.Rodin in cooperation with E.Pelinovsky), insight into river landslides in Nizhny Novgorod region and a possibility of local tsunami generation (I.Nikolkina, I.Didenkulova), establishing the parameters of wave climate at coasts of the Kurzeme Peninsula (K.Pindsoo, M.Zujev, T.Soomere), establishing the interconnec-

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tions between the classical compressibility of velocity fields and the finite-time compressibility (A.Giudici, T.Soomere, J.Kalda), extension of the technique of Okubo-Weiss parameter to study the structure of surface currents in the Gulf of Finland (T.Torsvik, B.Viikmäe), hindcast of sediment flow along the Curonian Spit under different wave climates (M.Viška, T.Soomere), optimizing breakwater configuration for vessel wakes and wind waves for Noblessner Port, Tallinn Bay (R.Männikus, T.Torsvik, T.Soomere), analysis of wave run-up on a vertical wall in a bay of a parabolic cross-section (I.Didenkulova S.Chatrae, E.Pelinovsky), and numerical simulation of surfactants' dynamics in the field of internal solitary waves (L.Averbukh with colleagues from Nizhny Novgorod).

3.1.5 Laboratory of Systems Biology

Analysis of Molecular Movement Reveals Latticelike Obstructions to Diffusion in Heart Muscle Cells.
Intracellular diffusion in muscle cells is known to be restricted. Although characteristics and localization of these restrictions is yet to be elucidated, it has been established that ischemia-reperfusion injury reduces the overall diffusion restriction. Here we apply an extended version of raster image correlation spectroscopy to determine directional anisotropy and coefficients of diffusion in rat cardiomyocytes. Our experimental results indicate that diffusion of a smaller molecule (1127 MW fluorescently labeled ATTO633-ATP) is restricted more than that of a larger one (10,000 MW Alexa647-dextran), when comparing diffusion in cardiomyocytes to that in solution. We attempt to provide a resolution to this counterintuitive result by applying a quantitative stochastic model of diffusion. Modeling results suggest the presence of periodic intracellular barriers situated $\sim 1\mu m$ apart having very low permeabilities and a small effect of molecular crowding in volumes between the barriers. Such intracellular structuring could restrict diffusion of molecules of energy metabolism, reactive oxygen species, and apoptotic signals, enacting a significant role in normally functioning cardiomyocytes as well as in pathological conditions of the heart (A.Illaste).

Molecular dynamics simulations of creatine kinase and adenine nucleotide translocase in mitochondrial membrane patch.
Interaction between mitochondrial creatine kinase (MtCK) and adenine nucleotide translocase (ANT) can play an important role in determining energy transfer pathways in the cell. Although the functional coupling between MtCK and ANT has been demonstrated, the precise mechanism of the coupling is not clear. To study the details of the coupling, we turned to molecular dynamics simulations. We introduce a new coarse-grained molecular dynamics model of a patch of the mitochondrial inner membrane containing a transmembrane ANT and an MtCK above the membrane. The membrane model consists of three major types of lipids (phosphatidylcholine, phosphatidylethanolamine, and cardiolipin) in a roughly 2:1:1 molar ratio. A thermodynamics-based coarse-grained force field, termed MARTINI, has been used together with the GROMACS molecular dynamics package for all simulated systems in this work. Several physical properties of the system are reproduced by the model and are in agreement with known data. This includes membrane thickness, dimension of the proteins, and diffusion constants. We have studied the binding of MtCK to the membrane and demonstrated the effect of cardiolipin on the stabilization of the binding. In addition, our simulations predict which part of the MtCK protein sequence interacts with the membrane. Taken together, the model has been verified by dynamical and structural data and can be used as the basis for further studies (J.Karo, et al.).
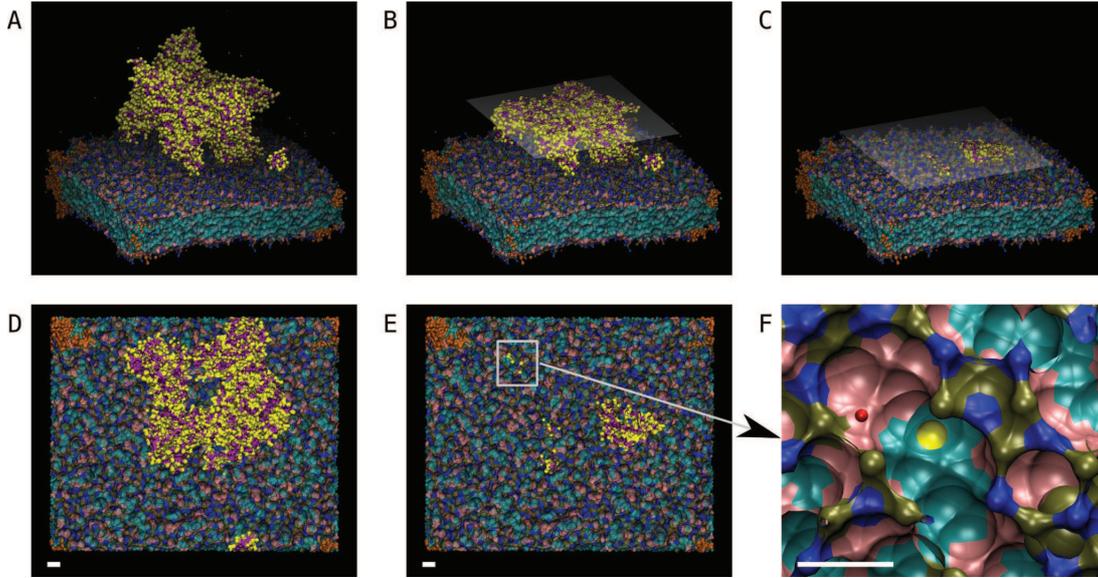
Figure 15: MtCK bound to the membrane by three (of four) C-terminal domains. The fourth C-terminal is above the membrane (not seen in the three-dimensional panels) at this moment. All six subplots show the state of the system in different details, A-C as side views and D-F as top views. The size of the simulation box is $185 \times 227 \times 191$ Å. Because of the periodic boundary condition, one trans-membrane ANT is shared with all four membrane corners, shown in orange. The membrane is shown using isosurface representation. Blue is used for nitrogen groups, brown for phosphate, pink for glycerol groups, and cyan for the rest of carbon atoms in the lipids. A, overall view of a single octameric MtCK protein that is strongly bound to the membrane. Amino acid backbones are shown in purple and side chains in yellow only. B and D, cross-section of the MtCK perpendicular to the normal membrane at 40Å shown from the side (B) and from the top (D). The half-transparent plane visualizes the cutting face. C and E, a similar cross-section cut by the plane perpendicular to the normal membrane at 7 Å and shown from the side (C) and the top (E). F, enlarged view of the location of the upper left MtCK corner bound to the membrane lipids. The yellow sphere is the closest protein side chain to POPC and POPE. The red sphere represents one Na ion. Scale bar = 10 Å.

Real-time Determination of Sarcomere Length of a Single Cardiomyocyte during Contraction.

Sarcomere length of a cardiomyocyte is an important control parameter for physiology studies on a single cell level; Its accurate determination in real-time is essential for performing single cardiomyocyte contraction experiments, for instance. The aim of this work is to develop an efficient and accurate method for estimating a mean sarcomere length of a contracting cardiomyocyte using microscopy images as an input. The novelty in developed method lies in (i) using unbiased measure of similarities to eliminate systematic errors from conventional auto-correlation function (ACF) based methods when applied to region of interest of an image, (ii) using a semi-analytical semi-numerical approach for evaluating the similarity measure to take into account spatial dependence of neighboring image pixels, (iii) and using a detrend algorithm to extract the sarcomere striation pattern content from the microscopy images. The developed sarcomere length estimation procedure has superior computational efficiency and estimation accuracy compared to the conventional ACF and spectral analysis based methods using Fast Fourier Transform. As shown by analyzing synthetic images with the known periodicity, the estimates obtained by the developed method are more accurate at the sub-pixel level than ones obtained using ACF analysis. When applied in practice on rat cardiomyocytes, our method was found to be robust to the choice of the region of interest that may (i) include projections of carbon fibers and nucleus, (ii) have uneven background, and (iii) be slightly disoriented with respect to average direction of sarcomere striation pattern. The developed method is implemented in open-source software (P.Peterson, et al.).
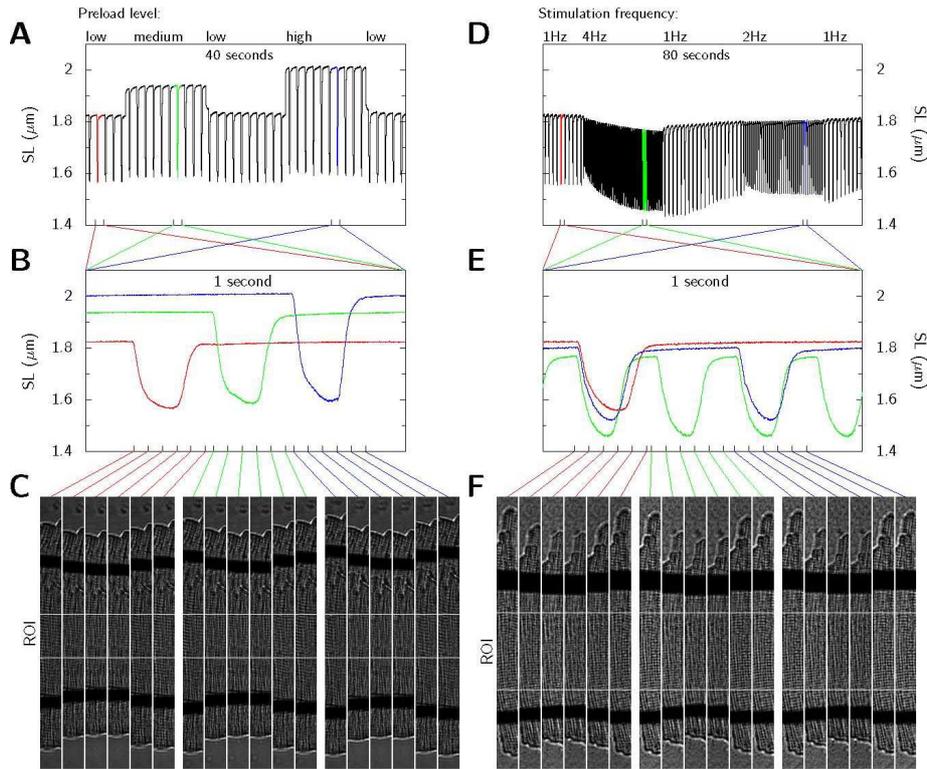
Figure 16: Determination of sarcomere lengths in single rat cardiomyocyte experiments with different preload levels (left plots) and different stimulation frequencies (right plots). Upper plots **A** and **D** show the time series of sarcomere lengths over experiment periods 40 and 80 seconds, respectively. During the experiment periods the preload and stimulation conditions are varied. Middle plots **B** and **E** show the sarcomere lengths over 1 second period as recorded during different loading conditions. Lower plots **C** and **F** show the transmission images of cardiomyocytes at time moments indicated with connecting lines between the middle and lower plots. The region between lines of white pixels indicates the ROI that is used for determining the mean sarcomere lengths for each captured image of cardiomyocytes.

Sensitivity Analysis of Flux Determination in Heart by $H_2^{18}O$ -provided Labeling Using a Dynamic Isotopologue Model of Energy Transfer Pathways.

In heart, the movement of energy metabolites between force-producing myosin, other ATPases, and mitochondria is vital for its function and closely related to heart pathologies. In addition to diffusion, transport of ATP, ADP, Pi, and phosphocreatine occurs along parallel pathways such as the adenylate kinase and creatine kinase shuttles. Two organ-level methods have been developed to study the relative flux through these pathways. However, their results differ. It was recently demonstrated that studies often suffer from the exclusion of compartmentation from their metabolic models. One study overcame this limitation by using compartmental models and statistical methods on multiple experiments. Here, we analyzed the sensitivity of the other method – dynamic labeling of phosphoryl groups and inorganic phosphate. For that, we composed a mathematical model tracking enrichment of the metabolites and evaluated sensitivity of labeling to different flux distribution scenarios. Our study shows that the dynamic method provides a measure of total flux, and not net flux as presumed previously, making the fluxes predicted from both methods consistent. Importantly, conclusions derived on the basis of labeling analysis, particularly those regarding the net flux through the shuttles in control and pathological cases, need to be reevaluated (D.W.Schryer, et al.).

An integrated method to quantify calcium fluxes in cardiac excitation-contraction coupling.

In cardiac excitation-contraction, calcium enters cytosol via L-type Ca^{2+}-channels (I_{Ca}) or reverse Na^+/Ca^{2+}-exchange (NCX_{rev}), or is released from the sarcoplasmic reticulum by Ca^{2+}-induced Ca^{2+}-release (CICR). The magnitude of calcium influx via the different pathways varies with the state of the cell. For example, in case of heart failure, CICR decreases and influx via NCX_{rev} increases. We have developed a method to quantify these calcium fluxes under physiological conditions. We used a combination of perforated patch clamp with fluorescence microscopy and mathematical modeling to study rainbow trout cardiomyocytes stimulated at 1.1 Hz. First, the action potential (AP) of each cell was recorded. Second, during AP-clamp, I_{Ca} or NCX were inhibited to determine their respective currents. Fluorescence changes induced by Ca^{2+}-transients were recorded using Fluo-4. To estimate the contribution of I_{Ca}, NCX, and CICR, we composed a mathematical model of Ca^{2+}-dynamics, which also takes intracellular buffering into account. For the given buffering constants, using spline-approximated fluxes through I_{Ca}, NCX and CICR, and fluorescence gain as parameters, the model estimates the intracellular Ca^{2+} and fluorescence transients. Spline approximation of I_{Ca}, and NCX fluxes can be found directly from the current measurements. CICR fluxes and other model parameters were found by least square fitting of the calculated and recorded fluorescence. We analyzed recordings from 9 cells, where I_{Ca} was inhibited, and 6 cells, where NCX was inhibited. The model implies that changes in total Ca^{2+} concentrations during AP are 365nM ($\sim$40%), 192nM ($\sim$20%) and 385nM ($\sim$40%) via I_{Ca}, NCX and CICR, respectively. The method can be applied to all species – including genetically modifiable mice and zebrafish – to study the cardiac functional phenotype under a range of physiological conditions (M.Laasmaa, R.Birkedal, M.Vendelin).
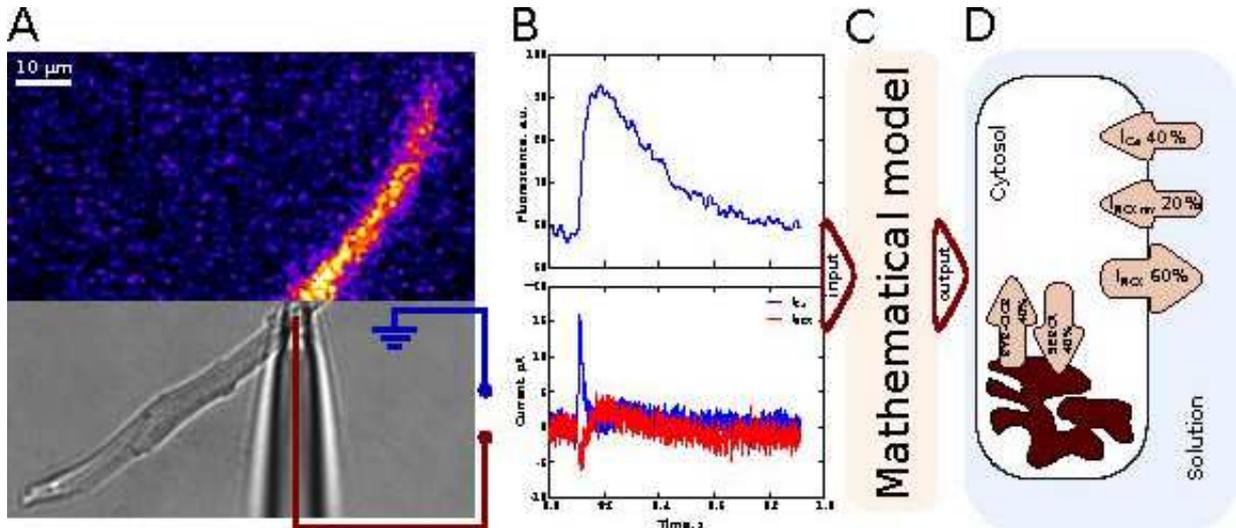
Figure 17: Illustration of the integrated method for quantifying Ca^{2+} fluxes in cardiac excitation-contraction coupling. On upper half of subplot A a typical fluorescence image of an isolated trout cardiomyocyte loaded with free calcium indicator Fluo-4 is displayed and on lower half of the subplot a transmission light image with patch pipette is shown. On subplot B transients of fluorescence signal and currents via I_{Ca} and I_{NCX} during action potential clamp are presented which are also typical inputs for the mathematical model C. On subplot D results of mathematical modeling are illustrated, showing contributions of different Ca^{2+} sources in cardiomyocyte.

Unchanged mitochondrial organization and compartmentation in creatine deficient GAMT −/− mouse heart. Disruption of the creatine kinase (CK) system in hearts of CK-deficient mice leads to changes in ultrastructure and regulation of mitochondrial respiration. We expected to see similar changes in creatine deficient mice, lacking the enzyme guanidinoacetate methyltransferase (GAMT) to produce creatine. The aim of this study was to

characterize the changes in cardiomyocyte mitochondrial organization, regulation of respiration and intracellular compartmentation associated with GAMT-deficiency. Three-dimensional mitochondrial organization was assessed by confocal microscopy. On populations of permeabilized cardiomyocytes, we recorded ADP- and ATP-kinetics of respiration, competition between mitochondria and pyruvate kinase for ADP produced by ATPases, ADP-kinetics of endogenous pyruvate kinase, and ATP-kinetics of ATPases. These data were analyzed by mathematical models to estimate intracellular compartmentation (see figure). Quantitative analysis of morphologic and kinetic data, as well as derived model fits show no difference between GAMT-deficient and wildtype mice. We conclude that inhibition of the CK-system by GAMT-deficiency does not alter mitochondrial organization and intracellular compartmentation in relaxed cardiomyocytes. This raises questions on the importance of the CK system as a spatial energy buffer in cardiomyocytes (J.Branovets, M.Sepp, S.Kotlyarova, N.Jepihhina, N.Sokolova, D.Aksentijevic, C.A.Lygate, S.Neubauer, M.Vendelin and R.Birkedal).

Using Raster Image Correlation Spectroscopy for the Detection of ADP/ATP Diffusion Restrictions in Rat Cardiomyocytes.

A series of experiments show the existence of ADP/ATP diffusion restrictions in rat cardiomyocytes. At present, the nature of these restrictions is still unknown. In this work we hypothesize that the restrictions are in the form of membrane-like diffusion barriers. We present a theoretical foundation for the use of raster image correlation spectroscopy (RICS) to determine the presence and the locations of such barriers. It is shown that in the proximity of the membrane, the diffusion pair correlation function (PCF) is not symmetric. For impermeable and semi-permeable membranes the difference between the PCF functions found for inhomogeneous and homogeneous media is an antisymmetric function with the membrane located exactly at the zero point. This property can be used to detect barriers. With a gaussian PSF, the PCF for an impermeable membrane can be calculated analytically, thus giving a convenient theoretical basis for the interpretation of microscopy data. In the case of small permeability, the correlation function can be expressed in a form where only one convolution type integral is present, useful for both numeric calculation and theoretical understanding (P.Simson, M.Vendelin, P.Peterson).

A Cross-Bridge Model Describing the Mechanoenergetics of Actomyosin Interaction.

In order to study the mechanical contraction and energy consumption by the cardiomyocytes we further developed an actomyosin model of Vendelin et al. (Ann. Biomed. Eng. 28:629640, 2000). The model is of a self-consistent Huxley-type and is based on Hill formalism linking the free energy profile of reactions and mechanical force. In several experimental studies it has been shown that the dependency between oxygen consumption and stress-strain area is linear and is the same for isometric and shortening contractions. We analyzed the free energy profiles of actomyosin interaction by changing free energies of intermediate states and activation of different reactions. The model is able to replicate the linear dependence between oxygen consumption and stress-strain area together with other important mechanical properties of a cardiac muscle (M.Kalda, et al.).
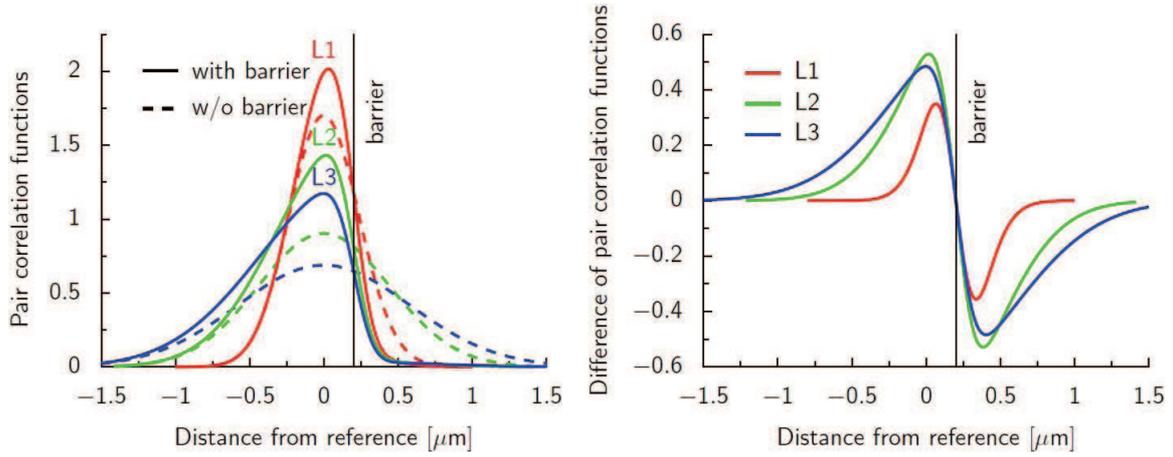
Figure 18: Left figure – solid lines indicate pair correlation functions near the diffusion barrier, dotted lines are the corresponding pair correlation functions (PCFs) for the homogenous case (no barrier). We see that in the presence of a barrier the PCF is higher near the barrier and the PCFs are asymmetric. Right figure – difference of nonhomogeneous and homogeneous pair correlation functions. These functions are zero exactly where the barrier is located. This property can be used to locate the barriers.
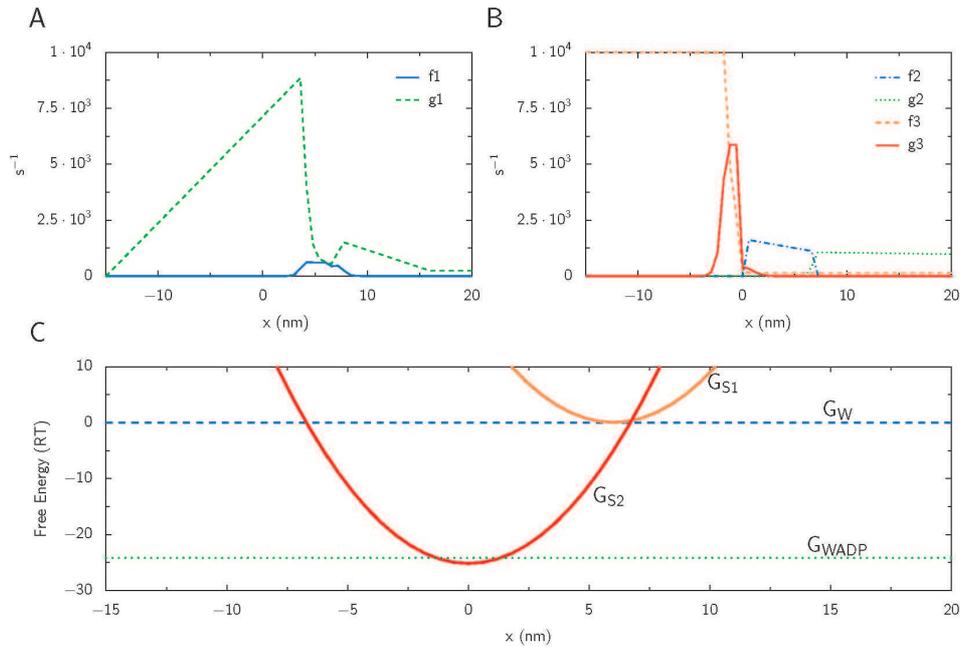
Figure 19: A,B: Cross-bridge cycling rates used in the cross-bridge model describing the mechanoenergetics of actomyosin interaction. C: Free energy profiles found by optimization of the mathematical model.

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Software development

P.Peterson. Web application Cluster Design for composing optimal CENS HPCC; http://egoist.ioc.ee/cluster_design/.

P.Peterson. A simple RPC wrapper generator to C/C++ functions; http://code.google.com/p/simple-rpc-cpp/.

P.Peterson, M.Kalda. Continued development of IOCBio Sarcomere length and fundamental period software; http://code.google.com/p/iocbio/wiki/IOCBioSarcomereLength.

P.Peterson, D.W.Schryer. IOCBio software for generation of mass isotopologue equations; http://code.google.com/p/iocbio/wiki/IOCBioOxygenIsotopeEquationGenerator.

P.Peterson. Continued development of the PyLibTiff package; http://code.google.com/p/pylibtiff/.

P.Peterson. Continued development of the f2py wrapper engine; http://www.scipy.org/F2py.

P.Peterson, M.Vendelin. Continued development of C++ software for executing experiment protocols on fluorescence and confocal microscopes; http://code.google.com/p/iocbio/wiki/IOCBioMicroscope.

A.Illaste. Continued development of linescan image analysis software LSJuicer; http://code.google.com/p/lsjuicer/.

3.1.6 Laboratory of Photoelasticity

The aim of the investigations has been development of photoelastic measaurement technology for residual stress measurement in glass articles of any shape.

To meet the demand from modern consumer electronics industry, the capability of the current scattered light method has been extended to measure stresses in chemically tempered glass, where only 10–50 microns thick layer is processed to have up to 1000 MPa surface stress. New polariscope SCALP-05 has been constructed to measure such glass (see Annex).

A new method for residual stress measurement in glass bottles has been developed. For residual stress measurement in glass bottles, integrated photoelasticity is being widely used. A drawback of this method is that the bottle must me placed into an immersion tank with matching immersion fluid. The new method does not need to apply the immersion technique, For that the residual stress in cylindrical bottles is considered as consisting of two parts. First, since the bottom of the bottle is thicker than the main part of the bottle, it obtains the glassy state later than the thin cylindrical part of the bottle. Thus the bottom causes in the lower part of the bottle a shear force and a bending moment. These forces may be considered as external load to the cylindrical part of the bottle. Their influence is described by the equations of the boundary effect of cylindrical shells. These stresses are named the form stresses. Form stresses can be measured by passing polarised light through the bottle along its diameter. Thus the immersion tehnique is not needed. Secondly, due to the temperature gradient through the bottle thickness during the forming process, parabolic stress distribution through the wall is created. These stresses are named the thickness stresses. Their direct measurement needs application of the immersion technique. Residual stresses in the bottle depend to a great extent on the speed of cooling down the bottle on the production line. One may assume that the cooling speed influences in similar way both the form stresses and thickness stresses. To find the correlation between the two kind of stresses one has to measure both the form stresses and the thickness stresses (using photoelastic tomography) for different cooling regimes on the production line. After this correlation has been established, both components of the residual stress can be determined on the production line by measuring only the form stresses without need to apply immersion technique (H.Aben, J.Anton et al.).

3.2 Institute of Cybernetics: Control Systems Department

The concepts of Lie derivative for discrete-time systems. The concept of the Lie derivative of the vector field, used in the study of the continuous-time dynamical systems, was extended for the discrete-time case. In the continuous-time case the Lie derivative of a vector field (1-form or scalar function) with respect to the system dynamics is defined as its rate of change in time. In the discrete-time case we introduce the algebraic definition of the Lie derivative, using the concepts of forward and backward shifts. The definitions of discrete-time forward and backward shifts of the vector field are based on the concepts of already known forward and backward shifts of the 1-forms and on the scalar product of 1-form and vector field. Further we show that the interpretation of the discrete-time Lie derivative agrees with its interpretation as the rate of change in the continuous-time case. Finally, the geometric property of the discrete-time Lie derivative is also examined and shown to mimic the respective property in the continuous-time case (T.Mullari, Ü.Kotta).

A transfer function approach to the realisation problem of nonlinear systems. The nonlinear realisation problem, i.e. the problem of finding the state equations of a nonlinear system from the transfer function representation being easily computable from the higher order input-output differential equation, was studied. The procedures for finding the state space realisations of a nonlinear system in the observer and controller canonical form, whenever they exist, were developed. The characteristic property of these procedures is that they require the minimal amount of computations and the realisations can practically be written down either from the adjoint transfer function or from the right factorisation of the transfer function. The (adjoint) transfer function itself is easily computable from the input-output differential equation, being often the end result of the system identification. The right factorisation of the transfer function, that requires to find the least common right multiple of two polynomials, may be replaced by much simpler problem of finding the least common left multiple of the respective adjoint polynomials. In doing so, one has to solve instead the differential equations only the algebraic equations. As a byproduct, the results of this approach also allow to compute the differentials of the state coordinates of the non-canonical realisations in a very simple way. Compared with the canonical realisations the set of certain one-forms that had to be exact, now have to constitute completely integrable vector spaces. Finally, it was demonstrated that the linearisation of state equations up to the input-output injection may be understood as the realisation problem in the observer canonical form (Ü.Kotta).

State-space realization of nonlinear control systems: unification and extension via pseudo-linear algebra. The tools of pseudo-linear algebra were applied to the realization problem, allowing to unify the study of the continuous- and discrete-time nonlinear control systems under a single algebraic framework. The realization of nonlinear input-output equation, defined in terms of the pseudo-linear operator, in the classical state-space form is addressed by the polynomial approach in which the system is described by two polynomials from the non-commutative ring of skew polynomials. This allows to simplify the existing step-by-step algorithm-based solution. The explicit formulas, allowing to compute the differentials of the state coordinates directly from the polynomial description of the nonlinear system, were derived. The method is straight-forward and better suited for implementation in different computer algebra packages such as *Mathematica* or *Maple* (J.Belikov, Ü.Kotta, M.Tõnso).

Explicit Formulas for the State Coordinates in Nonlinear MIMO Realization Problem on Homogeneous Time Scales. The problem of realization of nonlinear multi-input multi-output equations, defined on homogeneous time scale, in the state-space form was studied. The time scale formalism allows to unify the computations for continuous- and discrete-time systems into a single set of general formulas. The polynomial approach, based on non-commutative ring of skew polynomials, allows to replace the existing step-by-step algorithm

based on certain sequences of differential one-forms by explicit formulas to compute the differentials of the state coordinates directly from system description (J.Belikov, Ü.Kotta, M.Tõnso).

Dynamic Measurement Feedback in Discrete-time Nonlinear Control Systems. The solution of two control problems for discrete-time nonlinear system was provided: dynamic output feedback linearization and disturbance decoupling by dynamic measurement feedback. First, the extended algorithm was given for dynamic output linearization of input-output equation. Second, sufficient conditions for solvability of the disturbance decoupling problem were found, based on the results for dynamic output feedback linearization. It was proved, that these conditions are necessary if we consider a dynamic measurement feedback in a specific triangular form (A.Kaldmäe, Ü.Kotta).

Extended Observer Form: Simple Existence Conditions. The problem of transforming the discrete-time single-input single-output nonlinear state equations into the extended observer form was studied. The main difference between the "traditional" observer form and the extended one is that the last, besides the input and output, also depends on a finite number of their past values. Such approach allows to enlarge the class of nonlinear systems for which the observer with linear error dynamics can be constructed. The simple necessary and sufficient conditions for the existence of the extended coordinate change and the output transformation, allowing to solve the problem, were formulated in terms of certain partial derivatives, related to the input-output equation, corresponding to the state equations. Due to the matrix representation the conditions can be checked almost by direct inspection. Moreover, a certain algorithm for transforming the state equations into the observer form was provided (V.Kaparin, Ü.Kotta).

Transformation the nonlinear state equations into the observer form: necessary and sufficient conditions in terms of one-forms. The necessary and sufficient conditions were provided for the existence of the state and output coordinate transformations, that transform the single-input single-output nonlinear continuous-time state equations into the observer form. The application of output transformation enlarges the class of systems for which the observer with linearizable error dynamics can be constructed. The solvability conditions are formulated in terms of unknown single-variable output dependent function and the differential one-forms, directly computable from the input-output equation, corresponding to the state equations. The algorithm for transformation of the state equations into the observer form was presented (V.Kaparin, Ü.Kotta).

Fixed order stabilizing controller design via random reflection segments. A novel randomized approach to fixed-order controller design is proposed for discrete-time SISO plants. It is based on the random generation of Schur stable polynomials using reflection coefficients and reflection segments of polynomials. Stable reflection segments are projected onto affine set of closed-loop characteristic polynomials which is defined by the controller parameters and the stable line segments in the controller parameter space are then determined. A novel approach is proposed for global and local optimization over reflection segment bunches on the basis of the weighted sum of absolute values of reflection coefficients (Ü.Nurges).

Stability of discrete-time systems via polytopes of reflection vector sets. The stability domain of discrete-time systems is investigated via reflection coefficients of characteristic polynomials of the system. Stable polytopes in the coefficients space of characteristic polynomials are defined starting from the sufficient stability condition in the polynomial reflection coefficients space by the use of different reflection vector sets. The volumes of these stable polytopes are calculated via triangulation method (Ü.Nurges).

Refinement-based development of timed systems. Refinement-based "correct-by-construction" development method supported by Event-B formalism has been extensively used in the domain of embedded and distributed systems design. For these domains timing analysis

is of great importance. However, in its present form, Event-B does not have a built-in notion of time. On the other hand, the theory of refinement of timed transition systems has been studied, but a refinement-based design of these systems is weakly supported by industrial strength methods and tools. In this research we have defined the superposition refinement relation in the class of Uppaal Timed Automata and shown how this relation is interrelated with the data refinement relation in Event-B. Using this interrelation we have presented an algorithm for mapping the Event-B specifications to Uppaal automata and shown how the formalism related tools complement each other in a refinement-based design flow. The approach is demonstrated on a fragment of Danfoss industrial automation case study (J.Vain).

Neural networks based system for the supervision of therapeutic exercises. Correctness in doing therapeutic exercises may play a key role for achieving complete rehabilitation of the patient's motor functions. Usually such exercises are performed either under the supervision of physiotherapists or on robotic simulators. Both cases lead rises in rehabilitation costs. Therefore, the attention was concentrated on the application of Neural Networks based Additive Nonlinear Auto Regressive eXogenous (NN-ANARX) models as computational tool of the supervision system for therapeutic exercises. Electronic accelerometers and gyroscopes attached to the human upper and lower limbs gather information about performed exercise in real time. Schematic diagram of marker placement and hand motions during on of the exercises is depicted in Fig. 20).
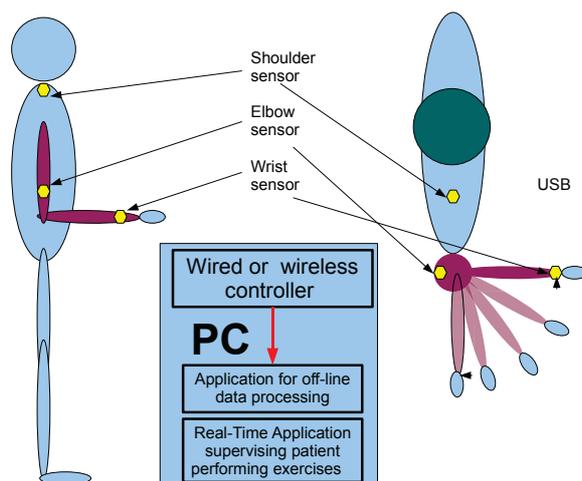
Figure 20: General structure of the system.

Trained on the data describing correctly done exercises neural network based dynamic model of the limb is used to find the difference between the actual and "ideal" performances and judge whether exercises are performed in a correct way or not (S.Nõmm).

Evolutionary design of the closed loop control on the basis of NN-ANARX model using genetic algorithm. Genetic algorithm was used to perform evolutionary design of the closed loop control for the given process. Main distinctive feature of the proposed approach is that arguments of the fitness function describe model, and therefore controller quality, both in the open and closed loops. Namely model validity with cross-correlation functions determined in the open loop and mean square error is measured for the performance in the closed loop with a controller, which equations analytically derived from the equations of the model. Technique proposed in the frameworks of this research allows implement the idea of building closed loop control for unknown process just on the basis of available input output data and reference signal. Roughly speaking, in many cases entire control problem from system identification to control

synthesis may be solved without human intervention there fore reliving human from routine of trials and errors (S.Nõmm).

Evaluation function optimization for the genetic algorithm based tuning of NN-ANARX model structure. The research was devoted to the application of genetic algorithm to adjust the NN-ANARX type structure improving performance of the identified model. Namely constructive procedure is proposed to choose parameters of the multi-criteria fitness function. Whereas main goal of the research is to find optimal linear combination of three qualitative parameters: ODCCF based criteria, mean square error and model order, those parameters are commonly used to evaluate model performance and validity. Numeric values of the fitness function coefficients for the most common classes of nonlinear systems proposed as a secondary result of the research (S.Nõmm).

3.3 University of Tartu: Optics group

By employing the effect of internal conical refraction in biaxial crystals, the transformation of the lowest-order Gaussian laser beams into optical vortex beams possessing orbital angular momentum has been demonstrated. The evolution of the generated vortex upon propagation has been analysed and compared with the reference Laguerre-Gauss beams.

Annular laser beams with radial and azimuthal polarization have been obtained in experiments, where two biaxial crystals were placed into the arms of a Mach-Zehnder interferometer. It has been shown that such an arrangement, where the effect of internal conical refraction in crystals is involved, may serve as a versatile tool for the formation of ring-shaped beams with a desired radial or azimuthal polarization.

A new computational scheme is proposed to deduce potential energy curves of diatomic molecules from spectroscopic data. First, combining *ab initio* data (if available) with experimental data on pure vibrational (rotationless) levels, one constructs a reliable initial potential (black curve on Fig. 21). Then one "removes" the zeroth level of that original potential to construct its isospectral transforms. To this end, three different methods (by Darboux, Abraham-Moses and Pursey) can be used. Thus one gets four almost equivalent probe potentials (see Fig. 21). Finally, one adds the centrifugal potential caused by rotation and tries to construct the "real" potential by fitting four independent theoretical datasets to the experimental rovibrational data.

Pulsed high-current sliding discharge on a sapphire surface has been used to excite gases (Ar, Kr) at a pressure of up to 25 atm. The spatial-time dynamics of the evolution of the sliding discharge is measured. The spectral and temporal dependences of its emission are analyzed, and the processes that affect the VUV emission of the plasma are discussed. The possibilities of a sliding discharge for direct pumping of gas lasers are demonstrated for XeCl and KrF excimer lasers with the lasing energy of 0.15 and 0.12 mJ, respectively, and a pulse repetition rate up to 1 kHz without circulation of the gas.

High spatial and temporal resolution of novel OCEAN TADPOLE spatial-spectral interferometer was demonstrated by measuring the impulse response of a circular diffraction grating (see Fig. 22). Under 30 fs pulse illumination the predecessor SEA TADPOLE interferometer demonstrated the existence of temporally separated diffraction orders propagating in "non-diffractive" manner with constant subluminal speed. OCEAN TADPOLE in combination with white light laser with octave spanning spectrum and 3 fs correlation time bestowed the temporal resolution even further. The measurements clearly demonstrated dispersive (meaning the pulse lengthens in time) propagation of the diffracted pulses and temporal focusability of the pulses into "nondiffractive" and dispersion-resistant quasi-Airy pulses in temporal domain due to the third order dispersion of grating and its substrate.
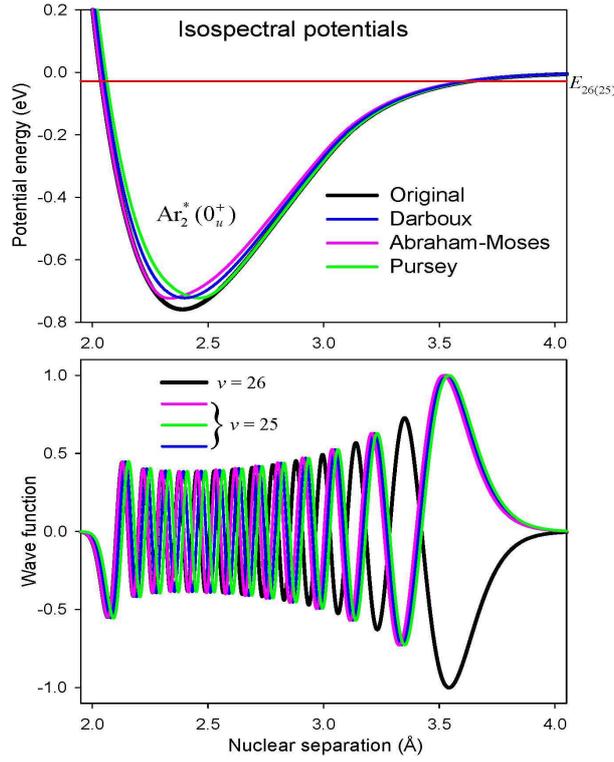
Figure 21: Four isospectral probe potentials for the lowest dipole allowed excimer state of argon molecule, which reproduce the experimentally observed levels with 0.01 cm^{-1} accuracy. Note that the wave functions in the lower graph are related to a level at exactly the same position.
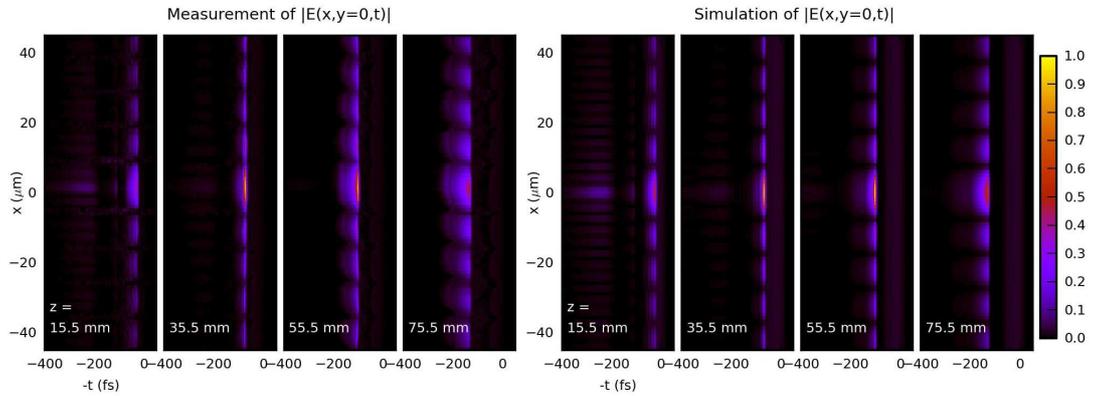
Figure 22: Spatio-temporal evolution of the impulse response of diffraction grating with circularly symmetric binary phase steps. Measurements were made with OCEAN TADPOLE spatial-spectral interferometer.

3.4 Research within international programmes

3.4.1 FP7 Marie Curie Initial Training Network (FP7-PEOPLE-1-1-ITN) Shapes, Geometry, Algebra www.saga-network.eu (01.11.2008 – 31.10.2013), led by Stiftelsen SINTEF (Norway); partners: University of Oslo (Norway); Johannes Kepler Universität Linz (Austria); Universidad de Cantabria (Spain); Vilnius University (Lithuania); National and Kapodistrian University Athens (Greece); INRIA – Institut National de Recherche en Informatique et Automatique (France); Fondazione GraphiTech (Italy); Missler Software (France); Kongsberg SIM (Norway); Participating Scientist: E.Quak.

This training network dealt with the potential of classical approaches in geometry and algebra for industrial applications of geometric modelling and computer-aided geometric design, investigated by young researchers hosted at the project partners and funded by the EC Research Executive Agency (REA). The concluding event of this network was the SAGA Final Workshop in Trento, Italy, October 9-11, where Ewald Quak gave a presentation on applying for EU research funding.

3.4.2 FP7 Project ESTwave "Educational, Scientific and Technological Aspects of Mesoscopic Continuum Physics for Waves in Complex Materials", PERG04-GA-2008-238191, 1.4.2008–31.3.2012, H.Herrmann.

3.4.3 Estonian-Polish joint research project under the agreement on scientific co-operation between the Polish Academy of Sciences and the Estonian Academy of Sciences
"Nonlinear control systems on time scales" 2010–2012.
(Estonian project coordinator: Ü.Kotta).

3.4.4 FP7 Marie Curie International Research Staff Exchange Scheme (PIRSES-GA-2011-295164-EUMLS) EU-Ukrainian Mathematicians for Life Sciences (EUMLS), http://www.math.uni-luebeck.de/EUMLS/ (1.4.2012 – 31.3.2016), led by Universität zu Lübeck (Germany). Participating Scientist: E.Quak.

The goal of the EUMLS project is to contribute to overcoming the historical communication and cross-disciplinary barriers that exist between the biosciences and mathematics through a comprehensive programme realizing a total of 205 months of research exchanges between five Ukrainian mathematical institutes and three partners in Germany (Universität zu Lübeck), Italy (Politecnico di Milano), and Norway (Univerity of Oslo), active in different aspects of computational life sciences. The first event of the project was the workshop Mathematics for Life Sciences, Kyiv, September 3–14, 2012, co-organized by E.Quak.

4. Funding

4.1 Target funding through the Ministry of Education and Research

1. Block grant SF0140077s08 "Nonlinear dynamics and complex systems" (2008–2013), PI: J.Engelbrecht.

2. Block grant SF0140018s08 "Synthesis of complex nonlinear control systems" (2008 – 2013), PI: Ü.Kotta.

3. Block grant SF0140007s11 "Wave dynamics for coastal engineering" (2011–2016), PI: T.Soomere.

4. Block grant SF0180073s07, "Development of new optical and spectroscopic techniques and their application in materials and plasma research" (2007–2012), PI: P.Saari.

5. Upgrade of scientific infrastructure of the block grant SF0140007s11 (2011–2012).

4.2 Estonian Science Foundation grants

1. J.Janno, grant 7728, "Inverse problems for materials with complex properties" (2009–2012).

2. P.Saari, grant 7870, "Femtosecond optics of linear and nonlinear localized waves" (2009–2013).

3. J.Kalda, grant 7909, "The role of turbulent mixing in the dynamics of the complex systems", (2009–2012).

4. V.Peet, grant 7971, "Nonlinear optical effects and laser light conversion in gases and solids" (2009–2012).

5. R.Birkedal, grant 8041, "Role of the Na+/Ca2+-exchanger in excitation-contraction coupling and energetics in rainbow trout cardiomyocytes" (2009–2012).

6. S.Nõmm, grant 8365, "Modeling and recognition of human gestures" (2010–2013).

7. A.Salupere, grant 8658, "Solitonic structures in nonintegrable systems and discrete spectral analysis" (2011–2014).

8. A.Berezovski, grant 8702, "Multiscale simulation of high strain rate dynamics in microstructured materials"(2011–2014).

9. M.Tõnso, grant 8787, "Computer algebra methods in control" (2011–2014).

10. I.Didenkulova, grant 8870, "Wave induced hazards in Estonian coastal waters" (2011–2014).

11. T.Soomere, grant 9125, "Quantification the reaction of the eastern Baltic Sea coast to changing wave conditions " (2012–2015).

4.3 International grants (see also 3.4)

1. Wellcome Trust International Senior Research Fellowship "Analysis of structural and functional aspects of compartmentation of adenine nucleotides in heart muscle cells" (2007–2012) – M.Vendelin.

2. MOBILITAS Top Researcher Grant MTT63 "Numerical particle tracking modeling for inhomogeneous turbulent water basins" (2011–2015) – T.Torsvik.

3. MOBILITAS Post-doctoral grant MJD270 "Statistics of extreme wave conditions and events for Estonian coastal waters" (2012–2014) – I.Nikolkina.

4. Norwegian Centre of Excellence "Mathematics for Applications"(CMA) – E.Quak.

5. Estonian-Bulgarian grant "Tsunamis in Inland Seas (Black and Baltic Seas)" (2012–2014) – I.Didenkulova.

6. Grant HyIV-FZK-03 "Long wave dynamics and statistics of the shoreline motion: influence of the asymmetry and nonlinearity of incoming waves" (Hydralab IV, Joint Research Activities, within the FP7 European Commission Funded Collaborative Research Project), (2010–2014) – I.Didenkulova.

7. "Systematic examination of arrhythmogenic calcium release in cardiac myocytes" (2009–2015) – H.Ramay.

8. "The theoretical study of mitochondrial energetic metabolism" (2010–2013) – J.Karo.

4.4 Additional funding

1. Grant "Science-based forecast and quantification of risks to properly and timely react to hazards impacting Estonian mainland, air space, water bodies and coasts"TERIKVANT (2012–2014) from the Estonian Research Council in the framework of supporting R&D in environmental technology (SFOS 3.2.0802.11-0043) – T.Soomere.

2. NanoCom - Nano-geometry and entanglement for design and prototyping of ceramic-based high-performance nano-composites (NanoCom) – J.Kalda, A.Berezovski.

3. Smart composites-design and manufacturing (SCDM) – A.Salupere, A.Braunbrück.

4.5 Supportive grants (travel, etc.)

1. J.Belikov, Doctoral Studies and Internationalisation Programme DoRa grant for attending 7th Vienna International Conference on Mathematical Modelling, Vienna, Austria, 15.01.2012–17.01.2012.

2. M.Kalda, A.Illaste, D.Schryer, Activity 8 of the ESF DoRa travel grant for attending The Biophysical Society's 56rd Annual Meeting in San Diego, California, 24.02.2012–29.02.2012.

3. J.Belikov, Doctoral School in Information and Communication Technology (IKTDK) grant for attending HYCON–EECI Graduate School on Control, Paris, France, 05.03.11–09.03.2012.

4. J.Belikov, European Embedded Control Institute grant for attending HYCON-EECI Graduate School on Control, Paris, France, 05.03.11–09.03.2012.

5. J.Vain, EAS funded participation in the Workshops on Foundations of Aspect-Oriented Languages (FOAL 2012), Potsdam, Germany, 25.03.2012–28.03.2012.

6. S.Nõmm, EITSA grant for attending The 2012 IEEE World Congress on Computational Intelligence (IEEE WCCI 2012), Brisbane, Australia, 10.06.2012–15.06.2012.

7. J.Belikov, Doctoral School in Information and Communication Technology (IKTDK) grant for attending seminar within the framework of FOMCON project, Bratislava, Slovakia, 18.06.2012–21.06.2012.

8. J.Vain, EITSA grant for attending 9th International Conference on Integrated Formal Methods (iFM'2012), Pisa, Italy, 18.06.2012–21.06.2012.

9. J.Belikov, SA Archimedes Kristjan Jaak grant for attending 2012 IEEE Multi-Conference on Systems and Control, Dubrovnik, Croatia, 03.10.2012–05.10.2012.

10. Ü.Nurges, EITSA grant for attending the 12th International Conference on Control, Automation, Robotics and Vision (ICARCV 2012), Guangzhou, China, 05.12.12–07.12.12.

11. M.Tõnso, EITSA travel grant for attending the 51st IEEE Conference on Decision and Control (CDC 2012), Hawaii, USA, 10.12.2012–13.12.2012.

12. H.Herrmann, EITSA grant, VisPar-2: 3D visualization system.

13. D.Kartofelev, Archimedes T6 grant approved (Dec. 2012) for working at laboratory of Aalto University, School of Electrical Engineering, Department of Signal Processing and Acoustics. During 2013 spring semester.

Remark: EITSA — Estonian Information Technology Foundation (EITF).

4.7 Total income of CENS in 2011–2012 (Euros)

Source	2011	2012
Targeted financing (TF)[1]	610660	613780
ESF grants[2]	187414	132662
External project funding[3]	526698	508405
EU Structural Funds[4]	29656	314000
Grand total	**1354428**	**1568847**

Remarks:

[1] Targeted financing is used to support evaluated R&D research topics (both basic and applied) from State budget through the Ministry of Education and Reserach.

[2] ESF grants are available to individuals as well as research groups who have to undergo a research project financing competition (this programme is closing).

[3] External project funding – R&D grants from and contracts with various Estonian and foreign institutions (Wellcome Trust, Humboldt Foundation, Marie Curie actions, etc).

[4] EU Structural Funds for supporting R&D activities implemented through the Archimedes Foundation (Implementation Agency of Structural Support), programme for Centres of Excellence in Research.

5. Publicity of Results

5.1 Publications

5.1.1 Theses

1. A.Errapart. Photoelastic Tomography in Linear and Nonlinear Approximation.
   PhD thesis, TUT Press, Tallinn 2012.

2. J.Belikov. Polynomial methods for nonlinear control systems.
   PhD thesis, TUT Press, Tallinn 2012.

3. O.Kurkina. Nonlinear dynamics of internal gravity waves in shallow seas.
   PhD thesis, TUT Press, Tallinn 2012.

4. A.Illaste. Analysis of Molecular Movements in Cardiac Myocytes.
   PhD thesis, TUT Press, Tallinn 2012.

5. D.Schryer. Metabolic Flux Analysis of Compartmentalized Systems using Dynamic Isotopologue Modeling.
   PhD thesis, TUT Press, Tallinn 2012.

6. M.Kääramees. A Symbolic Approach to Model-based Online Testing.
   PhD thesis, TUT Press, Tallinn 2012.

5.1.2 Papers (refereed)

IoC Department of Mechanics and Applied Mathematics

1. J.Engelbrecht, A.Salupere. Soliton ensembles and solitonic structures. Applicable Analysis, 2012, 91 (2), 237–250.

2. J.Engelbrecht, F.Pastrone. Nonlinear waves in complex microstructured solids. Memorie della Accademia delle Scienze di Torino – Classe di Scienze Fisiche, Matematiche e Naturali, 2011, 35, 23–36 (published in 2012).

3. H.Herrmann, J.Engelbrecht. Comments on mesoscopic continuum physics: evolution equation for the distribution function and open problems. Proc. Estonian Acad. Sci., 2012, 61, 71–74.

4. M.Eik, H.Herrmann. Raytraced images for testing the reconstruction of fibre orientation distributions. Proc. Estonian Acad. Sci., 2012, 61, 128–136.

5. J.-P.Suuronen, A.Kallonen, M.Eik, J.Puttonen, R.Serimaa, and H.Herrmann. Analysis of short fibres orientation in steel fibre reinforced concrete (sfrc) using x-ray tomography. J. Materials Sci., 2012, 1–10 (online first).

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10. M.Berezovski, A.Berezovski. On the stability of a microstructure model. - Computational Materials Science, 2012, 52, 193–196.

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12. A.Ravasoo. Interaction of bursts as a detector of material inhomogeneity. Acta Acustica united with Acustica, 2012, 98, 864–869.

13. M.Järvekülg, R.Välbe, J.Jõgi, A.Salundi, T.Kangur, V.Reedo, J.Kalda, U.Mäeorg, A.Lõhmus, and A.E.Romanov. A solgel approach to self-formation of microtubular structures from metal alkoxide gel films. Physica Status Solidi A – Applications and Materials Science, 2012, 209 (12), 2481–2486.

14. K.Tamm, A.Salupere. On the propagation of 1D solitary waves in Mindlin-type microstructured solids. Mathematics and Computers in Simulation, 2012, 82 (7), 1308–1320.

15. A.Stulov. Analysis of the nonlinear effect of the capo bar-string interaction in grand piano. Acoustics 2012 Proc., Nantes, France, 23–27 April 2012, 1217–1221.

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17. M.Kalda, P.Peterson, J.Engelbrecht, and M.Vendelin. A cross-bridge model describing the mechanoenergetics of actomyosin interaction. - In: G.Holzapfel and E.Kuhl (eds), Proc. IUTAM Symposium on Computer Models in Biomechanics, Stanford, 2011. Springer, 2012, 91–102.

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66. Ü.Nurges, S.Avanessov. Fixed order stabilizing controller design via random reflection segments. - In: The 12th Int. Conf. Control, Automation, Robotics and Vision, ICARCV 2012: 5–7 December 2012, Guangzhou, China: Piscataway, NJ: IEEE, 2012, 530–535.

67. S.Nõmm, A.Kuusik, S.Ovsjanski, I.Malmberg, M.Parve, L.Orunurm. Neural networks based system for the supervision of therapeutic exercises. - In: Neural Information Processing : 19th International Conference, ICONIP 2012, Doha, Qatar, November 12–15, 2012, Proc., Part IV: (Eds.) Huang, Tingwen; Zeng, Zhigang; Li, Chuandong; Leung, Chi Sing. Berlin: Springer, 2012, (Lecture Notes in Computer Science; 7666), 364–371.

68. S.Nõmm, K.Vassiljeva, E.Petlenkov. Evaluation function optimization for the Genetic Algorithm based tuning of NN-ANARX model structure. - In: 2012 IEEE World Congress on Computational Intelligence, WCCI 2012: June 10–15, Brisbane, Australia: Piscataway, NJ: IEEE, 2012, 1682–1688.

69. K.Sarna, J.Vain. Exploiting Aspects in Model-Based Testing. - In: Foundations of Aspect-Oriented Languages 2012: March 26, 2012, Potsdam, Germany: New York: ACM, 2012, 45–47.

70. A.Tepljakov, E.Petlenkov, J.Belikov. Application of the Newton method to first-order implicit fractional transfer function approximation. - In: MIXDES 2012: 19th Intern. Conf. Mixed Design of Integrated Circuits and Systems, 24–26 May 2012, Warsaw, Poland, [Proc.]: (Eds.) A.Napieralski. Lódž: IEEE, 2012, 473–477.

71. A.Tepljakov, E.Petlenkov, J.Belikov. A flexible MATLAB tool for optimal fractional-order PID controller design subject to specifications. - In: Proc. 31st Chinese Control Conf., July, 2012, Hefei, China: (Eds.) Li, Weiping; Zhao, Qianchuan. Hefei: IEEE, 2012, 4698–4703.

72. A.Tepljakov, E.Petlenkov, J.Belikov. Implementation and real-time simulation of a fractional-order controller using a MATLAB based prototyping platform. - In: BEC 2012: 13th Biennial Baltic Electronics Conf. [Proc., Tallinn University of Technology, October 3–5, 2012, Tallinn, Estonia]: Piscataway, NJ: IEEE, 2012, 145–148.

73. A.Tepljakov, E.Petlenkov, J.Belikov. Application of Newton's method to analog and digital realization of fractional-order controllers. Int. J. Microelectronics and Computer Science, 3 (2), 45–52.

74. J.Vain, E.Halling. Constraint-based testing scenario description language. - In: BEC 2012: 2012 13th Biennial Baltic Electronics Conf. [Proc., TUT, October 3–5, 2012, Tallinn, Estonia]: Piscataway, NJ: IEEE, 2012, 89–92.

75. K.Vassiljeva, E.Petlenkov, J.Belikov. GA based optimization of NN-SANARX model for adaptive control of nonlinear systems. - In: 2012 IEEE World Congress on Computational Intelligence, WCCI 2012: June 10–15, Brisbane, Australia: IEEE, 2012, 1674–1681.

76. K.Vassiljeva, E.Petlenkov, S.Nõmm. Evolutionary design of the closed loop control on the basis of NN-ANARX model using genetic algorithm. - In: Neural Information Processing: 19th Int. Conf., ICONIP 2012, Doha, Qatar, November 12–15, 2012, Proc., Part I: (Eds.)

Huang, Tingwen; Zeng, Zhigang; Li, Chuandong; Leung, Chi Sing. Berlin: Springer, 2012, (Lecture Notes in Computer Scince; 7663), 592–599.

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77. P.Saari. Photon localization revisited. - In: Quantum Optics, Intech 2012, pp. 49–66.

78. A.Treshchalov, A.Lissovski. A vacuum ultraviolet source based on a sliding discharge. J. Optical Technology, 2012, 79 (8), 456–461.

79. A.Treshchalov, A.Lissovski. Multi-band spectral structure and kinetics of the third continua in Ar, Kr and Xe gases excited by a pulsed discharge. The European Physical Journal D - Atomic, Molecular, Optical and Plasma Physics, 2012, 66(4), 95–103.

80. A.Treštšalov, A.Lissovski. A vacuum ultraviolet source based on a sliding discharge. J. Optical technology, 79 (8), 15–23 (in Russian).

81. M.Selg. Observable quasi-bound states of the H2 molecule. J. Chemical Physics, 2012, 136, 114113.

82. P.Piksarv, P.Bowlan, M.Lõhmus, H.Valtna-Lukner, R.Trebino, P.Saari. Diffraction of ultrashort Gaussian pulses within the framework of boundary diffraction wave theory. J. Optics, 2012, 14 (1), 015701.

83. M.Lõhmus, P.Bowlan, P.Piksarv, H.Valtna-Lukner, R.Trebino, P.Saari. Diffraction of ultrashort optical pulses from circularly symmetric binary phase gratings. Opt. Lett., 37, 1238–1240.

84. P.Piksarv, H.Valtna-Lukner, A.Valdmann, M.Lõhmus, R.Matt, P.Saari. Temporal focusing of ultrashort pulsed Bessel beams into Airy-Bessel light Bullets. Opt. Express, 20, 17720–17229.

5.2.1 Research Reports

1. Mech 304/12.   A.Berezovski, J.Engelbrecht, A.Salupere, K.Tamm, T.Peets, M.Berezovski. Dispersive waves in microstructured solids.

5.2.2 Lecture Notes

1. Mech 9/2012   Heiko Herrmann. Software tools for science and engineering.
2.   J.Kalda. Electrical Circuits.
3.   J.Kalda. Formulas for IPhO (in English, translated into Portuguese, Indonesian and Arabic languages).

5.2.3 Submitted papers

1. A.Berezovski, J.Engelbrecht, A.Salupere, K.Tamm, T.Peets, and M.Berezovski. Dispersive waves in microstructured solids. International J. Solids and Structures, (submitted).

2. J.Engelbrecht, A.Berezovski. Internal structure and internal variables in solids. J. Mechanics of Materials and Structures, (accepted).

3. A.Ravasoo. Tone bursts for characterization of exponentially graded materials. Proc. Estonian Acad. Sci., (submitted).

4. A.Ravasoo. Modified constitutive equation for quasi-linear theory of viscoelasticity. J. Engineering Mathematics, (accepted).

5. A.Stulov, D.Kartofelev. Vibration of strings with nonlinear supports. Applied Acoustics, (submitted).

6. A.Stulov. Mathematical model of echolocation of fish-catching bats. Wave Motion, Available online 19 December 2012, (accepted).

7. K.Tamm, T.Peets. On the influence of internal degrees of freedom on dispersion in microstructured solids. Mechanics Research Communications, 2013, 47, 106–111.

8. I.Mandre, J.Kalda. Efficient method of finding scaling exponents from finite-size Monte-Carlo simulations. European J. Physics B, (accepted).

9. J.Kalda, J.Kikas, M.Heidelberg, S.Ainsaar, R.Lõhmus. IPhO 2012: how magnets curve the water. European J. Physics, (submitted).

10. J.Kalda. Physics Cup — IPhO2012: ten challenging problems. European J. Physics, (submitted).

11. R.Kitt. Economic decision making: application of the theory of complex systems. In: M.Ausloos (Ed), Chaos Theory in Politics, (accepted).
E-print: http://arxiv.org/abs/1208.1277.

12. Z.Bartosiewicz, Ü.Kotta, E.Pawłuszewicz, M.Tõnso, M.Wyrwas. Algebraic formalism for nonlinear control systems on homogeneous time scales. Proc. the Estonian Academy of Sciences, (accepted).

13. V.Kaparin, Ü.Kotta. Extended Observer Form: Simple Existence Conditions. International J. Control, (accepted).

14. V.Kaparin, Ü.Kotta. Transformation the nonlinear state equations into the observer form: necessary and sufficient conditions in terms of one-forms. Kyberneetika, (submitted).

15. V.Kaparin, Ü.Kotta. Observable space of nonlinear control system on homogeneous time scale. Proc. Estonian Acad. Sci., (submitted).

16. Ü.Kotta, M.Tõnso, A.Ye.Shumsky, A.N.Zhirabok. Feedback linearization and lattice theory. Systems & Control Letters, (in press).

17. E.Reilent, A.Kuusik, S.Nõmm, S.Ovsjanski, L.Orunurm. Wearable system for patient motor condition assessment and training monitoring. - In: IEEE EMBS Special Topic Conference on Point-of-Care Healthcare Technologies, Bangalore, India, January 16–18, 2013, (accepted).

18. M.Eik, K.Lõhmus, M.Tigasson, M.Listak, J.Puttonen, H.Herrmann. Combined DC-conductivity testing to photometry for measuring fibre orientations in SFRC, J. Materials Science, (accepted).

19. R.Haber, J.Prehl, K.H.Hoffmann, H.Herrmann. Diffusion of Oriented Particles in Porous Media, EPL, (submitted).

20. A.Treshchalov, A.Lissovski. Light emission from heteronuclear Ar-Kr doubly Ionized excimer molecules, European Physical J.D., (submitted).

21. P.Peterson, M.Kalda, M.Vendelin. Real-time Determination of Sarcomere Length of a Single Cardiomyocyte during Contraction. Am J. Physiol Cell Physiol, Article, (in press).

22. J.Kalda, T.Soomere, A.Giudici. On the finite-time compressibility on the surface currents in the Gulf of Finland, the Baltic Sea. J. Marine Systems, doi: 10.1016/j.jmarsys.2012.08.010 Available online 11.09.2012 (in press).

23. N.C.Delpeche-Ellmann, T.Soomere. Investigating the Marine Protected Areas most at risk of current-driven pollution in the Gulf of Finland, the Baltic Sea, using a Lagrangian transport model, Marine Pollution Bulletin, doi: 10.1016/j.marpolbul.2012.11.025 Available online 06.12.2012.

24. T.Soomere, A.Räämet. Decadal changes in the Baltic Sea wave heights. J. Marine Systems, (submitted).

25. T.Soomere, M.Viška. Simulated sediment transport along the eastern coast of the Baltic Sea. J. Marine Systems, (accepted) .

26. B.Viikmäe, T.Soomere. Spatial pattern of current-driven hits to the nearshore from a major marine highway in the Gulf of Finland. J. Marine Systems, (submitted).

27. I.Zaitseva-Pärnaste, T.Soomere. Interannual variations of ice cover and wave energy flux in the north-eastern Baltic Sea. Annals of Glaciology, (submitted).

28. N.C.Delpeche-Ellmann, T.Soomere. Using Lagrangian models to assist in maritime management of Coastal and Marine Protected Areas. J. Coastal Research., (submitted)

29. I.Nikolkina, T.Soomere, I.Didenkulova. Wave climate in Peipsi Lake. J. Coastal Research, (submitted).

30. T.Soomere. Extending the observed Baltic Sea wave climate back to the 1940s. J. Coastal Research, (submitted).

31. I.Didenkulova, A.Sheremet, T.Torsvik, T.Soomere. Characteristic properties of different vessel wake signals. J. Coastal Research, (submitted).

32. A.Giudici, T.Soomere. Identification of areas of frequent patch formation from velocity fields. J. Coastal Research, (submitted).

33. B.Viikmäe, T.Torsvik, T.Soomere. Spatial pattern of current-driven hits Impact of horizontal eddy-diffusivity on Lagrangian statistics for coastal pollution from a major marine fairway. Ocean Dynamics, (submitted).

34. I.Didenkulova, P.Denissenko, A.Rodin and E.Pelinovsky. 2013. Effect of asymmetry of incident wave on the maksimum runup height. J. Coastal Research, (submitted).

35. P.Denissenko, I.Didenkulova, A.Rodin, M.Listak and E.Pelinovsky. 2013. Experimental statistics of long wave runup on a plane beach. J. Coastal Research, (submitted).

36. D.C.Kim, K.O.Kim, E.Pelinovsky, I.Didenkulova and B.H.Choi, 2013. Three-dimensional tsunami runup simulation for the port of Koborinai on the Sanriku coast of Japan. J. Coastal Research, (submitted).

37. I.Didenkulova, E.Pelinovsky. Transformation of irregular wave field along a quartic bottom profile. Proc. Estonian Acad. Sci., (accepted).

38. I.Nikolkina, I.Didenkulova and E.Pelinovsky. Potentially hazardous areas for landslides in the banks of water basins of Nizhny Novgorod region. Privolzhskiy Scientific J. (in Russian).

39. I.Didenkulova, E.Pelinovsky. Analytical solutions for tsunami waves generated by submarine landslides in narrow bays and channels. Pure and Applied Geophysics, (accepted).

40. I.Didenkulova, A.Rodin. A typical wave wake from high-speed vessels: its group structure and run-up. Nonlinear Processes in Geophysics, (under review).

41. I.Didenkulova. Tsunami runup in narrow bays: the case of Samoa 2009 tsunami. Natural Hazards, (published online).

5.2.4 Popular science

1. J.Kalda. Läbi ja lõhki olümpiaadimees. (Through and through an olympiad guy), interview by Oleg Košik). Horisont, 5, 20–25 (in Estonian).

2. T.Soomere. Mida uut on teadusele andnud kiirlaevalainete uuringud Tallinna lahel? (Studies into wakes from fast ferries have open new perspectives for wave science), Horisont, 2012, 3, 4 (in Estonian).

3. T.Soomere. Tagasi laine ja aine partnerluse juurde (Back to the partnership of waves and matter). - In: G.Pretor-Pinney, Lainevaatleja käsiraamat (Preface to the book "The wavewatcher's companion" by G.Pretor-Pinney), Imeline Teadus, Tallinn 2012, 9–13 (in Estonian).

4. T.Soomere. Katastroofide füüsika: tsunami ja tormiaju (Physics of disasters: tsunami and storm surge). - In: Laumets L., Lang L., Truuver K., Nemliher R. (eds.), Katastroofid Maa ajaloos (Disasters in the history of Earth). Schola Geologica VIII. Eesti Loodusuurijate Selts, 2012, Tartu, 41–54 (in Estonian).

5. I.Nikolkina, E.Pelinovsky. Gravity flows and long waves in liquid: application to marine natural disasters. Saarbrücken: LAP LAMBERT Academic Publishing, 2012 (in Russian).

6. T.Soomere. Nord Stream majanduse, poliitika ja keskkonnahoiu ristteel (Nord Stream on the cross-roads of economy, politics and environmental concerns). Meremees (The Mariner), 2012, 3, 12–13 (in Estonian).

7. T.Soomere. Olla tippteadlane ja prohvet korraga (Top scientist or a prophet). Tallinna Tehnikaülikooli aastaraamat 2011 (XIX), Tallinna Tehnikaülikool, 2012, 343–346 (in Estonian).

8. I.Didenkulova. Runup of long waves on a plane beach: modelling and analysis or real events. LAP LAMBERT Academic Publishing GmbH & Co. KG, 260 p. ISBN: 978-3-8484-9450-7, 2012 (in Russian).

9. E.Quak. Zero is Expensive! Article in SIAM News (the newsletter of the Society of Industrial and Applied Mathematics – SIAM, over 13 000 individual and almost 500 institutional members), Volume 45, Number 4, May 2012.

5.2.5 Other papers / Science policy

1. J.Engelbrecht. Arvamusi akadeemikutelt (Opinions from fellows of the Academy). Eesti TA Aastaraamat 2011, 2012, 230–234.

2. J.Engelbrecht. Akadeemiad ja ALLEA (Academies and ALLEA). Eesti TA Aastaraamat 2011, 2012, 247–270.

3. J.Engelbrecht. Centre for Nonlinear Studies, In: Estonian Centres of Excellence in Research, Tartu, 2012, 26–27.

4. J.Engelbrecht. Teaduse tipptase - pühendunud inimesed, hea keskkond ja julged eesmärgid (Top quality in science – dedicated people, good environment and high targets). Päevaleht, 14.08.2012.

5. J.Engelbrecht. Mittelineaarsete protsesside analüüsi keskus (Centre for Nonlinear Studies). Ibid.

6. J.Engelbrecht. Intervjuu K. Kellole: Normaalne maailm ongi mittelineaarne (An interview: Normal world is nonlinear), Õpetajate Leht, No 35, 05.10.2012.

7. J.Engelbrecht. Mitmekesisusest veel (On diversity). Lehed ja tähed, No 6, 2012, 118–119.

8. J.Engelbrecht. H.Kerese elufilosoofiast (Philosophy of H.Keres). Postimees, 17.11.2012.

9. J.Engelbrecht. Kuidas portreteerida Endel Lippmaad (How to portray Endel Lippmaa). Raamat No 7(68), 2012.

10. R.Kitt. Koolirahast ei peaks saama "kooliraha" ühiskonnale: tudeng, kes lõpetab ülikooli ja asub kohe tööle välisriiki, maksku koolitusraha tagasi. (Tuition fee should apply to the student, not to the society). Eesti Päevaleht, 7. Feb. 2012.

11. R.Kitt. Uus majandus on läbi, juhtimine kaose tingimustes jätkub. (New economy is over; management under chaotic regime continues). Director 3 (2012), pp. 12.

12. R.Kitt. Tööturg peaks muutuma vabamaks. (Labour market should become more liberal). Postimees: Minu Ettevõte, 24. April 2012.

13. R.Kitt. Paindlikkust töösuhetes takistavad müüdid. (Flexible employment conditions are opposed by myths). Äripäev 4. July 2012.

14. R.Kitt. Viiskümmend aastat kapitalismi ja vabadust. (Fifty years of capitalism and freedom), Akadeemia. 2012, 24(10), 1831–1845.

5.3 Conferences

1. International Conference on Computational and Experimental Engineering and Sciences, Crete, Greece, April 30 – May 4, 2012.
H.Aben. An algorithm of photoelastic tomography for complete determination of axisymmetric stress fields.

2. 15th International Conference on Experimental Mechanics, Porto, Portugal, 22–27 July, 2012.
A.Errapart. Determination of all stress components of axisymmetric stress state in photoelastic tomography.

3. EUROMECH Colloquium 540, Advanced Modelling of Wave Propagation in Solids, Prague, Czech Republic, 1–3 October, 2012.
A.Berezovski – co-chairman.
A.Berezovski, J.Engelbrecht, M.Berezovski. Influence of internal structures on wave dispersion in solids.
A.Salupere, K.Tamm. On the influence of material properties on the wave propagation in Mindlin-type microstructured solids.

4. 8th European Solid Mechanics Conference, Graz, Austria, July 9–13, 2012.
   A.Berezovski. Jump Conditions at Discontinuities in Solids: Numerical Implementation.
   A.Ravasoo. Interaction of bursts for acoustodiagnostics of functionally graded materials.
   H.Herrmann, M.Eik. Analytical description of fibre orientation distributions in short fibre reinforced materials based on mCT imaging.
   M.Eik, J.Puttonen, H.Herrmann. Orientation distribution of fibres in short-fibre reinforced concrete: evaluation and introduction to constitutive relations.

5. 23rd International Congress of Theoretical and Applied Mechanics (ICTAM2012), Beijing, China, 19–24 August, 2012.
   A.Berezovski, J.Engelbrecht. Waves in microstructured solids: dispersion and thermal effects.
   A.Salupere, K.Tamm. Evolution of solitary waves in Mindlin-type microstructured materials.

6. 25th Nordic Seminar on Computational Mechanics, Lund, Sweden, 25–26 October, 2012.
   A.Berezovski, J.Engelbrecht, M.Berezovski. Wave propagation and dispersion in microstructured solids.

7. Latvian Concrete Days, Riga. 1–2 November, 2012.
   H.Herrmann: Analytical Description of Fibre Orientation Distributions in Short Fibre Reinforced Materials based on mCT Imaging,

8. Network meeting of the Alexander von Humboldt Foundation. Aachen, Germany, 25–27 April, 2012.
   H.Herrmann. Mechanics with internal Variables.

9. Humboldt-Kolleg "Innovation und Widerstand". Helsinki, 18–20 October, 2012.
   E.Pastorelli, H.Herrmann. Visualization of Microstructure.

10. Acoustics 2012, Nantes, France, 23–27 April, 2012.
    A.Stulov. Analysis of the nonlinear effect of the capo bar-string interaction in grand piano.
    A.Stulov. Modeling of the part-pedaling effect in the piano.

11. In Biophysical Society's 56rd Annual Meeting in San Diego, California, USA, 24–29 February, 2012.
    M.Kalda, P.Peterson, M.Vendelin. Incorporating cooperativity into Huxley-type cross-bridge models in thermodynamically consistent way.
    N.Sokolova, M.Vendelin, R.Birkedal. Distribution of intracellular ADP diffusion restriction in trout cardiomyocytes.
    A.Illaste, M.Laasmaa, P.Peterson, M.Vendelin. Analysis of molecular movement reveals lattice like obstructions to diffusion in heart muscle cells.
    N.Jepihhina, N.Beraud, M.Sepp, R.Birkedal, M.Vendelin. Permeabilized rat cardiomyocyte response demonstrates intracellular origin of diffusion obstacles.
    D.W.Schryer, P.Peterson, A.Illaste, M.Vendelin. Mathematical model of oxygen labeling to study heart energy transfer.
    J.Karo, P.Peterson, M.Vendelin. Molecular Dynamics Simulations of Creatine Kinase and Adenine Nucleotide Translocase in Mitochondrial Membrane Patch.

12. 2nd Ph.D. School on "Mathematical Modeling of Complex Systems", Pescara, Italy, 16–18 July, 2012.
    I.Mandre. R.Kitt – participants.

13. 7th Vienna International Conference on Mathematical Modelling (MATHMOD 2012), Vienna, Austria, January 14–17, 2012.

J.Belikov, Ü.Kotta. Symbolic Polynomial Tools for Nonlinear Control Systems.
M.Tõnso, Ü.Kotta. Implementation of the tools of functions' algebra: first steps.

14. The 9th International Conference on System Identification and Control Problems
(SICPRO'12), Moscow, Russia, January 30 – February 2, 2012.
Ü.Nurges. On the fixed order stabilizing controller design by reflection segments approach.

15. 2nd International Conference on Pervasive and Embedded Computing and Communication
Systems (PECCS 2012), Rome, Italy, February 24–26, 2012.
J.Vain. Model based continual planning and control framework for assistive robots.

16. Workshops on Foundations of Aspect-Oriented Languages (FOAL 2012), Potsdam,
Germany, March 25–28, 2012.
J.Vain. Exploiting aspects in model-based testing.

17. 2012 IEEE World Congress on Computational Intelligence (IEEE WCCI 2012), Brisbane,
Australia, June 10–15, 2012.
S.Nõmm. Evaluation function optimization for the Genetic Algorithm based tuning of
NN-ANARX model structure

18. 9th International Conference on Integrated Formal Methods (iFM 2012), Pisa, Italy,
June 18–21, 2012.
J.Vain. Refinement-based development of timed systems.

19. The 2012 American Control Conference (ACC 2012), Montréal, Canada, June 27-29, 2012.
A.Kaldmäe, Ü.Kotta. Dynamic measurement feedback in discrete-time nonlinear control
systems.

20. 20th Mediterranean Conference on Control and Automation (MED 2012), Barcelona,
Spain, July 3–6, 2012.
Ü.Nurges. Reflection segments based stability domain approximation of the robust PID
controller parameters.

21. 13th Biennial Baltic Electronics Conference (BEC 2012), Tallinn, Estonia, October 3–5,
2012.
J.Vain. Constraint-based test scenario description language.

22. 2012 IEEE Multi-Conference on Systems and Control, Dubrovnik, Croatia, October 3–5,
2012.
J.Belikov. Explicit formulas for the state coordinates in nonlinear MIMO realization problem on homogeneous time scales.

23. The 19th International Conference on Neural Information Processing (ICONIP2012),
Doha, Qatar, November 12–15, 2012.
S.Nõmm. Neural networks based system for the supervision of therapeutic exercises.

24. The 12th International Conference on Control, Automation, Robotics and Vision
(ICARCV 2012), Guangzhou, China, December 5–7, 2012.
Ü.Nurges. Fixed order stabilizing controller design via random reflection segments.

25. 51st IEEE Conference on Decision and Control, Maui, Hawaii, USA, December 10–13,
2012.
Ü.Kotta, M.Tõnso. Practical polynomial formulas in MIMO nonlinear realization problem.
Ü.Kotta. Dual algebraic framework for discrete-time nonlinear control systems.

26. Photonics Europe 2012, Brussels, Belgium, 16–19 April 2012.
V.Peet. Laser beam shaping by conical refraction in biaxial crystals.

27. 8th EOS Topical Meeting on Diffractive Optics (DO 2012); Delft, Netherlands, 27 February – 1 March 2012.
P.Piksarv, M.Lõhmus, H.Valtna-Lukner, P.Bowlan, R.Trebino, P.Saari. Time-domain measurement of diffraction phenomena.

28. XVIIIth International Conference on Ultrafast Phenomena. Lausanne, Switzerland, 8–13 July, 2012.
P.Saari, P.Bowlan, H.Valtna-Lukner, M.Lõhmus, P.Piksarv, R.Trebino. Complete Spatiotemporal Measurement of Bessel-X Pulses and Other Ultrafast Diffraction Phenomena.
P.Piksarv, H.Valtna-Lukner, A.Valdmann, M.Lõhmus, R.Matt, P.Saari. Measuring the Suppression of Ultrashort Pulses into Airy-Bessel Light Bullets with Almost Single-Cycle Temporal Resolution.

29. IEEE Photonics Conference (IPC). Burlingame, CA, USA, 23–27 September, 2012.
P.Piksarv, H.Valtna-Lukner, A.Valdmann, M.Lõhmus, R.Matt, P.Saari. Measuring the temporal focusing of ultrashort Airy-Bessel wave packets.

30. Northern Optics. Snekkersten, Denmark, 19–21 November, 2012.
P.Piksarv, H.Valtna-Lukner, A.Valdmann, M.Lõhmus, R.Matt, P.Saari. Suppression of temporal spread of ultrashort pulses using Airy-Bessel light bullets.

31. LOTE PhD Conference, Voore, Jõgevamaa, Estonia, 18–19 May, 2012.
P.Piksarv. Mõõtes valguse ühte võnget (Measuring ultrashort light pulses).

32. 5th International Workshop "Coastline Changes of the Southern Baltic Sea – Past and Future Projection (CoPaF)" together with Workshop "Operational decision-making based on atmospheric conditions (PROZA)," University of Gdansk, Institute of Oceanography, Gdynia, 19–21 March, 2012.
T.Soomere. Simulated sediment flux along the eastern Baltic Sea coast (20.03.2012, invited paper).

33. EGU General Assembly, Vienna, Austria, 22–27 April, 2012.
A.Rodin, I.Didenkulova. A typical wave wake from high-speed vessels: its group structure and run-up.
I.Nikolkina, I.Didenkulova. Rogue waves in 2006–2011.
Posters:
I.Didenkulova, A.Rodin. Statistics of waves within a ship wake.
A.Rodin, I.Didenkulova, E.Pelinovsky. Nonlinear interaction of large-amplitude unidirectional waves in shallow water.
I.Nikolkina, I.Didenkulova. Waves generated by landslides in rivers: data of Nizhniy Novgorod region.
Sh.Chatraee, I.Didenkulova. Effective fully-reflective boundary conditions at the shore for modeling of wave processes in long bays.
P.Denissenko, I.Didenkulova, E.Pelinovsky, J.Pearson. Laboratory study of statistical characteristics of nonlinear long wave runup on a beach.
B.Viikmäe, T.Soomere. Patterns of hits to the nearshore from a major fairway in the Gulf of Finland.
I.Didenkulova, E.Pelinovsky. Nonlinear wave runup in long bays and firths: Samoa 2009 and Tohoku 2011 tsunamis.
X.Lu, T.Soomere, E.Stanev, J.Murawski. Event driven approach for the identification of the environmentally safe fairway in the south-western Baltic Sea and Kattegat.

I.Didenkulova, E.Pelinovsky, A.Rodin. Formation of shallow water rogue waves taking into account wave breaking effects.

I.Didenkulova was also a convener and a chair of sessions NH5.3/NP7.3/OS2.6 "Nonlinear Dynamics of the Coastal Zone" and NH5.1 "New developments in tsunami science and in mitigation of tsunami risk, including early warning." She is also a scientific officer of the Natural Hazards (HN) section for "Sea and Ocean Hazards."

34. 2012 IEEE/OES Baltic International Symposium "Ocean: Past, Present and Future. Climate change research, Ocean Observation & Advanced Technologies for regional sustainability", Klaipeda, Lithuania, 08–11 May, 2012.

    K.Pindsoo, T.Soomere, M.Zujev. Decadal and long-term variations in the wave climate at the Latvian coast of the Baltic Proper.

    T.Soomere, K.Myrberg, O.Andrejev. A future technology of environmental management of semin-enclosed seas.

    I.Nikolkina, I.Didenkulova. River landslides in Nizhny Novgorod region and a possibility of local tsunami generation.

    A.Rodin. Ship waves in Tallinn Bay, Baltic Sea: their parameters, group structure and runup

    I.Nikolkina, I.Didenkulova. Chronicle of rogue waves for 2006–2011.

    R.Männikus, T.Soomere, T.Torsvik. Optimizing breakwater configuration for vessel wakes and wind waves.

    I.Didenkulova, A.Rodin. Statistics of shallow water rogue waves in Baltic Sea conditions: the case of Tallinn Bay.

    T.Torsvik. Consistency of residence time calculations based on Lagrangian trajectory analysis in ocean modeling.

    B.Viikmäe, T.Torsvik, T.Soomere. Analysis of the structure of currents in the Gulf of Finland using the Okubo-Weiss parameter.

    M.Viška, T.Soomere. Hindcast of sediment flow along the Curonian Spit under different wave climates.

    A.Giudici, J.Kalda, T.Soomere. On the compressibility of surface currents in the Gulf of Finland, the Baltic Sea.

35. Mathematical school-conference "Lobachevsky reading 2012", Kazan, Russia, 1–6 November, 2012.

    E.Averbukh. Quantification of surface manifestations of extreme wave fields.

    Using the bundled software IGWRESEARCH for numerical simulation films dynamics in the field of internal waves in the Baltic region.

36. "The future of the Technical Science 2012", Nizhny Novgorod, Russia, 18 May, 2012.

    A.Rodin. Extreme waves in shallow water (won the III prize).

37. JONSMOD 2012, Brest, France, 21–23 May, 2012.

    B.Viikmäe. Spatial Pattern of Hits to the Nearshore from a Major Marine Highway in the Gulf of Finland.

    T.Torsvik. Vatlestraumen tidal current - Characterization of local transport properties.

38. International Symposium on "Seasonal Snow and Ice" in Lahti, Finland, 28 May–01 June, 2012.

    I.Zaitseva-Pärnaste. Interannual variations of ice cover and wave energy flux in the north-eastern Baltic Sea (poster).

39. 35th AMOP Technical Seminar on Environmental Contamination and Response , Vancouver, British Columbia, Canada, 05–07 June, 2012.

T.Soomere. A preventive method for minimizing environmental risks based on the optimization of the location of potentially dangerous activities.

40. 22nd International Ocean and Polar Engineering Conference (ISOPE 2012), Rhodes (Rodos), Greece, 17–22 June, 2012.
I.Didenkulova. Resonant generation of tsunami waves by submarine landslides in fjords.

41. 10th Industrial Challenges in CAD, Geometric Modelling and Simulation Workshop, Darmstadt, Germany, March 22–23, 2012.
Co-organized by E.Quak.

42. Workshop "Mathematics for Life Sciences" of the Marie Curie International Research Staff Exchange Scheme EUMLS (EU-Ukrainian Mathematicians for Life Sciences), Kyiv, September 3–14, 2012.
Co-organized by E.Quak.

43. Final Workshop of the Marie Curie Initial Training Network SAGA (Shapes, Geometry, Algebra), Trento, Italy, October 9–11, 2012.
E.Quak gave a presentation on applying for EU research funding.

44. Regional Humboldt Kolleg "Innovation and Resistance", University of Helsinki, Finland, October 19–20, 2012.
E.Quak participated.

45. Workshop "Computational Geometry and Ontologies for Cultural Heritage 3D Digital Libraries – What are the future alternatives for Europeana?" at the 4th International Euro-Mediterranean Conference on Cultural Heritage (EuroMed 2012) www.euromed2012.eu, Limassol, Cyprus, October 29 – November 3, 2012.
E.Quak co-organized the workshop and co-chaired it on October 30, 2012.

46. Graduate School and 10th Eurographics Symposium on Geometry Processing (SGP2012), in cooperation with ACM SIGGRAPH (USA), www.ioc.ee/sgp12, Tallinn, Estonia, 14–15 and 16–18 July, 2012, respectively.
Organized by E.Quak as the Conference Chair with technical support from A.Giudici and K.Pinsoo providing organisational assistance.
T.Soomere, M.Eelsalu, O.Kurkina, M.Viška displayed five poster presentations at the poster session:
I.Didenkulova, E.Pelinovsky. Nonlinear dispersive properties of hazardous waves in the-coastal zone. I.Didenkulova, E.Pelinovsky. Nonreflecting wave propagation and u-shaped bays. E.Pelinovsky, A.Rodin. Transformation of strongly nonlinear wave in shallow water. O.Kurkina, A.Kurkin, E.Rouvinskaya. Models of KdV-hierarchy for internal waves in a three-layer fluid. The Baltic Way Team, BalticWay: The potential of currents for environmental management of the Baltic Sea.

47. 33rd General Assembly of the European Seismological Commission (ESC 2012), Moscow, Russia, 22 August, 2012.
I.Nikolkina. Tsunamis In Russian Rivers, Lakes and Reservoirs.

48. BACC II: Assessment of climate change in the Baltic Sea basin, Tallinn, Estonia, 06–07 September, 2012.
T.Soomere, M.Viška, I.Nikolkina, E.Averbukh, K.Pindsoo and M.Eelsalu participated.

49. 11th Colloquium on Baltic Sea Marine Geology, Helsinki/Stockholm, Finland/Sweden, 19–21 September, 2012.
T.Soomere, M. Viška. On the stability of Curonian Spit under changing wave climate.

M.Viška, T.Soomere. Decadal variations of simulated sediment transport patterns along the eastern coast of the Baltic Sea

K.Pindsoo, T.Soomere. Interannual, decadal and long-term variations in the wave fields at the Latvian coast of the Baltic Proper.

50. 6th International student conference "Aquatic environmental research", Palanga Lithuania, 17–19 October, 2012.

E.Averbukh. Dynamics of surfactants in the field of edge waves in coastal areas.

K.Pindsoo. The water level rise caused by wave set-up in the urban area of the city of Tallinn, Estonia.

M.Eelsalu. Wave energy potential in the coastal waters of Lithuania and Latvia.

A.Giudici. Compressibility of surface currents patterns analysis in the Gulf of Finland, the Baltic Sea.

51. 1st Annual ANDROID Conference, Tallinn, Estonia, 18 October, 2012.

T.Soomere. Reflections on marine coastal disaster management and resilience building in the eastern Baltic Sea (invited keynote lecture).

52. Advanced research workshop "Environmental security of the European cross-border energy supply infrastructure" sponsored by the NATO Science for Peace and Security Programme (Moscow, Sergeev Institute of Environmental Geoscience, Russian Academy of Sciences, 30–31 October, 2012).

T.Soomere. Towards the new generation of techniques for the environmental management of maritime activities (invited lecture).

5.4 Seminars

5.4.1 Tallinn Seminars on Mechanics (CENS)

1. 5.1.2012, M.Kree (Marseille University): Correlation of the admixture originating from separate sources and mixed by a turbulent flow.

2. 9.1.2012, J.Vain: On the analysis problems of emerging behavior of robot swarms.

3. 16.1.2012, A.Ravasoo: Bursts interaction versus smooth material inhomogeneity.

4. 23.1.2012, D.Schryer: Metabolic Flux Analysis of Compartmentalized Systems using Dynamic Isotopologue Modeling.

5. 30.1.2012, D.Kartofelev: Deformation Wave Propagation in Felt: Dispersion Analysis.

6. 6.2.2012, T.Fulop ((Hungary): Rheology, Plasticity, and Thermal Expansion in a Nonequilibrium Thermodynamical Framework.

7. 13.2.2012, A.Illaste: Analysis of Molecular Movements in Cardiac Myocytes.

8. 27.2.2012, I.Sertakov: 2D wave motion in microstructured solids.

9. 5.3.2012, M.Eik: Isotropic tensor functions in the context of constitutive theory for SFRC.

10. 12.3.2012, A.Stulov: Pedaling piano.

11. 19.3.2012, J.Szwabinski (University of Wrocław): Stability of a food web with closed nutrient cycle.

12. 26.3.2012, T.Soomere: Simulated sediment transport patterns along sedimentary coasts of the eastern Baltic Sea.

13. 2.4.2012, A.Berezovski: On the high-order dispersion wave equations.

14. 16.4.2012, I.Nikolkina: Rogue waves in the World;
M.Zujev and K.Pindsoo: Decadal and long-term variations in the wave climate at the Latvian coast of the Baltic Proper;
A.Rodin: A typical wave wake from high-speed vessels: its group structure and run-up.

15. 23.4.2012, A.Giudici: On the compressibility of surface currents in the Gulf of Finland, the Baltic Sea;
M.Viška: Hindcast of sediment flow along the Curonian Spit under different wave climates;
R.Männikus: Optimizing breakwater configuration for vessel wakes and wind waves.

16. 7.5.2012, A.Errapart: Photoelastic tomography in linear and nonlinear approximation.

17. 14.5.2012, M.Heidelberg (University of Tartu): On the transport of passive scalars in two-dimensional stationary velocity fields.

18. 21.5.2012, A.Stulov: Gradient-elastic model for description of wave processes in nonlinear geomechanics.

19. 4.06.2012, Prof. A.Krasnikovs (Riga Technical University): Mechanics of fiber concretes.

20. 11.6.2012, K.Tamm: The Role of Nonlinearity and Dispersion on Wave Motion in Microstructured Solids.

21. 18.6.2012, M.Viška: Modelling of shoreline evolution.

22. 6.8.2012, B.Ranguelov (Space and Solar-Terrestrial Research Institute, Bulgarian Academy of Science): Natural hazards - nonlinearities and applications.

23. 21.8.2012, V.Välimäki (Aalto University): Musical Acoustics.

24. 27.8.2012, V.Berg: Discrete Element Simulation of SFRC.

25. 27.8.2012, H.Herrmann: Analytical Description of Fibre Orientation Distributions in Short Fibre Reinforced Materials based on mCT Imaging.

26. 17.9.2012, M.Heidelberg (University of Tartu): Nonlinear oscillations in tunnel diode.

27. 8.10.2012, S.Ainsaar (University of Tartu): Diffusion in 2D washboard potential.

28. 22.10.2012, A.Salupere, K.Tamm: On the influence of material properties on the wave propagation in Mindlin-type microstructured solids.

29. 29.10.2012, I.Sertakov: 2D waves in microstructured solids.

30. 5.11.2012, J.Kalda: Giant dispersion of particles in multi-dimensional potential velocity field.

31. 13.11.2012 CENS Seminar: Institute of Cybernetics at TUT and TU Institute of Physics JOINT SEMINAR in Tartu, Institute of Physics.

32. 19.11.2012, M.Mustonen: Bass guitar modeling based on experimental data.

33. 26.11.2012, A.Braunbrück: Evaluation of exponentially graded material properties based on ultrasound.

34. 3.12.2012, A.Ravasoo. Parametric plots for qualitative acoustodiagnostics.

35. 10.12.2012, B.Viikmäe: Impact of horizontal eddy-diffusivity on Lagrangian statistics for coastal pollution from a major marine fairway.

5.4.1.1 Seminars of the Wave Engineering Group

1. 07.02.2012, T.Torsvik: Course in Numerical Computing, lecture 1: Floating-Point Arithmetic, linear equations, pivoting and permutation matrix, LU factorization, operational counts: FLOPS.

2. 14.02.2012, T.Soomere: Preparing a Manuscript for a Peer-reviewed International Journal, lecture 1.

3. 21.02.2012, T.Torsvik: Course in Numerical Computing, lecture 2: Effect of roundoff errors, norms, sparse matrices and band matrices, interpolating polynomial, piecewise linear interpolation, cubic spline interpolation.

4. 27.02.2012, T.Soomere: Preparing a Manuscript for a Peer-reviewed International Journal, lecture 2.

5. 06.03.2012, T.Torsvik: Course in Numerical Computing, lecture 3: Bisection, Newton's method, an intractable example, secant method, fixed-point interation, advanced zero finding methods, value finding, optimization.

6. 13.03.2012, T.Soomere: Preparing a Manuscript for a Peer-reviewed International Journal, lecture 3.

7. 20.03.2012, T.Torsvik: Course in Numerical Computing, lecture 4: Models and curve fitting, Censgui, Norms, Householder reflections, QR Factorization, Pseudoinverse and Rank deficiency, Exercises.

8. 27.03.2012, T.Soomere: Preparing a Manuscript for a Peer-reviewed International Journal, lecture 4.

9. 03.04.2012, T.Torsvik: Course in Numerical Computing, lecture 5: Basic Quadrature Rules, Integrating Discrete Data, Excercises.

10. 10.04.2012, T.Torsvik: Course in Numerical Computing, lecture 6: Systems of equations, Linearized Differential Equations, Single-Step Methods, The BS23 Algorithm.

11. 17.04.2012, T.Torsvik: Course in Numerical Computing, lecture 7: Stiffness, Events, Multistep Methods, Errors, Performance.

12. 15.05.2012, T.Torsvik: Course in Numerical Computing, lecture 8: Discretization methods, The Finite Difference Methods, Matrix Representation, Example: The one-way wave equation, Stability and Convergence of numerical schemes, Summary.

13. 11.09.2012, E.Averbukh: Bottom and near-surface processes in the boundary areas of the ocean.

14. 18.10.2012, M.Viška: Decadal variations of simulated sediment transport patterns along the eastern coast of the Baltic Sea.

15. 02.10.2012, K.Pindsoo: The water level rise caused by wave set-up in the urban area of the City of Tallinn, Estonia.

16. 09.10.2012, M.Eelsalu: Wave energy potential in the north-eastern Baltic Sea and Estonian coastal waters.

17. 16.10.2012, T.Torsvik: Wave engineering: state of art and future plans.

18. 23.10.2012. I.Nikolkina: Aquatic environmental research: main findings and outlook.

19. 30.10.2012, T.Torsvik: Overview of geoscience software.

20. 06.11.2012, T.Torsvik: Analysis of wave measurements using spectrograms.

21. 20.11.2012, I.Nikolkina: LATEX for scientists and engineers.

22. 27.11.2012, B.Viikmäe: Impact of horizontal eddy-diffusivity on Lagrangian statistics for coastal pollution from a major marine fairway.

23. 04.12.2012, T.Torsvik: Drifter data and its analysis.

24. 11.12.2012, B.Viikmäe: Quantification and characterization of mesoscale eddies with different automatic identification algorithms.

5.4.1.2 Seminars Nonlinear Control Group

1. 22.05.2012 Seshadhri Srinivasan (IoC): Control and optimization challenges in smart grids.

2. 01.06.2012, Prof. Claude H.Moog (Institut de Recherche en Communications et en Cybernétique de Nantes IRCCyN): Nonlinear time-delay control systems theory.

3. 10.09.2012, Prof. Tõnu Kasvand (Concordia University): Technology versus biology in vision.

4. 11.09.2012, Małgorzata Wyrwas (BialystokiUniversity of Technology): Reducibility conditions for nonlinear discrete-time systems: behavioral approach.

5. 12.09.2012, Prof. Ewa Pawłuszewicz (Bialystoki University of Technology): On fractional systems research in Bialystok University of Technology.

6. 30.10.2012–01.11.2012, Dr. Felix Antritter, Lecture course: Tracking control for nonlinear systems: the flatness based approach.

5.4.2 Lectures and seminars outside CENS

1. Lecture: Introduction to Fractal Music, D.Kartofelev under the TUT course Nonlinear Dynamics and Chaos (collaboration with Jüri Engelbrecht, D.Sc). Course code in TUT curriculum: EMR 0060.

2. Seminar at the Laboratory of Spektroscopy and Material Science. Institute of Physics, University of Tartu, 1 February 2012.
J.Kalda. Turbulentne segunemine: lihtsasti keeruliseks. (Turbulent mixing: simple way into complexity).

3. VIII summer school on geology "Schola Geologica VIII", Nelijärve, Estonia, 05–07 October 2012.
T.Soomere. Katastroofide füüsika: tsunami ja tormiaju. (Physics of disasters: tsunami and storm surge).
J.Kalda. Katastroof kui juhumuutlikkuse ilming. (Catastrophe as a manifestation of intermittency).

4. Department of Applied Mathematics of Nizhny Novgorod State Technical University, Nizhny Novgorod, Russia, 17 May 2012.
   A.Rodin. Nonlinear deformation of large amplitude waves in shallow water.

5. Helmholtz-Zentrum Geesthacht, Germany, 30 May 2012.
   I.Nikolkina. Rogue waves in the World Ocean.

6. Summer school "The language of science" organised by teadus.ee, Käsmu, Estonia, 24–26 August 2012.
   T.Soomere. How the sea talks to us.

7. Nikolai Alumäe mechanics lecture 2012, 12 September, 2012.
   M.Vendelin. Molecular movements in cardiac myocytes.

8. Conference on marine sciences organised on the occasion of 10-year anniversary of the Marine Systems Institute, Tallinn, 29 September 2012.
   T.Soomere. At the border of sea and land. (Maa ja mere piiril).

9. UT Summer School of Exact Sciences, Voore, Estonia, 26–28 October 2012.
   A.Salupere. On nonlinear waves and solitons.

10. Public forum "Liquified natural gas: challenges and options". Tallinn, Estonia, 07 November 2012.
    T.Soomere. LNG terminali asukohavalik Soome lahe kontekstis. (On potential locations of the LNG terminal on the coast of the Gulf of Finland).

11. Seminar to the Space and Solar-terrestrial research Institute, Bulgarian Academy of Science (Sofia, Bulgaria).
    I.Didenkulova. Rogue waves in the World: manifestations and mechanisms of generation.

12. Seminar in the State Technical University (Nizhny Novgorod, Russia).
    I.Didenkulova. Long wave dynamics in the coastal zone: application to marine natural hazards.

13. Department of Applied Mathematics of Nizhny Novgorod State Technical University, Nizhny Novgorod, Russia, 7 December 2012.
    I.Didenkulova. Long wave dynamics in the coastal zone: application to marine natural hazards.

14. Department of Applied Mathematics of Nizhny Novgorod State Technical University, Nizhny Novgorod, Russia, 19 December 2012.
    A.Rodin Theoretical and experimental study of long wave runup on a beach.

5.5 Meetings and events

5.5.1. Meetings and events in CENS

CENS members' reports on Autumn seminar — Laulasmaa, November 9–10, 2012.

1. Seshadhri Srinivasan: Predictive smart thermostat controller.

2. Vadim Kaparin: Extended observer form for discrete-time nonlinear control systems.

3. Ülo Nurges: On the fixed order stabilizing controller design by reflection segments approach.

4. Sven Nõmm: Identifiability and identification.

5. Jelena Branovets: Structural and energetic modifications in cardiomyocytes from mice with modified creatine kinase system.

6. Natalja Jepihhina: Permeabilized rat cardiomyocyte response demonstrates intracellular origin of diffusion obstacles.

7. Päivo Simson: Extracting intracellular information from molecular fluctuations.

8. Johan Anton: Stress measurement in chemically tempered glass.

9. Tarmo Soomere: Applications of wave dynamics and Lagrangian transport for coastal engineering and management.

10. Tomas Torsvik: Lagrangian particle tracking – influence of particle diffusion.

11. Irina Nikolkina: Wave climate in Peipsi Lake.

12. Elena Averbukh: Dynamics of long waves and their surface manifestations.

13. Andrea Giudici: On the compressibility of surface currents in the Gulf of Finland: theoretical foundations and new results on a 1nm model.

14. Jüri Engelbrecht: Complex dynamical processes in solids and tissues.

15. Jaan Kalda: Turbulent mixing: simple yet complex.

16. Heiko Herrmann, Marika Eik: Methodology and micromechanical modelling of fibre orientations in SFRC.

17. Arvi Ravasoo: Quo vadis, acoustodiagnostics?

18. Dmitri Kartofelev: Musical instruments and nonlinearly supported strings.

19. Ivan Sertakov: 2D waves in microstructured solids.

On 6–7 June the 12th Tallinn Glass Stress Summer School was organised with four participants from Germany and Israel (H.Aben, J.Anton).

Workshop: **Measurement, Visualisation, Modelling and Simulation of complex/microstructured materials**; 5–6 June 2012.
Convener: H.Herrmann.

1. H.Herrmann (CENS): Constitutive Model for SFRC: First Numerical Results and Future Steps.

2. M.Eik (CENS): Measurements of fibre orientation distributions: mCT, photometry.

3. A.Krasnikovs (Riga Tech. Univ., Latvian Academy of Sciences): Mechanics of fiber concretes.

4. E.Pastorelli (CENS): Introduction to 3D visualization.

5. M.Listak (TUT Centre of Biorobotics): Measurements of fibre orientation distributions: DC-conductivity robot.

6. P.Lumme (Rudus OY): Casting of steel fibre reinforced concrete and bending experiments.

30 March 2012: Vice-president of the Russian Academy of Sciences N.P.Laverov, Academician-Secretary of the Division of Earth Sciences A.O.Gliko and Head of the Office for International Research Projects Y.K.Shiyan visited the Institute of Cybernetics and the Wave Engineering Laboratory.

24 September 2012: the team of the Wave Engineering Laboratory organised the **Intense Day on Waves in Fluids**, a mini-conference with four presentations by distinguished wave researchers Christian Kharif (Marseille, France), Efim Pelinovsky, Tatiana Talipova (Nizhny Novgorod, Russia) and Henrik Kalisch (Bergen, Norway).

6. Research and teaching activities

6.1. Meetings and events organised elsewhere

1. 22–23 March, 2012: 10th Industrial Challenges in CAD, Geometric Modelling and Simulation Workshop, Darmstadt, Germany, Workshop series founded and co-organized by E.Quak for the tenth time, with TU Darmstadt and the Fraunhofer Institute for Computer Graphics.

2. 31 March, 2012: T.Soomere visited the Molycorp Ltd., Sillamäe, together with the vice-president of the Russian Academy of Sciences N.P.Laverov and the Head of the Office for International Research Projects Y.K.Shiyan.

3. 14–15, July 2012: Graduate School of the 10th Eurographics Symposium on Geometry Processing (SGP2012) www.ioc.ee/sgp12, Tallinn, Estonia. Organised on the premises of Baltic Computer Systems by E.Quak as the SGP2012 conference chair, with A.Giudici providing technical support.

4. 16–18, July 2012: 10th Eurographics Symposium on Geometry Processing (SGP2012), in cooperation with ACM SIGGRAPH (USA), www.ioc.ee/sgp12, Tallinn, Estonia. Organised on the premises of the Estonian Academy of Sciences by E.Quak as the SGP2012 conference chair, with A.Giudici providing technical support. K.Pindsoo occasionally contributed to the organisation.

5. 28 May, 2012: The team of the Wave Engineering Laboratory organised in cooperation with and in premises of the Estonian Academy of Sciences the international seminar "Complexity and Crisis Management in Society and Environment". T.Soomere presented the paper "FuturICT teams and challenges for Estonia".

6. 29 May, 2012: The team of the Wave Engineering Laboratory organised in cooperation with and in premises of the Estonian Academy of Sciences the joint meeting of the Estonian, Latvian and Lithuanian FuturICT teams. T.Soomere presented the paper "Search of hidden patterns for environmental management of anthropogenic marine hazards".

7. 3–14 September, 2012: Workshop "Mathematics for Life Sciences" of the Marie Curie International Research Staff Exchange Scheme EUMLS (EU-Ukrainian Mathematicians for Life Sciences), Kyiv, co-organized by E.Quak.

8. 29 October – 3 November , 2012: Workshop "Computational Geometry and Ontologies for Cultural Heritage 3D Digital Libraries - What are the future alternatives for Europeana?" at the 4th International Euro-Mediterranean Conference on Cultural Heritage (EuroMed

2012) www.euromed2012.eu , Limassol, Cyprus. Workshop co-organized and co-chaired by E.Quak.

6.2 International cooperation

- Laboratory of Photoelasticity participates in an informal academic cooperation on the topic "Stress field in locally plastically deformed glass". Head of the team is Prof. C.R.Kurkjian from the University of Southern Mayne (USA). The other participants are Prof. R.Oldenbourg (Marine Biology Laboratory, Woods Hole, USA), Prof. S.Chandrasekhar (Purdue University, USA), Prof. S.Yoshida (Shiga Prefecture University, Japan) and Nippon Electric Glass (Japan).

- Laboratory of Photoelasticity participates also in the project of Brookhaven National Laboratories (USA) to build a neutrino observatory. BNL has asked Rudolph Instruments Ltd (USA) to check the photomultiplier tubes (PMT's), needed for the neutrino observatory (20 000 PMT's will be installed), for residual stress. Rudolph Instruments has ordered for these measurements a polariscope AP-07, manufactured at Glasstress Ltd, and training of their personnel in the stress measurement tachnology. For that, Laboratory of Photoelasticity organised on 14–15 May 2012 in Newark, NJ, a US Summer School on Glass Stress Measurement. The Summer School attracted participants from Rudolph Instruments Ltd, Digipol Technologies Ltd, Sensitron Semiconductors, Emhart Glass Research and University of Louisville. A polariscope AP-07 was left at Rudolph Instruments and for the time being the engineers of this company measure residual stress in different PMT's with the aim to find most suitable PMT's for the neutrino observatory.

- J.Kalda has been appointed as the Academic Advisor for the International Physics Olympiad team of Saudi Arabia.

- Mutual cooperation between the Department of Signal Processing and Acoustics (Aalto University, School of Electrical Engineering, Espoo, Finland) and the Institute of Cybernetics at Tallinn University of Technology: (A.Stulov, D.Kartofelev).

- Collaboration with (1) Slovak University of Technology: Dr. Miroslav Halás, (2) Institut de Recherche en Communications et en Cybernétique de Nantes (IRCCyN): Prof. Claude H.Moog, (3) Far Eastern Federal University: Prof. A.N.Zhirabok. Collaboration includes joint publications, exchange visits, seminars for graduate students.

- Estonian-Hungarian Joint Research Project under the Agreement on Scientific Cooperation between the Estonian Academy of Sciences and the Hungarian Academy of Sciences 2010–2012 "Multi-scale thermomechanics of complex systems".

- Scientific cooperation on Nonlinear waves in inhomogeneous solids for 2012–2014 between Institute of Thermomechanics of Academy of Sciences of Czech Republic and Centre for Nonlinear Studies of Institute of Cybernetics at TUT.

- Scientific cooperation on Nonlinear waves in complex media for 2012–2015 between PRES Centre Val de Loire University (France) and CENS.

- Scientific cooperation on crack propagation and damage description for 2013–2015 between Department of Mechanics and Design, Tampere University of Technology and CENS.

- I.Didenkulova participated in a Workshop dedicated to EU ERC grants and The Seventh Framework Programme (FP7), University of Bremen, Germany. 25 September 2012.

- I.Didenkulova and A.Rodin conducted an experimental study "Long wave dynamics and statistics of the shoreline motion: influence of the asymmetry and nonlinearity of incoming waves" in the Large wave flume (Grosser Wellenkanal) in Forschungszentrum Küste (FZK), Hannover, Germany on 15–26 October 2012. The program was funded by Hydralab IV (Joint Research Activities, within the FP7 European Commission Funded Collaborative Research Project, 2010–2014).

6.3 Teaching activities

6.3.1 Courses:

1. J.Engelbrecht – courses in TUT (MSc level):
   – Mathematical modelling (assistant T.Peets);
   – Nonlinear Dynamics and Chaos (assistant D.Kartofelev).

2. J.Engelbrecht – Teaching abroad:
   – in the Graduate School of the University of Turin:
      Complexity (a short course).

3. A.Salupere – courses in TUT:
   – Fundamentals of Elasticity (assistant K.Tamm);
   – Continuum Mechanics;
   – Theory of Elasticity;
   – Seminars and Special Seminars for MSc and PhD students.

4. A.Braunbrck – courses in TUT:
   – Technical Mechanics I;
   – Technical Mechanics II;
   – Statics (assistant T.Peets);
   – Dynamics.

5. P.Peterson – courses in TUT:
   – EMR9740 Scientific programming with Python.

6. J.Belikov – courses in TUT:
   – ISS0010 System Theory (BSc)
   – ISS0030 Modeling and Optimization (MSc)

7. Ü.Nurges – course in TTK University of Applied Sciences:
   – TLM394 System Theory (BSc)

8. S.Nõmm – course in TUT:
   – ITI8580 Hybrid Control Systems (MSc and PhD)

9. S.Nõmm – courses in EBS:
   – ECO234 Introduction to Econometrics (BSc)
   – ECO234 Introduction to Econometrics, rus. (BSc)
   – ECO134 Introduction to Econometrics (BSc)
   – MAT105 Mathematics and Statistics for Business I (BSc)
   – ECO539 Qualitative and Quantitative Research Methods (MSc)
   – ECO539 Qualitative and Quantitative Research Methods, eng (MSc)

10. J.Vain – courses in TUT:
    – ITI0060, Formal Methods (in Embedded Systems Design) (MSc)

– ITX8025, Formal Methods (in Embedded Systems Design) (MSc)
– ITI0021, Logic Programming (BSc and MSc).

11. T.Soomere – course in IoC/TUT:
    – Preparing a manuscript for a peer-reviewed international journal;
    – a short lecture course on philosophy of natural sciences to the Institute of Theology
      (Estonian Lutheran Church, 5 academic hours, 05 October 2012;
    – Intense course "Wave dynamics" to master students in the faculty of geographic sciences
      in Klaipeda University by T.Soomere (assisted by Elena Averbukh),
      14–24 November 2012.

12. M.Zujev – courses in Estonian Marine Academy:
    – Hydromechanics;
    – Marine Physics;
    – Coastal Sea Hydrodynamics;
    – Port Structures;
    – Introduction into Hydrography;
    – Hydrographic Project.

13. A.Räämet – course in Tallinn University of Technology:
    – Structural Mechanics

Courses in University of Tartu:

14. P.Saari:
    – Quantum mechanics;
    – Advanced quantum mechanics.

15. M.Selg:
    – Applications of quantum mechanics in experimental physics.

16. H.Lukner:
    - Physics and technology, lectures of optics.

17. P.Piksarv:
    – Practical course in physics III - Optics.

6.3.2. Participation in other events, transfer of knowledge:

1. J.Engelbrecht:
   – Graduate School of Civil Engineering, TUT;
       talk on excellence in research, May 4, 2012.
   – Workshop "Complexity and Crisis Management in Society and Environment",
       panelist, 29, 2012.
   – Centennial of H.Keres. Fellow of the Estonian Academy of Sciences.
       Talk on principles in research, November 11, 2012.

2. J.Kalda has been a vice-chairman, and M.Heidelberg and S.Ainsaar — members of the
   Academic Committee of the 43rd International Physics Olympiad (43. IPhO; 15–24. July,
   Tallinn/Tartu, Estonia). Additionally, J.Kalda was the head of the theoretical examination
   of the 43. IPhO; for more details, see Appendix.

3. J.Kalda has been invited to attend the 2nd World Physics Olympiad (WoPhO), Jakarta,
   Indonesia, as the Board member of the WoPhO, 27 December 2012 – 3 January 2013.

4. J.Kalda, lecture course "The art of problem solving: electrical circuits" (Rhiyadh, Mawhiba, 19–24 October, 2012.
the King Abdul-Aziz and his Companions Foundation for Giftedness and Creativity).

5. J.Vain, course in Åbo Academi University (Finland): Online Testing of Nondeterministic Systems with the Reactive Planning Tester (PhD).

6. J.Vain, research direction "Smart Space Services"leader, ELIKO Competence Center.

7. M.Tõnso and Ü.Kotta, visit of Institute of Mathematics and Physics, Bialystok University of Technology (Poland) within the cooperation with Prof. Zbigniew Bartosiewicz (13–19 May, 2012).

8. J.Belikov, participation in seminar within the framework of FOMCON project, Bratislava, Slovakia, (18–21 June, 2012).

9. J.Belikov, participation in module "Introduction to Nonlinear Control"(H.Khalil). HYCON-EECI Graduate School on Control (5-9 March, 2012).

10. I.Nikolkina was the referee of the MSc thesis "Environmental aspects of wave impact on a sea wall" by Mr. Shahabedin Chatraee, Faculty of Civil Engineering, Tallinn University of Technology, Tallinn, Estonia, 05 June 2012.

11. A.Rodin participated in the Gene Golub SIAM Summer School 2012 "Simulation and Supercomputing in the Geosciences", Monterey, USA, 29 July–10 August 2012.

12. O.Kurkina participated in the summer school "Fluid Dynamics of Sustainability and the Environment" organised jointly by the Department of Applied Mathematics and Theoretical Physics (DAMTP), University of Cambridge, and Laboratoire d'Hydrodynamique et Laboratoire de Météorologie, Ecole Polytechnique Paris Tech, Cambridge, UK, 09–21 September 2012.

13. T.Soomere was the first opponent of the PhD thesis "Evolution of statistics of weakly nonlinear unidirectional waves over a sloping bottom" by Mrs. Huiming Zeng, Faculty of Mathematics and Natural Sciences, University of Oslo, Norway, 02 November 2012.

14. T.Soomere was invited as the external examiner of the PhD thesis "Investigation of access channel sedimentation processes and the impact of capital dredging on harbour circulation patterns" by Kyle Spiers, The University of Waikato, New Zealand, December 2012.

15. I.Nikolkina was the referee of the MSc thesis "Long waves in the ocean generated by shock wave from an explosion in the atmosphere" by A.S.Zheltikova, Faculty of Physics, Lomonosov Moscow State University, Moscow, Russia, 25 December 2012.

16. I.Didenkulova was the referee of the MSc thesis "Numerical model of tsunami propagation in the open ocean and its interaction with the coast" by A.V.Tarasenko, Faculty of Physics, Lomonosov Moscow State University, Moscow, Russia, 29 August 2012.

17. E.Quak organized the Graduate School of the 10th Eurographics Symposium on Geometry Processing (SGP2012) www.ioc.ee/sgp12, Tallinn, Estonia, 14–15 July, 2012.

18. E.Quak gave a presentation on applying for EU research funding at the Final Workshop of the Marie Curie Initial Training Network SAGA (Shapes, Geometry, Algebra) in Trento, Italy, October 9–11, 2012.

6.4. Visiting fellows
For shorter period

1. Dr. Peter Ván and Dr. Tamas Fülöp: Department of Theoretical Physics, Wigner RCP, RMKI, Budapest, Hungary, January 30 – February 8, 2012.

2. Dr. Jiří Plešek, Dr. Dušan Gabriel, Dr. Radek Kolman: Institute of Thermomechanics, Academy of Sciences of the Czech Republic, Prague, Czech Republic, 28–30 March, 2012.

3. Prof. Claude H.Moog, Institut de Recherche en Communications et en Cybernétique de Nantes IRCCyN, 31 May - 3 June, 2012.

4. Dr. Anna-Maria Perdon, Universita Politecnica delle Marche, 9–14 June, 2012.

5. Prof. Henk Nijmeijer, Eindhoven University of Technology, 10–12 June, 2012.

6. Dr. Małgorzata Wyrwas, Białystok University of Technology, 9–14 September, 2012.

7. Prof. Ewa Pawłuszewicz, Białystok University of Technology, 9–14 September, 2012.

8. Prof. Tõnu Kasvand, Concordia University, 10 September, 2012.

9. Prof. Felix Antritter, Universität der Bundeswehr München, October – November, 2012.

10. Yu Kawako, Osaka University, 30 August – 20 November, 2012. Visiting PhD student under supervision of Ü.Kotta.

11. Prof. Eduardo Aranda-Bricaire, CINVESTAV Mexico, 17–25 October, 2012.

12. Hongyan Liu, Åbo Akademi University, 1–30 September, 2012, Activity 5 of the ESF DoRa programme visiting PhD student under supervision of Jüri Vain.

13. Prof. Kevin E.Parnell, James Cook University, Australia, to discuss perspectives in joint studies of ship-induced waves, coastal management and coastal engineering, 05–11 July 2012.

14. Prof. Dr. Andrey Kurkin Department of Applied Mathematics, Nizhny Novgorod State Technical University; to activate research collaboration in the field of internal waves in multi-layered environment, with applications to the Baltic Sea conditions, 01 July – 05 August 2012.

15. Prof. Dr. Andrey Kurkin Department of Applied Mathematics, Nizhny Novgorod State Technical University; to finalise the principles of the collaboration agreement between the Tallinn University of Technology and Nizhny Novgorod State Technical University, 28 November – 05 December 2012.

16. Prof. DSc Garo Mardirossian and Assoc. Prof. Boiko Ranguelov, Space Research and Technologies Institute, Bulgarian Academy of Sciences, Sofia, to present a seminar paper and to start cooperation in joint studies of wave research and coastal management, 06–10 August 2012.

17. Prof. Christian Kharif (Non-Equilibrium Phenomena Research Institute and Grande Ecole d'ingénieurs – Ecole Centrale Marseille), prof Henrik Kalisch (Department of Mathematics, University of Bergen, Norway), prof. Efim Pelinovsky and dr. Tatiana Talipova (Department of Nonlinear Geophysical Processes, Institute of Applied Physics & Department of Applied Mathematics, Nizny Novgorod State Technical University, Nizny Novgorod, Russia), and prof Andrey Kurkin (Department of Applied Mathematics, Nizhny Novgorod

State Technical University) to participate in the Intense Day on Waves in Fluid (24.09) and in the defence of the PhD thesis of Oxana Kurkina. Prof. Kharif and prof. Kalisch were the opponents of this PhD thesis that was co-supervised by prof. Pelinovsky, 23–25 September 2012.

18. Dr. Pamela Bowlan, Max Born Institute, Berlin, Germany, September 11–16, 2012. Joint scientific work in the laboratory and seminars within the physical optics workgroup.

For longer periods

1. Elena Averbukh, Fellowship of the President of Russian Federation, 1 September 2012 – 30 June 2013.

2. Viktoria Berg (DAAD RISE Program). University of Kassel. Joint Scientific work on numerical simulations and seminars, 31 May – 29 August 2012.

3. Kirill Sorudeykin, Kharkov National University of Radioelectronics, 1 September 2012 – 30 June 2013, Activity 5 of the ESF DoRa programme visiting PhD student under supervision of J.Vain.

4. E.Pastorelli (DoRa) – PhD student.

5. Andrea Giudici, MSc Technician, PhD student

6. Oxana Kurkina, Cand. Sc., PhD 2012.

7. Irina Nikolkina, PhD Researcher Post Doc.

8. Shahabedin Chatraee, Technician, 2011–2012, MSc 2012.

9. Nicole Delpeche, MSc E, PhD student.

10. Maija Viška, MSc Technician, PhD student.

11. Artem Rodin, MSc Technician, PhD student.

12. Seshadhri Srinivasan, Senior Researcher.

6.5 Graduate studies

Department of Mechanics and Applied Mathematics:
Promoted:

1. PhD:
   A.Errapart.   Photoelastic Tomography in Linear and Nonlinear Approximation.

2. MSc:
   M.Heidelberg.   Diffusion in Stationary Turbulent Media (supervisor J.Kalda).
   J.Jõgi.   Modelling of Nanostructures in Materials Sciences (supervisor J.Kalda).

In progress:

1. PhD:

D.Kartofelev.	Piano string vibration: the role of bridge impedance (supervisor A.Stulov).
M.Eik.	Orientation distribution of fibres in short-fibre reinforced concrete: evaluation and introduction to constitutive relations (supervisor H.Herrmann).
E.Pastorelli.	3D virtual reality visualization techniques for microstructured materials and virtual reality systems improvements (supervisors: H.Herrmann, J.Engelbrecht).
I.Mandre.	Percolation phenomena in complex systems (supervisor J.Kalda).
P.Avila.	Biorobotics for turbulent medium (supervisors J.Kalda, M.Listak).
S.Ainsaar.	Stochastic transport in two- and three-dimensional structures (supervisors J.Kalda, Teet Örd – University of Tartu).
M.Heidelberg.	Transport processes in fluctuating media (supervisor J.Kalda).
J.Jõgi.	Semiempirical modeling of structure and functional properties relationships of micro- and nanostructured materials (supervisor J.Kalda).

2. MSc:

I.Georgievskaja (Jelissejeva).	Numerical simulation of wave propagation using finite element method (supervisor A.Berezovski).
E.Vaselo.	Applications of statistical topography in complex systems (supervisor J.Kalda).
M.Lints.	Numerical simulation of propagation of nonlinear dispersive waves (supervisor A.Salupere).
M.Mustonen.	Electric guitar sound modelling based on experimental data (supervisor A.Stulov, co-supervisor D.Kartofelev).

Laboratory of Systems Biology:
Promoted:

1. PhD:

A.Illaste.	Analysis of Molecular Movements in Cardiac Myocytes (supervisor M.Vendelin).
D.Schryer.	Metabolic Flux Analysis of Compartmentalized Systems using Dynamic Isotopologue Modeling (supervisors M.Vendelin, T.Paalme, P.Peterson).

In progress:

1. PhD:

J.Branovets.	Structural and energetic modifications in cardiomyocytes from mice with modified creatine kinase system (supervisor R.Birkedal).
N.Jepihhina.	Heterogeneity of energetic parameters in cardiomyocytes (supervisor M.Vendelin).
M.Kalda.	Mechanoenergetics of a single cardiomyocyte (supervisors M.Vendelin, P.Peterson).

M.Laasmaa.	Studies of the relationship between excitation-contraction coupling and energetics on trout cardiomyocytes (supervisors P.Peterson, R.Birkedal).
M.Sepp.	Estimation of diffusion restrictions in cardiomyocytes using kinetic measurements (supervisor M.Vendelin).
P.Simson.	Localization of diffusion restrictions in cardiomyocytes (supervisors P.Peterson, M.Vendelin).
N.Sokolova.	Energetics and contractility in heart of rainbow trout (supervisor R.Birkedal).
M.Mandel.	Bioenergetics of mitochondrial dynamics in neurons (supervisors A.Kaasik – University of Tartu, M.Vendelin).

2. MSc:
M.Poroson.
S.Kotlyarova.

Laboratory of Wave Engineering:
Promoted:

1. PhD:

O.Kurkina.	Nonlinear dynamics of internal gravity waves in the Baltic Sea (supervisors E.Pelinovsky and T.Soomere).

1. MSc:

R.Männikus.	Improving breakwater configuration in Noblessner Port against wind waves and vessel wakes (supervisors T.Torsvik, T.Soomere).
Sh.Chatraee.	Environmental aspects of wave impact on a sea wall (supervisor I.Didenkulova).

In progress:

1. PhD:

I.Zaitseva-Pärnaste.	Wave climate changes of the Baltic Sea and their economical consequences (supervisor T.Soomere).
A.Giudici.	Quantification and visualisation of current-induced risk of coastal pollution (supervisor T.Soomere).
B.Viikmäe.	Optimizing fairways in the Baltic sea using patterns of surface currents (supervisor T.Soomere).
A.Rodin.	Evolution, runup and breaking of strongly nonlinear sea waves in the nearshore (supervisors I.Didenkulova and T.Soomere).
M.Viška.	Evolution and forecast of open sedimentary coasts in the Baltic Sea conditions (supervisor T.Soomere), promotion expected 2014.
N.Delpeche.	Using improved understanding of the circulation pattern in the Gulf of Finland to minimize coastal pollution (supervisor T.Soomere), promotion expected 2013.

1. MSc:

M.Zujev.	Wave climate at the eastern Baltic Sea coast (supervisor T.Soomere).
K.Pindsoo.	Wave set-up at the coasts of Tallinn Bay (supervisor T.Soomere).
M.Eelsalu.	Wave energy potential in the Estonian coastal sea (supervisor T.Soomere).

Control Systems Department:

Promoted:

1. PhD:
   J.Belikov. Polynomial methods for nonlinear control systems (supervisor: E.Petlenkov (TUT), consultant Ü.Kotta).

   M. Kääramees. A symbolic approach to model-based online testing (supervisor: J.Vain).

2. MSc:
   A.Kaldmäe. Disturbance decoupling of nonlinear control systems (supervisors: E.Redi and Ü.Kotta).

   M.Lapuskin. Application for gesture based control of the Pioneer" robot with manipulator (supervisor S.Nõmm).

   S.Erap. Gesture based PC interface with kinect sensor (supervisor S.Nõmm).

   V.Põldra. Application for the preliminary analysis of geometric and phonetic measurements (supervisor S.Nõmm).

In progress:

1. PhD:
   V.Kaparin. Transformation of the nonlinear state equations into the observer form (supervisor Ü.Kotta).

   A.Kaldmäe. Advanced design of nonlinear discrete-time and delayed systems (supervisors Ü.Kotta and C.H.Moog).

   S.Avanessov. Robust adaptive output controller (co-supervisor Ü.Nurges).

   A.Anier. Motion recognition via abstract interpretation. (supervisor J.Vain).

   K.Sarna. Aspect-oriented model engineering in distributed model-based testing (supervisor J.Vain).

   M.Markvardt. The method of model-based generation of test data for reactive planning testers (supervisor J.Vain).

   K.Haavik. Model-based distributed testing method for web-based banking applications (supervisor J.Vain).

2. MSc:
   K.Halturina. Computer algebra tools for feedback linearization and computation of flat outputs (cosupervisor M.Tõnso).

   K.Buhhalko. Modelling of human gesture for medical application (supervisor S.Nõmm).

   Je.Borushko. Modelling of human gesture for medical application (supervisor S.Nõmm).

   M.Borkenstain. Technische Universität Ilmenau. Development of a gesture based user interface in medical environment on requirements by medical doctors by using the Microsoft Kinect sensor (supervisor S.Nõmm).

Optics group:

In progress:

1. PhD:
   P.Piksarv. Teoretical and experimental study of formation and propagation of localized pulses and their implementation in nonlinear optics (supervisor P.Saari).

2. MSc:
   A.Valdmann.

6.6 Distinctions and awards
Fellows:

1. J.Kalda was awarded Diploma from the President and Secretariat of the International Physics Olympiads for outstanding organization of the 43rd International Physics Olympiad.

2. J.Kalda was awarded Diploma from the Ministry of Education of Saudi Arabia and King Abdulaziz & his Companions foundation for Giftedness and Creativity for the contribution to the preparation of the Saudi team of International Physics Olympiad.

3. T.Soomere was elected the Scientist of the Year (2011) in the Tallinn University of Technology (January 2012).

4. T.Soomere was elected to Vice-Chair of the European Marine Board.

5. E.Quak received a Eurographics Recognition of Service Award for having served as the Conference Chair of the 10th Eurographics Symposium on Geometry Processing (SGP2012), held in cooperation with ACM SIGGRAPH (USA), in Tallinn, Estonia, July 16–18, 2012.

6. P.Saari received Recognition of Service Award for having served as a reviewer of journals of the Optical Society of America.

Students:

1. E.Averbukh, Awarded diploma for the best presentation on mathematical school-conference "Lobachevsky reading 2012" (Kazan (Volga) Federal University, Institute of Mathematics and Mechanics n.a. NI Lobachevsky, Russia).

2. E.Averbukh. Scholarship for young scientists of the academician G.A.Razuvaev, 2012–2013.

3. M.Eik received T.Mõis Scholarship from the TUT.

4. J.Jõgi, I prize of the Estonian national student research competition-2012 in the category of MSc students (supervisors J.Kalda and A.Lõhmus).

5. A.Kaldmäe – received the 1st award in the student research competition of Tallinn University for the master thesis "Disturbance Decoupling of Nonlinear Control Systems" (supervisors E.Redi and Ü.Kotta).

6. A.Kaldmäe - received the 3rd prize in National Students Research Contest 2012 in natural and technical sciences (in MSc subgroup).

7. K.Halturina – received the 2nd award in the student research competition of Tallinn University for the bachelor thesis "Lattice-ordered sets and algebraic lattices" (supervisor E.Redi).

8. MSc thesis of Rain Männikus "Improving breakwater configuration in Noblessner Port against wind waves and vessel wakes" (Tuule- ja laevalainete mõju vähendamise võimalustest Noblessneri sadama lainemurdjate rekonstrueerimisel) won II prize at the state competition of students' research work (supervisors T.Torsvik and T.Soomere), 14 December 2012.

9. Presentation by A.Rodin won a prize Nizhny Novgorod State Technical University, Russia.

6.7 Other activities

6.7.1 Participation on programme committees, reviewing papers:

1. A.Berezovski:
   Journal of Mechanical Science and Technology, Proceedings of the Royal Society A, Continuum Mechanics and Thermodynamics, ZAMM - Zeitschrift für Angewandte Mathematik und Mechanik, Composites Part B (reviewer).

2. M.Vendelin:
   American Journal of Physiology – Cell Physiology (reviewer).
   Biophysical Journal (reviewer).
   PhD thesis of M.Kuum (reviewer).

3. J.Kalda:
   Physical Review Letters and Physical Review E (reviewer);
   Advisory Board of the International Physics Olympiad (member);
   International Jury of the World Physics Olympiad (member);
   Steering Committee and Academic Committee of the 43rd Physics Olympiad (held in Tallinn and Tartu, Estonia, 15–24 July 2012) (member).

4. J.Vain:
   Formal Methods 2012, (reviewer);
   The 24th IFIP Int. Conference on Testing Software and Systems (ICTSS'12) (committee member);
   Nordic Workshop on Programming Theory (committee member);
   Baltic Electronic Conference BEC2012 (committee member);
   SNPD'03 Workshop on High-Level Approaches to Parallel and Distributed Computing (committee member).

5. T.Soomere:
   Steering committee of the Baltic Sea Science Congress (member);
   Scientific council of the Laboratory of Multiphase Flows at TUT (member);
   Commission on science of the TUT Council (member);
   Environmental Engineering and Management Journal (reviewer);
   Boreal Environment Research (reviewer);
   Journal of Marine Systems (reviewer).

6. J.Engelbrecht:
   Committees of the Ministry of Higher Education and Research (member);
   Academic Council of the Graduate School of the Faculty of Civil Engineering (chairman);
   Board of Trustees of the TEA Encyclopedia (vice-chairman);
   Humboldt Club Estonia (chairman).

7. Ü.Kotta:
   IFAC Symposium on Nonlinear Control Systems 2013, Toulouse, France (committee member).

8. P.Saari:
   Optics Express (reviewer);
   Optics Letters (reviewer);
   Optics Communications (reviewer);
   Applied Optics (reviewer);
   Journal Optical Society America (reviewer).
   Academic Committee of the 43rd Physics Olympiad (member).

9. A.Stulov:
   INTAS and ERA.NET RUS – evaluator of grant applications.

6.7.2. Participation in journal editorial boards:

1. Proceedings of Estonian Academy of Sciences – Ü.Kotta.

2. Acta Mechanica et Automatica – Ü.Kotta.

3. Estonian Journal of Engineering – J.Engelbrecht (editor in chief), T.Soomere (co-editor).

4. Applied and Computational Mechanics – A.Berezovski, J.Engelbrecht.

5. Applied Mechanics – J.Engelbrecht.

6. Journal Theoretical and Applied Mechanics – J.Engelbrecht.

7. Trames – J.Engelbrecht.

8. Akadeemia – J.Engelbrecht.

9. Estonian Journal of Earth Sciences – T.Soomere (co-editor).

10. Journal of Marine Systems – T.Soomere.

11. Oceanologia – T.Soomere.

12. Boreal Environment Research – T.Soomere.

13. Estonian Journal of Earth Sciences – T.Soomere.

14. Estonian Journal of Engineering – T.Soomere.

15. Journal of Waterway, Port, Coastal, and Physica Scripta – T.Soomere.

16. Marine Pollution Bulletin – T.Soomere.

17. Ocean Engineering Geophysical – T.Soomere.

18. Natural Hazards and Earth System Sciences – T.Soomere.

19. Proceedings of the Estonian Academy of Sciences – T.Soomere.

20. Natural Hazards and Earth System Sciences – I.Didenkulova.

21. The Scientific World Journal – I.Didenkulova.

22. Journal of Mathematics in Industry (JMiI) – E.Quak.

23. Journal of Laser Physics – P.Saari.

6.7.3. Participation in professional organizations:

1. IFAC technical committee for nonlinear control systems (member): Ü.Kotta.

2. IFAC contact person in Estonia: S.Nõmm.

3. IEEE TC-CACSD Action Group on Polynomial Methods for Control System Design (chair): Ü.Kotta.

4. Nordic Association for Computational Mechanics: (member of executive committee): A.Berezovski.

5. EUROMECH – European Mechanics Society: A.Berezovski, J.Engelbrecht, A.Ravasoo, A.Salupere, K.Tamm.

6. ISIMM – The International Society for the Interaction of Mechanics and Mathematics: A.Berezovski, J.Engelbrecht.

7. European Geosciences Union, scientific officer of Sea hazard devision: I.Didenkulova.

8. International Tsunami Comission: member T.Soomere, Estonian representative: I.Didenkulova.

9. Member of the Expert Council of the Rogue Wave Research Center: I.Didenkulova.

10. Marine Board of the European Science: Estonian representative and vice-chair: T.Soomere.

11. Marine Board of the Estonian Academy of Sciences: chair: T.Soomere.

12. EASAC Environmental Steering Panel: Estonian representative: T.Soomere.

13. EC evaluation of Integrated Project proposals for the ICT Call 7: E.Quak.

14. EC evaluation of the call for Marie Curie Industry Academia Fellowships and Pathways: E.Quak.

15. IUTAM's General Assembly: Estonian representative: A.Salupere.

16. International Commission for Optics. Chairman of the Estonian Committee: P.Saari.

17. Optical Society of America, senior member: P.Saari.

6.7.4 Estonian public bodies:

1. The Board of the Estonian Academy of Sciences: J.Engelbrecht, T.Soomere, P.Saari.

2. The Academic Council of the State President: P.Saari, R.Kitt.

6.7.5 Science and Politics:

1. J.Vain participated in preparing of SDA report "Cyber-security: The vexed question of global rules".

2. T.Soomere participated in the kick-off meeting of the Nordic Hub of the Future and Emerging Technologies (FET) Flagship project FuturICT with an oral presentation "FuturICT in Estonia" (Helsinki, 22–23.02.2012).

3. T.Soomere presented the invited lecture "A future technology of environmental management of the Gulf of Finland" to the planning seminar of the Gulf of Finland Year 2014 (Helsinki, Finnish Environment Institute, 29.02.2012).

4. T.Soomere presented the paper "NordStream: umbsõlmed hüdrodünaamikas või väljakutse Läänemere mereteadusele?" (Challenges of NordStream for the Baltic Sea science) to the meeting of the commission on environmental affairs of Riigikogu (Estonian Parliament) 2.03.2012.

5. T.Soomere presented the invited paper "The risk of coastal flooding" (Rannikualade üle-ujutusrisk Eesti kontekstis) to the special seminar on Environmental Impact Assessments organised by the Estonian Society of Municipal Engineering (Eesti Kommunaalmajanduse ühing), (Tallinn, Lillepaviljon 27.03.2012).

6. T.Soomere presented the paper "Basic research towards solving problems of coastal engineering" to the joint seminar "Challenges in Earth Sciences" of Estonian Academy of Sciences and Russian Academy of Sciences (Tallinn, Estonian Academy of Sciences 30.03.2012).

7. T.Soomere participated in the spring meeting of the European Academies Scientific Advisory Council (EASAC) Environment Steering Panel (Brussels, Belgium, 24.04.2012).

8. T.Soomere participated in the spring Plenary Meeting of the European Marine Board. He was elected as Vice Chair of this board (Southampton, UK, 15–16.05.2012).

9. T.Soomere participated in the ExCom meeting (15.10) and the fall Plenary Meeting (16–17.10) of the European Marine Board (Texel, The Netherlands, 15–17.10. 2012).

10. T.Soomere participated in the spring meeting of the European Academies Scientific Advisory Council (EASAC) Environment Steering Panel (Brussels, Belgium, 23.10.2012).

11. T.Soomere was co-organiser of the public seminar on doctoral studies and moderated the panel discussion (Estonian Academy of Sciences, Tallinn, Estonia, 24.10.2012).

12. P.Saari presented the talk "21 years of Estonian Science Foundation in retrospect". Conference on Science Policy (Tallinn, 29.02.2012).

6.7.6. Media reflections
About us

1. K.Kello, Kuidas uurida kivistunud tormide ajalugu. Tapjalained kuival maal (Petrified history of storms. Monster waves in dry land), Õpetajate Leht (The Teachers' Weekly), 41/2012, p. 12, based on the interview with T.Soomere, 16 November 2012 (in Estonian).

Media outreach

1. An interview with T.Soomere about progress activities of the Marine Commission of the Estonian Academy of Sciences and about the recently published collection of popular science papers "Scientific thought in Estonia VII. Oceanology. Limnology. Coastal science"; Kuku Raadio, Marine Hour, 14.01.2012.

2. T.Soomere gave an interview to the state TV channel about the potential environmental impacts of the Nord Stream gas pipeline; reflected as the following news "ERR: Eesti eksperdid on Nord Streami keskkonnauuringute suhtes skeptilised", Postimees Online, 20:55 on 07.07; broadcast in the major news program "Aktuaalne Kaamera", 07 July 2012.

3. T.Soomere presented a longer comment to the state radio channel Vikerraadio commented news program "Uudis+" about the plans of Nord Stream AG to apply for a research permit in the Estonian exclusive economic zone; live on air 12:20-12:40, 16 August 2012.

4. T.Soomere was invited as "Summer Guest" to the state radio channel Vikerraadio in the framework of the 1-hour "live on air" broadcast "Uudis+" (a commented news program) to discuss the past, present and future of the Baltic Sea; live on air 14:00-15:00, 27 August 2012.

5. T.Soomere was interviewed by the state radio channel "Raadio4" with questions about the sensitivity of the Baltic Sea with respect to anthropogenic pressure and about the potential impact of large coastal and offshore engineering structures (such as Nord Stream) on the marine environment; in the program "Before the noon" 11:40-12:00 (in Russian), 28 August 2012.

6. Interview with T.Soomere about the environmental issues in the Baltic Sea in the context of the application for research permit in the Estonian exclusive economic zone by Nord Stream AG; Kuku Raadio, Marine Hour, 01 September 2012.

7. Interview with E.Averbukh, Fellow of the President of the Russian Federation in the Wave Engineering Laboratory, about her plans for the research stay, with reference to the tsunami research of I.Didenkulova and comments of T.Soomere about the international dimension of the laboratory; broadcast in the major state TV news program "Aktuaalne Kaamera" (Russian version ETV2 19:30, Estonian version ETV 20:00), 14 September 2012.

8. Interview with T.Soomere on the occasion of publishing the Estonian translation of the book by Gavin Pretor-Pinney "Wavewatcher's companion"; Kuku Raadio, Marine Hour, 15 September 2012.

9. E.Averbukh was interviewed by the state radio channel "Raadio4" about her plans for the research stay in the Wave Engineering Laboratory, 20 September 2012.

10. Interview with T.Soomere to the state TV channel about the opinion of the Estonian Academy of Sciences concerning the application for research permit in the Estonian EEZ by Nord Stream AG; broadcast within the major news program "Aktuaalne Kaamera" in both Estonian and Russian versions, 05 October 2012.

11. Interview with T.Soomere to the news program of the international TV channel "The First Baltic Channel" (Pervõi Baltiiskii Kanal, in Russian) about the opinion of the Estonian Academy of Sciences concerning the application for research permit in the Estonian EEZ by Nord Stream AG, 08 October 2012.

12. A longer interview with T.Soomere to the popular science program "Puust ja punaseks" (Simply about science) to the radio channel Raadio2 about general wave dynamics and properties of ocean waves, 26 October 2012.

13. Interview with T.Soomere about possibilities to preventively mitigate the environmental impact of potential pollution released by ships by means of optimizing the location of the fairways, state radio channel Vikerraadio, 02 December 2012.

14. E.Averbukh. TV program "10 minutes with Nizhny Novgorod State Technical University n.a. R.E.Alekseeva" with reference about cooperation with TTU and Putin scholarship (channel Russia24), 4 December 2012.

15. Interview with J.Engelbrecht in radio channel Kuku on publications on research (January 2012).

16. Interview with J.Engelbrecht in radio channel Kuku on Estonian Centres of Excellence in Research (June, 2012).

17. Interview with J.Engelbrecht and M.Vendelin in radio channel Kuku on CENS (December 2012).

18. Interview with J.Engelbrecht by K.Kello on nonlinear processes (in Õpetajate leht – Teacher's Newspaper), N 35, 2012.

19. Interview with P.Saari on future of lighting in radio channel Vikerraadio (23 August, 2012).

20. A comment by P.Saari on Physics Nobel Prize in national daily Postimees (10 October, 2012).

7. Summary

The year 2012 was the first full year within the programme "Estonian Centres of Excellence in Research": There are 12 Centres in the programme and the Heads of Centres formed the informal Council of Centres in order to coordinate science policy ideas which come from top scientists. The Chairman of this Council is Jüri Engelbrecht. The Council collected the opinions on current science policy actions in Estonia as seen from Centres of Excellence. The views were formulated on further support of excellence and on research funding in general. A special media release on all Centres of Excellence was published in one of the Estonian daily newspapers (Eesti Päevaleht).

The CENS is pleased with 6 PhD promotions and the mobility of researchers. Several researchers from other countries joined CENS: and several researchers from CENS work temporarily abroad as post-docs or visiting researchers: M.Berezovski in the USA (WPI), A.Illaste in Switzerland (University of Bern), T.Peets in Hong Kong (the City University), I.Didenkulova in Germany as a Humboldt Fellow (MARUM), T.Mullari in Austria (Linz University).

The results were presented at various World- or European-scale conferences and/or meetings: ICTAM 2012 in Beijing, Euromech Solid Mechanics Conference in Graz, Euromech 540 in Prague, EGU General Assembly in Vienna, 2012 IEEE/OES Baltic International Symposium in Klaipeda, etc.

CENS organized the following conferences and/or meetings the International Glass School, the Workshop on Visualisation and an Intense Day on Waves in Fluids. J.Kalda was a mastermind behind the International Physics Olympia 2012 in Tartu/Tallinn (see Annex) and a book "Love for Physics".

We continued to pay a lot of attention to public relations by science popular articles and radio broadcasts. The problems of the Baltic Sea are in focus by T.Soomere. For explaining complexity, R.Kitt has published himself an essay and initiated the translation of the book by M.Caldwell "Outliers: a story of success"continuing the tradition started in 2011 when he initiated the translation of the book by N.N.Taleb "Fooled by randomness".

CENS members are active in science policy being the members of governmental committees and boards (J.Engelbrecht, T.Soomere, P.Saari) including also the Academic Council of the State President (P.Saari, R.Kitt).

The challenge for 2013 is to continue with a growing attention to high-quality publications and co-operation. The procurement for a new computer cluster took longer than expected but the new cluster should be launched in 2013. There is a need to write new applications for basic funding which actually concerns all the groups of CENS. In 2013, the preparation for the IUTAM Symposium on Complexity of Nonlinear Waves, scheduled for 2014, must begin (see Annex). This Symposium will mark 15 years of CENS.

Annexes

1. Staff of CENS.

2. Abstracts.

3. 43rd International Physics Olympiad.

4. Information on the 3D Visualisation System.

5. Information on the Photoelastic scattered light polariscope SCALP.

6. Information on the IUTAM Symposium 2014 "Complexity of Nonlinear Waves".

Annex 1: The staff of research teams in CENS in 2012:

Nonlinear dynamics

Head of team: Jüri Engelbrecht, DSc.
Leading scientist: Hillar Aben, DSC. *Senior researchers:* Leo Ainola, DSc; Johan Anton, PhD; Arkadi Berezovski, PhD; Heiko Herrmann, PhD; Jaan Kalda, PhD; Arvi Ravasoo, PhD; Andrus Salupere, PhD; Anatoli Stulov, PhD. *Researchers:* Mihhail Berezovski, PhD; Olari Ilison, PhD; Robert Kitt, PhD; Maksim Säkki,PhD; Kert Tamm PhD; Andrei Errapart, PhD; Tanel Peets, PhD; Marika Eik, MSc. *PhD students:* Dmitri Kartofelev, Mihkel Kree, Emiliano Pastorelli, Indrek Mandre, Jakob Jõgi, Piret Avila, Siim Ainsaar. *Other:* Kristi Juske, Mati Kutser PhD, Tatjana Kosmatšova, Pilvi Veeber.

Wave engineering

Head of team: Tarmo Soomere, DSC.
Senior researchers: Irina Didenkulova, PhD; Ewald Quak, PhD; Tomas Torsvik, PhD. *Researchers:* Irina Nikolkina, PhD; Andrus Räämet, PhD; Oxana Kurkina, PhD, Andrus Kask (until 04/2012); *PhD students:* Nicole Delpeche-Ellmann, Bert Viikmäe, Andrea Giudici, Artem Rodin, Inga Zaitseva-Pärnaste, Maija Viška, Elena Averbukh. *Other:* Katri Pindsoo, Mihhail Zujev, Maris Elsalu (from 04/2012), Vitalii Pavlov (from 08/2012), Marika Org (from 11/2012), Katri Kartau (until 02/2012), Mikk Viidebaum (until 05/2012), Shahabedin Chatrace (until 06/2012), Rain Männikus (until 07/2012).

Systems biology

Head of team: Marko Vendelin, PhD.
Senior researchers: Rikke Birkedal Nielsen, PhD; Janus Karo, PhD; Pearu Peterson, PhD; Hena Ramay, PhD. *Researchers:* Ardo Illaste, PhD; David Schryer, PhD. *PhD students:* Jelena Branovets, Natalja Jepihhina, Mari Kalda, Martin Laasmaa, Päivo Simson, Mervi Sepp, Niina Sokolova. *Other:* Merle Mandel, Sirel Rootsmaa, Svetlana Kotlyarova.

Optics

Head of team: Peeter Saari, DSC.
Senior researchers: Rein Kink, PhD; Viktor Peet, PhD; Kaido Reivelt, PhD; Matti Selg, PhD; Aleksei Trestsalov, PhD. *Researchers:* Margarita Kink, PhD; Aleksandr Lissovski, PhD; Heli Lukner, PhD; Jüri Maksimov, PhD. *PhD students:* Peeter Piksarv. *Other:* Aavo Kippasto, Agu Anijalg, Madis Lõhmus, Sergei Tsarenko, Vladimir Tsubin

Nonlinear control theory

Head of team: Ülle Kotta, DSc.
Senior researchers: Ülo Nurges, PhD; Sven Nõmm, PhD; Jüri Vain, PhD; Seshadhri Srinivasan, PhD; Maris Tõnso, PhD. Researchers: Tanel Mullari, PhD; Juri Belikob, PhD. *PhD students:* Vadim Kaparin; Arvo Kaldmäe; *PhD students in TUT* (Aivo Anier, Sergei Avanesov, Kristjan Haavik, Jaagup Hirve, Maili Markvart, Külli Sarna). *Other:* Kristina Halturina. As a rule PhD students have part-time positions.

Annex 2: Abstracts

1. A.Berezovski. Jump Conditions at Discontinuities in Solids: Numerical Implementation. 8th European Solid Mechanics Conference (ESMC-2012), Graz University of Technology, Austria, July 9–13, 2012. CD–ROM, Book of Abstracts, 73612.

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3. A.Salupere, K.Tamm. On the influence of material properties on the wave propagation in Mindlin-type microstructured solids. Euromech Colloquium 540 Advanced Modelling of Wave Propagation in Solids, Prague, Czech Republic, 1–3 October 2012. Book of Abstracts, 116-117.

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29. O.E.Kurkina, I.I.Didenkulova, A.R.Giniyatullin, T.G.Talipova, E.N.Pelinovsky. Weakly nonlinear internal waves in two-layer flow of variable depth. Abstracts of Swedish Marine Sciences Conference, Kalmar, 19–21 November 2012, Maritime Academy, 20.

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59. A.Giudici, T.Soomere, J.Kalda. Copressibility of surface currents patterns analysis in the Gulf of Finland, the Baltic Sea. Ibid, 14.

60. K.Pindsoo, T.Soomere. The water level rise caused by wave set-up in the urban area of the city of Tallinn, Estonia. Ibid, 20.

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Annex 3: 43rd International Physics Olympiad

Estonia was the hosting country of the 43rd International Physics Olympiad, 15–24. July 202. This event was attended by the delegations of 80 countries and ca 700 participants (contestants, team leaders, observers and visitors). The researchers of CENS were actively participating in the organization of this venue. In particular, J. Kalda, M. Heidelberg, S. Ainsaar and S. Zavjalov were the members of the Academic Committee; J. Kalda was also the head of the theoretical examination and a member of the Steering Committee.

In total, five problems were given to the contestants; J. Kalda was the author of the Theoretical Problem No 1 ("Focus on sketches"), S. Ainsaar – of the Theoretical Problem No 3 ("Protostar formation", and M. Heidelberg – of the Experimental Problem No 2 ("Nonlinear Black Box"). S. Zavjalov was the organizer of the "University Fair" — an event for the contestants which was attended by the representatives of several leading universities of the world (including the Oxford University and MIT). Apart from the creation of the problem texts, solutions, and grading schemes, as well as designing the experimental apparatus, each problem authorship included also the responsibility of giving a lecture to the International Board members, leading the discussions with the International Board over the possible amendments to the problem texts, supervising the grading of the contestants' solutions, and supervising the moderation (the process when the team leaders discuss the contestants' marks with the grading teams).

J. Kalda was also responsible for the online competition "Physics Cup- IPhO2012" (http://www.ipho2012.ee/physicscup/) which took place 01. Sept. 2011 – 14. July 2012; there were 268 participants from 46 countries. This involved the design of 10 problems, grading and discussions with the contestants, as well as the compilation of the solutions — using the solutions contributed by the contestants. Additionally, he was the author of the Section "Physics Solver Mosaic" (http://www.ipho2012.ee/physicscup/physics-solvers-mosaic/), which included five lessons ("Minimum or maximum?", " Fast or slow?", "Force diagrams or generalized coordinates?", "Are Trojans stable?", and "Images or roulette?").

To help the students when preparing for the IPhO, J. Kalda has prepared a brochure "Formulas for IPhO', which has been translated into Portuguese, Indonesian, Arabic, and Estonian.

Finally, J. Kalda, M. Heidelberg, and S. Ainsaar were the editors of the section "Feynman's Corner" of the IPhO Newsletter (the archive of this section can be found at http://www.ipho2012.ee/newsletter/category/feynmans-corner/). This section included physical puzzles regarding phenomena which can be met in every-day life (such as: "Have you noticed that the lower boundary of clouds is flat, but the upper boundary is "puffy". Why?"); a puzzle was followed by its solution in the next issue of the Newsletter.

To conclude: according to the feedback from the participants, the 43rd IPhO was one of the best-organized International Physics Olympiads; this includes both the technical side (lectures, excursions, etc), as well as the problems. Let us cite a contestant from China, Hengyun Zhou: "I liked this year's IPhO problems very much. Having gone through most of the past papers, I think that this year's problems are the best to date. First, they consisted of difficult enough problems, and left most of the thinking process for the students so that we had to use all our knowledge and skills to figure out the correct approach to the problems. Many of the problems in the past paved the entire way for the students so all students had to do was follow the instructions, but this year we had to come up with a method of our own. Additionally, this year's problems emphasised the physics rather than mathematic skills. The most difficult part in the problems was building an appropriate model, and that part really intrigued me, although I failed to build a correct model in many problems in the end."

On separate sheets, the following material can be found: covers of books "Physics is Love" — an overview of the 43rd IPhO; Arabic translation of the "Formulas for IPhO"; IPhO training material on the subject of electrical circuits.

PHYSICS IS LOVE

الفريق السعودي لأولمبياد
الفيـزياء الـدولي STIPhO

Formulas for IPhO

Jaan Kalda

2nd Training Camp for Physics Olympiad

ELECTRICAL CIRCUITS

Jaan Kalda

Eat　　　Sleep　　　Do Physics

Küberneetika Instituut

Tallinna Tehnikaülikool

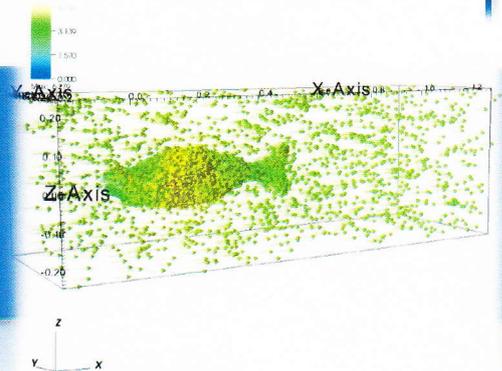Centre for Nonlinear Studies

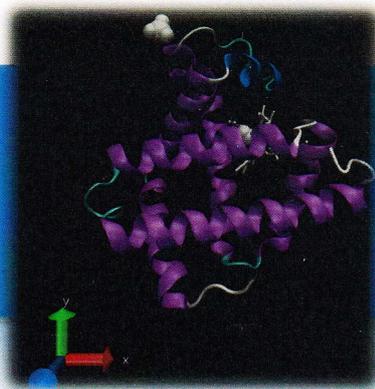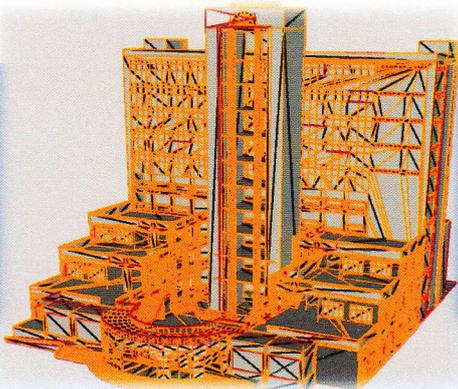(Estonian Centre of Excellence in Research)

3D Visualization Group
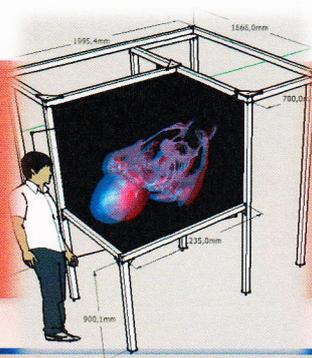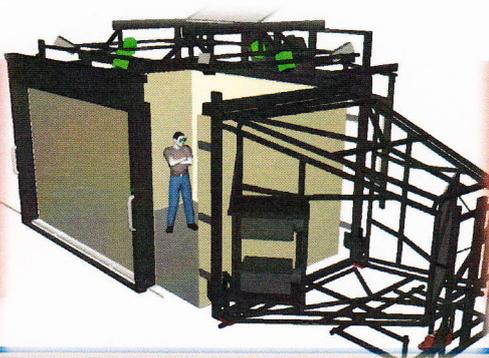
- **Research on complex micro-structured materials**

- **3D Visualization**
  - As a research tool in material sciences, mechanics
  - As a development topic
  - As a service (e.g. for architecture, archeology, design, biochemistry, etc..)

- **Consulting for 3D and Virtual Reality technologies**

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Photoelastic scattered light polariscope
SCALP

for through-the-thickness stress measurement in architectural glass panels and automotive glazing

Easy to use

Place the device on the panel at the measurement point, apply immersion and start the measurement from the computer. After five seconds stress distribution through the thickness is shown on the screen of the laptop.

Features
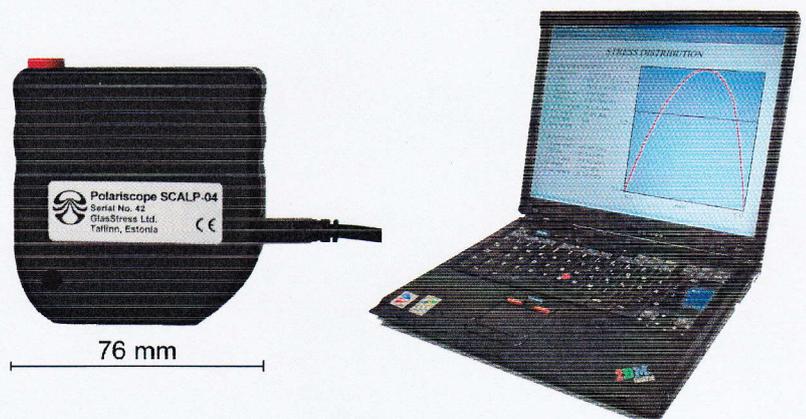
Measures stress distribution
   through the thickness
Measures from air and tin side
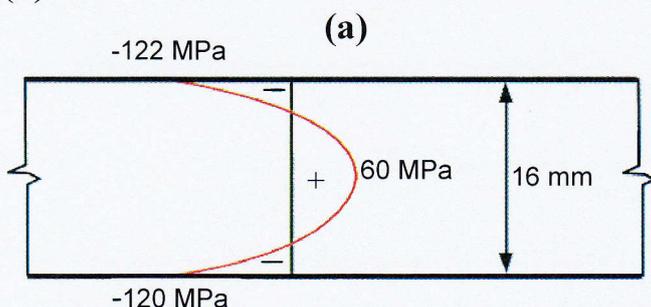On the spot stress measurement
   in existing buildings

Weight	315 g
Precision	
	±1 MPa (max stress < 20 MPa)
	±5 % (max stress > 20 MPa)
Measurement time	5 sec

76 mm

Examples of application

Stress distribution through the thickness in an architectural glass panel (a) and in a sidelite (b).
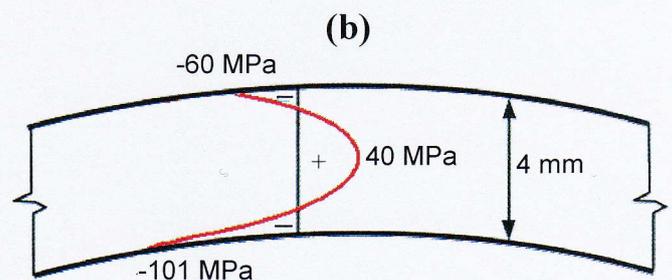
(a)

-122 MPa
60 MPa
16 mm
-120 MPa

(b)

-60 MPa
40 MPa
4 mm
-101 MPa

Complexity of Nonlinear Waves
IUTAM SYMPOSIUM 2014

Area : Solid & Fluid

Chairman: A. Salupere; Co-Chairman: G.A. Maugin

Hosting Institution: Institute of Cybernetics at Tallinn University of Technology, Estonia

Prospective dates: 8–12 September 2014

Wave motion is the key mechanism of interest to many fields of science, such as mechanics, acoustics, seismology, oceanography, coastal and offshore engineering, electromagnetism, etc. Despite an extreme variety of physical appearances of wave phenomena, different disciplines share many mathematical models and numerical methods.

In recent years there is an increased interest in advanced mathematical models and computational methods for wave problems across the borders of specific applications. The conceptual similarity of mathematical models for wave motion in solids and fluids leads to similar formalism in analysis. Our purpose is to foster research into different aspects of nonlinear wave phenomena – the theoretical, the computational and the applied – through promoting the transfer of competence over the existing borders of classical research disciplines. The synergy of many fields will serve as final goal.

We focus on essentially nonlinear problems where complicated original mathematical models are derived, innovative ideas are applied for computing, and novel applications are intensively created in a number of research fields. Interaction of nonlinearity with accompanying effects such as changing properties of the medium sheds further light to understanding and forecast of physical phenomena. The Symposium will provide a forum for presentation and discussion of innovative complex models and methods including computer based simulation of dynamical processes in mechanics.

The main organiser of the Symposium is the Centre of Nonlinear Studies (CENS) at Institute of Cybernetics, where the complexity of wave fields in solids and fluids has been one of the focal issues for a long period (a previous IUTAM Symposium in 1982). One of the key speakers at the symposium will be Prof. Jüri Engelbrecht, the Head of CENS, who will celebrate his 75th anniversary in 2014.

CENS

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