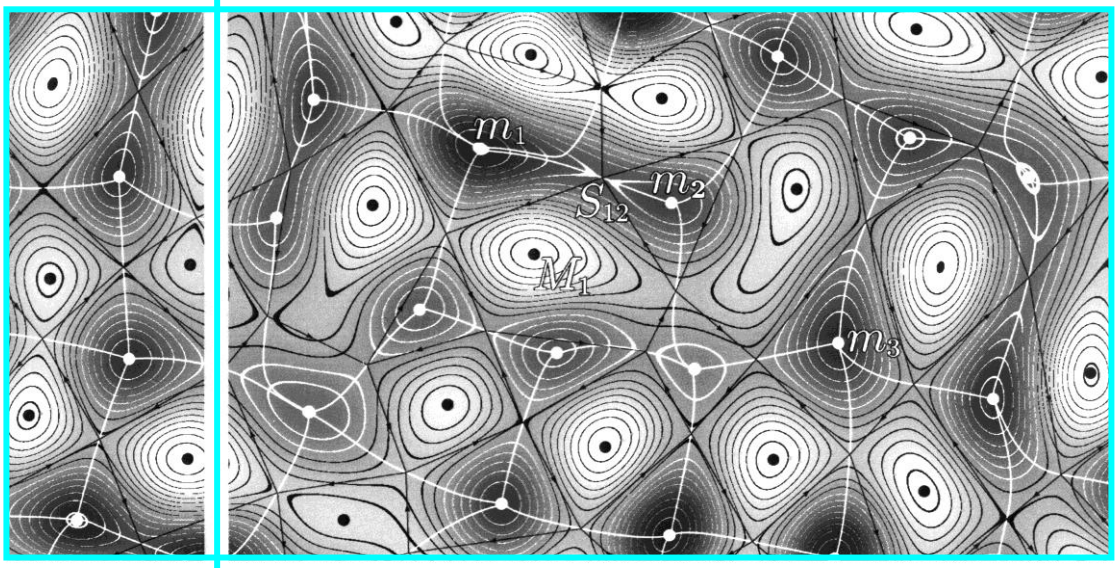
CENS

CENTRE FOR NONLINEAR STUDIES



2011 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

2011

Tallinn

Contents

1. Introduction
2. Overview on CENS and highlights
3. Current results 2011
4. Funding
5. Publicity of results
6. Research and teaching activities
7. Summary

Annex

Abstract

This Report gives a brief overview on activities of CENS in 2011. 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 the work plan of CENS and some additional information.

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.

The International Advisory Board

Prof. F. Allgöwer, University of Stuttgart; Prof. St. Bishop, University College London;
Prof. R. Grimshaw, Loughborough University; Dr. R. Grunwald, Max-Born-Institute, Berlin;
Prof. G. Holzapfel, Graz University of Technology; Prof. G.A. Maugin, University of Paris 6;
Prof. F. Pastrone, University of Turin; Prof. G. Stepan, Budapest University of Technology and Economics.

.

Sisukord

1. Sissejuhatus
2. Ülevaade CENSist ja olulised tulemused
3. Põhitulemused 2011
4. Finantseerimine
5. Publikatsioonid, konverentsid
6. Tegevus ja õppetöö
7. Kokkuvõte

Lisa

Lühikokkuvõte

Aruanne sisaldab ülevaadet CENSi (Mittelineaarsete Protsesside Analüüsi Keskuse) tegevusest 2011.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 CENSi tööplaan 2011–2015 ja täiendav informatsioon.

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. In Section 3, current research results in 2011 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.

2. Overview on CENS

The core groups of CENS belong to the Institute of Cybernetics at Tallinn UT. At various stages up to 2011, some other research groups were attached:
Biomedical Engineering Centre, Tallinn UT,
Chair of Geometry, Institute of Pure Mathematics; Tartu University,
Laboratory for Proactive Technologies, Tallinn UT.

Research is always characterized by changes. The world is changing fast and by definition research must be several steps ahead of changes in society. CENS has defined its focus as follows:
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 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.

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 ener-

getics 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 has competence 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, FuturICT, Humboldt Foundation, etc.

CENS has personnel of 75, of whom 30 are PhD students. In 2011, the researchers from 10 countries work in CENS. The International Advisory Board is the direct link to the international community and an international network with many research centres working on same problems has been developed.

Highlights of research

Nonlinear Dynamics

- The theory of canonical thermomechanics is formulated in terms of dual internal variables. This approach allows to derive consistently mathematical models of wave motion in microstructured solids which take into account dispersive and temperature effects.
- The large scale analysis of dispersive and nonlinear effects has revealed mechanisms of wave profile distortions and emergence of solitary waves in microstructured solids.
- The theory of short fibre reinforced materials is derived based on using alignement tensors and orientational parameters. The theory is applied for description of fibre reinforced concrete and composites.
- The algorithms based on counterpropagating ultrasonic bursts are derived for solving the inverse problems of FGMs.
- A novel governing equation for waves in felt is derived which has been used to analyse the piano hammers and vibrations of piano strings.
- An algorithm of photoelastic tomography for the determination of 3D stress fields is derived and its reliability checked in the axisymmetric case against the measurements of stresses in glass fibres and in stems of wine glasses.
- The stochastic triplet-map model of turbulent mixing is extended to describe the passive tracers in compressible flows and the patchiness of pollutants on the sea surface described.

- A novel method of determining scaling exponents from finite-size Monte-Carlo simulation data has been tested using fractal sets like percolation clusters.

Wave Engineering

- A comprehensive description of spatial patterns of variations in the Baltic Sea wave properties.
- A novel method is proposed for the optimisation of marine fairways, based on the quantification of various offshore areas according to the probability of pollution released in these areas to reach vulnerable regions, and it is tested for the Gulf of Finland.
- Beach profiles may develop a two-section almost-equilibrium structure under joint impact of short wind waves and groups of long ship waves. The upper section of the profile is convex and follows the 4/3 power law at small depths and in the swash zone.
- A new mechanism producing onshore transport of substantial amounts of water remote from the fairway through wake waves generated by high-speed vessels is described based on high-resolution water surface profiling.
- A higher-order (2+4) Korteweg-de Vries-like equation for interfacial waves was derived in a symmetric three-layer fluid.
- The worldwide statistics of rogue wave accidents in 2006–2010 demonstrate that the largest number of accidents occur at the coast and in the coastal zone.
- The rogue wave formation within nonlinear hyperbolic systems is only possible through nonlinear wave-wave or/and wave-bottom interaction.
- Statistical parameters of the wave inundation on a plane beach are calculated within nonlinear shallow water theory and studied experimentally. The probability of coastal floods grows with an increase in the nonlinearity of the incident wave field.
- Resonant amplification of tsunami waves, induced by underwater landslides and the problems of wind set-down and set-up relaxation in inclined U-shaped bays are studied analytically within nonlinear shallow water theory.

Systems Biology

- It is demonstrated that intracellular structures impose significant diffusion obstacles in rat cardiomyocytes using a single cell preparation.
- An open-source package for deconvolution of confocal microscopy images is developed.
- Stopping criteria for deconvolution of the images have been found.
- The analysis of local recovery of sarcoplasmic reticulum calcium release suggests that local refilling of SR controls calcium spark. amplitude recovery
- A symbolic Gauss-Jordan elimination routine for analyzing large metabolic networks has been developed.

Optics

- The boundary diffraction wave theory has been generalized and adopted for Gaussian pulses. Predictions of the theory have been verified experimentally by measuring of diffraction of ultrashort optical pulses on various screens. Paper by P.Piksarv et al on the results of the study has been selected into list of top best articles of Journal of Optics by the Editorial Board.
- A set-up for spatiotemporal measurement of ultrashort impulse responses of optical systems with up to 5-femtosecond temporal resolution has been accomplished by using supercontinuum laser source and photonic crystal fibres.
- Nonlinear second-harmonic generation with laser beams transformed by internal conical refraction in a biaxial crystal has been studied, and transformation of vortex Laguerre-Gauss laser beams by conical refraction several specific second-harmonic beam profiles have been demonstrated.

Nonlinear Control Theory

- The reduction and realization problems have been solved for nonlinear control systems applying the theory of non-commutative polynomials. The main advantage of polynomial approach is 'computability'; the theoretical results are complemented by explicit formulas yielding a short program code in Mathematica-based symbolic software.
- The inversive differential ring, associated with a nonlinear control system, defined on a non-homogeneous but regular time scale is constructed and equipped with three operators (delta- and nabla-derivatives and forward shift operator) whose properties are studied. The developed formalism unifies/extends those for continuous- and discrete-time systems.
- A distributed planning and control framework for human assistive robots has been developed and its prototype was implemented for Scrub Nurse Robot constructed (and used) by Mijawaki Laboratory in Tokyo Denki University.

3. Current results 2011

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, general theory.
The formal structure of generalized continuum theory is recovered by means of the extension of canonical thermomechanics with dual weakly non-local internal variables and extra entropy fluxes. The canonical thermomechanics provides the best framework for such generalization. It is shown that the structure of Cosserat, micromorphic, and second gradient theories can be recovered in terms of dual internal variables in a natural way. It should emphasized, however, that any new balance laws has not been introduced, only the Clausius-Duhem inequality was exploited for the derivation of evolution equations for the dual internal variables. The theory is applied for the thermoelastic description of microstructured solids. It appears that in the framework of the internal variables theory it is possible to obtain a hyperbolic evolution equation

for microtemperatures keeping the parabolic evolution equation for the macrotemperature. Effects of microtemperature gradients exhibit themselves on the macrolevel due to the coupling of equations of macromotion and evolution equations for macro- and microtemperatures. It is demonstrated that the dual internal variables can provide a contribution in both reversible and dissipative processes in microstructured media (A.Berezovski, J.Engelbrecht, G.A.Maugin).

The consistent structures of governing equations for dispersive waves are established. Based on our earlier results in 2010 for the general 3D theory, the 1D setting is used in order to demonstrate explicitly how the structure of the governing equations depend on the constitutive free energy function. The adopted phenomenological approach is based on material formulation of continuum mechanics and provides the full thermodynamic consistency due to the dual internal variable concept. The derived governing equation for longitudinal waves is well-grounded and covers many known cases. Its typical feature is that besides the fourth-order derivatives it includes also the changes in the velocity of wave propagation at macroscale due to the coupling. This effect is also demonstrated by direct numerical computations for regular and random microstructure distribution. The fourth-order terms in the governing equation are explicitly related to various terms in free energy function and reflect the effects of micro-elasticity and microinertia. The possibilities for further generalizations or simplifications are analysed. It is shown that nonlinear terms can easily be introduced in the framework of the dual internal variables approach resulting in a generalized nonlinear dispersive wave equation. The cubic macroscopic nonlinearity leads to the Boussinesq equation (A.Berezovski, J.Engelbrecht, M.Berezovski).

The full dispersion analysis is carried out for the Mindlin-type model of microstructured solids using the full model and its hierarchical approximation. The applicability of both models is analyzed on the basis of dispersion curves. Special attention is paid to the clarification of effects caused by the optical dispersion branches which stems from the stationary motion of a microstructure. It is demonstrated how the behaviour of dispersion curves (or corresponding phase and group velocities) are reflected in wave profiles as for initial value as well as for boundary value problems. In this way emerged wave packets or high frequency oscillations behind or in front of the main wave are explained in detail. A single scale model is generalised to a multiscale model and the corresponding dispersion analysis is carried out (T.Peets).

Waves in microstructured solids, solitonics.

The emergence of soliton trains and interaction of solitons are analyzed by using a Boussinesq-type equation derived from a Mindlin-type model of microstructured solids and which describes the propagation of bi-directional waves. The governing equation includes scale parameters which show explicitly the influence of the embedded microstructure and it has a hierarchical structure composed by two wave operators. The analysis is based on numerical simulation using the pseudospectral method. It is shown how the number of solitons in emerging trains depends on the initial excitation. The head-on collision of emerged solitons is not fully elastic due to radiation but the solitons preserve their identity after collision and the speed of solitons is retained while the radiation keeps a certain mean value (A.Salupere, K.Tamm, J.Engelbrecht).

The detailed analysis of emerging soliton trains is carried out for several nonlinear models which all are related to the basic Mindlin-type theory: the system of two second-order equations and corresponding hierarchical equations (in terms of displacement as well in terms of deformation) derived from the previous case by the slaving principle, the corresponding single equation of the fourth order and a hierarchical equation derived from the previous case by the slaving principle. Model equations are solved numerically by using the pseudospectral method. In case of fourth-order derivatives, a special change of variables is proposed. The accuracy of the method is tested against the known solutions with checking the conserved quantities at every integration step. It is demonstrated that the initial symmetric pulse will evolve to an asymmetric shape and the waves propagating to the different directions (right and left) evolve differently in

time. It is shown that interactions between propagating solitary waves are not fully elastic but over short time intervals and over a low number of interactions the behaviour of waves is soliton-like. The governing parameters characterizing the differences between the various models are linked to the speeds long and short waves in the system. It is demonstrated that predictions from linear dispersion analysis hold also for the nonlinear cases. However, nonlinearity introduces additional effects (asymmetry between pulses propagating in opposite directions, formation of peakons, etc.) not taken into account by (linear) dispersion analysis (K.Tamm).

Waves in microstructured solids, numerics.
The thermodynamic consistency is a desired feature of numerical algorithms for physical problems. Such a consistency can be achieved if the computational cells are considered as discrete thermodynamic systems. It is shown that faithful, accurate, and conservative finite-volume algorithms are compatible with thermodynamics through the identification of numerical fluxes and excess quantities (A.Berezovski).

Wave propagation in heterogeneous materials with a secondary substructure is studied numerically in case of a pulse-type external excitation. The influence of the changing position of different layers is demonstrated on example of double periodic laminates (M.Berezovski, A.Berezovski, J.Engelbrecht).

Theory of short fibre reinforced materials.
Different methods of describing the orientation of fibres in short fibre reinforced composite have been discussed. It has been clearly shown, that the two commonly used methods for steel fibre reinforced concrete, the orientation number and orientation profile, are insufficient. The newly proposed alignment tensors and corresponding (orientational) order parameter and macroscopic director overcome these limitations. The order parameter has the advantage over the orientation number, that it is related to the expectation value of the second Legendre polynomial, a special case of spherical harmonics, which are well known in electrodynamics and quantum mechanics. Especially by use of higher order alignment tensors it is possible to describe the orientation distribution of the fibres accurately in three dimensions. In addition the alignment tensors can be easily used to formulate constitutive equations. These constitutive equations are tensor equations and contain only objective quantities, especially they are independent from any pre-chosen projection direction. They can be used to calculate the stresses in any direction. Furthermore all quantities are fields, i.e. they can vary along the material. Although steel fibre reinforced concrete has been chosen as an example, the methods are applicable to all kinds of short fibre reinforced composites (H.Herrmann, M.Eik).

Mesoscopic continuum physics: evolution equation for the distribution function and open questions.
Different usage scenarios of the distribution function with its evolution equation together with different versions of the balance of mass have been described. Although these may seem obvious, they have not been mentioned in the literature before. The problem of (virtually) disconnected mesoscopic domains has been discussed. The problem that continuous three dimensional domains may become discontinuous when using the mesoscopic space is not inherent to the strict high dimensional formulation used here, but just more visible. It also appears in the "traditional formulation"used by other authors. Under certain circumstances, i.e. when the mescoscopic domain becomes non-connected, mesoscopic continuum physics requires a strongly non-local formulation of constitutive functions, a weakly non-local formulation – containing gradients – is not sufficient anymore (H.Herrmann, J.Engelbrecht).

Raytraced images for testing the reconstruction of fibre orientation distributions.
The orientation distribution of fibres is relevant for the properties of many different kinds of materials from many fields, like biology and engineering. In short fibre reinforced composites it is essential for the properties of these materials. PoV-Ray - the Persistence of Vision Raytracer - is a program to create photorealistic images using raytracing. A sort of "creative misuse"of this program in science is presented, as it was originally developed as an artistic software. However the ability to create virtual images of virtual parts, to test the image recognition software, that is used to measure the fibre orientation distribution, and to be able to compare the result with the known distibution is a huge step forward. The focus is on slicing/photometry, but also CT-like images or microscope images could be produced and used to test segmentation and skeletonization algorithms (M.Eik, H.Herrmann).

A novel technique for measurement and description of fibre orientation distributions in concrete reinforced by short fibres.
The fibre orientation distribution has an important impact on the properties of short fibre reinforced composites. A measurement procedure within fibre orientation for steel fibre reinforced concrete (SFRC) is presented and the outcome of experiments with real size floor slabs made from this composite is analysed. It is shown that the orientation distribution varies between the center and the edge of the slab. The advantages and shortcomings of slicing with photometry for measuring fibre orientations are discussed and methods proposed to overcome these shortcomings. For the analytic description of fibre orientation distributions alignment tensors are introduced (H.Herrmann).

Microstructured media: challenges of steel fibre reinforced concrete in load bearing structures.
Cement-matrix composites are one of many composite material systems, usually consisting of two phases, fibre as reinforcement and concrete as matrix. This article focuses on the composite, reinforced with metal fibers The main role of fibres is to carry the load, while the concrete matrix serves to transfer and distribute the load to the fibres. The efficiency of load transferring from matrix to fibres depen on the matrix- fibre bonding interface and anchorage length of the fibre. Additionally the problem associated with the orientation of fibres in the matrix, is one of the most important and plays a significant role in determining the yield stress of the composite. Also explores a possible parallel between the conventional and steel fibre reinforced concrete (M.Eik).

3.1.2 General nonlinear wave theory

Acoustodiagnostics of inhomogeneous solids.
Material inspection by ultrasonic waves is an important component of modern manufacturing. Different ultrasonic techniques have been developed for this purpose. The widely used methods are the pulse and the burst (tone burst) methods frequently used to bind the time of flight or the shape disturbances with the material properties. The inhomogeneity of material properties leads to the necessity of extracting more information from the data of wave propagation. Therefore, utilization of interaction of ultrasonic waves is one of the very promising methods for this purpose.

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. The novelty of the research work in this year in comparison with the previous work consists in proposal to use a special case, by which the proper choice of the parameters of ultrasonic bursts leads to the effect when the oscillations evoked by counterpropagating bursts in the homogeneous material disappear, as a reference

state for ultrasonic nondestructive determination of the homogeneity of material properties or the presence of variation in these properties.

The problem is studied theoretically on the basis of the five constant nonlinear theory of elasticity. The counterpropagating bursts are excited simultaneously on opposite parallel boundaries of the specimen. The analytical solution to the one-dimensional governing equation of motion is derived for the case of superposition of bursts in homogeneous material. Nonlinear interaction of bursts in the functionally graded material (FGM) with strongly changing properties is studied numerically on the basis of the nonlinear equation of motion making use of the programme package Maple.

Influence of material inhomogeneity on this special case of bursts interaction is studied by considering the FGMs with exponential variation of material properties close to the boundaries of the specimen. Such materials may be employed in many important areas as coatings and interfacial regions for the purpose of reducing residual and thermal stresses and increasing bounding strength. The main attention is paid on the analyses of the boundary oscillation data evoked in the material by nonlinear counter-propagation and interaction of bursts. The symmetric and asymmetric exponential variation of material properties on the modulation of the boundary oscillations is studied. It is concluded that the variation of material properties is reverberated in boundary oscillation profiles. It cleared up that the modulation of boundary oscillation profiles caused by the variable density and the linear part of elasticity is of the same order while changes caused by the nonlinear part of elasticity manifest themselves in higher order small phenomena.

The analyses of the results of numerical simulations leads to the conclusion that the sensitivity of the boundary oscillation profiles to the scheme of material properties variation and to the kind of inhomogeneous material property enables easily to determine

(i) deviation of material properties from the preliminary determined basic homogeneous properties,
(ii) the presence of inhomogeneity in these properties,
(iii) the kind of the variable material property,
(iv) the scheme of material properties variation.

Clarification of nonlinear effects evoked by the ultrasound in the weakly inhomogeneous material with the finite thickness is proceeded. The one-dimensional propagation and reflection of the longitudinal wave in the exponentially graded material is studied on the basis of the five constant nonlinear theory of elasticity. The analytical perturbative solution is derived for description of multiple reflections of the wave in the specimen with two parallel stress-free boundaries. The analysis of the solution confirmed the increase of nonlinear effects in the forward-propagating wave and decrease of these effects in the back-propagating wave after reflection from the opposite boundary. In addition, the relations between the first harmonic amplitude and the phase shift of the wave and exponentially graded material density and linear part of elasticity are clarified. Several acoustodiagnostic problems were posed and solved.

The obtained results enable elaboration of algorithms for nondestructive ultrasonic characterization of the properties of strongly and weakly inhomogeneous FGMs (A.Ravasoo, A.Braunbrück).

Vibration of the string with nonlinear contact conditions and deformation wave propagation in the piano hammer felt.

The main goal is accurate modeling of the piano string - capo bar interaction. It requires that the curvature of the V-shaped section be recognized and included. The model that realizes this with numerical calculation is described, and results relating the effect of the capo bar are presented. The propagation of longitudinal deformation waves through a felt material is investigated. To consider the longitudinal deformation waves propagation through a wool felt material, the con-

stitutive equation of the felt was chosen in a form, which corresponds to the hammer felt model. Deformation waves are studied numerically by using a finite difference method. A bell-like pulse propagation is considered, and the influence of the felt parameters on the changing of the pulse form is analyzed (A.Stulov, D.Kartofelev).

3.1.3 Fractality and econophysics

The stochastic triplet-map model of turbulent mixing has been extended to the mixing of passive tracers in compressible flows, and to the mixing of finite-life-time particles. The stochastic triplet map is a powerful tool for numerical and analytical turbulence studies, developed independently at CENS, and by the research group of A.R Kerstein. Hitherto it has not been suited for studying compressible flows; likewise, it was not possible to analyse the mixing of decaying tracers of finite life-time (such as evaporating pollution on water surface, or dying plankton).

A Fokker-Planck equation describing the evolution of the k-spectrum of passive scalars in compressible flows has been derived analytically. This is an efficient tool for analytical studies of the statistical properties of tracer fields. The breakthrough has been achieved by making a connection between the smallest finite-time Lyapunov exponent of chaotic velocity fields, and transport along the coordinate describing logarithmic increase in tracer density gradient.

A novel concept of finite-time compressibility has been introduced; it has been shown that at the limit of Kraichnan flows, it coincides with the classical compressibilities, and in the case of real, time-correlated flows, it provides more reliable results. In collaboration with the Laboratory of Wave Engineering, the finite-time compressibility map of the Gulf of Finland has been created, which allows us to predict the patchiness of the pollutants on the sea surface (J.Kalda, M.Kree, P.Avila, M.Heidelberg, D.Hernandez).

In collaboration with the Institute of Physics, UT, the cracking of sol-gel films has been modelled and numerically simulated with a variant of spring-block model, which is adapted to describe inhomogeneous drying of films lying on a non-solid substrate. The model results made it possible to understand the dependence of the structure of cracks on the control parameters of the respective experiments. This is an important step towards an optimal design of the sol-gel film cracking experiments, bringing towards industrial applications, such as the production of nanotubes (formed from the film fragments) (J.Kalda, J.Jõgi).

Monte-Carlo simulation scheme has been developed to study the electrical conductivity of thin films of PEDT/PSS complex, using the morphology created by the Mesodyn-software; these simulations are aimed to test the earlier created simplified model of bottleneck-conductivity. These results advance the theoretical understanding of the electrical conductivity of the PEDT/PSS films, which has been scarce up till now, and which is important for several practical applications of material sciences, eg. for the design of solar elements (J.Kalda).

A novel method of determining scaling exponents from finite-size Monte-Carlo simulation data (developed at CENS) has been tested for reliability and performance (as compared to the classical methods) using analytically well-understood fractal sets (such as percolation clusters and hulls); criteria for choosing the optimal method parameters have been formulated. The results show clearly the superiority of this new technique, which has a wide spectrum of applications in the context of statistical physics of complex systems (I.Mandre).

Using the historical data-series of the USD and DEM exchange rates, a multiscaling behaviour of the currency markets has been studied; anomalous scaling around and below the time-scale of one day has been established. These results are useful for devising optimal currency trading strategies, in particular for risk minimization around the market closure time (R.Kitt).

3.1.4 Laboratory of Photoelasticity

Optical nonlinearity and photoelasticity.
The aim of the investigations has been development of the theory and algorithms of photoelastic tomography for the determination of three-dimensional stress fields.

In photoelastic tomography of axisymmetric stress fields the axial stress and shear stress are directly determined from the measurement data. For the calculation of the radial and circumferential stress components from the axial and shear stress distributions an algorithm has been developed. In the case of residual stresses, the radial and circumferential stress components can be obtained by integrating the equilibrium equation and the generalized sum rule. In the case of stresses due to external loads, the other stress components can be obtained by integrating the equilibrium and compatibility equations. It has been shown analytically and graphically for both cases that integration must start at the axis and proceed along the positive direction of the radial coordinate. Only in this case the solution of the equations converges. The initial value for integration is obtained by trial and error method such that the values of radial and circumferential stresses at the external surfaces obtained by integration satisfy boundary conditions, which are determined experimentally. In the case of solid specimens only one trial is necessary. The reliability of the algorithm has been checked by measuring stresses in a glass fibre, loaded by an indenter, and residual stresses in the stem of a wine glass.

It has been shown that the residual stress at the surface of tempered glass panels may vary both locally (at a distance equal to the distance between the cooling jets) and globally, i.e., stresses near the edges and corners of the panels may be considerably different from the stresses in the middle part of the panels. It is also shown that in the middle part of the panels the stresses are usually isotropic while near the edges the stresses depend on the direction. Measurements were carried out with the scattered light polariscope SCALP (GlasStress Ltd) (H.Aben et al.).

3.1.5 Laboratory of Systems Biology

Permeabilized rat cardiomyocyte response demonstrates intracellular origin of diffusion obstacles.
Intracellular diffusion restrictions for ADP and other molecules have been predicted earlier based on experiments on permeabilized fibers or cardiomyocytes. However, it is possible that the effective diffusion distance is larger than the cell dimensions due to clumping of cells and incomplete separation of cells in fiber preparations. The aim of this work was to check whether diffusion restrictions exist inside rat cardiomyocytes or are caused by large effective diffusion distance. For that, we determined the response of oxidative phosphorylation (OxPhos) to exogenous ADP and ATP stimulation in permeabilized rat cardiomyocytes using fluorescence microscopy. The state of OxPhos was monitored via NADH and flavoprotein autofluorescence. By varying the ADP or ATP concentration in flow chamber, we determined that OxPhos has a low affinity in cardiomyocytes. The experiments were repeated in a fluorometer on cardiomyocyte suspensions leading to similar autofluorescence changes induced by ADP as recorded under the microscope. ATP stimulated OxPhos more in a fluorometer than under the microscope, which was attributed to accumulation of ADP in fluorometer chamber. By calculating the flow profile around the cell in the microscope chamber and comparing model solutions to measured data, we demonstrate that intracellular structures impose significant diffusion obstacles in rat cardiomyocytes (M.Vendelin, et al.).

Application of regularized Richardson-Lucy algorithm for deconvolution of confocal microscopy images.
Although confocal microscopes have considerably smaller contribution of out-of-focus light than widefield microscopes, the confocal images can still be enhanced mathematically if the

optical and data acquisition effects are accounted for. For that, several deconvolution algorithms have been proposed. As a practical solution, maximum-likelihood algorithms with regularization have been used. However, the choice of regularization parameters is often unknown although it has considerable effect on the result of deconvolution process. The aims of this work were: to find good estimates of deconvolution parameters; and to develop an open source software package that would allow testing different deconvolution algorithms and that would be easy to use in practice. Here, Richardson-Lucy algorithm has been implemented together with the total variation regularization in an open source software package IOCBio Microscope. The influence of total variation regularization on deconvolution process is determined by one parameter. We derived a formula to estimate this regularization parameter automatically from the images as the algorithm progresses. To assess the effectiveness of this algorithm, synthetic images were composed on the basis of confocal images of rat cardiomyocytes. From the analysis of deconvolved results, we have determined under which conditions our estimation of total variation regularization parameter gives good results. The estimated total variation regularization parameter can be monitored during deconvolution process and used as a stopping criterion. An inverse relation between the optimal regularization parameter and the peak signal-to-noise ratio of an image is shown. Finally, we demonstrate the use of the developed software by deconvolving images of rat cardiomyocytes with stained mitochondria and sarcolemma obtained by confocal and widefield microscopes (M.Vendelin, et al.).

Recovery of cardiac calcium release is controlled by sarcoplasmic reticulum refilling and ryanodine receptor sensitivity.
In heart cells, the mechanisms underlying refractoriness of the elementary units of sarcoplasmic reticulum (SR) Ca2+ release, Ca2+ sparks, remain unclear. We investigated local recovery of SR Ca2+ release using experimental measurements and mathematical modelling. Repeated Ca2+ sparks were induced from individual clusters of ryanodine receptors (RyRs) in quiescent rat ventricular myocytes, and we examined how changes in RyR gating influenced the time-dependent recovery of Ca2+ spark amplitude and triggering probability. Repeated Ca2+ sparks from individual sites were analysed in the presence of 50 nM ryanodine with: (i) no additional agents (control); (ii) 50 M caffeine to sensitize RyRs; (iii) $50\mu M$ tetracaine to inhibit RyRs; or (iv) 100 nM isoproterenol to activate β-adrenergic receptors. Sensitization and inhibition of RyR clusters shortened and lengthened, respectively, the median interval between consecutive Ca2+ sparks (caffeine 239 ms; control 280 ms; tetracaine 453 ms). Recovery of Ca2+ spark amplitude, however, was exponential with a time constant of -100 ms in all cases. Isoproterenol both accelerated the recovery of Ca2+ spark amplitude ($\tau = 58ms$) and shortened the median interval between Ca2+ sparks (192 ms). The results were recapitulated by a mathematical model in which SR [Ca2+] depletion terminates Ca2+ sparks, but not by an alternative model based on limited depletion and Ca2+-dependent inactivation of RyRs. Together, the results strongly suggest that: (i) local SR refilling controls Ca2+ spark amplitude recovery; (ii) Ca2+ spark triggering depends on both refilling and RyR sensitivity; and (iii) β-adrenergic stimulation influences both processes (M.Vendelin, et al.).

Symbolic flux analysis for genome-scale metabolic networks.
With the advent of genomic technology, the size of metabolic networks that are subject to analysis is growing. A common task when analyzing metabolic networks is to find all possible steady state regimes. There are several technical issues that have to be addressed when analyzing large metabolic networks including accumulation of numerical errors and presentation of the solution to the researcher. One way to resolve those technical issues is to analyze the network using symbolic methods. The aim of this paper is to develop a routine that symbolically finds the steady state solutions of large metabolic networks. A symbolic Gauss-Jordan elimination routine was developed for analyzing large metabolic networks. This routine was

tested by finding the steady state solutions for a number of curated stoichiometric matrices with the largest having about 4000 reactions. The routine was able to find the solution with a computational time similar to the time used by a numerical singular value decomposition routine. As an advantage of symbolic solution, a set of independent fluxes can be suggested by the researcher leading to the formation of a desired flux basis describing the steady state solution of the network. These independent fluxes can be constrained using experimental data. We demonstrate the application of constraints by calculating a flux distribution for the central metabolic and amino acid biosynthesis pathways of yeast. We were able to find symbolic solutions for the steady state flux distribution of large metabolic networks. The ability to choose a flux basis was found to be useful in the constraint process and provides a strong argument for using symbolic Gauss-Jordan elimination in place of singular value decomposition (M.Vendelin, et al.).

Software development.

P.Peterson, M.Kalda. Software to compute the length of cardiac sarcomeres in real time from a series of microscope images; http://code.google.com/p/iocbio/wiki/IOCBioSarcomereLength.

P.Peterson. Software to control a Strathkelvin 929 Oxygen System;
http://code.google.com/p/iocbio/wiki/IOCBioStrathKelvin.

A.Illaste. Development of a multi-platform tool for analysing fluorescence vs. time data (LSJuicer); http://code.google.com/p/lsjuicer/.

P.Peterson. Python wrapper to the C++ Deconv library by Y. Sun et al. (see details in J. Microscopy 236, 3:180-193, 2009); http://code.google.com/p/pylibdeconv/.

P.Peterson, D.W.Schryer. Computationally efficient sparse symbolic Gauss-Jordan elimation routine; http://code.google.com/p/sympycore/wiki/SteadyStateFluxAnalysis.

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

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.

3.1.6 Laboratory of Wave Engineering

Wave climate in the Baltic Sea.
Historical visual observations and numerical hindcasts were merged to reveal the basic features of the wave properties and to identify the variations in wave height in different scales in the Baltic Sea. The analysis is based on numerically simulated wave climatology in high resolution (3 miles) for the entire Baltic Sea over 38 years (1970-2007) by the WAM wave model driven by adjusted geostrophic winds under ice-free conditions, and visually observed wave properties from Vilsandi, Pakri, Narva-Jõesuu, Nida, Palanga and Klaipeda.

The wave height follows the seasonal variation in wind speed with a maximum in October-January and with a substantial variability on weekly scales. The annual mean wave height reveals nearly synchronous interannual variations along the entire coast of Estonia until the mid-1980s after which this coherence is lost. The length of the ice season is almost uncorrelated with the annual mean wave heights (T.Soomere, I.Zaitseva-Pärnaste, A.Räämet).

There exist extensive spatial patterns in linear trends of average and extreme wave heights but almost no changes in the basinwide wave activity and wave periods. Most of the open sea areas host substantial trends from -2.5 cm/decade up to +3 cm/decade. The changes are concentrated in a few calendar months. The largest increase is in January, February and May,

whereas in September and especially in November the wave height has substantially decreased. Variations in extreme wave heights generally show similar patterns of changes but in several areas the trends in average and extreme wave heights are different.

An attempt is made to consolidate results from a number of recent studies into spatial patterns of variations in the Baltic Sea wave properties. We demonstrate that a large part of the mismatches between long-term changes to wave properties at selected sites can be explained by the rich spatial patterns in changes that are not resolved by the existing observation network. The spatial scales of such patterns vary from $>$ 500 km for short-term interannual variations down to about 100 km for long-term changes (T.Soomere, A.Räämet).

The short-term (1-3 years) interannual variability of the annual mean wave height is almost coherent along the entire eastern coast in 1958–1986. This coherence is completely lost from about 1987. The decadal courses of wave activity match each other relatively well at Nida and Vilsandi until about 1992, after which the annual mean wave height behavior is completely different at these sites. The largest difference between the long-term course in the wave height is found between Vilsandi (where the wave activity increases by a factor of two in 1987–1997 and decreases even more since then) and Narva-Jõesuu (where the wave activity gradually decreases over the entire observation period) (I.Zaitseva-Pärnaste, T.Soomere, O.Tribštok). Basic features of the wave climate in the Arkona basin (south-western Baltic Sea) were established based on 20 year long time series of in situ measurements (T.Soomere in cooperation with R.Weisse and A.Behrens, HZG Geesthacht).

Preventive methods for coastal protection.

The Lagrangian trajectory model TRACMASS based on velocities of surface currents combined with relevant statistical analysis is used for the identification of transport patterns in the surface layer of the Gulf of Finland and associated optimum fairways. The focus was on the new technique that addresses the potential for a systematic increase in the time until an adverse impact (for example, an oil spill) reaches a vulnerable sea area and a corresponding decrease in the probability of the impact reaching such an area after an accident has happened. The idea behind the approach is to identify areas of reduced risk, which are statistically safer for travel, in terms of the probability of the transport of accidental pollution to vulnerable areas.

The analysis shows the presence of semi-persistent (with a typical lifetime from a week to a few months) features of the surface-layer dynamics in the Gulf of Finland. The modeled surface dynamics mostly hosts an Ekman-type drift and contains an anticyclonic gyre occupying the western part of the gulf. The most intense net transport along the coasts occurs in the western and central parts of the gulf but contains relatively intense largely meridional transport pathways in some seasons (T.Soomere, N.Delpeche, B.Viikmäe, E.Quak, in cooperation with H.E.M.Meier and K.Döös). A measure of risk of ship traffic, which systematically accounts for the potential increase in the sailing distance associated with the proposed approach, is introduced and analyzed. The resulting gain from the use of the optimal fairways is estimated for the test area of the Gulf of Finland (T.Soomere, E.Quak, in cooperation with O.Andrejev, and A.Sokolov). It is demonstrated that in certain sea areas there exists a well-defined optimum location for dangerous activities (e.g., a route for tankers), deviation from which leads to a rapid increase in the risk to the environment. There also exist extensive areas where the probabilities of a coastal hit are very small and where there is considerable freedom in the choice of the location of potentially dangerous activities (B.Viikmäe, T.Soomere, K.E.Parnell, N.Delpeche).

Based on the listed developments, a method for the optimization of marine fairways is proposed and tested for the Gulf of Finland. The offshore areas are quantified according to the probability to reach vulnerable regions of pollution released in these areas. The method consists of an eddy-resolving circulation model, a scheme for tracking of Lagrangian trajectories, a technique for the calculation of quantities characterizing the potential of different sea areas to

supply adverse impacts, and routines to construct the optimum fairway. The use of the optimum fairway would decrease the probability of coastal pollution by 40% or increase the average time of pollution reaching the coast from 5.3 to about 9 days in the Gulf of Finland. The sensitivity of this method with respect to the spatial resolution of the underlying hydrodynamic model is analyzed by means of calculation of the relevant maps with spatial resolutions of 2, 1 and 0.5 nautical miles. The spatially averaged values of the probability and particle age display hardly any dependence on the resolution. In contrast, the optimum locations for fairways depend substantially on the resolution. It is concluded that models with a grid step exceeding half the local baroclinic Rossby radius are suitable for a quick check of whether or not any potential gain from this method is feasible, whereas higher-resolution simulations with eddy-resolving models are necessary for detailed planning. The asymptotic values of the average probability and particle age are suggested as an indicator of the potential gain from the method in question and also as a new measure of the vulnerability of the nearshore of water bodies to offshore traffic accidents (T.Soomere, O.Andrejev, A.Sokolov, K.Myrberg). The optimum fairways are mostly located to the north of the gulf axis (by 2–8 km in average) and meander substantially in some sections. The robustness of the results of this approach is quantified as the typical root-mean-square deviation (6–16 km) between the optimum fairways specified by different criteria and also by means of calculation of the "corridors"for the almost optimum fairways. Drastic variations in the width of these corridors (2-30 km for the average width of 15 km) signify that the sensitivity of the results with respect to small changes in the environmental criteria may vary greatly in different parts of the gulf (T.Soomere, M.Berezovski, E.Quak, B.Viikmäe).

Wakes from high-speed vessels.
A new mechanism producing onshore transport of substantial amounts of water remote from the fairway through wake waves generated by high-speed vessels is described based on high-resolution water surface profiling. An elevation event that arrives in remote areas well after the precursors is able to carry large amounts of water. Its interaction with the leading waves of wakes may produce water level set-up under groups of high ship waves. The backflow of this water potentially contributes to fast removal of sediment from non-equilibrium beaches during the later phase of the wake-wave event (T.Soomere, I.Didenkulova, in cooperation with K.E.Parnell, James Cook University, Australia).

Beach dynamics resulting from the interplay of vessel wave wakes and background wind waves are studied experimentally using data obtained in 2008 in Tallinn Bay. The beach profile is presented schematically as a power law for the water depth $h \sim x^b$ with the distance x from the coast and an exponent b. It is shown that wind waves of longer period are more energetic and are able to accrete the beach which generally loses sediment due to ship wakes (I.Didenkulova, E.Pelinovsky, T.Soomere and K.E.Parnell). Amazingly, beach profiles may develop a two-section almost-equilibrium structure under the joint impact of short wind waves and groups of long ship waves. The upper section of the profile is convex and follows the power law $h \sim x^{4/3}$ at small depths and in the swash zone. The ability of short groups of highly energetic waves to regularly build up such profiles from those created by random sea waves is a principally new feature of wave-coastal interaction that may have extensive consequences for the estimates of wave-induced coastal hazards (I.Didenkulova, T.Soomere).

It is demonstrated that long waves induced by high-speed ferries sailing at near-critical speeds in semi-sheltered relatively shallow areas serve as a convenient physical model for tsunami waves. These waves can model nearshore dynamics and runup of tsunami waves caused by landslides, including processes of wave refraction, diffraction and sea-bottom interaction in bays and harbors as the key governing nondimensional parameters of the largest ship waves and landslide tsunamis are in the same order of magnitude (I.Didenkulova, T.Soomere, in cooperation with E.Pelinovsky). Characteristics of about 150 wakes from fast ferries sailing in Tallinn

Bay in June 2009 were measured using an echosounder at a depth of 2.7 m, and 2.4 km from the sailing line. The shape of the highest vessel waves was analyzed in terms of crest-trough asymmetry. Maximum wave heights (up to 0.7 m) occurred exclusively for the longest waves with periods 10 s. These waves are substantially nonlinear with wave crests typically exceeding wave troughs by a factor of 1.3. (D.Kurennoy, T.Soomere, in cooperation with K.E.Parnell).

Internal waves in a three-layer medium.
The geographical and seasonal distributions of kinematic and nonlinear parameters of long internal waves obtained on a base of GDEM climatology in the Baltic Sea region are examined. The key outcome is an express estimate of the expected internal wave parameters for different regions of the Baltic Sea. The central kinematic characteristic is the near-bottom velocity in internal waves in areas where the density jump layers are located in the vicinity of the seabed. In such areas internal waves are the major driver of sediment resuspension and erosion processes and may also be responsible for destroying the laminated structure of the sedimentation regime (that frequently occurs in certain areas of the Baltic Sea).

A higher-order (2+4) Korteweg-de Vries-like equation for interfacial waves was derived in a symmetric three-layer fluid, with equal depths of the uppermost and the lowermost layers. In such a case, the coefficients of the leading nonlinear terms of the modified Korteweg-de Vries (mKdV) equation vanish simultaneously and there exists a specific balance between the leading nonlinear and dispersive terms. The dynamics is governed by an extension to the mKdV equation that contains a cubic and a quintic nonlinearity of the same magnitude and possesses solitary wave solutions of different polarity. The collisions of solitary wave solutions to the resulting equation are weakly inelastic (O.Kurkina, T.Soomere, in cooperation with colleagues from Niznhy Novgorod).

Coastal processes.
Numerically estimated wave properties and the associated closure depth along the eastern Baltic Sea coast from the Sambian Peninsula up to Pärnu Bay were compared against the existing data about accumulation and erosion. Typical values of the closure depth are 5-6 m on the open Baltic Sea coast, 3-4 m in the Gulf of Riga and 2-2.5 m in semi-sheltered smaller bays. The longshore variations in wave intensity can be used to identify the location of major accumulation and erosion domains: the sections that host the largest change in the wave height along the coast reveal erosion or accumulation features depending on the predominant wave approach direction (T.Soomere, M.Viška, A.Räämet, in cooperation with J.Lapinskis, University of Latvia). There exist considerable interannual variations (but no statistically significant trend) in the overall wave activity at Lithuanian coastal observation sites for 1993–2008. The directional distribution of wave approach directions has become considerably narrower since about 2002; most prominently at Palanga. Calculations of longshore sediment transport indicate that this change apparently leads to a decrease in the sediment supply to the Curonian spit and to a certain starvation of the Lithuanian coast (T.Soomere in cooperation with L.Kelpšaite and I.Dailidiene).

Potential reasons for the drastic intensification and step-like nature of coastal erosion in the Neva Bay area (the easternmost part of the Gulf of Finland) are analyzed based on field observations and hydrometeorological data. Beaches in this area evolve under overall sediment deficit and are relatively vulnerable with respect to changes in the external forcing factors. Extreme erosion events occur when high waves excited by long-lasting western or south-western storms attack the coast during high storm surges in the absence of stable sea ice. Since 2004 the frequency of occurrence of such combinations has increased mostly owing to late freezing of the bay. An increase in the number and severity of extreme erosion events in the future is likely. The coasts are also under gradually increasing anthropogenic pressure (D.Ryabchuk, A.Kolesov, B.Chubarenko, M.Spiridonov, D.Kurennoy, T.Soomere).

The key features of appearance and functioning (from the viewpoint of sediment transport

processes) of an interesting class of almost equilibrium, bayhead beaches located in bays deeply cut into the mainland along the northern coast of Estonia are systematically described. They develop in an essentially non-tidal, highly compartmentalized coastal landscape mostly under the influence of wave action; although often suffering from a certain sediment deficit, they are stabilized by the postglacial land uplift. It is demonstrated that net sand changes for such beaches can be estimated directly from the properties of the equilibrium beach profile, land uplift rate, and loss or gain of the dry beach area. As an example, the parameters and longshore transport patterns are evaluated for Pirita Beach. Another type of highly dynamic equilibrium exists owing to the interplay of the effects of river flow and wave action at the mouths of large rivers such as the Narva River (T.Soomere, in cooperation with T.Healy, University of Waikato). A systematic estimate of the sediment budget based on the theory of the equilibrium beach profile is presented for Valgerand on the northern coast of Pärnu Bay. Littoral drift of sand from this eroding beach is directed to the east and finally blocked by the jetties in the Pärnu River mouth. The eroding section is about 1 km in length and loses about 1000 m3 of sand annually. The major accumulation area is located to the north of the Pärnu River mouth where up to 4000 m3 of sediment accumulates annually (K.Kartau, T.Soomere, in cooperation with H.Tõnisson).

Rogue waves in the sea.

An amazing phenomenon is a sporadic occurrence of unexpectedly high (rogue) waves on the sea surface. The mechanisms of rogue wave formation (including deep and shallow water and coastal floodings) are reviewed. Nonlinear effects which may cause rogue waves are emphasized. The generality of the physical mechanisms suggested for the rogue wave explanation is discussed; they are valid for rogue wave phenomena in other media such as solid matters, superconductors, plasmas and nonlinear optics (I.Didenkulova, in cooperation with A.Slunyaev, E.Pelinovsky).

In the framework of nonlinear hyperbolic systems it is shown that the nonlinearity in the random Riemann (travelling) wave, which manifests in the steeping of the face-front of the wave, does not lead to the extreme wave formation. A strongly-nonlinear Riemann wave cannot be described by the Gaussian statistics for all components of the wave field. It is shown that rogue waves can appear in nonlinear hyperbolic systems only as a result of nonlinear wave-wave or/and wave-bottom interaction. Two special cases of wave interaction with a vertical wall (interaction of two Riemann waves propagating in opposite directions) and wave transformation in the basin of variable depth are studied in detail (I.Didenkulova in cooperation with E.Pelinovsky).

The evidence of rogue wave existence all over the world during last five years (2006–2010) has been collected based mainly on mass media sources. Only events associated with extensive damage or with loss of lives are included. The waves occurred not only in deep and shallow zones of the World Ocean, but also at the coast, where they were manifested as either sudden flooding of the coast or high splashes over steep banks or sea walls. From the total 131 reported events, 78 were identified as evidence of rogue waves (which are expected to be at least twice larger than the significant wave height). The background significant wave height was estimated from the satellite wave data. The rogue waves at the coast, where the significant wave height is unknown or meaningless, were selected based on their unexpectedness and hazardous character. The resulting statistics suggests that extreme waves cause more damage in shallow waters and at the coast than in the deep sea (I.Nikolkina, I.Didenkulova).

The properties of extreme (freak) surface waves in shallow water and their shape are analysed based on the high-resolution records in Tallinn Bay, the Baltic Sea, measured at the water depth 2.7 m from 21 June to 20 July 2008. The data set contains 97 freak waves, which occur in both calm and relatively rough weather conditions. It is shown that typical shapes of

freak waves in the nearshore differ from those which are known for the deep sea. No groups of subsequent extreme waves, like the famous "Three sisters"usually reported by eyewitnesses and measured instrumentally in the open sea, are found for the coastal zone. All freak waves in the records are single waves: 63 % of them have positive, 19.5 % sign-variable and 17.5 % negative shape. Both the frequency of occurrence and the wave height of positive freak waves are correlated with the significant wave height. The height of sign-variable freak waves, which are observed only in relatively calm weather conditions, also changes in accordance with the significant wave height, while the height of negative freak waves shows no explicit dependence on the background wave height. About 90 % of all recorded freak waves have the height in the range from 2.0 to 2.3 times the significant wave height. About 10 % of freak waves with the largest amplification (from 2.3 to 3.2 times the significant wave height) have a negative shape and their amplification factor decreases with an increase in the significant wave height (I.Didenkulova).

Wave dynamics in the coastal zone.

The random long wave runup on a beach of constant slope is studied in the framework of the rigorous solutions of the nonlinear shallow-water equations. These solutions are used for the calculation of the statistical characteristics of the vertical displacement of the moving shoreline and its horizontal velocity. The probability characteristics of the runup heights and extreme values of the shoreline velocity coincide in the linear and nonlinear theory. If the incident wave is represented by a narrow-band Gaussian process, the runup height is described by a Rayleigh distribution. The significant runup height can also be found within the linear theory of long wave shoaling and runup. Wave nonlinearity nearshore does not affect the Gaussian probability distribution of the velocity of the moving shoreline. However, the vertical displacement of the moving shoreline becomes non-Gaussian due to wave nonlinearity. Its statistical moments are calculated analytically. The mean water level increases (set-up), the skewness is always positive and kurtosis is positive for weak amplitude waves and negative for strongly nonlinear waves. The probability of wave breaking is also calculated and conditions of validity of the analytical theory are discussed. The probability of coastal floods increases with an increase in the nonlinearity. Randomness of the wave field nearshore leads to an increase in the width of the wave spectrum (I.Didenkulova in cooperation with E.Pelinovsky, A.Sergeeva). These effects are studied experimentally in the water flume at the University of Warwick. Statistics of wave runup (displacement and velocity of the moving shoreline and their extreme values) is analyzed for the incident wave field with the narrow-band spectrum for different amplitudes of incident waves. It is shown experimentally that the distribution of the shoreline velocity does not depend on amplitude (nonlinearity) and coincides with the distribution of the vertical velocity in the incident wave field as it is predicted in the statistical theory of nonlinear long wave runup. Statistics of runup amplitudes shows the same behavior as that of the incident wave amplitudes. However, the distribution of the wave runup on a beach differs from the statistics of the incident wave elevation. The mean sea level at the coast rises with an increase in amplitude (nonlinearity), causing wave set-up on a beach, which agrees with the theoretical predictions. At the same time values of skewness and kurtosis for wave runup are similar to those for the incident wave field and they might be used for the forecast of sea floods at the coast (I.Didenkulova in cooperation with P.Denissenko, E.Pelinovsky, J.Pearson).

Nonlinear interaction of long unidirectional waves is studied numerically in the framework of nonlinear shallow water theory in the basin of constant depth. The interaction of two initially separated unidirectional waves occurs only when the waves transformed into the shock waves overtake each other. The interaction of two large-amplitude wave crests results in the formation of one shock wave of triangular shape, which is qualitatively similar to the outcome of the nonlinear interaction of two weak-amplitude waves. The formation of shock waves from

initially negative disturbances (wave troughs) is accompanied by the generation of reflected waves of negative polarity. These waves additionally influence the process of interaction. The interaction of waves of opposite polarities is possible only when the leading wave is negative (I.Didenkulova, A.Rodin in cooperation with E.Pelinovsky).

Resonant effects.
Reflection of long sea waves from an underwater slope joint with an even bottom is studied in the framework of shallow water theory. It allows estimating the role of pointwise reflection from the inflection point of the bottom profile and distributed reflection from the underwater slope. The case of nonreflecting bottom profile ($h \sim x^{4/3}$, where h is water depth and x is coordinate) is studied in detail. In this case the wave reflects from the inflection point only (pointwise reflection). The coefficients of reflection and transmission from the bottom relief are calculated. The sum of squares of their modules differs from 1 for all profiles except the nonreflecting one. This difference is explained by distributed re-reflections (resonance effects) along the underwater slope, which lead to the difference in the wave height from the known Green's law (I.Didenkulova in cooperation with E.Pelinovsky).

Generation and resonant amplification of tsunami waves, induced by underwater landslides is studied in the basin of variable depth in the framework of shallow water theory. Two different scenarios of landslide motion are considered: a) the resonant motion of the landslide of a variable volume; b) the constant-speed motion of the landslide of a constant volume. In both cases amplitude of tsunami waves varies non-monotonically in time (I.Didenkulova, I.Nikolkina in cooperation with E.Pelinovsky).

Wave dynamics in inclined bays and channels.
The problem of long wave shoaling and runup in U-shaped bays (such as fjords) and underwater canyons is studied in the framework of 1D shallow water theory with the use of an assumption of the uniform current on the cross-section. The wave shoaling in bays, when the depth varies smoothly along the channel axis, is studied with the use of asymptotic approach. In this case a weak reflection provides significant shoaling effects. The existence of traveling (progressive) waves, propagating in bays, when the water depth changes significantly along the channel axis, is studied within rigorous solutions of the shallow water theory. It is shown that traveling waves do exist for certain bay bathymetry configurations and may propagate over large distances without reflection. Wave runup in such bays is significantly larger than for a plane beach (I.Didenkulova in cooperation with E.Pelinovsky).

The case of an inclined channel of a parabolic cross-section is also studied in the framework of nonlinear shallow water theory. Nonlinear shallow water equations can in this case be written in 1D form and solved analytically with the use of the hodograph transformation. This approach generalizes the well-known Carrier-Greenspan transformation for long wave runup on a plane beach. In the case of an inclined channel of a parabolic cross-section it leads to the associated spherical symmetrical linear wave equation. The solution of the Cauchy problem can be expressed in terms of elementary functions and has a simple form for any kind of initial conditions. Wave regimes associated with various localized initial conditions, corresponding to problems of evolution and runup of N-waves and wind set-down and set-up relaxation, are considered and analyzed. Special attention is paid to the wave breaking criterion for waves at the coast, which appears to provide a condition of applicability for the hodograph transformation. The wave breaking condition is obtained and discussed for each of the studied problems (I.Didenkulova in cooperation with E.Pelinovsky).

Synergy between working groups: *Wave Engineering – Nonlinear Dynamics.*

(i) Dispersion properties of surface motions and associated spreading rates of initially closely located water particles in the surface layer of the Gulf of Finland were estimated using autonomous surface drifters. The average spreading rate increases with the increase in the distance between drifters. The typical spreading rate is about 200 m/day for separations below 0.5 km, 500 m/day for separations below 1 km and in the range of 0.5–3 km/day for separations in the range of 1–4 km. The spreading rate does not follow Richardson's law. The initial spreading, up to a distance of about 150 m, is governed by the power law with an exponent of 0.27, whereas for larger separations the distance increases proportionally to the power law with an exponent of 2.5 (T.Soomere, M.Viidebaum, J.Kalda).

(ii) Studies of waves in layered solids showed a great similarity to water waves with channels with varying depth; common efforts towards the analysis of the robustness of optimum fairways specified by different criteria (M.Berezovski, A.Berezovski).

3.2. Institute of Cybernetics: Control Systems Department

Realization of discrete-time nonlinear input-output equations: polynomial approach.
The reduction and realization problems have been solved for discrete-time multi-input multi-output nonlinear control systems by applying the theory of non-commutative polynomials. First, the necessary and sufficient reducibility condition was presented in terms of the greatest common left divisor of two polynomial matrices associated with the set of the higher order input-output (i/o) difference equations of the system. The condition also provides a method for system reduction, i.e. for finding the irreducible representation of the set of the i/o equations, being transfer equivalent to the original system representation. Second, to solve the realization problem, a formula was presented for computing the differentials of the state coordinates directly from the polynomial description of the nonlinear system. The polynomial approach addressed is more direct and requires noticeably less computations than earlier methods represented in terms of subspaces of differential one-forms (Ü.Kotta, M.Tõnso).

Kähler differentials and ordinary differentials in nonlinear control theory.
In the algebraic approach to nonlinear control systems two similar notions, namely Kähler differentials and the formal vector space of differential one-forms having the properties of ordinary differentials, are frequently used to study the systems. It has been proved that the formal vector space of differential one-forms is isomorphic to a quotient space (module) of Kähler differentials. These two modules coincide when they are modules over a ring of linear differential operators over the field of algebraic functions. Some remarks and examples demonstrating when the use of Kähler differentials might not be appropriate are also considered (Ü.Kotta).

Linear Input-Output Equivalence and Row Reducedness of Discrete-Time Nonlinear Systems.
The problem of linear input-output (i/o) equivalence of meromorphic nonlinear control systems, described by implicit higher order difference equations, is studied. It is proved that any system is linearly i/o equivalent to a row-reduced form. The constructive algorithm is given for finding the required transformation. The latter amounts to 1) multiply the set of i/o equations $\varphi = 0$ from left by a unimodular matrix $A(\delta)$, whose entries are non-commutative polynomials in the forward-shift operator δ, and 2) define certain multiplicative subset of the difference ring of analytic functions which introduces some inequations that should be satisfied (Ü.Kotta, S.Nõmm).

Control systems on regular time scales and their differential rings.
The algebraic construction of the inversive differential ring, associated with a nonlinear control system, defined on a nonhomogeneous but regular time scale has been described. The ring of meromorphic functions in system variables is constructed under the assumption that the system is submersive, and equipped with three operators (delta- and nabla-derivatives, and the forward shift operator) whose properties are studied. The formalism developed unifies the existing theories for continuous- and discrete-time nonlinear systems, and accommodates also the case of non-uniformly sampled systems. Compared with the homogeneous case the main difficulties are noncommutativity of delta (nabla) derivative and shift operators and the fact that the additional time variable t appears in the definition of the differential ring. The latter yields that the new variables of the inversive closure, depending on t, have to be chosen to be smooth at each dense point t of the time scale (Ü.Kotta).

The relationship between single- and multi-experiment observability for discrete-time nonlinear control systems.
The connection between the concepts of the single-experiment and the multi-experiment unobservability of a nonlinear discrete-time control system is studied. The main result claims that if the system is single-experiment unobservable and the observable space is integrable, then the system is also multi-experiment unobservable. For the proof of the main result a novel mathematical technique, the so-called algebra of functions, is used (V.Kaparin, Ü.Kotta).

Submersivity assumption for nonlinear control systems on homogeneous time scales.
The condition that allows construction of the s-differential fields for nonlinear control systems, described by the set of inputoutput (i/o) higher-order delta-differential equations, defined on a homogeneous time scale has been derived. This condition is related to the submersivity assumption of the extended system, associated with i/o equations, but is formulated directly in terms of i/o equations (Ü.Kotta).

Static state feedback linearizability: relationship between two methods.
The the explicit relationship between two sets of necessary and sufficient conditions for static state feedback linearizability of a discrete-time nonlinear control system has been established. A detailed algorithm is presented for finding the state coordinate transformation. Finally, the methods are compared from the point of view of computational complexity. The examples illustrate the theoretical results (T.Mullari, Ü.Kotta, M.Tõnso).

Minimal realisation of bilinear and quadratic inputoutput difference equations in state-space form. Realisability property of discrete-time bilinear and quadratic input-output (i/o) equations in the classical state-space form has been studied. Constraints on the parameters of the i/o model are suggested that lead to realizable models. Using new formulae for computing basis vectors of certain vector spaces of differential one-forms, the complete list of the third- and fourth-order realizable i/o bilinear models, and a new realizable subclass of an arbitrary order is suggested. Moreover, the sufficient conditions of the second- and third-order realizable i/o quadratic models are also given. The developed theory and algorithms are illustrated by means of several examples (J.Belikov, P.Kotta, Ü.Kotta).

Disturbance decoupling of discrete-time nonlinear systems by static measurement feedback.
The disturbance decoupling problem (DDP) has been addressed for nonlinear systems, extending the results for continuous-time systems into the discrete-time case. Sufficient conditions are given for the solvability of the problem. The notion of the rank of a one-form is used to find the static measurement feedback, that solves the DDP whenever possible. Moreover, necessary and sufficient conditions are given for single-input single-output systems as well as for multi-input

single-output systems under the additional assumption (A.Kaldmäe, Ü.Kotta).

Randomized approach to fixed-order controller design.
The problem of stabilizing fixed-structure controller design is one of the hard problems in linear control theory (NP-hard). Efficient methods for the solution of the problem are not known and cannot be devised in principle. The solution methods are either based on sufficient conditions or lean upon numerical procedures. A novel randomized approach to fixed-order controller design is proposed for discrete-time SISO plants. This is one of the mixed methods, which combines the random search of stable polynomials and the analytical design of a controller. It is based on the random generation of Schur stable polynomials using reflection coefficients and reflection segments of polynomials. Stable reflection segments are then projected onto affine set of closed-loop characteristic polynomials which is defined by the controller parameters. At last the stable line segments in the controller parameter space are determined. It is reasonable to increase the collection of stabilizing controllers by addition some generating stable polynomials with stable sets of reflection segments. Then the number of segments of stabilizing controllers increases considerably (Ü.Nurges, S.Avanessov).

Robust state controller design.
A solution to the robust pole assignment problem via reflection coefficients of polynomials is provided for discrete time SISO and MIMO linear systems. The solution is based on polytopic sufficient stability conditions formulated via reflection vectors of a family of stable polynomials. In fact the entire class of controllers attaining polytopic or interval specifications is obtained as a convex set which offers further advantages to the designer. The exact choice of intervals used in specifications is up to designer. For SISO systems a robust state controller and the polytopic uncertain plant which is stabilized by this controller have been found. For MIMO systems the problem is solved for an uncertain interval plant (Ü.Nurges).

Stable polytopes of reflection vector sets.
The convex approximation of the stability region in the polynomial coefficients space is a useful tool for many parametric robust control tasks. Much research work has been done to approximate the Schur stability domain by boxes, ellipsoids or other convex sets. The aim of the study was to find less conservative inner approximations of the stability domain by polytopes starting from different sets of reflection coefficients. First, the stability of the polytope generated by a cuboid of reflection coefficients is studied. Then the different stable polytopes of reflection vectors are investigated. At last the Schur invariant transformation is used in order to increase the volume of stable polytopes. The volumes of all these stable polytopes are calculated in order to compare the approximation quality (Ü.Nurges, S.Avanessov).

Automatization of the structural identification with application of novel goodness criteria.
Validation of identified neural networks (NN) based models and their structural identification constitute main results achieved during last year. As a first step, Combined Omni Directional Cross -Correlation Functions (ODCCF) based validation procedure were adopted to study qualitative differences between neural networks based Nonlinear Autoregressive Exogenous and Additive Nonlinear Autoregressive Exogenous (ANARX) models of the same order, identified on the basis of the same input-output data. In addition proposed technique were adjusted to allow qualitative grading of the identified NN-based models with respect to ODCCF. This enriched the set of qualitative characteristics describing goodness of identified NN-based model (S.Nõmm, Ü.Kotta).
The second and third steps were mainly made to automate the process of the model order determination and model structure adjustments. On the second step main attention were paid to the development of the algorithm to determine the order of NN-based ANARX model for the given input-output data, whereas stopping criteria was determined on the basis of ODCCF

grading and mean square error. Since in many cases model order may have the same importance as the model quality and validity an attempt to use it as qualitative characteristic of the model alongside with mean square error and ODCCF based grading were made during the third step of research. Classic genetic algorithm was applied to adjust the structure of the NN-based ANARX model, namely to simplify the structure of the corresponding network by eliminating certain connections whereas the fitness function of the algorithm were calculated on the basis of mean square error, ODCCF based grading and model order. Proposed algorithm has allowed to obtain a set of models with similar in their overall performance but differ in structure, goodness parameters and model order (S.Nõmm, J.Belikov).

Formal methods for complex robotic and embedded systems.
A model-based robot planning and control framework for human assistive robots – namely for Scrub Nurse Robots has been developed. We focus on endoscopic surgery as one of the most relevant surgery type for applying robot assistants. We have demonstrated that our framework provides means for seamless integration of sensor data capture, cognitive functions for interpretation of sensor data, model based continual planning and actuation control. The novel component of the architecture is a distributed continual planning system implemented based on the Uppaal timed automata model-based verification and control tool suite. The distributed and modular architecture of the framework enables flexible online reconfiguration and easy adaptability to various application contexts. Online learning and safety monitoring functions ensure timely and safe updates of software components on-the-fly (J.Vain, A.Anier).

Refinement based development technology supported by Event-B modelling and verification tool has been extensively used in the domain of embedded and distributed systems design. For these domains timing analysis and refinement of timing specifications are of at most importance. In its present form the Event-B lacks sufficient support for timing analysis and refinement of timed specifications yet. On the other hand, the formalisms convenient for timing and scheduling analysis such as Timed I/O Automata, timed Petri Nets etc. are less focusing on supporting refinement based development, especially data refinement. We have defined a refinement relation in terms of Uppaal Timed Automata and shown how this relation is interrelated with the data refinement relation in Event-B. Using this mapping we present a way how these two formalisms could complement each other in a refinement based design flow. The usability of the results will be demonstrated on a fragment of an industrial case study (J.Vain).

A model-based construction method of an online tester for black-box testing has been developed. Contemporary model-based online test generators focusing mainly on computationally cheap but far from optimal planning strategies cover just a fraction of the wide spectrum of test control strategies. Typical examples of those used are simple random choice and anti-ant. Exhaustive planning during online testing of nondeterministic systems looks out of reach because of the low scalability of the methods in regard to the model size. The reactive planning tester (RPT) studied is targeted to fill the gap between these two extremes. The key idea of RPT lies in offline static analysis of the IUT (implementation under test) model to prepare the data and constraints for efficient online reactive planning. The external behavior of the IUT is modelled as an output observable nondeterministic EFSM (extended finite state machine) with the assumption that all the transition paths are feasible. A test purpose is attributed to the transitions of the IUT model by a set of Boolean variables called traps that are used to measure the progress of the test run. We present a way to construct a tester that at runtime selects a suboptimal test path from trap to trap by finding the shortest path that covers unvisited traps within planning horizon. The principles of reactive planning are implemented in the form of the decision rules of selecting the shortest paths at runtime. Based on an industrial scale case study, namely the city lighting system controller, we demonstrate the practical use of the RPT for systems with high degree of nondeterminism, deep nested control loops, and requiring strictly bounded tester response

time. Tuning the planning horizon of the RPT allows a trade-off to be found between close to optimal test length and scalability of tester behavior with computationally feasible expenses (J.Vain, K.Raiend).

3.3 University of Tartu: Optics group

Nonlinear second-harmonic generation with laser beams transformed by internal conical refraction in a biaxial crystal has been studied, and several specific second-harmonic beam profiles have been demonstrated. Transformation of vortex Laguerre-Gauss laser beams by conical refraction has been studied. An original optical set-up for full spatio-temporal recording of 3D impulse responses of optical elements has been built. The set-up is based on a white-continuum laser, photonic crystal fibers, and a CCD-spectrograph. The temporal resolution 5 femtosec has been achived. Characteristic parameters (energetic positions, widths, lifetimes) of spectroscopically observed (or potentially observable) quasi-bound energy levels for the ground state H2 molecule were determined with high accuracy. A new interpretation was given to the "exotic" level E14,4, located extremely close to the molecule's dissociation limit: it turns to be a very narrow resonance with lifetime of over 5 minutes. An optimal apparatus configuration and appropriate laser treatment methods have been worked out on the basis of doubled-frequency Nd-YAG laser (532 nm, 1W). Over 20 medical laser devices are introduced in different rehabilitation centres of Tartu and Tallinn in collaboration with laser company Estla Ltd. Time-resolved excitation spectra were measured at 10K in the 4–20 eV energy range for the luminescence of self-trapped and various localized excitons in LuAG single crystals.

Time-resolved VUV-UV emission of Ar, Kr, and Xe gases (Rg), excited by a pulsed discharge, has been measured to clarify the origin of the multi-band structure of the 3^{rd} continua. This structure has been connected with Rg^{2+} ions produced in different excited states. These precursors lead to the formation of several bound excimer states Rg^{2+*}, which decay radiatively to the repulsive states $(Rg^{+} + Rg^{+})$ (P.Saari. et al.).

3.4 Research within international programmes

3.4.1 FP7 Marie Curie Re-integration grant ESTSpline (FP7-PEOPLE-2007-2-2-ERG) "Educational, Scientific and Technological aspects of Splines"(01.05.2008–30.04.2011), Principal Scientist E.Quak.

The ESTSpline project was designed to given an edge in applied mathematics to the Institute of Cybernetics by providing funding to establish the Wave Engineering Laboratory. The funding enabled establishment of a two-member administration team for the Wave Lab, critically important to its function as the researchers were freed from administrative tasks and able to focus on the research at hand, in particular, on industrial application of three-dimensional geometric modelling. This funding also enabled the realisation of an applied mathematics and visualization laboratory at the TUT in Estonia that has blossomed and whose team has already made significant contributions in co-operation with the Re-integration grant ESTWave also located at the Institute of Cybernetics. With the official approval by the EC Research Executive Agency (REA) of the final reporting after the end of the project period, the ESTSpline project is now successfully concluded.

3.4.2 FP7 Marie Curie Initial Training Network (FP7-PEOPLE-1-1-ITN) Shapes, Geometry, Algebra www.saga-network.eu (01.11.2008–31.10.2012), 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 deals 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 major event of this network was the SAGA Fall School in Vilnius, Lithuania, September 27–30, with survey presentations by eminent international scientists in this field, for example Carl de Boor, professor emeritus of the University of Wisconson-Madison and 2003 recipient of the US national Medal of Science in mathematics. The Fall School was co-organized by Ewald Quak, who also gave an overview presentation on EU research funding.

3.4.3 BONUS+ (Baltic Organisations' Network for Funding Science) project BalticWay "The potential of currents for environmental management of the Baltic Sea maritime industry"(2009 – 2011). Collaboration with the Swedish Meteorological and Hydrological Institute (Norrköping), Laser Diagnostic Instruments (Tallinn), Danish Meteorological Institute, Department of Meteorology, University of Stockholm, Institute for Coastal Research, GKSS Geesthacht, Finnish Institute of Marine Research, and Leibniz Institute of Marine Sciences at the University of Kiel. Project coordinator T.Soomere.

The ever increasing impact of the marine industry on vulnerable sea areas such as the Baltic Sea, and especially the increase in risks associated with potential oil pollution from ship traffic or oil platforms, calls for novel methods for mitigating beforehand the impact of such risks on vulnerable areas. The BalticWay project aims at developing the innovative concept of fairway design to reduce the danger to vulnerable areas through a substantial decrease of marine-industry-induced environmental risks and impacts on bio-diversity, particularly on fragile ecosystems. The core objective is to develop a scientific platform for a low-cost technology of environmental management of shipping, offshore, and coastal engineering activities. The focus is on methods for preventive reduction of offshore environmental risks that are transported by surface currents to the coasts. By placing maritime activities in the safest offshore areas, the consequences of potential accidents can be minimised before they occur.

The approach makes use of the existence of semi-persistent current patterns that considerably affect the properties of pollution propagation. The investigations concentrate on the Gulf of Finland and the Darss Sill. The offshore areas of these basins have been quantified in terms of the probability for the pollution released in a particular spot to reach the beach and the time it usually takes for the pollution to reach the coast. The results have been applied for suggesting optimisation of ship routes in terms of minimising the risk of coastal pollution. For example, in the Gulf of Finland the gain from the use of the optimum fairway is about 40% in terms of the decrease in the probability of coastal pollution. The use of the optimum fairways may almost double the typical time it takes for the pollution to reach the coast.

3.4.4. Operational partnership in the the FP7/Horizon2020 Future and Emerging Technologies pilot project FuturICT. Estonian national coordinator T.Soomere.

FuturICT has the ambition to be at the heart of a revolutionary 21st Century science, which will use and develop information and communication technologies (ICT) to create a decision support system, combining data with models in order to solve the grand challenges humanity is facing. FuturICT will lift our knowledge of social and economic systems to a new level of understanding, enabling us to discover promising paths towards a sustainable future.

3.4.5 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.

3.4.6 NordForsk (Coordinating and Funding Nordic Research Advisory Body on Nordic Research Policy) project "Nordic Network on Dependability – NODES"2006–2011 (Member of board: J.Vain).

3.4.7 COST Action IC0801 – "Agreement Technologies", (2009–2012), http://www.agreement-technologies.eu/.

3.4.8 Estonian-Polish joint research project under the agreement on scientific cooperation 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).

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.

4.2 Estonian grants (Estonian Science Foundation)

1. H.Aben, ETF grant 7840, "Complex algorithms for tomography of photoelasticity" (2009–2011).
2. T.Soomere, ETF grant 7413, "Spatial and temporal variability of the Baltic Sea wave fields in changing climatic conditions" (2008–2011).
3. I.Didenkulova, Grant 8870, "Wave induced hazards in Estonian coastal waters" (2011–2014).
4. J.Kalda, ETF grant 7909, "The role of turbulent mixing in the dynamics of the complex systems" (2009–2012).
5. J.Vain, ETF grant 7667, "Synthesis of model-based reactive planners for nondeterministic and distributed systems" (2008–2011).
6. M.Vendelin, ETF grant 7344, "Mechanoenergetics of an isolated single cardiomyocyte" (2008–2011).

7. R.Savimaa, ETF grant 7693, “Modelling of time-sensitive processes and emergent behaviour in multi-functional and virtual organisations” (2008–2011).
8. J.Janno, ETF grant 7728, “Inverse problems for materials with complex properties” (2009–2012).
9. R.Birkedal, ETF grant 8041, “Role of the Na+/Ca2+-exchanger in excitation-contraction coupling and energetics in rainbow trout cardiomyocytes” (2009–2012).
10. S.Nõmm, ETF grant 8365, “Modeling and recognition of human gestures” (2010–2013).
11. M.Tõnso, ETF grant 8787, “Computer algebra methods in control” (2011–2014).
12. M.Selg, ETF grant 7318, “Dynamics of neutral and ionized excimers in rare gases, their plasmas and crystals” (2008–2011).
13. V.Peet, ETF grant 7971, “Nonlinear optical effects and laser light conversion in gases and solids” (2009–2012).
14. P.Saari, ETF grant 7870, “Femtosecond optics of linear and nonlinear localized waves” (2009–2012).

4.3 International grants (see also 3.4)

1. Wellcome Trust International Senior Research Fellowship (2007–2012) – M.Vendelin.
2. Feodor Lynen fellowship of the German Alexander von Humboldt foundation (initially awarded 2008–2011) – H.Herrmann.
3. MOBILITAS Top Researcher Grant MTT63 “Numerical particle tracking modeling for inhomogeneous turbulent water basins” (2011–2015) – T.Torsvik.

4.4 Additional funding

1. Institute of Cybernetics at TUT – basic funding.
2. Grant from Tallinn University of Technology for a TUT Centre of Excellence.
3. Estonian Programme for Centres of Excellence (from August 2011).

4.5 Supportive grants (travel, etc.)

1. A.Kaldmäe, J.Belikov, European Embedded Control Institute grants for attending HYCON-EECI Graduate School on Control, 28.02.2011–2.03.2011.
2. J.Belikov, SA Archimedes Kristjan Jaak grant for attending HYCON-EECI Graduate School on Control, 28.02.11–2.03.11.
3. J.Belikov, SA Archimedes Kristjan Jaak grant for attending 2011 International Joint Conference on Neural Networks, San Jose, USA, 31.07.2011–5.08.2011.
4. T.Mullari, EITSA travel grant for attending the 31st IASTED International Conference on Modelling, Identification, and Control, Innsbruck, Austria, 14.02.2011–16.02.2011.

5. S.Nõmm, EITSA travel grant for attending 2011 International Joint Conference on Neural Networks, San Jose, USA, 31.07.2011–5.08.2011.

6. J.Belikov, M.Tõnso, T.Mullari, EITSA travel grant for attending IFAC World Congress 2011, Milan, Italy, 28.08.2011–2.09.2011.

7. J.Belikov, EITSA travel grant for attending the 50th IEEE Conference on Decision and Control and European Control Conference, Orlando, Florida, USA, 12.12.2011–15.12.2011 and for attending the 9th IEEE International Conference on Control & Automation, Santiago, Chile, 19.12.2011–21.12.2011.

8. V.Kaparin, Ü.Nurges, EITSA travel grants for attending the 9th IEEE International Conference on Control & Automation, Santiago, Chile, 19.12.2011–21.12.2011.

9. A.Kaldmäe, Doctoral Studies and Internationalisation Programme DoRa grant for attending HYCON-EECI Graduate School on Control, 28.02.11–2.03.11.

10. J.Belikov, A.Kaldmäe, Doctoral Studies and Internationalisation Programme DoRa grant for attending 18th International Conference on Process Control, Strbske Pleso, High Tatras, Slovak Republic, 14.06.2011–17.06.2011.

11. J.Belikov, Doctoral Studies and Internationalisation Programme DoRa grant for attending 2011 International Joint Conference on Neural Networks, San Jose, USA, 31.07.2011–5.08.2011.

12. J.Belikov, Doctoral Studies and Internationalisation Programme DoRa grant for attending IFAC World Congress 2011, Milan, Italy, 28.08.2011–2.09.2011.

13. D.Kartofelev, Doctoral Studies and Internationalisation Programme DoRa grant for attending Symposium on the Acoustics of Poro-Elastic Materials Italy, Ferrara, 14.12.2011–16.12.2011.

14. A.Rodin, Doctoral Studies and Internationalisation, Programme DoRa 8 travel grant for attending European Geosciences Union General Assembly 2011, Vienna, Austria, 3.04.2011–8.04.2011.

15. M.Berezovski, Doctoral Studies and Internationalisation Programme DoRa travel grant to attend the 3rd International Conference for Heterogeneous Materials Mechanics (ICHMM 2011), Shanghai, China, 22.05.2011–26.05.2011.

16. M.Berezovski, SA Archimedes Kristjan Jaak grant to attend the 21st International Workshop on Computational Mechanics of Materials, 2011 Limerick, Ireland, 22.08.2011–24.08.2011.

5. Publicity of Results

5.1.1 Research Reports

1.	Mech 301/11.	A.Berezovski. Numerical simulation of thermal microstructure effects.
2.	Mech 302/11.	CENS. Recent Problems on Dispersive Waves.
3.	Mech 303/11.	T.Soomere. Changes to coastal processes in the vicinity of Aegna jetty resulting from the reconstruction works.

5.1.2 Lecture Notes

1.	Mech 8/2011	A.Berezovski, Introduction to Fracture Mechanics.
2.	E-course in Moodle	P.Saari, Quantum computing and Cryptography; http://moodle.ut.ee/

5.2 Publications

5.2.1 Books, proceedings and theses

1. J.Janno J.Engelbrecht. Microstructured Materials: Inverse Problems. - Berlin: Springer, 2011, 160 pp.

2. Vibration Problems ICOVP 2011: Supplement, The 10th International Conference on Vibration Problems, [Prague, September 5–8, 2011] / Eds. Š.Segl'a, J.Tuma, I.Petríková, L.Pešek, J.Zapoměl, A.Kruisová, O.Gendelman, A.Berezovski. - Liberec: Technical University of Liberec, 2011. 546 p.

3. T.Peets. Dispersion analysis of wave motion in microstructured solids. PhD thesis, TUT Press, Tallinn, 2011.

4. K.Tamm. Wave propagation and interaction in Mindlin-type microstructured solids: numerical simulation. PhD thesis, TUT Press, Tallinn, 2011.

5.2.2 Papers (refereed)

IoC Department of Mechanics and Applied Mathematics

1. J.Engelbrecht, A.Salupere, K.Tamm. Waves in microstructured solids and the Boussinesq paradigm. - Wave Motion, 2011, 48, 8, 717-726.

2. A.Berezovski, J.Engelbrecht, G.A.Maugin. Thermoelasticity with dual internal variables. - J. Thermal Stresses, 2011, 34, 5-6, 413-430.

3. A.Berezovski, J.Engelbrecht, G.A.Maugin. Generalized thermomechanics with dual internal variables. - Archive of Applied Mechanics, 2011, 81, 2, 229-240.

4. A.Berezovski, J.Engelbrecht, M.Berezovski. Dispersive wave equations for solids with microstructure. - In: Vibration Problems ICOVP 2011 : The 10th Int.l Conf. Vibration Problems / Eds. J.Náprstek [et al.]. Dordrecht : Springer Proc. in Physics 139, 2011, 699-705.

5. A.Berezovski, J.Engelbrecht, M.Berezovski. Waves in microstructured solids: a unified viewpoint of modeling. - Acta Mechanica, 2011, 220, 1-4, 349-363.

6. M.Berezovski, A.Berezovski, J.Engelbrecht. Wave propagation in heterogeneous materials with secondary substructure. - In: Advances in Heterogeneous Material Mechanics (2011) : Proc. Third Int. Conf., May 22-26, 2011, Shanghai, China / Eds. J. Fan [et al.]. Lancaster : DEStech Publications, Inc., 2011, 531-534.

7. A.Berezovski. Thermodynamic interpretation of finite volume algorithms. - J. Structural Mechanics, 2011, 44, 3, 156-171.

8. M.Rousseau, G.A.Maugin, M.Berezovski. Elements of study on dynamic materials. - Arch. Appl. Mech., 2011, 81/7, 925-942.

9. H.Herrmann, M.Eik. Some comments on the theory of short fibre reinforced materials. - Proc. Estonian Acad. Sci., 2011, 60, 3, 179-183.

10. M.Eik, J.Puttonen. Challenges of steel fibre reinforced concrete in load bearing structures. - Rakenteiden mekaniikka, 44(1), 44-64.

11. J.Janno, J.Engelbrecht. Inverse problems for microstructured materials. - In: ECCOMAS Thematic Conference on Inverse Problems in Mechanics of Structures and Materials, IPM 2011 : Conf. Proc., 27–30 April 2011, Rzeszów-Sieniawa, Poland / Eds. Z.Waszczyszyn, L.Ziemianski. Rzeszów : Rzeszów Univ. of Technology Publishing House, 2011, 43-44.

12. J.Kalda. k-spectrum of decaying, aging and growing passive scalars in Lagrangian chaotic fluid flows. - J. Physics: Conference Series, 2011, 318, 052045 (6pp).

13. T.Kaevand, J.Kalda, V.Kukk, A.Öpik, Ü.Lille. Correlation of the morphology and electrical conductivity in thin films of PEDT/PSS complex: an integrated meso-scale simulation study. - Molecular Simulation, 2011, 37(6), 495-502.

14. J.Jõgi, M.Järvekülg, J.Kalda, A.Salundi, V.Reedo, A.Lõhmus. Simulation of cracking of metal alkoxide gel film formed on viscous precursor layer using a spring-block model. - EPL - A Letters J. Exploring the Frontiers of Physics, 2011, 95(6), 64005-p1-64005-p6.

15. I.Mandre, J.Kalda. Monte-Carlo study of scaling exponents of rough surfaces and correlated percolation. - The European Physical J. B - Condensed Matter, 2011, 107-113.

16. A.Ravasoo. Counter-propagation of harmonic waves in exponentially graded materials. - J. Sound and Vibration, 2011, 330, 16, 3874-3882.

17. M.Rousseau, G.A.Maugin, M.Berezovski. Elements of study on dynamic materials. - Archive of Applied Mechanics, 2011, 81, 7, 925-942.

18. K.Tamm, A.Salupere. On the emergence of asymmetric waves in the Mindlin-Engelbrecht-Pastrone model. - In: Proc. 24th Nordic Seminar on Computational Mechanics [NSCM24] / Eds. J.Freund, R.Kouhia. Aalto : Aalto University, 2011, 99-102. (Aalto Univ. publication series SCIENCE + TECHNOLOGY ; 23).

Laboratory of Systems Biology

19. N.Jepihhina, N.Beraud, M.Sepp, R.Birkedal, M.Vendelin. Permeabilized rat cardiomyocyte response demonstrates intracellular origin of diffusion obstacles. - Biophysical J., 2011, 101, 9, 2112-2121.

20. M.Laasmaa, M.Vendelin, P.Peterson. Application of regularized Richardson-Lucy algorithm for deconvolution of confocal microscopy images. - J. Microscopy, 2011, 243, 2, 124-140.

21. D.W.Schryer, M.Vendelin, P.Peterson. Symbolic flux analysis for genome-scale metabolic networks. - BMC Systems Biology, 2011, 5: 81.

22. H.R.Ramay, O.Z.Liu, E.A.Sobie. Recovery of cardiac calcium release is controlled by sarcoplasmic reticulum refilling and ryanodine receptor sensitivity. - Cardiovascular Research, 2011, 91(4), 598605.

Laboratory of Photoelasticity

23. H.Aben, L.Ainola, A.Errapart. Photoelastic tomography as hybrid mechanics. - In: Recent Advances in Mechanics : Selected Papers from the Symposium, Academy of Athens, Athens, Greece, 17–19 September, 2009, Organised by the Pericles S.Theocaris Foundation in Honour of P.S.Theocaris, on the Tenth Anniversary of His Death / Eds. A.N.Kounadis, E.E.Gdoutos. Heidelberg : Springer, 2011, 181-190.

24. J.Anton, A.Errapart, M.Paemurru, D.Lochegnies, S.Hödermann, H.Aben. On the inhomogeneity on residual stresses in tempered glass panels. - In: Glass Performance Days [GPD 2011] : Conf. Proc., 17–20 June, Tampere, Finland. Tampere : Glaston Finland OY, 2011, 119-121.

25. A.Errapart, H.Aben, L.Ainola, J.Anton. Photoelastic tomography for the measurement of thermal and residual stresses in glass. - In: Thermal Stresses 2011 [9th Inter. Congress, June 5–9, 2011, Budapest] : with Naotake Noda Symposium, Budapest, Hungary. Budapest : Budapest Univ. of Technology and Economics; Hungarian Acad. Sci., Budapest, Hungary, 2011, 1-4.

26. A.Errapart. Determination of all stress components of axisymmetric stress state in photoelastic tomography. - In: Advances in Experimental Mechanics VIII : Selected, peer-reviewed papers of the 8th Intern. Conf. on Advances in Experimental Mechanics: Integrating Simulation and Experimentation for Validation, (BSSM 2011), September 7–9 2011, Edinburgh, Scotland / Eds. R.L.Burguete [et al.]. Durnten-Zuerich : Trans Tech Publications, 2011, 434-439.

27. S.Hödemann, J.Kikas, H.Aben, J.Anton, A.Errapart. Effects of ray bending in scattered light photoelasticity for tempered and annealed glass plates. - In: Advances in Experimental Mechanics VIII : Selected, peer-reviewed papers of the 8th Int. Conf. on Advances in Experimental Mechanics: Integrating Simulation and Experimentation for Validation, (BSSM 2011), September 7–9 2011, Edinburgh, Scotland / Eds. R.L.Burguete [et al.]. Dumten-Zuerich, 2011, 440-445.

28. A.Errapart, H.Aben. Photoelastic tomography in the axisymmetric and non-axisymmetric case. - Forum on recent developments in Volume Reconstruction techniques applied to 3D fluid and solid mechanics 2011. Futuroscope-Poitiers, France, 2011, 127-130.

29. H.Aben, A.Errapart. Photoelastic tomography with linear and non-linear algorithms. - Exp. Mech., 2011, vol. 51, DOI 10.1007/s11340-011-9575-z, 15p.

Laboratory of Wave Engineering

30. I.Didenkulova, E.Pelinovsky. Rogue waves in nonlinear hyperbolic systems (shallow-water framework). - Nonlinearity, 2011, 24 (3), R1-R18.

31. I.Didenkulova, E.Pelinovsky, A.Sergeeva. Statistical characteristics of long waves nearshore. - Coastal Engineering, 2011, 58 (1), 94-102.

32. I.Didenkulova, I.Nikolkina, E.Pelinovsky. Resonant amplification of tsunami waves generated by an underwater landslide. - Doklady Earth Sciences, 2011, 436 (1), 66-69.

33. T.Soomere, A.Räämet. Long-term spatial variations in the Baltic Sea wave fields. - Ocean Science, 2011, 7 (1), 141-150.

34. T.Soomere, N.Delpeche, B.Viikmäe, E.Quak, H.E.M.Meier, K.Döös. Patterns of current-induced transport in the surface layer of the Gulf of Finland. - Boreal Environment Research, 2011, 16 (Supplement A), 49-63.

35. D.Ryabchuk, A.Kolesov, B.Chubarenko, M.Spiridonov, D.Kurennoy, T.Soomere. Coastal erosion processes in the eastern Gulf of Finland and their links with geological and hydrometeorological factors. - Boreal Environment Research, 2011, 16 (Supplement A), 117-137.

36. I.Didenkulova. Shapes of freak waves in the coastal zone of the Baltic Sea (Tallinn Bay). - Boreal Environment Research, 2011, 16 (Supplement A), 138-148.

37. T.Soomere, I.Zaitseva-Pärnaste, A.Räämet. Variations in wave conditions in Estonian coastal waters from weekly to decadal scales. - Boreal Environment Research, 2011, 16 (Supplement A), 175-190.

38. L.Kelpšaite, I.Dailidiene, T.Soomere. Changes in wave dynamics at the south-eastern coast of the Baltic Proper during 1993-2008. - Boreal Environment Research, 2011, 16 (Supplement A), 220-232.

39. I.Didenkulova, E.Pelinovsky. Runup of tsunami waves in U-shaped bays. - Pure and Applied Geophysics, 2011, 168 (6-7), 1239-1249.

40. I.Didenkulova, E.Pelinovsky, T.Soomere, K.E.Parnell. Beach profile change caused by vessel wakes and wind waves in Tallinn Bay, the Baltic Sea. - J. Coastal Research, 2011, Special Issue 64, 60-64.

41. K.Kartau, T.Soomere, H.Tõnisson. Quantification of sediment loss from semi-sheltered beaches: a case study of Valgerand Beach, Pärnu Bay, the Baltic Sea. - J. Coastal Research, 2011, Special Issue 64, 100-104.

42. D.Kurennoy, K.E.Parnell, T.Soomere. Fast-ferry generated waves in south-west Tallinn Bay.- J. Coastal Research, 2011, Special Issue 64, 165-169.

43. I.Zaitseva-Pärnaste, T.Soomere, O.Tribštok. Spatial variations in the wave climate change in the eastern part of the Baltic Sea. - J. Coastal Research, 2011, Special Issue 64, 195-199.

44. A.Räämet, T.Soomere. Spatial variations in the wave climate change in the Baltic Sea. - J. Coastal Research, 2011, Special Issue 64, 240-244.

45. T.Soomere, O.Andrejev, A.Sokolov, E.Quak. Management of coastal pollution by means of smart placement of human activities. - J. Coastal Research, 2011, Special Issue 64, 951-955.

46. B.Viikmäe, T.Soomere, K.E.Parnell, N.Delpeche. Spatial planning of shipping and offshore activities in the Baltic Sea using Lagrangian trajectories. - J. Coastal Research, 2011, Special Issue 64, 956-960.

47. O.Kurkina, E.Pelinovsky, T.Talipova, T.Soomere. Mapping the internal wave field in the Baltic Sea in the context of sediment transport in shallow water. - J. Coastal Research, 2011, Special Issue 64, 2042-2047.

48. O.Andrejev, T.Soomere, A.Sokolov, K.Myrberg. The role of spatial resolution of a three-dimensional hydrodynamic model for marine transport risk assessment. - Oceanologia, 2011, 53 (1-TI), 309-334.

49. T.Soomere, A.Räämet. Spatial patterns of the wave climate in the Baltic Proper and the Gulf of Finland. - Oceanologia, 2011, 53 (1-TI), 335-371.

50. T.Soomere, K.E.Parnell, I.Didenkulova. Water transport in wake waves from high-speed vessels. - J. Marine Systems, 2011, 88 (1), 74-81.

51. O.E.Kurkina, T.G.Talipova. Huge internal waves in the vicinity of the Spitsbergen Island (Barents Sea). - Natural Hazards and Earth System Sciences, 2011, 11 (3), 981-986.

52. T.Soomere, O.Andrejev, A.Sokolov, K.Myrberg. The use of Lagrangian trajectories for identification the environmentally safe fairway. - Marine Pollution Bulletin, 2011, 62 (7), 1410-1420.

53. I.Didenkulova, E.Pelinovsky. Reflection of a long wave from an underwater slope. - Oceanology, 2011, 51 (4), 568-573.

54. I.Didenkulova, E.Pelinovsky. Nonlinear wave evolution and runup in an inclined channel of a parabolic cross-section. - Physics of Fluids, 2011, 23 (8), Art. No. 086602.

55. T.Soomere, M.Berezovski, E.Quak, B.Viikmäe. Modeling environmentally friendly fairways using Lagrangian trajectories: a case study for the Gulf of Finland, the Baltic Sea. - Ocean Dynamics, 2011, 61 (10), 1669-1680.

56. I.Didenkulova, T.Soomere. Formation of two-section cross-shore profile under joint influence of random short waves and groups of long waves. - Marine Geology, 2011, 289 (1-4), 29-33.

57. A.Slunyaev, I.Didenkulova, E.Pelinovsky. Rogue Waters. - Contemporary Physics, 2011, 52 (6), 571-590.

58. I.Nikolkina, I.Didenkulova. Rogue waves in 2006–2010. - Natural Hazards and Earth System Sciences, 2011, 11 (11), 2913-2924.

59. I.Didenkulova, E.Pelinovsky, T.Soomere. - Can the waves generated by fast ferries be a physical model of tsunami? Pure and Applied Geophysics, 2011, 168 (11), 2071-2082.

60. O.E.Kurkina, A.A.Kurkin, T.Soomere, E.N.Pelinovsky, E.A.Rouvinskaya. Higher-order (2+4) Korteweg-de Vries-like equation for interfacial waves in a symmetric three-layer fluid. - Physics of Fluids, 2011, 23 (11), Art. No. 116602, 13 pp.

61. T.Soomere, M.Viidebaum, J.Kalda. On dispersion properties of surface motions in the Gulf of Finland. - Proc. Est. Acad. Sci., 2011, 60 (4), 269-279.

62. P.Denissenko, I.Didenkulova, E.Pelinovsky, J.Pearson. Influence of the nonlinearity on statistical characteristics of long wave runup. - Nonlinear Processes in Geophysics, 2011, 18 (6), 967-975.

63. T.Soomere, T.Healy. On the dynamics of "almost equilibrium"beaches in semi-sheltered bays along the southern coast of the Gulf of Finland. - In: The Baltic Sea Basin (J.Harff, S.Björck, P.Hoth, eds.). Central and Eastern European Development Studies, Part 5, Springer, 2011, Heidelberg Dordrecht London New York, 255-279.

64. I.Didenkulova, M.Viška, D.Kurennoy. Change of the coast profile under the joint effect of ship and wind waves. - Fundamental and Applied Hydrophysics, 2011, 4 (2), 66-78.

65. T.Soomere, R.Weisse, A.Behrens. Wave climatology in the Arkona basin, the Baltic Sea. - Ocean Science Discussions, 2011, 8 (6), 2237-2270.

66. I.Didenkulova, E.Pelinovsky, A.Rodin. Nonlinear interaction of large-amplitude unidirectional waves in shallow water. - Est. J. Eng., 2011, 17 (4), 289-300.

67. T.Soomere, M.Viška, L.Lapinskis, A.Räämet. Linking wave loads with the intensity of coastal processes along the eastern Baltic Sea coasts. - Est. J. Eng., 2011, 17 (4), 359-374.

68. T.Soomere, O.Kurkina. Statistics of extreme wave conditions in the south-western Baltic Sea). Fundamental and Applied Hydrophysics, 2011, 4 (4), 43-57 (in Russian).

69. T.Soomere. Contribution of fundamental research towards solving challenges of changing times in coastal science and management, Research in Estonia (J.Engelbrecht and G.Varlamova, eds.). Estonian Academy of Sciences, 2011, Tallinn, 206-226.

IoC Department of Control Systems

70. Z.Bartosiewicz, Ü.Kotta, E.Pawluszewicz, M.Wyrwas. Control systems on regular time scales and their differential rings. - MCSS : Mathematics of Control, Signals, and Systems, 2011, 22, 3, 185-201.

71. J.Belikov, M.Halás, Ü.Kotta, C.H.Moog. Model Matching Problem for Discrete-time Nonlinear Systems: Transfer Function Approach. - In: Proc. 9th IEEE Int. Conf. on Control and Automation, ICCA 2011, Santiago, Chile, December 19–21, 2011, 360-365.

72. J.Belikov, P.Kotta, Ü.Kotta, A.S.I.Zinober. Minimal realisation of bilinear and quadratic input-output difference equations in state-space form (online first). - Int. J. of Control, 2011, 84, 12, 2024-2034.

73. J.Belikov, Ü.Kotta, A.Leibak. Transfer matrix and its Jacobson form for nonlinear systems on time scales: Mathematica implementation. - In: Full Papers : 18th Int. Conf. Process Control '11 : June 14–17, 2011, Tatranská Lomnica, Slovakia / Eds. M.Fikar, M.Kvasnica. Bratislava : Slovak Univ. of Technology, 2011, 141-146.

74. J.Belikov, E.Petlenkov. Region of admissible values for discrete-time nonlinear control system linearized by output feedback. - In: Preprints of the 18th IFAC World Congress : August 28 – September 2, 2011, Milano, Italy / Eds. S.Bittanti [et al.]. Milano : IFAC, 2011, 209-214.

75. J.Belikov, Ü.Kotta, M.Tõnso. An explicit formula for computation of the state coordinates for nonlinear i/o equation. - In: Preprints of the 18th IFAC World Congress : August 28 – September 2, 2011, Milano, Italy / Eds. S.Bittanti [et al.]. Milano : IFAC, 2011, 7221-7226.

76. J.Belikov, Ü.Kotta, M.Tõnso. Minimal realization of nonlinear MIMO equations in state-space form: polynomial approach. - In: Proc. 50th IEEE Conf. on Decision and Control and European Control Conference, CDC-ECC 2011, Orlando, FL, USA, December 12–15, 2011, 7735-7740.

77. J.Belikov, Ü.Kotta, M.Tõnso. On Applicability of LPV Tools for Bilinear Systems. - In: Proc. 9th IEEE Int. Conf. on Control and Automation, ICCA 2011, Santiago, Chile, December 19–21, 2011, 366-371.

78. Ü.Kotta, P.Kotta, M.Tõnso, M.Halás. State-Space Realization of Nonlinear Input-Output Equations: Unification and Extension via Pseudo-Linear Algebra. - In: Proc. 9th IEEE Int. Conf. on Control and Automation, ICCA 2011, Santiago, Chile, December 19–21, 2011, 354-359.

79. J.Belikov, E.Petlenkov. Neuro-fuzzy dynamic pole placement control of nonlinear discrete-time systems. - In: The 2011 Int. Joint Conf. on Neural Networks, IJCNN 2011 Conf. Proc. : San Jose, California, USA, July 31 – August 5, 2011. Piscataway, NJ : IEEE, 2011, 1577-1582.

80. G.Fu, M.Halás, Ü.Kotta, Z.Li. Some remarks on Kähler differentials and ordinary differentials in nonlinear control theory. - Systems & Control Letters, 2011, 60, 9, 699-703.

81. A.Kaldmäe, Ü.Kotta. Disturbance decoupling of discrete-time nonlinear systems by static measurement feedback. - In: Full Papers : 18th Int. Conf. on Process Control '11 : June 14–17, 2011, Tatranská Lomnica, Slovakia / Eds. M.Fikar, M.Kvasnica. Bratislava : Slovak Univ. of Technology, 2011, 135-140.

82. V.Kaparin, Ü.Kotta. Extended Observer Form for Discrete-Time Nonlinear Control Systems. - In: Proc. 9th IEEE Int. Conf. on Control and Automation, ICCA 2011, Santiago, Chile, December 19–21, 2011, 507-512.

83. V.Kaparin, Ü.Kotta, A.Ye.Shumsky, A.N.Zhirabok. A note on the relationship between single- and multi-experiment observability for discrete-time nonlinear control systems. - Proc. Estonian Acad. Sci., 2011, 60, 3, 174-178.

84. Ü.Kotta, M.Tõnso. Relationship between two polynomial realization methods. - In: Full Papers : 18th Int. Conf. on Process Control '11 : June 14–17, 2011, Tatranská Lomnica, Slovakia / Eds. M.Fikar, M.Kvasnica. Bratislava : Slovak Univ. of Technology, 2011, 147-152.

85. Ü.Kotta, A.Ye.Shumsky, A.N.Zhirabok. Output feedback disturbance decoupling in discrete-time nonlinear systems. - In: Proc. of the 18th IFAC World Congress : Milano, Italy, August 28 – September 2, 2011 / Eds. S.Bittanti [et al.]. Milano : IFAC, 2011, 239-244.

86. Ü.Kotta, T.Mullari, A.Ye.Shumsky, A.N.Zhirabok. Accessibility and feedback linearization for SISO discrete-time nonlinear systems: new tools. - In: Full Papers : 18th Int. Conf. on Process Control '11 : June 14–17, 2011, Tatranská Lomnica, Slovakia / Eds. M.Fikar, M.Kvasnica. Bratislava : Slovak Univ. of Technology, 2011, 153-161.

87. Ü.Kotta, B.Rehak, M.Wyrwas. On submersivity assumption for nonlinear control systems on homogeneous time scales. - Proc. Estonian Acad. Sci., 2011, 60, 1, 25-37.

88. Ü.Kotta, Z.Bartosiewicz, S.Nõmm, E.Pawluszewicz. Linear input-output equivalence and row reducedness of discrete-time nonlinear systems. - IEEE Transactions on Automatic Control, 2011, 56, 6, 1421-1426.

89. T.Mullari, Ü.Kotta, Z.Bartosiewicz, E.Pawluszewicz. Discrete-time Lie derivative with respect to system dynamics. - In: Preprints of the 18th IFAC World Congress : August 28 – September 2, 2011, Milano, Italy / Eds. S.Bittanti [et al.]. Milano : IFAC, 2011, 11000-11005.

90. T.Mullari, Ü.Kotta, M.Tõnso. Static state feedback linearizability: relationship between two methods. - Proc. Estonian Acad. Sci., 2011, 60, 2, 121-135.

91. T.Mullari, Ü.Kotta. Simple conditions for the existence of an extended observer form. - In: Proc. 31st IASTED Int. Conf. on Modelling, Identification, and Control [MIC] : February 14 – 16, 2011, Innsbruck, Austria / Ed. M.H.Hamza. [Calgary : Acta Press], 2011, 348-355.

92. Ü.Nurges. Robust state controller via reflection coefficient assignment. - Proc. Est. Acad. Sci., 2011, 60, 1, 38-47.

93. Ü.Nurges. Discussion on: "On the generation of random stable polynomials". - European J. Control, 2011, 17, 2, 160-161.

94. Ü.Nurges, S.Avanessov. Fixed order stabilizing controller design via reflection segments of polynomials. - In: 2011 19th Mediterranean Conf. on Control and Automation (MED) : June 20–23, 2011, Aquis Corfu Holiday Palace, Corfu, Greece. Corfu : IEEE, 2011, 225-229.

95. Ü.Nurges, S.Avanessov. Four types of stable polytopes via reflection coefficients of polynomials. - In: Proc. 18th IFAC World Congress : Milano, Italy, August 28–September 2, 2011 / Eds. S.Bittanti [et al.]. Milano : IFAC, 2011, 6646-6650.

96. Ü.Nurges, S.Avanessov. Stability Domain of Fixed Order Controllers via Reflection Segments of Polynomials. - In: Proc. 9th IEEE Int. Conf. on Control and Automation, ICCA 2011, Santiago, Chile, December 19–21, 2011, 112-117.

97. S.Nõmm, J.Belikov. Online identification of the system order with ANARX structure. - In: Adaptive and Intelligent Systems : Second International Conference, ICAIS 2011, Klagenfurt, Austria, September 6–8, 2011, Proc. / Ed. A.Bouchachia. Berlin : Springer, 2011, 5-15. (Lecture Notes in Artificial Intelligence ; 6943).

98. S.Nõmm, Ü.Kotta. Comparison of neural networks-based ANARX and NARX models by application of correlation tests. - In: The 2011 Int. Joint Conf. on Neural Networks, IJCNN 2011 Conf. Proc. : San Jose, California, USA, July 31 – August 5, 2011. Piscataway, NJ : IEEE, 2011, 2113-2118.

99. S.Nõmm, K.Vassiljeva, J.Belikov, E.Petlenkov. Structure Identification of NN-ANARX Model by Genetic Algorithm with Combined Cross-correlation-test Based Evaluation Function. - In: Proc. 9th IEEE Int. Conf. on Control and Automation, ICCA 2011, Santiago, Chile, December 19–21, 2011, 65-70.

100. R.Tenno, S.Nõmm. Partially Observed Stochastic Bilinear System Control. - In: Proc. 9th IEEE Int. Conf. on Control and Automation, ICCA 2011, Santiago, Chile, December 19–21, 2011, 951-956.

101. A.Tepljakov, E.Petlenkov, J.Belikov. FOMCON: Fractional-order modeling and control toolbox for MATLAB. - In: Proceedings of the 18th Int. Conf. Mixed Design of Integrated Circuits and Systems, MIXDES 2011 : Gliwice, Poland 16–18 June, 2011, Mixed Design of Integrated Circuits and Systems (MIXDES), 2011 Proc. of the 18th Int. Conf. / Ed. A.Napieralski : IEEE, 16-6-2011, 684-689.

102. J.Vain, M.Kääramees, M.Markvardt. Online testing of nondeterministic systems with reactive planning tester. - In: Dependability and Computer Engineering : Concepts for Software-Intensive Systems / Eds. L.Petre, K.Sere, E.Troubitsyna. Hershey, PA : IGI Global, 2011, Ch. Chapter 7, 113-150.

103. J.Vain, A.Kull, M.Kääramees, M.Markvardt, K.Raiend. Reactive testing of nondeterministic systems by test purpose directed tester. / Eds. J.Zander, I.Schieferdecker, P.J.Mosterman : CRC Press-Taylor & Francis Group, LLC, 2011, Ch. Chapter 15, 425-452.

104. K.Vassiljeva, J.Belikov, E.Petlenkov. Neural networks based minimal or reduced model representation for control of nonlinear MIMO systems. - In: The 2011 Int. Joint Conf. on Neural Networks, IJCNN 2011 Conf. Proc. : San Jose, California, USA, July 31 – August 5, 2011. Piscataway, NJ : IEEE, 2011, 1706-1713.

105. K.Vassiljeva, J.Belikov, E.Petlenkov. Genetic algorithm based structure identification for feedback control of nonlinear MIMO systems. - In: Adaptive and Intelligent Systems : Second Int. Conf., ICAIS 2011, Klagenfurt, Austria, September 6–8, 2011, Proc. / Ed. A.Bouchachia. Berlin : Springer, 2011, 215-226. (Lecture Notes in Artificial Intelligence; 6943).

UT Optics Group

106. V.Peet. Conical refraction and formation of multiring focal image with Laguerre-Gauss light beams. - Optics Letters, 2011, 36, 2913-2915.

107. V.Peet, S.Shchemelyov. Frequency doubling with laser beams transformed by conical refraction in a biaxial crystal.- J. Optics, 2011, 13, 055205(6pp)

108. M.Selg. A quasi-bound rovibrational state of hydrogen molecule resulting from hyperfine proton-electron spin-spin interaction. - EPL, 2011, 96(1), 10009.

109. V.Babin, V.Bichevin, V.Gorbenko, M.Kink, A.Makhov, Yu.Maksimov, M.Nikl, G.Stryganyuk, S.Zazubovich, Yu.Zorenko. Time-resolved spectroscopy of exciton-related states in single crystals and single crystalline films of Lu3Al5O12 and Lu3Al5O12:Ce. - Physica Status Solidi (b), 2011, 248(6), 1505-1512.

110. E.Shulga, K.Pohako, A.Treshchalov, U.Joost, V.Kisand, I.Kink. Functionalisation of aligned carbon nanotubes with nitric acid vapour. - Micro & Nano Letters, 2011, Vol. 6, Iss. 8, 704-708.

111. 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.

5.2.3 Abstracts

1. M.Vendelin, M.Kalda, P.Peterson, J.Engelbrecht. Incorporating cooperativity into Huxley-type cross-bridge models in thermodynamically consistent way. IUTAM Symp on Computer Models in Biomechanics. Stanford, August 28 – September 2, 2011. Book of Abstracts, 30-31.

2. A.Tepljakov, E.Petlenkov, J.Belikov. On fractional-order calculus applications to industrial control problems. - In: Info- ja kommunikatsioonitehnoloogia doktorikooli IKTDK viienda aastakonverentsi artiklite kogumik : 25–26. novembril 2011, Nelijärve. [Tallinn : Tallinna Tehnikaülikool], 2011, 47-50.

3. K.Vassiljeva, E.Petlenkov, J.Belikov. Neural networks based identification for control. - In: Info- ja kommunikatsioonitehnoloogia doktorikooli IKTDK viienda aastakonverentsi artiklite kogumik : 25–26. novembril 2011, Nelijärve. [Tallinn : Tallinna Tehnikaülikool], 2011, 157-160.

4. A.Stulov, D.Kartofelev. Acoustical properties of the wool felt. - In: SAPEM 2011 : Symposium on the Acoustics of Poro-Elastic Materials, December 14–16, 2011 Ferrara: Ferrara: University of Ferrara, Italy, 2011.

5. H.Herrmann, M.Eik. On the theory of short fibre reinforced materials. - In: 16th Intern. Conf. on Composite Structures (ICCS16), Porto, Portugal, 2011.

6. M.Eik, H.Herrmann. Measuring fibre orientation in steel fibre reinforced concrete. - In: 16th Intern. Conf. on Composite Structures (ICCS16), Porto, Portugal, 2011.

7. B.Viikmäe, T.Soomere, N.Delpeche-Ellmann. Technology for finding optimum fairways for environmental management in the Baltic Sea. - In: International Conference on Fundamentals, Experiments, Numeric and Applications "Particles in turbulence", March 16-18, 2011 Univ. of Potsdam (Germany), Book of Abstracts, 2011, 78-79.

8. E.Pelinovsky, I.Didenkulova. Freak waves in the field of the nonlinear non-dispersive shallow-water waves. - Geophysical Research Abstracts, 2011, 13, EGU2011-37.

9. A.Rodin, E.Pelinovsky. Large-amplitude simple and shock waves in shallow water. Geophysical Research Abstracts, 2011, 13, EGU2011-62.

10. I.Didenkulova, I.Nikolkina, E.Pelinovsky, and N.Zahibo. Tsunami waves generated by submarine landslides of variable volume. - Geophysical Research Abstracts, 2011, 13, EGU2011-101.

11. I.Didenkulova. Freak waves in the coastal zone of the Baltic Sea. - Geophysical Research Abstracts, 2011, 13, EGU2011-102.

12. I.Didenkulova, E.Pelinovsky. Nonlinear wave evolution and runup in inclined channels. - Geophysical Research Abstracts, 2011, 13, EGU2011-103.

13. I.Didenkulova, E.Pelinovsky, T.Soomere, K.Parnell, M.Viška. Beach response on the interplay of two wave systems: ship wakes and winds waves. - Geophysical Research Abstracts, 2011, 13, EGU2011-104.

14. I.Didenkulova, E.Pelinovsky. Long wave interaction with the sea wall in a basin of variable depth. - Geophysical Research Abstracts, 2011, 13, EGU2011-105.

15. I.Nikolkina, I.Didenkulova, E.Pelinovsky, N.Zahibo. Runup of landslide-generated waves. - Geophysical Research Abstracts, 2011, 13, EGU2011-109.

16. I.Didenkulova, I.Nikolkina. Freak waves in 2006-2010. - Geophysical Research Abstracts, 2011, 13, EGU2011-108.

17. N.Chaykovskaya, A.Rodin. Psychological characteristics of human behavior at a rogue-wave event. - Geophysical Research Abstracts, 2011, 13, EGU2011-3981.

18. O.Kurkina, T.Talipova, E.Pelinovsky, T.Soomere, A.Giniyatullin. Prognostic characteristics of internal waves for the Baltic Sea. - Geophysical Research Abstracts, 2011, 13, EGU2011-4559.

19. P.Denissenko, I.Didenkulova, J.Pearson, E.Pelinovsky. Statistical characteristics of the non-linear run-up measured in a wave flume. - Geophysical Research Abstracts, 2011, 13, EGU2011-5111.

20. T.Soomere, O.Andrejev, K.Myrberg, A.Sokolov. Quantification of the potential of offshore areas in terms of Lagrangian transport of danger to vulnerable regions. - Geophysical Research Abstracts, 2011, 13, EGU2011-6897.

21. I.Didenkulova, E.Pelinovsky. Abnormal amplification of tsunami waves at special bottom geometries. - Geophysical Research Abstracts, 2011, 13, EGU2011-7245.

22. B.Viikmäe, T.Soomere, N.Delpeche-Ellmann. Optimizing fairways for environmental management in the Baltic Sea. - In: 3rd International Workshop on Modeling the Ocean. Book of Abstracts (06-09 June 2011, Qingdao, China), 2011, 66.

23. I.Didenkulova, E.Pelinovsky. Abnormal amplification of tsunami waves at special bottom geometries. - In: Abstracts of the XXV IUGG General Assembly, Melbourne, Australia, 2011, 28 June-7 July, 1441.

24. I.Didenkulova, E.Pelinovsky. Nonlinear-dispersive properties of hazardous waves in the coastal zone. - In: Abstracts of the XXV IUGG General Assembly, Melbourne, Australia, 2011, 28 June-7 July, 2103.

25. E.Pelinovsky, I.Didenkulova, I.Nikolkina, N.Zahibo. Analytical tests in the theory of tsunami wave generation by submarine landslides in a basin of variable depth. - In: Abstracts of the XXV IUGG General Assembly, Melbourne, Australia, 28 June – 7 July, 725.

26. T.Soomere. Towards the use of currents for environmental management of vulnerable sea areas. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 16.

27. A.Giudici, J.Kalda. Compressibility of sea surface created by 3D current field. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 57.

28. M.Viidebaum, J.Kalda, T.Soomere. Dispersion properties of surface currents in the Gulf of Finland. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 60.

29. O.Andrejev, T.Soomere, A.Sokolov, K.Myrberg. Environmentally safe fairways over fields generated by Lagrangian particles statistics: an application to the Gulf of Finland. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 70.

30. B.Viikmäe, T.Soomere, N.Delpeche-Ellmann. Optimizing fairways to reduce environmental risks in the Baltic Sea. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 88.

31. M.Viška, T.Soomere, K.Kartau, A.Räämet. Patterns of sediment transport along the Latvian and Estonian coasts along the Baltic Proper and the Gulf of Riga. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 91.

32. I.Didenkulova, M.Viška, D.Kurennoy. Change of the beach profile under the joint effect of ship and wind waves. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 95.

33. A.Räämet, T.Soomere. Decadal changes in significant wave height in the Baltic Sea. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 96.

34. I.Didenkulova. Freak waves in the coastal zone of the Baltic Sea. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 98.

35. K.Kartau, M.Viška, T.Soomere. Decadal variations of wave-driven sediment transport processes in the Gulf of Riga. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 99.

36. A.Rodin, E.Pelinovsky. Transformation of large-amplitude nonlinear wave in shallow water. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 270.

37. O.Kurkina, A.Kurkin, D.Dorokhov, V.Gorbatsky, E.Morozov, A.Pankratov. Distribution, vertical structure and seasonal variability of horizontal currents near the Curonian Spit in southeastern Baltic Sea in 2010. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 272.

38. E.Shurgalina, E.Pelinovsky, I.Didenkulova. Life-time estimates for weak-amplitude freak waves caused by the dispersive focusing mechanism. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 274.

39. N.Kolesova, A.Kask, V.Alari, U.Raudsepp. The role of abiotic factors on spatial distribution of dominant zoobenthic species in the northwestern coastal sea of Estonia. - In: Book of Abstracts. 8th Baltic Sea Science Congress, RSHU, St. Petersburg, Russia, August 22-26, 2011, 317.

40. P.Saari, P.Bowlan, H.Valtna-Lukner, M.Lõhmus, P.Piksarv, R.Trebino. X-type localized waves in femtosecond optics. - In: Ultrafast Optics, UFO VIII, September 26-30, 2011, Monterey, United States, 2011, 229-230.

41. M.Selg. Nonadiabatic state-independent potential for the hydrogen molecule in ground electronic state. - In: Europhysics Conf. Abstracts, 35C, 150 (2011): 43rd Conf. European Group for Atomic Systems (EGAS), Fribourg (Switzerland), June 28 - July 2, 2011. (Eds.) Weis, A.; Dousse, J-Cl.; Allan, M.; Knowles, P.

42. M.Selg. A quasi-bound state of hydrogen molecule resulting from hyperfine proton-electron spin-spin interaction. - In: 22nd Colloquium on High-Resolution Molecular Spectroscopy, Dijon, France, August 29–September 2, 2011. Universite de Bourgogne, Dijon, France:, 2011, p. 157.

43. P.Piksarv, P.Bowlan, M.Lõhmus, H.Valtna-Lukner, R.Trebino, P.Saari. Propagation of ultrashort pulses behind diffracting screens. - In: Abstracts Book: 22nd Congress of ICO: Light for the Development of the World; Puebla, Mexico; Aug. 15-19, 2011. (Toim.) Rodriguez-Vera, R.; Diaz-Uribe, R., 2011, 298-298.

44. A.Lissovski, A.Treshchalov. Multi-band structure of the third continua spectra of Ar, Kr and Xe gases excited by a pulsed discharge. - In: Proc. 30th Intern. Conf. on phenomena in ionized gases, ICPIG 2011, C10 (4p).

45. P.Piksarv, P.Bowlan, M.Lõhmus, H.Valtna-Lukner, R.Trebino, P.Saari. Propagation of ultrashort pulses behind diffracting screens. - In: Proc. of SPIE: 22nd Congress of ICO: Light for the Development of the World, Puebla, Mexico, Aug. 15-19, 2011. (Toim.) Rodriguez-Vera, R. SPIE, 2011, 801131-1-801131-10.

5.2.4 Submitted papers

1. H.Aben, J.Anton, A.Errapart. Photoelasticity for the measurement of thermal tresidual stresses in glass. Encyclopedia of Thermal Stresses. Ed by R. Hetnarski. Springer. 16 p.

2. H.Aben, J.Anton, A.Errapart. Photoelastic techniques for residual stress measurement in homogeneous and composite glass articles. Residual Stresses in Composite Materials. Ed. by M.M.Shokrieh. Woodhead Publishing Ltd. 24 p.

3. J.Engelbrecht, A.Salupere. Soliton ensembles and solitonic structures. Applicable Analysis (accepted).

4. A.Berezovski, M.Berezovski, J.Engelbrecht. Two-scale microstructure dynamics. J. Multiscale Modelling (submitted).

5. M.Berezovski, A.Berezovski, and J.Engelbrecht. Numerical simulation of one-dimensional microstructure dynamics. Int. J. Structural Stability and Dynamics (submitted).

6. A.Berezovski, J.Engelbrecht. Waves in microstructured solids: dispersion and thermal effects. 23rd Intern. Congress of Theoretical and Applied Mechanics (ICTAM2012) (submitted).

7. J.Engelbrecht, A.Berezovski. Internal structure and internal variables in solid continua. Eur. J. Mech. Solids (submitted).

8. J.Engelbrecht, F.Pastrone. Nonlinear waves in complex microstructured solids. Acc. Sc. Torino - Memorie Sc.Fis. (submitted).

9. M.Vallikivi, A.Salupere, H.-H.Dai. Numerical simulation of propagation of solitary deformation waves in a compressible hyperelastic rod. Mathematics and Computers in Simulation (in press).

10. A.Salupere. On hidden solitons in KdV related system. Mathematics and Computers in Simulation, 2011 (submitted).

11. A.Ravasoo. Modified constitutive equation for quasi-linear theory of viscoelasticity. J. Engin. Mathematics (accepted).

12. A.Ravasoo. Interaction of bursts as a detector of material inhomogeneity. Acta Acustica united with Acustica (submitted).

13. A.Stulov, D.Kartofelev. Vibration spectrum of a piano string with nonlinear contact condition. Int. J. Non-Linear Mechanics (submitted).

14. A.Stulov. Mathematical model of echolocation of fish-catching bats. J. Wave Motion (submitted).

15. K.Tamm, A.Salupere. On the propagation of 1D solitary waves in Mindlin-type microstructured solids. - Mathematics and Computers in Simulation, 2011 (in press).

16. M.Eik, H.Herrmann. A novel technique for measurement and description of fibre orientation distributions in concrete reinforced by short fibres. CCR (submitted).

17. M.Eik, H.Herrmann. Raytraced images for testing the reconstruction of fibre orientaion distributions. Proc. Est. Acad. Sci. (submitted).

18. H.Herrmann, J.Engelbrecht. Comments on mesoscopic continuum physics: Evolution equation for the distribution function and open questions. Proc. Est. Acad. Sci., 61(1) (accepted).

19. I.Didenkulova, E.Pelinovsky. Nonlinear wave effects at the nonreflecting beach. Nonlinear Processes in Geophysics, 2012, 19 (1), 1-8., doi: 10.5194/npg-19-1-2012.

20. O.E.Kurkina, A.A.Kurkin, E.A.Ruvinskaya, E.N.Pelinovsky, T.Soomere. Dynamics of solitons in non-integrable version of the modified Korteweg-de Vries equation, JETP Letters, 2012, 95 (2), 98-103 (in Russian).

21. I.Nikolkina, I.Didenkulova. Catalogue of rogue waves reported in media in 2006–2010. Natural Hazards, 2011. doi: 10.1007/s11069-011-9945-y (accepted, available on-line)

22. T.Soomere, R.Weisse, A.Behrens. Wave climatology in the Arkona basin, the Baltic Sea. Ocean Science, under discussion.

23. I.Didenkulova, E.Pelinovsky, A.Rodin. Rogue wave formation in shallow water taking into account the effect of wave breaking. Fundamental and Applied Hydrophysics (submitted).

24. 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, Ocean Dynamics (submitted).

25. I.Didenkulova, K.Pindsoo, S.Suuroja. Classification of cross-shore profiles along Estonian coasts of the Baltic Sea by their shape in terms of power approximation of the beach in the nearshore zone, J. Marine Systems (submitted).

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

27. J.Kalda, T.Soomere, A.Giudici. On the compressibility of the surface currents in the Gulf of Finland, the Baltic Sea, J.Marine Systems (submitted).

28. I.Didenkulova, A.Rodin. A typical wave wake from high-speed vessels: its group structure and run-up, J. Marine Systems (submitted).

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

30. I.Didenkulova. Tsunami runup in narrow bays: the case of Samoa 2009 tsunami, Pure and Applied Geophysics (submitted).

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

32. M.Selg. Observable quasi-bound states of the H2 molecule. J. Chemical Physics (revised version currently under review).

33. 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, European Physical J. D (submitted).

34. P.Saari. Photon localization revisited, Chapter in book: Quantum Optics, Intech 2012 (submitted).

5.2.5 Popular science

1. J.Kalda. Tai Kuningriigist teatepulka toomas (Bringing the baton from the Kingdom of Thailand). Horisont, 2011, 5, 57-58 (in Estonian).

2. J.Kalda. Ülesanne kui meelelahutus (Exercise as fun). Horisont, 2011, 4, 55 (in Estonian).

3. T.Soomere. Kuidas mõõta randade tervist (How to measure the health of beaches). Loodusesõber (The Friend of Nature, popular science journal), 2011, 2, 22-26 (in Estonian).

4. T.Soomere. Tõhuku maavärin ja tsunami (Tõhuku earthquake and tsunami). Horisont (the leading popular science journal), 2011, 3, 28-30 (in Estonian).

5. A.Kask, J.Kask. Sadamarajatiste mõju rannajoone arengule lääne pool Toila sadamat (The influence of port construction on the evolution of the coastal section to the west of the Port of Toila). Keskkonnatehnika (Environmental Engineering), 2011, 3, 36-37 (in Estonian); English summary on p. 47.

6. A.Kask, J.Kask. Setete liikumine Naissaare idaosa rannavööndis (Sediment motion in the nearshore of the eastern part of the Island of Naissaar). Keskkonnatehnika, 2011, 7, 34-37 (in Estonian), English summary on p. 47.

7. I.Puura, T.Soomere. Environmental impact and potential risks stemming from the Nord Stream pipeline, "Gorisonty Estonii", 2011, 68-75 (in Russian).

8. T.Soomere BALTICWAY - The potential of currents for environmental management of the Baltic Sea maritime industry. BONUS in Brief, November 2011, p. 7.

9. T.Soomere. Läänemere lainekliima Eesti ranniku kontekstis (The Baltic Sea wave climate in the context of the Estonian coast). Teadusmõte Eestis VII. Meri. Järved. Rannik (edited collection of popular papers about developments in oceanography, limonology and coastal sciences in Estonia) (T.Soomere, T.Nõges, eds.). Eesti Teaduste Akadeemia, 2011, Tallinn, 69-82 (in Estonian).

10. I.Didenkulova. Lainepõhised ohud rannavööndis (Wave-induced hazards in the nearshore). Teadusmõte Eestis VII. Meri. Järved. Rannik (T.Soomere, T.Nõges, eds.). Eesti Teaduste Akadeemia, 2011, Tallinn, 103-115 (in Estonian).

11. T.Soomere. Preventiivsed meetodid ranniku kaitseks mere sisemise dünaamika abil (Preventive methods for the coastal protection). Teadusmõte Eestis VII. Meri. Järved. Rannik (T.Soomere, T.Nõges, eds.). Eesti Teaduste Akadeemia, 2011, Tallinn, 197-211 (in Estonian).

12. I.Didenkulova. Shoaling and runup of long waves generated by high-speed ferries. EEA booklet. 2011.

13. M.Patriarca, E.Heinsalu, R.Kitt, J.Kalda. Majandusfüüsika Eestis (Econophysics in Estonia). - In: Eesti Füüsika Seltsi Aastaraamat 2010. Tartu : Eesti Füüsika Selts, 2011, 81-92 (in Estonian).

5.2.6 Other papers / Science policy

1. J.Engelbrecht. Solitoni mitu nägu (Soliton – one face or many?). In: TTÜ Aastaraamat (Yearbook TUT) 2010, ed by V.Mägi, Tallinn, 2011, 125-129 (in Estonian).

2. J.Engelbrecht. Juured Helme kihelkonnas (Roots in Helme County). In M.Koldits (ed.) Juured (Roots), Tallinn, 2011, 123-124 (in Estonian).

3. J.Engelbrecht. Academies in Time and Space. ALLEA Biennial Yearbook 2008, ALLEA, Amsterdam, 2011, 9-22.

4. J.Engelbrecht. ALLEA in 2006–2008: Report to the General Assembly, April 2008, Madrid. Ibid, 79-87.

5. J.Engelbrecht. Arvamusi akadeemikutelt (Opinions from fellows), Eesti Teaduste Akadeemia Aastaraamat 2010 XVI (43). Eesti TA, Tallinn, 2011, 197-199.

6. J.Engelbrecht. Internationalisation of research in Estonia. International Business Handbook Estonia 2011-2012. Euroinformer, Tallinn, 2011, 169-177.

7. J.Engelbrecht. On research in Estonia. Science and Society, 2011, No 6, 67-74.

8. J.Engelbrecht. Reeglitest ja ekspertidest. Sissejuhatus raamatule P.Miller, "Tark parv". (On rules and experts, Introduction to the book by P.Miller, "The Smart Swarm"), Tallinn, Äripäev, 2011, 7-11 (in Estonian).

9. J.Engelbrecht. Introduction: towards a knowledge-based society. In: J.Engelbrecht (ed), Research in Estonia. Present and Future. Estonian Acad.Sci., Tallinn, 2011, 7-24.

10. T.Soomere. Tõrvikuid läites (Lighting up the torches). - In: Usk vabadusse (Belief into freedom), EELK Konsistoorium (A.Velliste, ed.), 2011, Tallinn, 240-251 (in Estonian).

11. R.Kitt. Komplekssed sotsiaalsüsteemid (Complex social systems). Akadeemia, 2011, N 10, 1787-1800 (in Estonian).

5.3 Conferences

1. 9th International Congress on Thermal Stresses 2011, Budapest, June 5–9, 2011.
   A.Errapart. Photoelastic tomography for the measurement of thermal and residual stresses in glass.

2. Glass Performance Days 2011, Tampere, Finland, June 17–20.
   J.Anton. On the inhomogeneity on residual stresses in tempered glass panels.

3. International Conference on Advances in Experimental Mechanics: Integrating Simulation and Experimentation of validation, Edinburgh, 2011.
   A.Errapart. Determination of all stress components of axisymmetric stress state in photoelastic tomography.
   S.Hödemann. Effects of ray bending in scattered light photoelasticity for tempered and annealed glass plates.

4. Forum on recent developments in Volume Reconstructions techniques applied to 3D fluid and solid mechanics 2011, Poitiers, 2011.
   A.Errapart. Photoelastic tomography in the axisymmetric and non-axisymmetric case.

5. International Conference for Heterogeneous Materials Mechanics (ICHMM), Shanghai, China, May 22–26, 2011.
   M.Berezovski, A.Berezovski, J.Engelbrecht. Numerical simulations of one-dimensional microstructure dynamics.

6. THERMAL STRESSES (TS2011), Budapest, Hungary, June 6–9, 2011.
   A.Berezovski, J.Engelbrecht, G.A.Maugin. Thermoelasticity with dual internal variables.

7. 10th biennial International Conference on Vibration Problems ICoVP-2011, Prague, Czech Republic, September 5–8, 2011.
   A.Berezovski, J.Engelbrecht, M.Berezovski. Dispersive wave equations for solids with microstructure.

8. 24th Nordic Seminar on Computational Mechanics, Helsinki, Finland, November 3–4, 2011.
   A.Berezovski. Thermodynamic interpretation of finite volume algorithms.
   K.Tamm, A.Salupere. On the emergence of asymmetric waves in the Mindlin-Engelbrecht–Pastrone model.

9. 11th Joint European Thermodynamics Conference, Chemnitz, Germany, June 27 – July 1, 2011.
   A.Berezovski, C.Papenfuss and P. Ván. Non-equilibrium thermodynamics of generalized mechanics - dual internal variables.

10. International Conference on Optimization and Analysis of Structures, The University of Tartu, Tartu, Estonia, August 25–27, 2011.
    A.Salupere. On pseudospectral method, discrete spectral analysis and solitons.

11. The Seventh IMACS International Conference on Nonlinear Evolution Equations and Wave Phenomena: Computation and Theory, University of Georgia, Georgia, USA, 2011, Athens, April 4–7.
    A.Salupere. On hidden solitons in KdV related systems.
    T.Peets. Internal scales and dispersive properties of microstructured materials.

12. Symposium on the Acoustics of Poro-Elastic Materials, Ferrara, Italy, December 14–16, 2011.
    D.Kartofelev, A.Stulov. Acoustical properties of the wool felt.

13. SimBioMa 2011, Konstantz; 28 September – 1 Oktober 2011.
    J.Jõgi, M.Järvekülg, J.Kalda, A.Salundi, A.Lõhmus. Spring-block model simulation of formation and rolling of metal alkoxide gel film segments.

14. 16th International Conference on Composite Structures (ICCS16), Porto, Portugal, 2011.
    H.Herrmann, M.Eik. On the Theory of Short Fibre Reinforced Materials.
    M.Eik, H.Herrmann. Measuring Fibre Orientation in Steel Fibre Reinforced Concrete.

15. Conference, planning and kick-off meeting of the Baltic Assessment Network (ACoast, Assessment of coastal observing systems in the Baltic Sea), Lauenburg, Germany, February 2–3.
    T.Soomere. Wind wave climatology on the eastern coast of the Baltic Sea.
    K.Kartau and M.Viška participated.

16. Science and policy conference "Building of the Nord Stream pipeline-consequences and potential hazards of the project", European Conservatives and Reformist's Group, Szczecin, February 22, 2011.
    T.Soomere. Nord Stream as a challenge and mirror for the Baltic Sea marine science.

17. International Conference on Fundamentals, Experiments, Numeric and Applications "Particles in turbulence", March 16–18, 2011 University of Potsdam (Germany).
    B.Viikmäe (co-authors T.Soomere, N.Delpeche-Ellmann). Technology for finding optimum fairways for environmental management in the Baltic Sea.

18. 9th Industrial Challenges in CAD, Geometric Modelling and Simulation Workshop, Darmstadt, Germany, March 31 – April 1, 2011.
    Co-organized by E.Quak.

19. EGU General Assembly, Vienna, Austria, April 3–8, 2011.
    I.Didenkulova was a conviner and a chair of two session:
    NH5.1. New developments in tsunami science and in mitigation of tsunami risk, including early warning (07.04); NH5.3/NP7.3/OS2.5 Nonlinear Dynamics of the Coastal Zone (06.04).
    I.Didenkulova, E.Pelinovsky. Nonlinear wave evolution and runup in inclined channels.
    I.Didenkulova. Freak waves in the coastal zone of the Baltic Sea.
    I.Didenkulova, I.Nikolkina, E.Pelinovsky, N.Zahibo. Tsunami waves generated by submarine landslides of variable volume.
    Poster presentations:
    I.Didenkulova, E.Pelinovsky. Abnormal amplification of tsunami waves at special bottom geometries.
    E.Pelinovsky, I.Didenkulova. Freak waves in the field of the nonlinear non-dispersive shallow-water waves.
    I.Didenkulova, I.Nikolkina. Freak waves in 2006–2010.
    I.Didenkulova, E.Pelinovsky. Long wave interaction with the sea wall in a basin of variable depth.
    I.Nikolkina, I.Didenkulova, E.Pelinovsky, N.Zahibo. Runup of landslide-generated waves.
    P.Denissenko, I.Didenkulova, J.Pearson, E.Pelinovsky. Statistical characteristics of the non-linear run-up measured in a wave flume.

I.Didenkulova, E.Pelinovsky, T.Soomere, K.Parnell, M.Vika. Beach response on the interplay of two wave systems: ship wakes and winds waves. N.Chaykovskaya, A.Rodin. Psychological characteristics of human behaviour at a roque-wave event.
A.Rodin, E.Pelinovsky. Large-amplitude simple and shock waves in shallow water.

20. Conference "The smart use of marine currents for environmental management"as a part of the BalticWay Annual Meeting, Palermo, April 11–12, 2011.
T.Soomere. Basic steps of the technology for fairway optimization.
B.Viikmäe. Equiprobability lines in the Gulf of Finland and the Baltic Proper.
M.Viidebaum. Experiments with surface drifters in the Gulf of Finland.
A.Giudici, E.Quak participated.

21. 11th International Coastal Symposium, Szczecin, Poland, May 9–13, 2011.
I.Didenkulova, E.Pelinovsky, T.Soomere, K.E.Parnell. Beach profile change caused by ship wakes and wind waves in Tallinn Bay, the Baltic Sea.
K.Kartau, T.Soomere, H.Tõnisson. Quantification of sediment loss from semi-sheltered beaches: a case study for Valgerand Beach, Pärnu Bay, the Baltic Sea.
D.Kurennoy, K.E.Parnell, T.Soomere. Fast-ferry Generated Waves in South-West Tallinn Bay.
I.Zaitseva-Pärnaste, T.Soomere, O.Tribštok. Spatial variations in the wave climate change in the eastern part of the Baltic Sea.
A.Räämet, T.Soomere: Spatial variations in the wave climate change in the Baltic Sea.
T.Soomere, O.Andrejev, A.Sokolov, E.Quak. Management of coastal pollution by means of smart placement of human activities.
B.Viikmäe, T.Soomere, K.E.Parnell, N.Delpeche. Spatial planning of shipping and offshore activities in the Baltic Sea using Lagrangian trajectories.
O.Kurkina, E.Pelinovsky, T.Talipova, T.Soomere. Mapping the internal wave field in the Baltic Sea in the context of sediment transport in shallow water (poster).

22. Dagstuhl Seminar on Geometric Modeling, Leibniz-Zentrum für Informatik, Dagstuhl, Germany, May 22–27, 2011.
E.Quak participated and gave a presentation on EU research funding.

23. The 3rd International Conference for Heterogeneous Materials Mechanics (ICHMM) China, Shanghai, May 22–29, 2011.
M.Berezovski (participated), A.Berezovski, J.Engelbrecht. Wave propagation in heterogeneous materials with secondary substructure.

24. BONUS Forum of Project Coordinators' meeting. Academy of Finland, Helsinki, June 15, 2011.
T.Soomere participated.

25. 3rd International Workshop on Modeling the Ocean (Qingdao, China, June 6–9, 2011).
B.Viikmäe (participated), T.Soomere, N.Delpeche-Ellmann. Optimizing fairways for environmental management in the Baltic Sea.

26. Kick-off meeting of the network "FuturICT's Interconnected Observatories of Society for a Resilient and Sustainable Future", KTH Zürich, June 16, 2011.
T.Soomere participated.

27. Annual meeting of the Alexander von Humboldt Foundation, Berlin. June 27–29, 2011.
T.Soomere participated.

28. Science and policy conference "Climate, renewable energy and sustainable development: The new geo-energy" organized by the Group of Conservatives and Reformists in the premises of the European Parliament (ASP 7 H 1), Brussels, 21 June, 2011.
T.Soomere, invited presentation Marine science in research for alternative energy sources.

29. International Union of Geodesy and Geophysics (IUGG) General Assembly 2011, June 28–July 7.
I.Didenkulova (co-author E.Pelinovsky). Abnormal amplification of tsunami waves at special bottom geometries.
E.Pelinovsky (co-authors I.Didenkulova, I.Nikolkina N.Zahibo). Analytical tests in the theory of tsunami wave generation by submarine landslides in a basin of variable depth.
I.Didenkulova, E.Pelinovsky. Nonlinear dispersive properties of hazardous waves in the coastal zone (poster presentation).

30. The 8th Baltic Sea Science Congress (BSSC), Saint Petersburg, Russia, August 22–26, 2011.
T.Soomere, I.Didenkulova: conviners and chairs of the thematic session: Interplay of physical, biological and geological processes in various spatial and temporal scales.
T.Soomere (plenary lecture). Towards the use of currents for environmental management of vulnerable sea areas.
Oral presentations:
B.Viikmäe, T.Soomere, N.Delpeche-Ellmann. Optimizing fairways to reduce environmental risks in the Baltic Sea.
M.Viška, T.Soomere, K.Kartau, A. Räämet. Patterns of sediment transport along the Latvian and Estonian coasts along the Baltic Proper and the Gulf of Riga.
M.Viidebaum, J.Kalda, T.Soomere. Dispersion properties of surface currents in the Gulf of Finland.
I.Didenkulova, M.Viška, D.Kurennoy. Change of the beach profile under the joint effect of ship and wind waves.
A.Räämet, T.Soomere. Decadal changes in significant wave height in the Baltic Sea.
I.Didenkulova. Freak waves in the coastal zone of the Baltic Sea.
K.Kartau, M.Viška, T.Soomere. Decadal variations of wave-driven sediment transport processes in the Gulf of Riga.
O.Andrejev, T.Soomere, A.Sokolov, K.Myrberg. Environmentally safe fairways over fields generated by Lagrangian particles statistics: an application to the Gulf of Finland.
A.Giudici, J.Kalda. Compressibility of sea surface created by 3D current field.
T.Soomere (walk-in presentation). Marine science in research for alternative energy sources.
A.Rodin, E.Pelinovsky. Transformation of large-amplitude nonlinear wave in shallow water (poster).
E.Shurgalina, E.Pelinovsky, I.Didenkulova. Life-time estimates for weak-amplitude freak waves caused by the dispersive focusing mechanism (poster).
O.Kurkina, A.Kurkin, D.Dorokhov, V.Gorbatsky, E.Morozov, A.Pankratov. Distribution, vertical structure and seasonal variability of horizontal currents near the Curonian Spit in southeastern Baltic Sea in 2010 (poster).
N.Kolesova, A.Kask, V.Alari, U.Raudsepp. The role of abiotic factors on spatial distribution of dominant zoobenthic species in the northwestern coastal sea of Estonia (poster).

31. International Association for Mathematical Geosciences (IAMG) conference "Mathematical Geosciencs at the Crossroads of Theory and Practice", Salzburg, Austria, September 5–9, 2011.

A.Giudici participated.

32. FuturICT session of the European Conference on Complex Systems ECCS'11, Vienna, September 12, 2011.
T.Soomere participated.

33. Summer school "Preventive methods for coastal protection", Klaipeda, September 18–20, 2011.
T.Soomere. Introduction into hydrodynamics of currents and waves.
T.Soomere. Basic steps of the BalticWay technology for coastal protection.
T.Soomere. Applications of the smart use of marine currents for environmental management.
E.Quak. Things that may go wrong.
E.Quak. Basics of EU financing and how to get it.
T.Torsvik. Introduction into 2D and 3D modelling of ocean currents.
B.Viikmäe, M.Viška, A.Giudici, K.Pindsoo, K.Kartau, M.Zujev, A.Rodin participated as students.

34. Fall School of the Marie Curie Initial Training Network SAGA (Shapes, Geometry, Algebra) in Vilnius, Lithuania, September 27–30, 2011.
The Fall School was co-organized by E.Quak, who also gave an overview presentation on EU research funding.

35. Workshop "Extreme Seas", Geneva, Switzerland, October 4–6, 2011.
I.Didenkulova. Rogue Waves in Shallow Water.

36. Students' conference in the Estonian Academy of Sciences, October 8, 2011.
O.Tribštok. Comparison of wave regimes along Estonian and Lithuanian coasts.

37. Fall Plenary Meeting of the European Science Foundation Marine Board, Madrid, October 13–14, 2011.
T.Soomere participated

38. BONUS Forum, Gdansk, Poland, October 24, 2011.
T.Soomere. The use of currents for environmental management of the maritime industry.

39. SIAM/ACM Joint Conference on Geometric and Physical Modeling Orlando, Florida, USA, October 24–27, 2011.
Co-organized by E.Quak, who arranged a two-part:
"Forward Looking Minisymposium"on future research challenges and moderated the "Forward Looking Panel Discussion".
He also gave a talk on "Challenges in 3D Modelling for remote tower operations in Air Traffic Control"as a part of the minisymposium.

40. The Future of Operational Oceanography, Hamburg, Germany, October 25–27, 2011.
T.Soomere. Towards the use of currents in environmentally safer management of maritime activities.

41. Rogue Waves 2011, Dresden, Germany, November 7–11, 2011.
I.Didenkulova. Invited presentation Rogue waves in the nearshore region.
T.Soomere. Invited presentation Rogue waves in shallow water and nearshore effects.

42. 55th annual Biophysical Meeting, Baltimore, Maryland, USA, March 5–9, 2011.
A.Illaste, M.Laasmaa, R.Birkedal, P.Peterson, M.Vendelin. Mapping Diffusion Coefficients of Fluorescent Dyes in Cardiomyocytes.
M.Laasmaa, M.Vendelin, P.Peterson. Application of regularized Richardson-Lucy algorithm for deconvolution of confocal microscopy images.
N.Sokolova, S.Provazza, A.Ainbinder, G.Beutner, D.G.Brdiczka, R.Birkedal, M.Vendelin, Shey-Shing Sheu. Regulation of mitochondrial permeability transition by ADP.

43. IUTAM Symposium on Computer Models in Biomechanics: from Nano to Macro, Stanford University, California, USA, 28 August – 1 September, 2011.
M.Kalda, P.Peterson, J.Engelbrecht, M.Vendelin. Incorporating cooperativity into Huxley-type cross-bridge models in thermodynamically consistent way.

44. 18th IFAC World Congress. Milano, Italy, August 28 – September 2, 2011.
T.Mullari.Simple conditions for the existence of an extended observer form.

45. 18th International Conference on Process Control, Slovakkia, Tatranska Lomnica, June 14–17, 2011.
A.Kaldmäe. Disturbance decoupling of discrete-time nonlinear systems by static measurement feedback.
J.Belikov. Transfer matrix and its Jacobson form for nonlinear systems on time scales: Mathematica implementation.
M.Tõnso. Relationship between two polynomial realization methods.
Ü.Kotta. Accessibility and Feedback Linearization for SISO Discrete-Time Nonlinear Systems: New Tools.
T.Mullari. Discrete-time Lie derivative with respect to system dynamics.

46. The 2011 International Joint Conference on Neural Networks, IJCNN 2011, San Jose, California, USA, July 31 – August 5, 2011.
J.Belikov.Neuro-fuzzy Dynamic Pole Placement Control of Nonlinear Discrete-time Systems.
S.Nõmm. Comparison of Neural Networks-based ANARX and NARX Models by application of correlation tests.

47. The 18th World Congress of the International Federation of Automatic Control: Milano, Italy, August 28 – September 2, 2011.
J.Belikov. Region of Admissible Values for Discrete-time Nonlinear Control System Linearized by Output Feedback.
M.Tõnso. An explicit formula for computation of the state coordinates for nonlinear i/o equation.
T.Mullari. Discrete-time Lie derivative with respect to the system dynamics.
Ü.Kotta. Output Feedback Disturbance Decoupling in Discrete-Time Nonlinear Systems.

48. International Conference on Adaptive and Intelligent Systems – ICAIS11, Klagenfurt, Austria, September 6–8, 2011.
S.Nõmm. Online identification of the system order with ANARX structure.

49. 50th IEEE Conference on Decision and Control and European Control Conference, CDC-ECC 2011, Orlando, FL, USA, December 12–15, 2011.
J.Belikov, Ü.Kotta, M.Tõnso. Minimal realization of nonlinear MIMO equations in state-space form: polynomial approach.

50. The 9th IEEE International Conference on Control and Automation, ICCA 2011, Santiago, Chile, December 19–21.
Ü.Kotta. On Applicability of LPV Tools for Bilinear Systems.
J.Belikov. Model Matching Problem for Discrete-time Nonlinear Systems: Transfer Function Approach.
M.Tõnso. On applicability of LPV tools for bilinear systems.
P.Kotta. State-Space Realization of Nonlinear Input-Output Equations: Unification and Extension Via Pseudo-Linear Algebra.
S.Nõmm. Structure Identification of NN-ANARX Model by Genetic Algorithm with Combined Cross-correlation-test Based Evaluation Function.
Ü.Nurges. Stability domain of fixed order controllers via reflection segments of polynomials.
V.Kaparin. Extended Observer Form for Discrete-Time Nonlinear Control Systems.

51. The European Conference on Lasers and Electro-Optics and the XIIth European Quantum Electronics Conference CLEO/Europe-EQEC, Munich, Germany, 22–26 May 2011.
V.Peet. Second harmonic generation using laser beams transformed by internal conical refraction.

52. 30 th International Conference on phenomena in ionized gases, ICPIG 2011, August 28 – September 2, Belfast, Northern Ireland, UK.
A.Lissovski, A.Treshchalov. Multi-band structure of the third continua spectra of Ar, Kr and Xe gases excited by a pulsed discharge.

53. Ultrafast Optics, UFO VIII, Monterey, United States, September 26–30, 2011.
P.Saari, P.Bowlan, H.Valtna-Lukner, M.Lõhmus, P.Piksarv, R.Trebino. X-type localized waves in femtosecond optics.

54. 22nd Congress of ICO: Light for the Development of the World; Puebla, Mexico; August 15–19, 2011.
P.Piksarv, P.Bowlan, M.Lõhmus, H.Valtna-Lukner, R.Trebino, P.Saari. Propagation of ultrashort pulses behind diffracting screens .

5.4 Seminars

5.4.1 Tallinn Seminars on Mechanics (CENS)

1. 3.1.2011, Arkadi Berezovski: “Internal variables and dispersive wave equations”.

2. 17.1.2011, Romi Mankin (TU): “Stohhastiline ostsillaator visko-elastses keskkonnas”.

3. 27.1.2011, Gianluca Sara (Palermo): “The influence of global climate changes on marine ecosystems: an analysis through life histories and niche modelling”.

4. 31.1.2011, Oksana Kurkina (Nizhny Novgorod, Russia): “Nonlinear internal gravity waves in stratified waters: models and dynamics”.

5. 7.2.2011, Peter Van (Hungary): “Temperature and heat conduction beyond Fourier law”.

6. 14.2.2011, Richard Wheeler (Edinburgh): “An overview of artificial immune systems”.

7. 28.2.2011, Jaan Kalda: “K-spectrum of decaying, aging and growing passive scalars in Lagrangian chaotic fluid flows”.

8. 14.3.2011, Andrei Errapart: “Photoelastic tomography for complete residual stress determination in axisymmetric specimen”.
9. 21.3.2011, Erkki Soika (TU): “Constructive Role of Environmental Noise in Ecological Modelsystems”.
10. 28.3.2011, Irina Nikolkina (Nizhny Novgorod, Russia): “Savage-Hutter model for avalanche dynamics in inclined channels: analytical solutions”.
11. 4.4.2011, Anatoli Stulov: “Impact, structure and waves”.
12. 11.4.2011, Arkadi Berezovski: “Thermoelasticity with dual internal variables”.
13. 18.4.2011, Andres Lahe (TUT): “On the EST method for rods”.
14. 2.5.2011, “Wave dynamics”, 3 talks.
15. 9.5.2011, Prof. Konstantin Lurye (Worcester Polytechnic Institute): “Material assemblies in space and time: dynamic materials”.
16. 16.5.2011, Kert Tamm: “Optical dispersion branch in MEP model”.
17. 23.5.2011, Ira Didenkulova: “Beach profile change caused by vessel wakes and wind waves in Tallinn Bay, the Baltic Sea”.
18. 30.5.2011, Oksana Kurkina: “Motion of sediment particles in surface and internal waves”.
19. 12.9.2011, Opening seminar of CENS.
20. 19.9.2011, Piret Avila: “The super-exponential growth of world population”.
21. 26.9.2011, Jaan Kalda: “K-spectrum of decaying and growing passive scalars in chaotic compressible fluid flows”.
22. 10.10.2011, Tomas Torsvik: “Numerical particle tracking modeling and prospects for Mobilitas project”.
23. 17.10.2011, Andres Braunbrück: “Harmonic burst in characterisation of exponentially graded material”.
24. 24.10.2011, Arkadi Berezovski: “Thermodynamic interpretation of finite volume algorithms”.
25. 31.10.2011, Kert Tamm: “Appearance of the spatial asymmetry in the Mindlin-Engelbrecht-Pastrone model”.
26. 2.11.2011, Alexander Ezersky (Universitè de Caen, Prantsusmaa): “Interaction of solitons with sandy bottom in a shallow water resonator”.
27. 7.11.2011, Narcisse Zahibo (University of the French West Indies and Guiana, Guadeloupe): “Innundation risks for Guadeloupe, Lesser Antilles”.
28. 21.11.2011, Tanel Peets: “Dispersion analysis of wave motion in microstructured solids”-(provisional defense of PhD).
29. 28.11.2011, Frédéric Dias (University College Dublin): “The numerical computation of violent waves - application to wave energy converters”.

5.4.1.1 Seminars of the Wave Engineering Group

1. 8.02 M.Viška. Usage of LIDAR (Light Detection and Ranging) technology and transect line method in the research of geological processes of Latvian sea-coast.
2. 2.03 M.Berezovski. Numerical methods.
3. 8.03 A.Rodin. Deformation of strongly nonlinear wave on shallow water.
4. 29.03 K.Kartau. Quantification of sediment loss from semi-sheltered beaches: a case study of Valgerand Beach, Pärnu Bay, the Baltic Sea.
5. 19.04 I.Nikolkina. Rogue waves 2006–2010.
6. 2.05 K.Kartau. Quantification of sediment loss from semi-sheltered beaches: a case study of Valgerand Beach, Pärnu Bay, the Baltic Sea.
7. 23.09 T.Soomere. Future plans of the Wave Engineering Laboratory.
8. 7.10 B.Viikmäe. Techniques and methods for optimizing fairways for environmental management in the Baltic Sea.
9. 14.10 M.Viidebaum. The Drifters.
10. 21.10 A.Räämet. Spatial variations in the wave climate change in the Baltic Sea.
11. 28.10 M.Viška. Patterns of sediment transport along the eastern Baltic Sea coast.
12. 4.11 M.Miani (Coastal Research Station – Forschungstelle Küste, Norderney, Germany). Hydrodynamic loads on Dyke retreat and study of wave propagation in inundated areas.
13. 11.11 I.Zaitseva-Pärnaste. Long-term variations of wind waves in the eastern part of the Baltic Sea.
14. 25.11 A.Rodin. Large amplitude waves in shallow water.
15. 5.12 O.Kurkina. Evolutionary stages of baroclinic tides.
16. 9.12 A.Giudici. On the compressibility of the surface currents in the Gulf of Finland, the Baltic Sea.

5.4.1.2 Seminars Optics Group

1. Weekly seminar of the Laboratory of Physical Optics.

5.4.2 Lectures and seminars outside CENS

1. June 13, 2011: Seminar of Hungarian Institute of Nuclear Physics (KFKI).
   A.Berezovski. Thermodynamic interpretation of finite volume algorithms.
2. September 9, 2011: Joint seminar of the expert group for Computational Mechanics of the Czech Society for Mechanics and the Institute of Thermomechanics of the Academy of Sciences of the Czech Republic.
   A.Berezovski. Microtemperature as an internal variable.

3. December 19, 2011: Mathematical Sciences Department Colloquium, Worcester Polytechnic Institute, Worcester, MA, USA.
   A.Berezovski. Numerical simulation of waves and fronts in inhomogeneous solids.

4. May 10, 2011: Department of Signal Processing and Acoustics at Aalto University, School of Electrical Engineering, Espoo, Finland.
   A.Stulov. Piano hammer impact.
   D.Kartofelev. Nonlinear string support.

5. December 13, 2011: Autumn Workshop of Institute of Cybernetics, Viinistu, Estonia.
   D.Kartofelev. Deformation Wave Propagation in Wool Felt.

6. January 14, 2011: Hotel Palmse, Palmse, Estonia.
   T.Soomere. New possibilities for handling marine coastal hazards.

7. January 24, 2011: National Library, Tallinn.
   T.Soomere. Contribution of marine science to the protection of Estonian coasts.

8. April 8, 2011: University of Palermo.
   T.Soomere. New aspects of the meaning of extreme waves in maritime engineering design.

9. May 26, 2011: Estonian Naturalists' Society, Tartu.
   T.Soomere. The possibilities of contemporary marine science for understanding and protection of Estonian coasts.

10. August 16, 2011: Institute for the Baltic Sea Research (Institut für Ostseeforschung), Warnemünde.
    T.Soomere. The use of currents for environmental management of offshore activities.

11. September 13, 2011: Institute of Coastal Research, Helmholtz-Zentrum Geesthacht.
    T.Soomere. The smart use of currents for environmental management of offshore activities.

12. September 14, 2011: Dept. of Data Analysis and Data Assimilation, Institute of Coastal Research, Helmholtz-Zentrum Geesthacht.
    T.Soomere. Spatio-temporal patterns in the Baltic Sea wave climate.
    M.Viška, T.Soomere. Patterns of sediment transport along the Eastern Baltic Sea coast.

13. October 27, 2011: Dept. of Mathematics, University of Bergen, Bergen, Norway.
    I.Didenkulova. Long wave runup on a beach: analytical approach.

14. December 21, 2011: Norwegian Meteorological Institute, Bergen, Norway.
    I.Didenkulova. Rogue waves in the sea and at the coast.

15. November 2, 2011: Technische Universität Chemnitz.
    H.Herrmann. Diffusion of Oriented Particles on Fractals.

16. November 2, 2011: Klaipeda University.
    H.Herrmann. Scripted Data Analysis.

5.5 Meetings and events
5.5.1. Meetings and events in CENS

German Ambassador Dr. Martin Hanz, accompanied by Dr. Sabine Feyertag and Ms. Aili Rehbein from the German embassy, visited the Institute of Cybernetics in response to the invitation by the four Humboldtians working in the institute (Humboldt research awardee J.Engelbrecht, fellow T.Soomere and Feodor Lynen fellows H.Herrmann and E.Quak). The visit started with a miniseminar with presentations by Andrus Salupere, Jüri Engelbrecht, Varmo Vene, Marko Vendelin, Ira Didenkulova and Heiko Herrmann reflecting the policy of the Institute of Cybernetics and the Center for Non-linear Studies, and a selection of hot research topics in the institute. The Ambassador also visited the laboratory of photoelasticity, laboratory of systems biology, laboratory of fonetics and the wave engineering laboratory and participated in a discussion meeting.

Visit of the French Ambassador, July 4, 2011.

The French Ambassador Frédéric Billet visited the Institute of Cybernetics, and Rémi Brochenin from the Institut Francais, at the invitation of Tarmo Uustalu. As part of the lectures given, E.Quak gave a short presentation of the wave engineering laboratory, which led to the participation of the lab in the month of French science in November, hosting some visitors (see below).

Workshop on Recent Problems on Dispersive Waves, Tallinn, December 6, 2011.
Convener: J.Engelbrecht.

J.Engelbrecht (CENS): *Introduction*.
H.-H.Dai (City University, Hong Kong): *Modeling, analysis and solutions for wave catching-up phenomena in a nonlinearly elastic composite bar*.
J.Plešek (Institute of Thermomechanics, Prague): *Accuracy and stability of finite element solution to wave propagation problem*.
A.Berezovski (CENS): *Dispersive effects reflected in wave equations*.
K.Tamm (CENS): *On the emergence of asymmetric waves in the Mindlin-Engelbrecht-Pastrone model*.

6. Research and teaching activities
6.1. Meetings and events organised elsewhere

Meeting of the Academic Council of the State President of Estonia, 24 March, Tallinn.
Convener: J.Engelbrecht.

J.Engelbrecht. *What is complexity*.
L.Mõtus. *State as a complex system*.
R.Kitt. *Social complexity*.

18th International Conference on Process Control, Tatranská Lomnica, Slovakia, June 14–17 2011.
Invited Session "Algebraic Methods in Control", organized by Ü.Kotta;
Participants: J.Belikov, A.Kaldmäe, T.Mullari, M.Tõnso, M.Halas and Ü.Kotta.

9th Industrial Challenges in CAD, Geometric Modelling and Simulation Workshop, Darmstadt, Germany, March 31 – April 1, 2011. Co-organized by E.Quak with TU Darmstadt and the Fraunhofer Institute for Computer Graphics;

The second BalticWay Annual Meeting, April 11-13. 2011, Excelsior Hotel, Palermo, Italy. Organised by the BalticWay team of the Wave Engineering Laboratory (T.Soomere, E.Quak, B.Viikmäe, M.Viidebaum, A.Giudici). The event started with a technical meeting, followed by a two-day scientific conference "The smart use of marine currents for environmental management" and ended with a planning meeting of a potential follow-up of a new BONUS project.

The following lectures were presented to the conference from the Wave Engineering Laboratory team:
T.Soomere. *Basic steps of the technology for fairway optimization*.
B.Viikmäe. *Equiprobability lines in the Gulf of Finland and the Baltic Proper*.
M.Viidebaum. *Experiments with surface drifters in the Gulf of Finland*.

International Summer School **Preventive methods for coastal protection**, September 18–20, 2011, Klaipeda University, Klaipeda, Lithuania
Was organised by the BalticWay team of the Wave Engineering Laboratory jointly with the Geophysical Sciences department of Klaipeda University. The school was dedicated to novel methods for coastal protection and maritime spatial planning developed within the BalticWay project. The focus was on techniques that use the intrinsic dynamics of ocean currents for the management of environmental risks in the context of the ever increasing human impact on various vulnerable sea areas. Particular treatment was given to the risks associated with potential oil pollution from ship traffic or oil platforms. The ever increasing potential of such risks calls for out-of-the box thinking towards safe management of the maritime activities and mitigating the impact of the associated risks on vulnerable areas. The program of the school comprised of the following lectures:
K.Myrberg. (Finnish Environmental Institute, Helsinki) *Introduction to the physical oceanography of the Baltic Sea*;
T.Soomere. *Introduction into hydrodynamics of currents and waves*;
T.Torsvik. Series of lectures *Introduction into 2D and 3D modelling of ocean currents*;
T.Eremina. (Russian State Hydrometeorological University, St. Petersburg) *Modeling of transport and transformation of pollutants in the marine environment*;
K.Döös. (Department of Meteorology, University of Stockholm, Sweden) *Modelling of Lagrangian trajectories and the TRACMASS code*;
E.Quak. Things that may go wrong;
T.Soomere. *Basic steps of the BalticWay technology for coastal protection*;
J.Murawsky. (Danish Meteorological Institute, Copenhagen) *Oil spill modelling*;
T.Eremina. *3D-modeling of the transport of suspended matter in the coastal zone*;
K.Döös. *Surface drifters in the Baltic Proper*;
J.Murawsky. *Operational oceanography in Denmark*;
T.Soomere. *Applications of the smart use of marine currents for environmental management*;
E.Quak. *Basics of EU financing and how to get it*.

Fall School of the Marie Curie Initial Training Network SAGA (Shapes, Geometry, Algebra) in Vilnius, Lithuania, September 27-30, http://www.sagaschool.lt/ with survey presentations by eminent international scientists in this field, for example Carl de Boor, professor emeritus of the University of Wisconson-Madison and 2003 recipient of the US national Medal of Science in mathematics.

The Fall School was co-organized by E.Quak, who also gave an overview presentation on EU research funding.

SIAM/ACM Joint Conference on Geometric and Physical Modeling Orlando, Florida, USA, October 24-27, 2011.
Co-organized by E.Quak, who arranged a two-part "Forward Looking Minisymposium" on

future research challenges and moderated the "Forward Looking Panel Discussion". He also gave a talk on "Challenges in 3D Modelling for Remote Tower Operations in Air Traffic Control" as part of the minisymposium.

Public presentation of the collection of foresights "Research in Estonia" and the edited popular science collection "Science in Estonia (VII): Sea. Lakes. Coast" (T.Soomere and T.Nõges, Eds.) in the Estonian Academy of Sciences 20.12.2011, J.Engelbrecht, T.Soomere.

6.2 International cooperation

- Laboratory of Photoelasticity of the Institute of Cybernetics 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.Chandrasekar (Purdue University, USA), Prof. S.Yoshida (Shiga Prefecture University, Japan) and Nippon Electric Glass (Japan).

- 9–10 June, 2011, Laboratory of Photoelasticity together with Glasstress Ltd organized in Tallinn the 11th Glass Stress Summer School with 8 participants from the USA, France, England , Germany and the Netherlands. Hosted by Glass technology Services, Sheffield, UK, the Sheffield Glass Stress Summer School was organized also in Sheffield, UK, 28–29 June with 8 participants from the companies Glass Technology Services and Pilkington.

- 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 Wave Motion in Nonlinear Media for 2009 – 2011 between Institute of Thermomechanics of Academy of Sciences of Czech Republic and Centre for Nonlinear Studies of Institute of Cybernetics at TUT.

- Swedish Meteorological and Hydrological Institute (Norrköping), Laser Diagnostic Instruments (Tallinn), Danish Meteorological Institute, Department of Meteorology, Univ. of Stockholm, Institute for Coastal Research, GKSS Geesthacht, Finnish Institute of Marine Research, and Leibniz Institute of Marine Sciences at the University of Kiel in the framework of the pan-Baltic BONUS-169 project BalticWay: The potential of currents for environmental management of the Baltic Sea maritime industry (2009 – 2011).

- Collaboration between CENS and Akhiezer Institute for Theoretical Physics, NSC Kharkov Institute of Physics and Technology on Intermittent Transport Processes (2008–2011).

  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).

- CENS has been chosen to be the Operational Partner in the the FP7/Horizon2020 Future and Emerging Technologies pilot project FuturICT, to which T.Soomere is the Estonian national coordinator. FuturICT has the ambition to be at the heart of a revolutionary 21st Century science, which will use and develop information and communication technologies to create a decision support system, combining data with models in order to solve the grand challenges humanity is facing.

- Collaboration between Ira Didenkulova and (1) Dept of Mathematics, University of Oslo: Prof. John Grue, (2) Institut de Recherche sur les Phenomenes Hors-Equilibre (IRPHE),

Marseille, France: Prof. Christian Kharif, (3) University of Antilles and Guyane, Guadeloupe: Prof. Narcisse Zahibo, (4) University of Bologna, Italy: Prof. Stefano Tinti, (5) Geolab UMR 6042 CNRS-UBP, University Blaise Pascal, Clermont-Ferrand, France: Dr. Raphael Paris, (6) University of Warwick, Coventry, UK: Dr. Petr Denissenko, (7) Norwegian Meteorological Institute (met.no), Bergen, Norway: Dr. Anne-Karin Magnusson.

- Collaboration with the GKSS Geesthacht (H.Günther): Pre-operational modelling of wave regime in the Gulf of Finland, Implementation of WaMoS in the Baltic Sea, E.Stanev: Predictive methods for coastal protection.
- T.Soomere and M.Viška visited the Institute of Coastal Research, Helmholtz-Zentrum Geesthacht, Germany, supported by the Alexander von Humboldt Foundation. June 18–September 17, 2011.
- Collaboration with the Finnish Environmental Institute and University of Helsinki: Physical oceanography of the Gulf of Finland and the Baltic Sea (K.Myrberg, M.Leppäranta), Planetary Boundary Layers (S.Zilitinkevich).
- Long-term collaboration with the Niznhy Novgorod State University (E.Pelinovsky): joint research into nonlinear and rogue waves, numerous joint publications; exchange and co-supervision of PhD students.
- Collaboration with Dept of Mathematics, University of Bergen (K.Dysthe, H.Kalisch).
- Long-term collaboration with James Cook University, Towsnville, Australia (K.E.Parnell) and A.P.Karpinsky Russian Geological Research Institute (VSEGEI), and Atlantic Branch of P.P.Shirshov Institute of Oceanology RAS.
- Emerging collaboration with Klaipeda University (L.Kelpšaite, I.Dailidiene) in studies into coastal processes and zone management.

6.3 Teaching activities

6.3.1 CENS seminars for graduate students

1. Seminar on bioenergetics for PhD students.

6.3.2 Courses:

1. A.Salupere – courses in TUT:
   - Fundamentals of Elasticity
   - Basic Biomechanics (Partly)
   - Continuum Mechanics
   - Theory of Elasticity
   - Seminars and Special Seminars for MSc and PhD students
2. K.Tamm – course in TUT:
   - Fundamentals of Elasticity
3. T.Peets – courses in TUT:
   - Statics
   - Dynamics
   - Nonlinear Dynamics and Chaos

4. A.Braunbrück – courses in Tallinn University of Technology:
   - Technical Mechanics I
   - Technical Mechanics II
   - Statics
   - Dynamics

5. H.Herrmann, A.Berezovski – course in Tallinn University of Technology:
   - Scientific Computing (EMR 9803)

6. I.Zaitseva-Pärnaste – courses in Estonian Marine Academy:
   - General Cartography
   - Mathematical Cartography
   - Water Quality Modelling

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

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

9. Ü.Nurges – courses in TUT:
   - ISS0030 Modeling and Optimization (MSc)

10. M.Tõnso – courses in TUT:
    - YMR0062 Nonlinear Control Systems and Computer Algebra II (PhD)

11. S.Nõmm – course in TUT:
    - ITI8580 Hybrid Control Systems (MSc, PhD)
    - YMR0063 Algebraic Methods in Nonlinear Control Systems (PhD)

12. S.Nõmm – courses in EBS:
    - ECO234 Introduction to Econometrics (BSc)
    - ECO 134 Introduction to Econometrics (BSc)
    - ECO 234 Introduction to Econometrics (BSc)
    - MAT105 Mathematics and Statistics for Business I (BSc)
    - MAT406 Mathematics and Statistics for Business II (BSc)

13. J.Vain – courses in TUT:
    - ITI0020 Logic Programming (BSc and MSc)
    - ITI0060 Formal Methods (MSc)
    - ITX8025 Formal Methods of System Design (MSc)
    - ITI9120 Advanced Topics in Computer Science (PhD)
    - IXX9601 Doctoral Seminar I (PhD)

14. T.Mullari – courses in TUT:
    - YFT0250 Electrodynamics (BSc)
    - YFR0020 Physics (BSc)
    - YFR0030 Physics (BSc)
    - YFR0080 Refresher Course in Physics (BSc)

15. J.Belikov – courses in TU:
    - ISS0010 System theory (BSc)

16. P.Saari – courses in University of Tartu:
    - Quantum mechanics
    - Advanced quantum mechanics
    - Quantum computing and cryptography

17. Course "Feedback linearization with internal stability of mechanical underactuated systems"for graduate students (organized by the Institute of Cybernetics at Tallinn University of Technology as the partner of Information and Communication Technology Doctoral School IKTDK) by Prof. Claude Moog (22.03.2011–01.04.2011)

6.3.3. Participation in other events, transfer of knowledge:

1. A.Kaldmäe, J.Belikov, participation in module "Normal Forms for Nonlinear Control Systems"(W.Respondek). HYCON-EECI Graduate School on Control (28 February – 2 March, 2011).

2. J.Kalda:
   Advisory board of the International Physics Olympiads
   International Jury of the World Physics Olympiad
   Head of the theoretical examination of the 43. International Physics Olympiad
   Steering Committee of the 43. International Physics Olympiad
   Jury of Estonian Physics Olympiads.

3. T.Soomere participated in the PhD examination of Irina Nikolkina as a member of the examination committee in University of Antilles and Guayane, Point-a-Pitre, Guadeloupe, 11 July 2011.

4. T.Soomere, T.Torsvik and E.Quak gave lectures to the International Summer School "Preventive methods for coastal protection", September 18–20, 2011, Klaipeda University, Klaipeda, Lithuania (see 6.1).

5. E.Quak, gave an overview presentation on EU research funding at the Fall School of the Marie Curie Initial Training Network SAGA (Shapes, Geometry, Algebra) in Vilnius, Lithuania, September 27–30.

6. Summer course for physics teachers, June 28, 2011, Tallinn.
   A.Salupere. Solitons – beautiful and multifaceted waves.
   J.Engelbrecht. Chaos and Complex systems.
   J.Kalda. Fractality in Nature and Society.
   J.Engelbrecht, M.Vendelin, M.Kalda. Physics and Heart.

7. J.Vain. Intensive course on "Distributed testing architectures"under the course "Software Architectures", 456502.0 Abo Akademi University (MSc)

6.4. Visiting fellows
For shorter period

1. Dr. Peter Ván, Hungarian Institute of Nuclear Physics (KFKI), 26 January – 09 February, 2011.

2. Prof. Claude Moog, Institut de Recherche en Communications et en Cybernétique de Nantes (IRCCyN), March 20–2 April, 2011.

3. Dr. Miroslav Halás, Slovak University of Technology, March 27–2 April, 2011.

4. Dr. Ewa Pawluszewicz, Białystok University of Technology, August 18–22, 2011.

5. Prof. Zbigniew Bartosiewicz, Białystok University of Technology, August 18–22, 2011.

6. Prof. Alexey N.Zhirabok, Far Eastern State Technical University, August 18–23, 2011.

7. Prof. Gianluca Sara, University of Palermo, 26–29 January, 2011.

8. Dr. Richard Wheeler, Edinburgh Scientific, as part of the ESTSpline project, February 12–27, 2011.

9. Prof. Emeritus Carl de Boor, University of Wisconsin-Madison, USA, September 21–25, 2011, in relation to the SAGA Fall School in Vilnius

10. Prof. Ronald Goldman, Rice University, Houston, Texas, in relation to the SAGA Fall School in Vilnius, September 21–25, 2011.

11. Dr. Alexander Ezersky, University of Caen Lower Normandy, in the framework of the month of French science, 1–4 November, 2011.

12. Marco Miani, Coastal Research Station, Norderney, Germany, 3–5 November, 2011.

13. Prof. Narcisse Zahibo, University of the French West Indies and Guiana, in the framework of the month of French science, 3–8 November, 2011.

14. Prof. Frédéric Dias, University College Dublin, in the framework of the month of French science, 28–30 November, 2011.

15. Dr. Andreas Ulrich, Physik Department E12 Technische Universität München Garching, Germany. Joint scientific work in the laboratory as well as Erasmus Program Lecture for students (6 two-hour lectures) "Light Sources and Gas Lasers — Low Temperature Plasma Physics and its Applications", September 21 – November 1, 2011.

16. Dr. Andras Szekeres, Budapest University of Technology and Economics, 24 September–4 October, 2011.

17. Prof. Jiři Plešek, Institute of Thermomechanics, Czech Academy of Sciences; Prague. April 26–29, December 4–7, 2011.

18. Dr. Alexey Porubov, Institute of Problems in Mechanics, St. Petersburg. April 26–28, 2011.

19. Prof. Hui-Hui Dai, City University of Hong Kong. December 4–7, 2011.

For longer periods

1. Irina Nikolkina, 20 February – 6 May 2011 as a visiting DoRa 5 PhD student under supervision of Ira Didenkulova.

6.5 Graduate studies

Department of Mechanics and Applied Mathematics:
Promoted:

1. MSc:
   - E.Pastorelli — (Università degli Studi di Genova): Tensor Visualization with Virtual Reality Displays (supervisors H.Herrmann, P.Magillo).

2. PhD:
   - T.Peets — Dispersion analysis of wave motion in microstructured solids (supervisor J.Engelbrecht).
   - K.Tamm — Wave propagation and interaction in Mindlin-type microstructured solids: numerical simulation (supervisor A.Salupere).

In progress:

1. MSc:
   - I.Jelissejeva — Numerical simulation of wave propagation using finite element method (supervisor A.Berezovski).
   - M.Heidelberg — Diffusion in Stationary Turbulent Media (supervisor J.Kalda).
   - J.Jõgi — Modelling of Nanostructures in Materials Sciences (supervisor J.Kalda).
   - 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).

2. 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 improuvements (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).

Laboratory of Systems Biology:
Promoted:

1. BSc
   - S.Kotlyarova — Tubuliini uuring difusioonitakistustega rakkudes, kasutades immunotsütokeemilisi meetodeid.
   - A.Klepinin — Comparative analysis of inhibition of endogenous ADP stimulated respiration by pyruvate kinase (PK) and phosphoenolpyruvate (PEP) system in rat and rainbow trout cardiomyocytes.
2. MSc:
   - N.Kolesnikov — Study of Ca2+ wave initiation in mammalian cardiac myocytes using confocal microscopy and computational methods.
   - P.Simson — Free surface problem with variable bottom and its solution using conformal mapping technique.

In progress:

1. PhD:
   - A.Illaste — Mathematical model of mitochondrial energy metabolism (supervisor M.Vendelin).
   - D.Schryer — ^{13}C impulse labeling studies with Saccharomyces cerevisiae (supervisor M.Vendelin).
   - M.Kalda — Mechanoenergetics of a single cardiomyocyte (supervisor M.Vendelin).
   - M.Sepp — Estimation of diffusion restrictions in cardiomyocytes using kinetic measurements (supervisor M.Vendelin).
   - N.Sokolova — Energetics and contractility in heart of rainbow trout (supervisor R.Birkedal).
   - N.Jepihhina — Heterogeneity of energetic parameters in cardiomyocytes (supervisor M.Vendelin).
   - M.Laasmaa — Studies of the relationship between excitation-contraction coupling and energetics on trout cardiomyocytes (supervisors P.Peterson, R.Birkedal).
   - P.Simson — Localization of diffusion restrictions in cardiomyocytes (supervisors P.Peterson, M.Vendelin).
   - J.Branovets — Structural and energetic modifications in cardiomyocytes from mice with modified creatine kinase system (supervisor R.Birkedal).

Laboratory of Wave Engineering:
Promoted:

1. Diploma:
   - K.Pindsoo — Estimates of sediment transport along the East coast of the Gulf of Riga (supervisor T.Soomere).
2. MSc:
   - K.Kartau — Development of the northern coast of Pärnu Bay (supervisor T.Soomere, co-supervisor H.Tõnisson).
   - O.Tribštok — Comparison of wave regimes along Estonian and Lithuanian coasts (supervisor T.Soomere).

M.Viidebaum — Experimental investigation of the relationship between pulse wave velocity and blood pressure on human arm based on Moens-Korteweg equation (supervisor K.Pilt).

3. PhD:
   - I.Nikolkina — Modelling dynamics of gravity flows and long waves in fluid with application to marine natural hazards (R.E.Alekseev Nizhny Novgorod State Technical University, supervisor E.N.Pelinovsky; Cand. Sci. in fluid mechanics).
   - I.Nikolkina — Modelling dynamics of gravity flows and long waves in fluid. Application to natural hazards in the Lesser Antilles (Université des Antilles Guyane, UFR Sciences, Campus de Fouillole, supervisors E.N.Pelinovsky and N.Zahibo; PhD).

In progress:

1. PhD:
   - I.Zaitseva-Pärnaste — Wave climate changes of the Baltic Sea and their economical consequences (supervisor T.Soomere), promotion expected 2013.
   - 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.
   - O.Kurkina — Nonlinear dynamics of internal gravity waves in the Baltic Sea (supervisor T.Soomere), promotion expected 2012.
2. MSc:
   - R.Männikus
   - S.Chatraee
   - M.Zujev
   - K.Pindsoo

Control Systems Department:

In progress:

1. PhD:
   - V.Kaparin — Transformation of the nonlinear state equations into the observer form (supervisor Ü.Kotta).
   - J.Belikov — Identification and control of complex nonlinear multi input multi output systems based on methods of artificial intelligence (supervisor E.Petlenkov).

A.Anier	Motion recognition via abstract interpretation (supervisor J.Vain).
M.Markvardt	Test data generation methods for input validation (supervisor J.Vain).
S.Avanessov	Robust adaptive output controller (cosupervisor Ü.Nurges).
K.Haavik	Model-based distributed testing method for web-based banking applications (supervisor J.Vain).
K.Sarna	Aspect-Oriented Model Engineering in Distributed Model-Based Testing (supervisor J.Vain).
J.Irve	Recognition and tracking of meaningful areas in medical image processing (supervisor J.Vain).

Optics group:
Promoted:

1. MSc:
   M.Lõhmus
   O.Rebane

In progress:

1. PhD:

P.Piksarv	Time-resoved measurement of localized optical pulses (supervisor P.Saari).

6.6 Distinctions and awards

Fellows:

1. P.Saari was awarded by Rozhdestvenski Optical Society of Russia with Yu.N.Denisyuk medal for pioneering research in spatiotemporal holography based on spectral hole-burning techniques.
2. I.Didenkulova was elected as a member of International tsunami comission (an Estonian representative) starting from 2012 (July 2011).
3. The BalticWay team led by T.Soomere was awarded a special mention in the BONUS+ Award 2011 competition for the best public engagement activity or product, for outstanding public engagement effort and high level key stakeholder involvement related to the topic of the environmental impact assessment of the Nord Stream pipeline (24.10.2011).
4. T.Soomere was awarded the title of the best scientist (journalist or teacher), that communicates science and technology for explaining actual problems of marine physics in popular-scientific papers and at public appearances at the distribution of 2011 Estonian Science Communication Awards (11.11.2011).
5. I.Didenkulova was awarded Humboldt foundation fellowship (2012–2014) for experienced researchers.

Students:

1. O.Tribštok received award in student research competition of the Estonian Academy's of Sciences for the master thesis "Comparison of wave regimes along Estonian and Lithuanian coasts" (supervisor T.Soomere) (08.11.2011).

2. M.Lõhmus was awarded the 1st prize of Ministry of Science and Education Contest for student scientists.

6.7 Other activities

6.7.1 Participation on programme committees, reviewing papers:

1. IUTAM Symposium on Computes Models in Biomechanics, Stanford, 2011, J.Engelbrecht.
2. IFAC Symposium on Nonlinear Control Systems 2013, Toulouse, France, Ü.Kotta.
3. IFAC World Congress 2011, Milan, Italy, Ü.Kotta.
4. 10th biennial International Conference on Vibration Problems, ICoVP 2011, Scientific Committee and the leader of the Conference Track "Wave Problems in Solid Mechanics"review papers for the 10th biennial International Conference on Vibration Problems, Composites B., A.Berezovski.
5. INTAS and ERA.NET RUS – evaluator of grant applications, A.Stulov.
6. Estonian representative in the Marine Board of the European Science Foundation (since 2007), T.Soomere.
7. Chair of the Marine Board of the Estonian Academy of Sciences (since 2007), T.Soomere.
8. EASAC Environmental Steering Panel, Estonian representative (since 2008), T.Soomere.
9. Elected as a member of International Tsunami Comission (since 2012), I.Didenkulova.
10. A member of EGU Plinius medal committee (since 2011), I.Didenkulova.
11. A member of EGU Outstanding Young Scientist Award Commission for the Natural Hazards Division, I.Didenkulova.
12. 8th Baltic Sea Science Congress (BSSC), Saint Petersburg, Russia, August 22–26, 2011, member of the Steering Committee T.Soomere, conveners and chairs of the thematic session: Interplay of physical, biological and geological processes in various spatial and temporal scales (23–24.08) T.Soomere, I.Didenkulova.
13. European Geosciences Union (EGU) General Assembly, Vienna, Austria, April 3–8, 2011, I.Didenkulova.
    Session 1: NH5.1 New developments in tsunami science and in mitigation of tsunami risk, including early warning.
    Session 2: NH5.3/NP7.3/OS2.5. Nonlinear Dynamics of the Coastal Zone.

6.7.2. Participation in journal editorial boards:

1. Estonian Journal of Engineering – J.Engelbrecht (editor-in-chief).
2. Journal Theoretical and Applied Mechanics (Warsaw) – J.Engelbrecht.
3. Applied Mechanics (Kiev) – J.Engelbrecht.
4. Proceedings of Estonian Acadamy of Sciences – Ü.Kotta.
5. Estonian Journal of Engineering (editor, hydrodynamics and coastal engineering); guest editor of issue 4/2011 Oceanograpy. Meteorology. Coastal Engineering) – T.Soomere.

6. Oceanoloogia – T.Soomere.
7. Journal of Marine Systems – T.Soomere.
8. Boreal Environment Research – T.Soomere.
9. Journal of Mathematics in Industry (JMiI) – E.Quak.
10. Natural Hazards and Earth System Sciences, guest editor of SIs "Sea Hazards" and "New developments in tsunami science: from hazard to risk" – I.Didenkulova.
11. Nonlinear Processes in Geophysics, guest editor of SI "Nonlinear waves in the ocean" – I.Didenkulova.
12. Laser Physics – P.Saari.

6.7.3. Participation in professional organizations:

1. IFAC technical committee for nonlinear systems: Ü.Kotta.
2. IFAC technical committee for human machine systems: S.Nõmm.
3. IFAC contact person in Estonia: S.Nõmm.
4. IEEE Technical Committee on Computational Aspects of Control System Design – Chairman of the Action Group on Polynomial Methods for Control System Design: Ü.Kotta.
5. European Geosciences Union, scientific officer of Sea hazard devision: I.Didenkulova.
6. International Tsunami Comission, member, Estonian representative: I.Didenkulova.
7. Marine Board of the European Science: Estonian representative: T.Soomere.
8. Marine Board of the Estonian Academy of Sciences: chair: T.Soomere.
9. EASAC Environmental Steering Panel: Estonian representative: T.Soomere.
10. EC evaluation of Integrated Project proposals for the ICT Call 7: E.Quak.
11. EC evaluation of the call for Marie Curie Industry Academia Fellowships and Pathways: E.Quak.
12. EC evaluation of the call for FET Flagships Pilot Programmes: J.Engelbrecht.

6.7.4 Science and Politics:

1. T.Soomerel presented the lecture "A future technology of environmental management for the Gulf of Finland" at the round-table session "Risks of maritime transportation and the need for response capacities" in the International Symposium "Baltic Sea Day" (Saint Petersburg, 21–23.03.2011).
2. T.Soomere was the chief organizer of the spring Plenary Meeting of the European Science Foundation Marine Board in the premises of the Estonian Academy of Science (Tallinn, Estonia, 10–11.05.2011).
3. T.Soomere presented the invited lecture "Marine science in research for alternative energy sources" in the conference "Climate, renewable energy and sustainable development: The new geo-energy" organized by the Group of Conservatives and Reformists in the premises of the European Parliament (ASP 7 H 1) (Brussels, 21.06.2011).

4. T.Soomere participated in the meetings of national coordinators of the FuturICT Flagship (Zürich, 28.06.2011 and Vienna, 11.09.2011).

5. T.Soomere participated in the fall Plenary Meeting of the European Science Foundation Marine Board (Madrid, Spain, 13–14.10.2011).

6. T.Soomere presented the note "The use of currents for environmental management of the maritime industry" about developments within the BONUS BalticWay project in the BONUS Forum (Gdansk, Poland, 24.10.2011).

7. T.Soomere participated in the joint meeting of the European Academies Scientific Advisory Council (EASAC) Environment Steering Panel and Energy Steering Panel (Brussels, Belgium, 11.11.2011).

6.7.5. Media reflections

About us

1. K.Kello. Tervik on suurem kui osade summa (The whole is larger than the sum of counterparts). Õpetajate Leht (Teachers Weekly) 7, p. 7, 18.02.2011.

2. K.Kello. Akadeemiline hulkurlus ja ülikoolide edetabel (Academic vagabondism and ranking list of universities) Õpetajate Leht (Teachers Weekly) 7, p. 7, 18.02.2011.

3. TV broadcast about coastal and wave science in the Wave Engineering Laboratory in the series "Püramiidi tipus" (The top of the pyramide), broadcast by the national TV channel ETV; repeated on 17 and 20 April, 16.04.2011.

4. R.Veskimäe. "Mees nagu mitme tundmatuga võrrand" (The man as an equation with multiple unknowns). Põline partituur. Intervjuud akadeemikutega (Interviews with academicians of the Estonian Academy of Sciences). Reves Grupp, Tallinn 2011, 13–29 (in Estonian).

Media outreach

1. S.Rebane. Teaduse sees on põnev (It is fascinating in science). – On J.Engelbrecht. Magazine "Elukiri", May, 2011, 20-24.

2. Interview with T.Soomere about progress in Estonian marine science and related policy: the role of Estonian marine scientists has considerably increased during the last years. Broadcast twice by Kuku Raadio in Marine Hour, 01.01.2011.

3. Interview with T.Soomere about patterns of climate changes in the Baltic Sea region. Broadcast in news program "Aktuaalne Kaamera" in the national TV channel ETV, 19.02.2011.

4. Interview with T.Soomere about first news concerning the Sendai (Tohuku) earthquake. Broadcast in radio channel Kuku Raadio at 16:00-16:30, 11.03.2011.

5. Interview with T.Soomere about the major features of the Sendai (Tohuku) earthquake. Broadcast in news program "Aktuaalne Kaamera" in the national TV channel ETV at 17:00 and 21:00, 11.03.2011.

6. Interview with T.Soomere about the course and consequences of the oil spill at the Gannet Alpha platform in the North Sea. Broadcast in radio channel "Kuku Raadio", 18.08.2011.

7. M.Filippov. Eksperdid kritiseerivad Nord Streami seirearuannet (Experts comment the Nord Stream monitoring report). Postimees 226 (6308), p. 6 , 29.09.2011.

8. M.Filippov. Nord Streami mõjudest rääkimine tõi auhinna (Talking about impacts of the Nord Stream pipeline brought a distinction). Postimees, 250 (6332), 27.10.2011. Also in Postimees Online at 14:56, 26.10.2011 and in the morning news of many radio channels on 27.10 2011.

9. Interview with T.Soomere about specific features and impact of autumn storm "Berit" on 24-28 November in the North Sea and Scandinavia. Broadcast in radio channel Kuku Raadio at 8:15-8:30, 29.11.2011.

10. M.Filippov. Torm Berit üllatas tugevusega mereteadlastki (The Berit storm was surprisingly strong). Postimees Online at 16:58, 29.11.2011.

11. M.Filippov. Soomere: Berit oli üllatavalt tugev torm (The Berit storm was surprisingly strong, Soomere says). Postimees 279 (6361), p. 7, 30.11.2011.

12. An 1-hour interview with T.Soomere and T.Nõges; Editors of the collection of popular sciences papers "Science in Estonia (VII): Sea. Lakes. Coast" in the broadcast "Kukkuv Õun" of Kuku Raadio about the basic features and messages of this collection, 18.12.2011.

13. Introduction and comments by T.Soomere to the documentary "Earth under water"; broadcast in the national TV channel ETV2 on 18.12.2011 and 21.12.2011.

14. An interview with T.Soomere to the national TV channel ETV about the impact of autumn storm Berit on the coasts of Saaremaa and on the potential reaction of the Estonian sedimentary coasts on changes to wind climate in the Baltic Sea basin; broadcast as a part of news about science within the major news program "Aktuaalne Kaamera" 23.12.2011; repeated as a part of news in several radio channels on 24.12.2011.

15. J.Kalda. Estonian Physical Society Autumn School, "Centre of Excellence CENS: complex systems inside and around us", 30.10.2011.

16. J.Kalda. Vikerraadio, "Labor": about quasi-crystals and chemistry Nobel prize, 9.10.2011.

17. J.Engelbrecht. Internationalization of research in Estonia. Subsection: 50 years of research (on the Institute of Cybernetics). Estonia. International Business Handbook, 2011–2012. Euroinformer, Tallinn, 2011, 172-174.

7. Summary

The most important event for CENS in 2011 was awarding the title "Estonian Centre of Excellence in Research" for 2011–2015 with additional funding over these years (ca 3 M €). This was possible only due to excellent research by all the fellows. Our application stressed the synergy between all the 5 groups (see Work Plan of CENS in Annex) and got high marks by reviewers.

Some citations from their reports:

On previous research: "*... grounding such an excellence centre [ie. CENS] provided indeed scientific excellence* ";

On future: "*... I find the research projects of the proposed centre impressive, involving physics, biology, engineering, mathematics and computer science* ".

"*... In research group as a whole are involved in a large number of individual projects, both in Estonia and internationally, and many of them have a connection to the hard - contested EU funding*".

"*... it is expected that the CENS will achieve more than the sum of the different groups separately...*"

Although officially the Centre of Excellence was recognized in August 2011, the work has started in early 2011 and there are several results which indicate the synergy between the groups.

Internally within CENS:

Nonlinear Dynamics – Wave Engineering: Dispersion properties of surface motions and associated spreading rates of initially closely located water particles in the surface layer of the Gulf of Finland were estimated using autonomous surface drifters. Instead of the simple Richardson's law, the spreading exhibits a combination of two different power laws for different initial separations. The results of the theoretical analysis of passive scalar turbulence have been applied to the marine sciences – allowing us to pinpoint the locations of the Baltic Sea, most prone to the formation of pollution patches due to the compressibility of the two-dimensional velocity field at the sea surface. Conversely, the experimental data obtained during the marine expeditions made it possible to advance the theoretical understanding of the tracer mixing by compressible flows.

Wave Engineering – Nonlinear Dynamics: Studies of waves in layered solids showed a great similarity to water waves with channels with varying depth; common efforts towards the analysis of the robustness of optimum fairways specified by different criteria.

With other research centres in Estonia:

Wave Engineering – Coastal group in the Institute of Ecology, University of Tallinn: A systematic estimate of the sediment budget based on the equilibrium beach profile is presented for Valgerand on the northern coast of Pärnu Bay.

Nonlinear Dynamics – Laboratory of Physics of Nanostructures, University of Tartu: Combining the theoretical knowledge regarding the modelling of complex systems with the experimental techniques of the Laboratory of Physics of Nanostructures has allowed to shed light into the physical processes responsible for the cracking of gel-sol films and subsequent formation of nanotubes.

Nonlinear Dynamics – Institute of Chemistry TUT: it has been possible to apply the methods of statistical topography (developed in CENS) to the analysis of the morphology of electrically conducting networks of polymer films (modelled in the Institute of Chemistry), and reveal thereby the presence of long-range correlations between the conducting elements.

Much attention has been paid to international cooperation (Pierre and Marie University, Paris; Turin University; Hong-Kong City University, Institute of Thermomechanics, Prague; James Cook University, Towsnville, Australia; Institute for Coastal Research, Helmholtz-Zentrum Geesthacht, Germany; University of Klaipeda; a number of papers written jointly with scientists from Nizny Novgorod State Technical University, A.P.Karpinsky Russian Geological Research Institute (VSEGEI), and Atlantic Branch of P.P.Shirshov Institute of Oceanology RAS).

CENS is becoming attractive to researchers and PhD students from other countries:
Wave Engineering Group – Dr. Tomas Torsvik (Norway) as a leading scientist, started in 2011;
Nonlinear Control Group – Dr. Seshadri Srinivasan (India) will join the team in 2012 as a senior scientist.

There are PhD students from other countries supported by the Estonian DoRa scheme:
in Wave Engineering Group: Artem Rodin (Russia), Andrea Giudici (Italy); Maija Viška - (Latvia);
in Nonlinear Dynamics Group: Emiliano Pastorelli (Italy) will join in 2012. Supported by the ERASMUS scheme is David Hernandez Merino (Spain).

CENS scientists have also been moving to other centres:
Dr. Ira Didenkulova won the A.v.Humboldt Scholarship for working in Germany in 2012 and
Dr Mikhail Berezovski started to work as an Assistant Professor at Worcester Polytechnic, Mass., USA in 2011.
It is worth to mention that together with Dr I.Didenkulova there are now 5 Humboldt fellows in CENS.

CENS has been chosen to be the Operational Partner in the FP7/Horizon2020 Future and Emerging Technologies pilot project FuturICT, to which T.Soomere is the Estonian national coordinator. FuturICT has the ambition to be at the heart of a revolutionary 21^{st} Century science, which will use and develop information and communication technologies to create a decision support system, combining data with models in order to solve the grand challenges humanity is facing.

As for disseminating the ideas of complexity, Dr Robert Kitt published a paper on Social Complex Systems in the Estonian Magazine “Akadeemia” and initiated the translation into Estonian of the book “Fooled by Randomness: the hidden role of chance in life and in the markets” by N.N.Taleb. J.Engelbrecht wrote a preface on rules and experts for an Estonian translation of the book “The Smart Swarm” by P.Miller.

T.Soomere was awarded with a special mention by the BONUS Consortium for outstanding public engagement effort and high level key stakeholder involvement related to the topic of the environmental impact assessment of the Nord Stream pipeline. He was also awarded the title of the best scientist (journalist or teacher) in Estonia that communicates science and technology to society.

From a more general view to science – J.Engelbrecht edited a book “Research in Estonia. Present and Future ” (Estonian Acad.Sci., Tallinn, 2011) where his Introduction “Towards a knowledge-based society ” describes the developments of research in Estonia from the viewpoint of complex systems. In the same book T.Soomere describes contributions of basic research towards solving challenges of changing times in coastal sciences and management.

European views on research are described by the book “The Sum of the Parts: ALLEA and academies ” by J.Engelbrecht and N.Mann (ALLEA, Amsterdam, 2011). A thorough overview of oceanography, limnology and coastal research was presented in the book “Scientific thought in Estonia VIII. Oceanography. Limnology. Coastal science ” (editor-in-chief T.Soomere).

For the next year, CENS is engaged in organizing of:

– 10th Symposium for Geometry Processing, July 2012, Tallinn (E.Quak);

– Euromech 540 on Advanced Modelling of Wave Propagation in Solids, Oct. 2012, Prague (A.Berezovski, J.Engelbrecht);

– International Physics Olympiad, July 2012, Tallinn/Tartu (J.Kalda);

– 12th Glass Stress Summer School (H.Aben).

Annex

1. Workplan of CENS for 2011–2015.
2. On monograph "Microstructured solids: Inverse Problems" by J.Janno, J.Engelbrecht (Springer, 2011).
3. Photoelasticity of Glass, information from GlasStress.
4. BONUS briefing, N 7, October 2011.
5. Dedicated centre for applied mathematics in Estonia. Cordis, Technology Marketplace.

Action plan

Centre for Nonlinear Studies – CENS

2011 - 2015

Head Jüri Engelbrecht

Board:

Jüri Engelbrecht
Ülle Kotta
Peeter Saari
Tarmo Soomere
Marko Vendelin

The contributing research teams

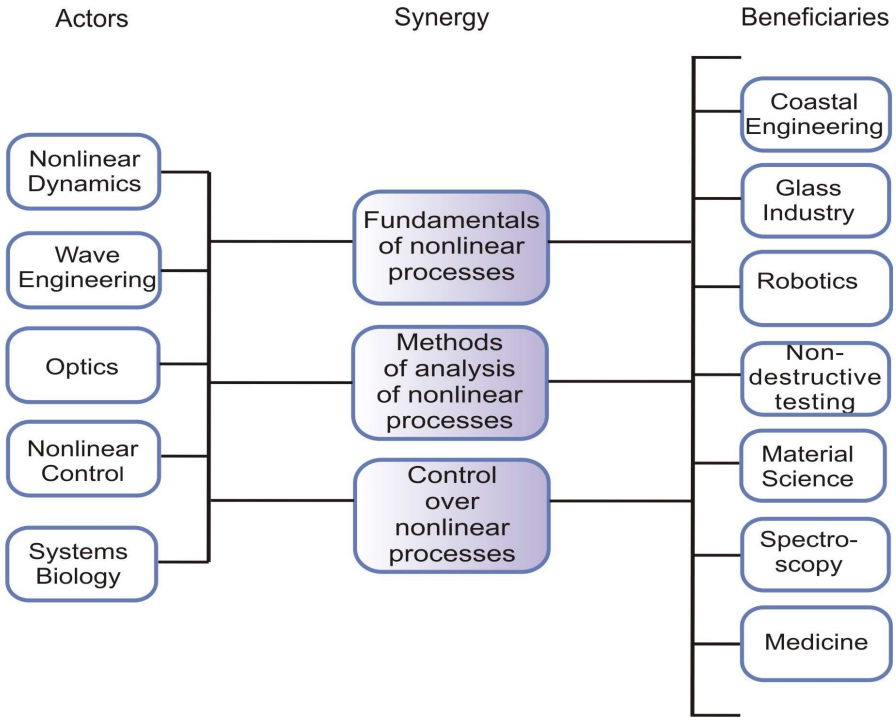
The constituents of our world inherently interact with each other and their environment in a nonlinear way resulting in phenomena, which cannot be predicted by simple linear approaches and theories. Although nonlinear studies originated in mathematics and physics, they are in general intrinsically multidisciplinary. Nonlinear processes are dominating in areas such as chemistry, medicine and physiology, and also computer sciences. More recently this list has been extended to economic and social sciences, and decision support and control systems.

Interactions of inherent nonlinearities and of the components of a whole (which differ widely in character, size and scale) give rise to new effects such as self-organization and the emergence of coherent structures over many scales. This challenges us to combine studies in the analysis, synthesis and control of nonlinear systems to spearhead major developments in contemporary science and meet the needs of society. Our goal is to carry out theoretical and experimental research in the analysis and control of nonlinear processes in a selection of natural and man-made physical and biological systems.

CENS was originally founded in 1994 as a cluster-type research unit to concentrate the national research efforts within nonlinear dynamics and related areas, and was an Estonian Centre of Excellence in Research in 2002-2007. Now the composition of the new CENS reflects both past successes and new challenges. Out of the original **Nonlinear Dynamics** (ND) group two teams have grown and become independently funded units: **Wave Engineering** (WE) and **Systems Biology** (SB). Two other groups have been invited to join to increase the scope and the potential for synergy: the **Optics** (OG) group and the **Nonlinear Control Systems** (NC) group. Four groups are part of the Institute of Cybernetics at Tallinn University of Technology; the Optics Group belongs to the Institute of Physics at the University of Tartu. Activities of Groups and possible beneficiaries are shown in Fig 1.

Fig. 1

Activities of CENS:



The **Nonlinear Dynamics** group holds key competence in (i) wave motion in solids, (ii) soft matter physics, and (iii) photoelasticity.

The studies in (i) focus on nonlinear deformation waves in micro-structured solids, which are of growing importance in contemporary technology (functionally graded materials, metal-ceramic composites, etc.). The team has internationally recognized competence in mathematical modelling [ND1][1] of wave motion, in the analysis of dispersive and nonlinear effects including emerging solitary waves, and in solving the inverse problems [ND2] of material characterization. The novel concept of internal variables [ND3] introduced by the group permits to unify the theoretical background in modelling. Based on these important results, the main goal is now to develop hierarchical multi-scale modelling of nonlinear wave motion in micro-structured materials relating mesoscopic physics to continuum mechanics. The studies will reflect the existence of possible nonlinearities over the scales, dispersive/dissipative effects and thermodynamical consistency in numerical calculations. The nonlinear effects will be used for new non-destructive testing methods of material characterization based on wave-wave and wave-material interaction. For understanding the behavior of the microstructure, 3D visualization methods and experiments must be developed.

For (ii), our studies deal with nonlinearities in interdisciplinary areas from mechanics to econophysics, which all are characterized by self-organization and power laws [ND4, ND5]. The new challenges include studies of turbulent mixing of passive scalars in oceans and flows of free-slip surfaces of turbulent water (problems of contamination),

[1]References are made to example publications of each group listed at the end of the text. See the attached CVs for the full list of publications of every scientist

droplet nucleation in warm clouds, and financial drawdown, which is analogous to turbulent mixing.

In (iii), the Laboratory of Photoelasticity deals with the analysis of stress fields in glasses [ND6], where the team has even created a spin-off company GlasStress. The goal here is to develop the theory and algorithms of nonlinear photoelastic tomography for non-destructive measurement of 3D stress fields, especially in very thin objects.

The Laboratory of **Wave Engineering** represents deep knowledge in nonlinear wave theory and modelling for fluids, with the focus on applications in the marine and coastal environment.

The team is the worldwide leader of studies into several classes of transient and localized wave phenomena (similar to those studied by OG for light waves, see below) such as soliton interactions, freak waves and vessel wakes in shallow water, and wave run-up [WE1–3]. Although linear ship wakes are well known, the importance of the remote impact of ship traffic due to nonlinear wake waves [WE4] has now been recognised through the analysis of the WE group. The role of nonlinear phenomena in surface wave fields is particularly large in semi-sheltered basins such as the Baltic Sea, where our studies [WE5] form the state-of-the-art of wave climate research. WE is also pioneering in the development towards engineering estimates of the magnitude of marine and wave-induced coastal hazards and creating novel methods for their mitigation [WE6] that have virtually no analogues in the world.

Topics of particular interest are: fundamentals of nonlinear wave phenomena (rogue waves, nonlinear interactions, run-up phenomena, 2D propagation, wave mathematics); properties and spatio-temporal variations of wave fields (wind waves, long-wave phenomena, ship waves, internal waves); applications for coastal engineering and coastal zone management (quantification of marine-induced hazards and wave loads, wave energy issues, preventive methods for environmental protection, etc.)

The Laboratory of **Systems Biology** has leading expertise in the analysis of the regulation of intracellular processes.

By experimental and theoretical analysis of highly non-linear phenomena, such as biological processes, SB members contributed to the understanding of the regulation of heart physiology on molecular [SB1], cellular [SB2, SB3], tissue [SB4], and organ level. We have developed new approaches to quantitatively analyze the morphology of live cells [SB5] as well as participate actively in the enhancement of mathematical analysis of microscope images [SB6]. The SB work has been recognized by a Wellcome Trust International Senior Research Fellowship, one of the most prestigious fellowships in the biological and medical sciences.

The main SB aim is to study the regulation of intracellular processes and understand the functional influences of highly nonlinear intracellular interactions. The focus is on energy transfer regulation and analysis of intracellular diffusion in heart muscle cells. In addition, we look on the development aspect of intracellular interactions (trout *vs* rat) and use genetically modified mice for perturbation of intracellular control. Future activities – using a combination of experimental (following ethical conditions) and theoretical methods – concern: analysis of diffusion of molecules in the crowded intracellular

environment of heart muscle cells; mathematical modeling of energy transfer networks in the heart muscle; energy consumption and regulation of energy transfer at different mechanical load protocols; the role of the Na+/Ca2+-exchanger in excitation-contraction coupling and energetics; interdependence of reactive oxygen species and Ca-signaling in initial stages of heart failure; molecular interaction between creatine kinase and adenine nucleotide translocase.

Areas of key expertise of the **Optics** group within the scope of CENS are ultrafast optics, optical and nonlinear spectroscopy, and especially the so-called localized waves (LW).

A breakthrough in the study and applications of electromagnetic and acoustic LWs occurred in the end of the 1990s, when OG introduced methods of physical and ultrafast optics into the subject (two pioneering papers [OG1, OG2] have received more than 270 citations). The study of LWs has expanded rapidly – a number of new teams have entered the field worldwide and new types of practically promising LWs have been discovered, e. g., nonlinear propagation of Bessel-type LWs and the so-called Airy beams and bullets have become a hot topic in Nature, Nature Photonics and other top-impact-factor journals.

Collaboration between OG and Georgia Tech researchers has recently resulted in a series of pioneering results (work summarized in [OG3] was selected by the worldwide magazine Optics & Photonics News into a set of 28 of "the most exciting peer-reviewed optics research to have emerged over the past 12 months."). The OG group also contributes to applying the Bessel-, Mathieu-, etc., conical beams/LWs in nonlinear spectroscopy [OG4] and addresses the problems of nonadiabaticity, quantum-mechanical inverse problems and solving the Schrödinger equation [OG6] that also describes deep-water waves, linking it to WE.

The **Nonlinear Control Systems** group holds unique competence in dynamical control systems on time scales [NC1, NC2, NC3].

This is an emerging area of research to model dynamics of interspersed continuous and discrete evolution periods that frequently and inherently occur in nonlinear environments (e.g. propagation of cracks or shock waves). The NC group also incorporates competence in robust control [NC4] and in synthesis methods of reactive planning algorithms that are highly efficient in on-line testing and autonomous robot action planning applications [NC5].

The NC group will focus on novel methods and tools for solving fundamental/generic problems for nonlinear control systems towards the unification of discrete- and continuous-time control systems. The aim is to integrate our research with progress in non-traditional application areas of control theory such as biology, environmental science and material science. Three formalisms (time scale calculus, pseudo-linear algebra and associated algebraic computation methods, and algebra of functions) complement each other to reduce the programming effort in symbolic software implementations. The algebra of functions allows the development of novel solutions for discrete event systems used in modern computer-based control. The time scale tools will be systematically applied to the analysis of hierarchical multi-scale control systems (that may be discrete or continuous at different levels and/or time models) using the recently introduced idea (Willems, 2007) that systems are interconnected by sharing variables, with the behavioral

approach as the supporting mathematical language. This systematic, modular and hierarchical methodology is easy to adapt to computer assisted modelling.

Synergy and added value

The key asset that makes synergy feasible is that all proposed studies are characterized by the decisive role of a few universal nonlinear phenomena (such as essential interaction between the constituents in a wide range of scales in space and time, emerging features and hierarchies, irreversibility, nonlinear feedback, etc.) that are intrinsic to all the seemingly different environments and that require multilevel control approaches over space and time scales. For example, equations and dynamics of rogue waves in marine (WE) and optical applications (OG) are equivalent (Solli et al. 2007); also solitons and their interactions in radically different environments are mathematically equivalent [WE1].

This universality makes it possible to immediately employ improved theoretical understanding and increased new research/experimental data in one field for progress in other areas. For example, continuum theory (ND) is the basis for dynamics of solids, fluids (incl. water waves, WE) and optics (OG). Nonlinear PDEs and difference equations are basic models for all the groups; and all will benefit from progress achieved in either analytical or numerical methods for any particular problem. Synergy is obtained by using unified approaches: control over the steering of solitons; control over the contraction of a single heart muscle cell; optical wavebeams and photoelasticity; long waves in solids and fluids; fractality in biophysics, mechanics, econophysics; internal variables from continuum theory to biophysics; similarity of modelling (Schrödinger equation) in optics and sea waves, etc. A summary of added values through synergy is depicted in Fig 2.

Fig. 2 Synergy:

Added value obtained / Added value given	Nonlinear Dynamics	Wave Engineering	Optics	Nonlinear Control	Systems Biology
Nonlinear Dynamics		methods, 2D soliton theory	optical wavebeams	control over steering solitons	internal variables in biophysics
Wave Engineering	methods, turbulent mixing, 3D images		models of dispersive waves	control over long waves	
Optics	solitons, laser-based tomography	solitons, wave packets		growth of nanotubes, control of loca-lised waves	spectro-scopy
Nonlinear Control	control over wave processes	control in environ-mental processes	control over wave processes		control in real time of single cell
Systems Biology	thermo-dynamics in physiology, 3D images		optical microscopy	control of cell energetics	

Consequently, the central aim is to further develop existing synergies between groups stemming from the original CENS (ND, WE, SB) and create new ones by involving additional groups that fit the general philosophy of nonlinearity (OG, NC), addressing

together similar problems in different media, at different scales and in different contexts. To act as catalysts, regular interdisciplinary seminars and workshops will be held to initiate and develop joint research, which is of course the ultimate measure for creating added value beyond just the sum of individual efforts. Sharing of unique equipment belonging to the individual teams (computer cluster, sea wave measurement systems, optical devices, etc.) is foreseen as well.

Expected results

The planned research is intrinsically *interdisciplinary* and *cross-disciplinary*, and is positioned at the intersection of several disciplines in contemporary research into mechanics, Earth sciences, coastal engineering and management, and control of complex systems and biosystems. The unifying tool is the theory of nonlinear wave equations (for propagation of energy through the medium) and complementary constitutive equations (describing changes to the properties of the medium).

The strategic aim is a unified framework for the analysis, synthesis and control of the mechanisms responsible for wave-driven impact in different media and on different scales, from large-scale coastal disasters to strongly nonlinear effects and feedbacks on engineering and cell energetics scales down to small-scale wave-driven processes in optical applications. We are going to systematically exploit that the scale-similarity and mathematical equivalence of different wave-driven phenomena in radically different media makes it possible to perform research for one specific safe and well-controlled situation, and then generalize the results to drastically different scales of forces, impacts and levels of danger: e.g., from tides and tsunamis down to local wind waves; from optical rogue waves up to monster waves in the deep ocean.

ND: New results are expected in explaining the hierarchical behavior of micro-structured solids and in solving the corresponding inverse problems. Theory and methods will be developed for nonlinear photo-elastic tomography as well as for turbulent mixing and transport.

WE: The focus will be on nonlinear wave dynamics and the impact of waves in the coastal environment (incl. coastal engineering structures), ranging from wave excitation and propagation over the sea surface to wave-coastal zone and wave-structure interaction. The research, formulated in terms of marine and coastal environments, is directed towards a unified framework for the analysis of the mechanisms responsible for wave-driven phenomena in various media governed by equivalent equations such as the KdV or Schrödinger equations.

SB: Research aims to explain regulatory mechanisms of metabolic processes and cell function in the heart. By applying expertise in thermodynamics of internal variables, non-linear dynamics (ND), control principles (NC), the additional knowledge about underlying processes involved in heart energetics and mechanics will be obtained. The results are expected to advance our understanding of such clinically important phenomenon as preconditioning in ischemia-reperfusion damage of the heart.

OG: The aims include both the theoretical and experimental study of new sophisticated and nonlinear generalizations of the LWs and their possible applications. Here the expertise of the other groups in soliton and nonlinear wave modelling, nonlinear

dynamics and control is most valuable. The goal of investigations of applying the Bessel-, Mathieu-, etc., conical beams/LWs in nonlinear spectroscopy is to get information about potentially useful nonlinear processes in crystals and fibers and to extend operational characteristics of available laser sources, with obvious applications and joint research in laser-based optical tomography.

NC: The development of generic tools independent of application domains is planned, thus providing the option to use them in a variety of settings. The goal is to integrate the methods of control with the research activities in other disciplines, branching out beyond traditional application areas of control systems, and becoming a contributor to high-risk long-range application areas such as systems biology (SB), environmental science (WE) and materials science (ND).

Societal importance

Within CENS, there is already a track record for timely and effectively reacting to urgent needs of society. For example, in January 2005, the WE work led to a timely warning about a devastating flood approaching Estonia after the failure of the routine warning system to issue a proper forecast [WE7], and in 2009 to the acceptance of a declaration of the Parliament of Estonia (Riigikogu) about major gaps in the analysis of the environmental impact of the Nord Stream pipeline.

In general, the proposed CENS research corresponds to the focal points of the ***Estonian R&D&I Strategy*** *Knowledge-based Estonia* 2007–2013. Our studies are related to high added value in material technology (ND, OG), information technologies (NC) as well as in health care (SB) and environmental protection (WE).

CENS research has a substantial societal dimension for Estonia in several aspects. The effective analysis of various nonlinear problems, solving the associated direct and inverse problems and applying the results to fundamental and engineering sciences (e.g., non-destructive testing based on the analysis of wave shapes, processes in microstructured and laminated materials, etc.) is a cornerstone of industrial progress. Understanding and forecasting wave-induced marine coastal hazards is crucial for a country with a 3800 km long coastline. Heart disease is a serious medical problem in Estonia and the entire world with a large fraction of the population affected by it. Our research into nonlinear mechanisms regulating intracellular processes and into functional influences of intracellular interactions contributes to its mitigation on a global scale. The application of ultrafast optics and the development of a new generation of laser devices not only contribute to science in general but also open the way for the development of high-tech production based on local competence, in this way increasing the competitiveness of Estonian industry.

European dimension

The overall objective of nonlinear studies corresponds to general European trends featured in EU projects such as *Complexity NET*, *Global Systems Dynamics*, *FuturICT* (all with CENS participation). CENS researchers are clearly competitive in the acquisition of international funding through the EU framework programmes, and from other sources such as the Wellcome Trust and the BONUS programme for funding Baltic Sea science. CENS members have been or are coordinators of several larger international projects (STREP Roboswarm, Transfer of Knowledge Project CENS-CMA, BONUS

project BalticWay), and the overall international funding for CENS-related research in the last 5 years exceeds 2.3 M€.

Human Capital development

All teams (note that the IoC is not a teaching body while the OG in Tartu has a substantial teaching load starting from 2nd-year students) have substantially contributed to teaching of both undergraduate and graduate students (e.g., 24 PhD and numerous MSc awarded under their supervision since 2000). In addition, 30 post-doc level researchers and 7 PhD students from abroad have been working in the IoC since 2006. CENS also has a significant contribution to gender balance: one team leader, 7 researchers and 10 PhD students are women.The contribution of the CENS members to the development and improvement of the curricula of the relevant fields in TU and TUT [(technical) physics, civil and environmental engineering, etc.), to international PhD studies and hosting post-doctoral research not only widens the scope of higher education in Estonia but clearly increases attractivity of the host universities and contributes towards both their internationalisation and educating the new generation of top-level Uni teachers in Estonia. Last but not least, the CENS cooperation will level off gaps in the existing local infrastructure and will bring the working environment (that does have some shortages to-day) to internationally recognised standards.

References

[ND1] Engelbrecht, J., Berezovski, A., Pastrone, F., Braun M. (2005), Waves in microstructured solids and dispersion, *Phil. Mag*., 85 (33–35), 4127–4141.

ND2] Janno, J., Engelbrecht J. (2005), An inverse solitary wave problem related to microstructured materials, *Inverse Problems*, 21, 2019–2034.

[ND3] Van, P., Berezovski, A., Engelbrecht J. (2008), Internal variables and dynamical degrees of freedom, *J. Non-Equilib. Thermodyn*., 33, 235–254.

[ND4] Kalda J. (2007), Sticky particles in compressible flows: aggregation and Richardson's law, *Phys. Rev. L*ett., 98 (6), 064501.

[ND5] Kitt, R., Säkki, M., Kalda J. (2009), Probability of large movements in financial markets, *Physica A: Statistical Mech. and Appl*., 388 (23), 4838–4844.

[ND6] Aben, H., Errapart A. (2007), A non-linear algorithm of photoelastic tomography for the axisymmetric problem, *Exp. Mech*., 47, 821–830.

[WE1] Soomere, T. (2009), Solitons interactions, in: Meyers, R.A. (editor), Encyclopedia of Complexity and Systems Science, Springer, vol. 9, 8479–8504.

[WE2] Soomere, T. (2010), Rogue waves in shallow water, *Eur. Phys. J. Special Topics*, 185, 81–96.

[WE3] Didenkulova, I., Pelinovsky, E., Soomere, T. (2009), Long surface wave dynamics along a convex bottom, *J. Geophys. Res*., 114, C07006.

[WE4] Soomere, T. (2005), Fast ferry traffic as a qualitatively new forcing factor of environmental processes in non-tidal sea areas: a case study in Tallinn Bay, Baltic Sea, *Environmental Fluid Mechanics* **5** (4), 293–323.

[WE5] Soomere, T., Räämet, A. (2011), Long-term spatial variations in the Baltic Sea wave fields, *Ocean Science*, 7 (1), 141–150.

[WE6] Andrejev, O., Soomere, T., Sokolov, A., Myrberg, K. (2011), The role of spatial resolution of a three-dimensional hydrodynamic model for marine transport risk assessment, *Oceanologia*, 53 (S), 1–26.

[WE7] Soomere, T. (2005), Estonia got storm warning from newspaper, *Scandinavian Shipping Gazette*, No 4, 25.02.2005, 26–29.

Solli, D.R., Ropers, C., Koonath, P., Jalali, B. (2007), Optical rogue waves, *Nature*, 450 (7172), 1054–1057.

[SB1] Vendelin, M., Lemba, M., and Saks, V. (2004). Analysis of functional coupling: Mitochondrial creatine kinase and adenine nucleotide translocase, *Biophys. J*., 87, 696–713.

[SB2] Vendelin, M., Kongas, O., and Saks, V. (2000). Regulation of mitochondrial respiration in heart cells analyzed by reaction-diffusion model of energy transfer, *Am. J. Physiol. Cell Physiol*., 278, C747–C764.

[SB3] Vendelin, M., Birkedal, R. (2008). Anisotropic diffusion of fluorescently labeled ATP in rat cardiomyocytes determined by raster image correlation spectroscopy, *Am. J. Physiol. Cell Physiol*., 295, C1302–C1315.

[SB4] Vendelin, M., Bovendeerd, P.H., Arts, T., Engelbrecht, J., Campen, D.H. (2000). Cardiac mechanoenergetics replicated by cross-bridge model, *Ann. Biomed. Eng*., 28, 629–640.

[SB5] Vendelin, M., Beraud, N., Guerrero, K., Andrienko, T., Kuznetsov, A., Olivares, J., Kay, L., and Saks, V.A. (2005). Mitochondrial regular arrangement in muscle cells: a 'crystal-like' pattern. *Am. J. Physiol. Cell. Physiol.*, 288, C757–C767.

[SB6] Laasmaa, M., Vendelin, M., Peterson, P. (2011). Application of regularized Richardson-Lucy algorithm for deconvolution of confocal microscopy images, *J. Microsc*. PMID: 21323670 (in press).

[OG1] Saari, P., Reivelt K. (1997), Evidence of X-shaped propagation-invariant localized light waves, *Phys. Rev. Lett*., 79 (21), 4135-4138

[OG2] Sõnajalg, H., Rätsep, M., Saari P. (1997), Demonstration of the Bessel-X pulse propagating with strong lateral and longitudinal localization in a dispersive medium, *Optics Lett*., 22 (5), 310–312.

[OG3] Bowlan, P., Valtna-Lukner, H., Lõhmus, M., Piksarv, P., Saari, P., Trebino, R. (2009), Measurement of the spatiotemporal electric field of ultrashort superluminal Bessel-X pulses, *Optics and Photonics News*, OSA, 20 (12) 42

[OG4] Peet, V., Shchemeljov S. (2003), Spectral and spatial characteristics of third-harmonic generation in conical light beams, *Phys. Rev. A*, 67 (1), 013801

[OG5] Treshchalov, A., Lissovski, A. (2009), VUV-VIS spectroscopic diagnostics of a pulsed high-pressure discharge in argon, *J. of Physics D: Applied Physics*, 42, 245203

[OG6] Selg M. (2001), Numerically complemented analytic method for solving the time-independent one-dimensional Schrödinger equation, *Phys. Rev. E*, 64 (5), 056701–12.

[NC1] Kotta, Ü,, Bartosiewicz, Z,, Pawluszewicz, E., Wyrwas, M. (2009), Irreducibility, reduction and transfer equivalence of nonlinear input-output equations on homogeneous time scales, *Systems & Control Letters*, 58 (9), 646–651.

[NC2] Casagrande, D., Kotta, Ü., Tõnso, M., Wyrwas, M. (2010), Transfer equivalence and realization of nonlinear input-output delta-differential equations on homogeneous time scales, *IEEE Transactions on Automatic Control*, 55 (11), 2601–2606.

[NC3] Bartosiewicz, Z., Kotta, Ü., Pawluszewicz, E., Wyrwas, M. (2011), Control systems on regular time scales and their differential rings, *Mathematics of Control, Signals, and Systems* (accepted).

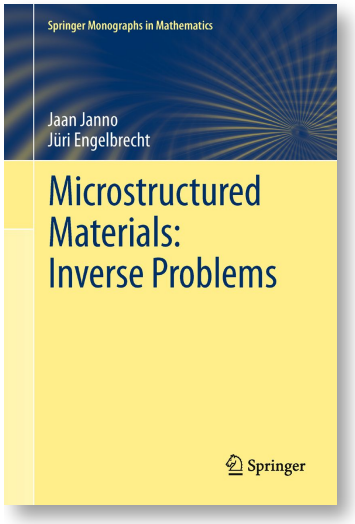
[NC4] Nurges, Ü. (2009), Reflection coefficients of polynomials and stable polytopes, IEEE Transactions on Automatic Control, 54, 1314–1318.

[NC5] Vain, J., Kääramees, M., Markvardt, M. (2011), Online testing of nondeterministic systems with reactive planning tester. In: Petre, L., Sere, K., Troubitsyna, E. (Eds.). Dependability and Computer Engineering: Concepts for Software-Intensive Systems (1–36). Hershey, PA: IGI Global [May, 2011].

Willems, J.C. (2007), The behavioral approach to open and interconnected systems, *IEEE Control Systems Mag*., 27 (6), 46–99.

Springer
the language of science

springer.com



J. Janno, Tallinn University of Technology, Estonia; J. Engelbrecht, Tallinn University of Technology, Estonia

Microstructured Materials: Inverse Problems

- Mathematical modelling is based on physical principles
- Physical models are interwoven with inverse problems
- A novel concept of using solitary waves for NDE is proposed

Complex, microstructured materials are widely used in industry and technology and include alloys, ceramics and composites. Focusing on non-destructive evaluation (NDE), this book explores in detail the mathematical modeling and inverse problems encountered when using ultrasound to investigate heterogeneous microstructured materials. The outstanding features of the text are firstly, a clear description of both linear and nonlinear mathematical models derived for modelling the propagation of ultrasonic deformation waves, and secondly, the provision of solutions to the corresponding inverse problems that determine the physical parameters of the models. The data are related to nonlinearities at both a macro- and micro- level, as well as to dispersion. The authors' goal has been to construct algorithms that allow us to determine the parameters within which we are required to characterize microstructure. To achieve this, the authors not only use conventional harmonic waves, but also propose a novel methodology based on using solitary waves in NDE. The book analyzes the uniqueness and stability of the solutions, in addition to providing numerical examples.

1st Edition., 2011, IX, 160 p. 30 illus., 3 in color.

Printed book

Hardcover

- **79,95 € | £72.00 | $99.00**
- *** 85,55 € (D) | 87,95 € (A) | SFr. 106.50**

eBook

Available from libraries offering Springer's eBook Collection, or for individual purchase via online bookstores.
A free preview is available on SpringerLink.

- **springer.com/ebooks**

MyCopy

Printed eBook exclusively available to patrons whose library offers Springer's eBook Collection.***

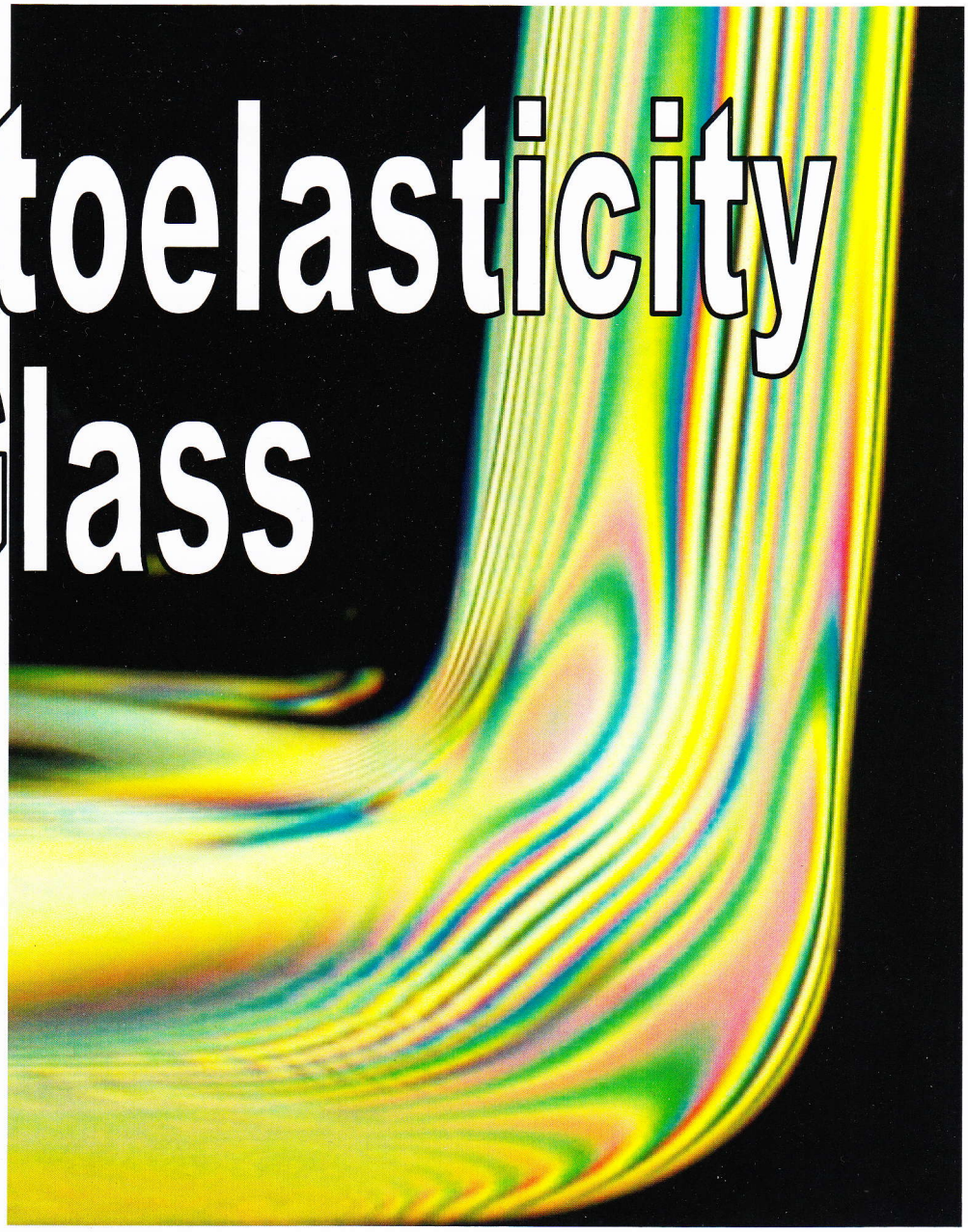
- **€ | $ 24.95**
- **springer.com/mycopy**

Order online at springer.com ► or for the Americas call (toll free) 1-800-SPRINGER ► or email us at: orders-ny@springer.com. ► or for the Americas call (toll free) 1-800-SPRINGER ► or email us at: orders-hd-individuals@springer.com.

The first € price and the £ and $ price are net prices, subject to local VAT. Prices indicated with * inlude VAT for books; the €(D) includes 7% for Germany, the €(A) includes 10% for Austria. Prices indicated with ** include VAT for electronic products; 19% for Germany, 20% for Austria. All prices exclusive of carriage charges. Prices and other details are subject to change without notice. All errors and omissions excepted.

*** Regional restrictions apply.

Photoelasticity of Glass



Modern photoelastic technology for residual stress measurement in glass

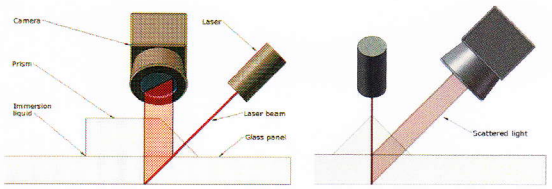
GlasStress

GLASS STRESS MEASUREMENT EQUIPMENT

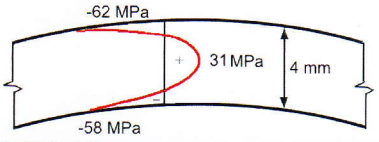
STRESS MEASUREMENT IN ARCHTECTURAL GLASS PANELS AND AUTOMOTIVE GLAZING

Scattered light polariscope SCALP

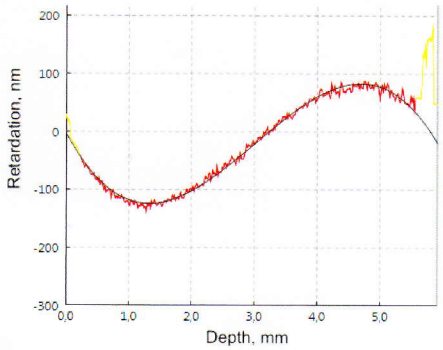
Optical measurement schema with the scattered light method



Stress measurement at the production line

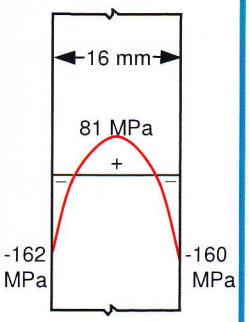


Optical retardation distribution along the laser beam

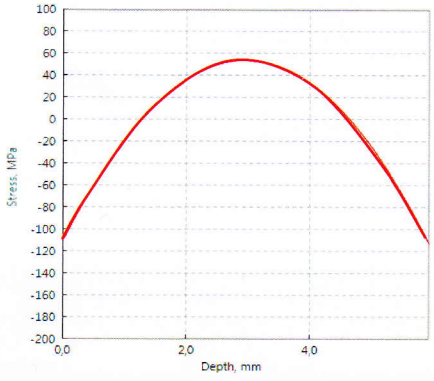


Measurement time is 3 sec

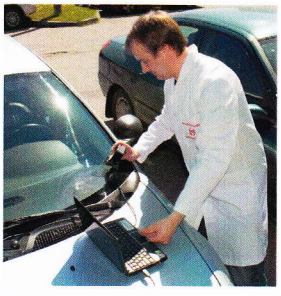
Stress measurement in a wall panel



Stress distribution through the thickness of the panel

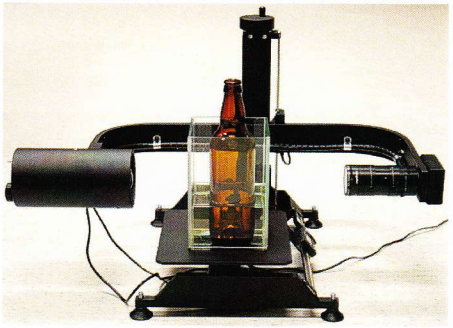


Stress measurement in the windshield on a car

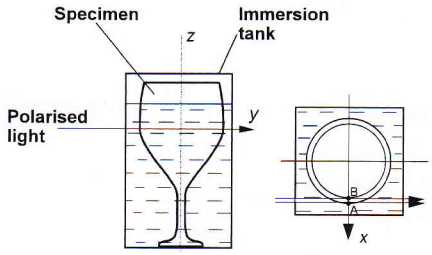


STRESS MEASUREMENT IN GLASS CONTAINERS, TUBES, PHARMACEUTICAL AMPULES AND TABLEWARE

Transmission polariscope AP



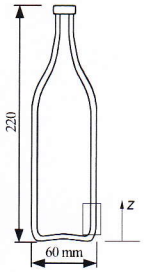
Optical set-up in integrated photoelasticity



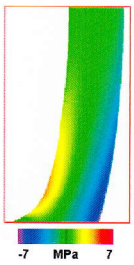
Measurement time is 10 sec

Stress measurement in a bottle

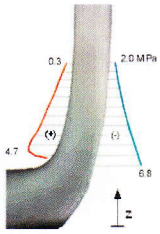
Geometry of the bottle



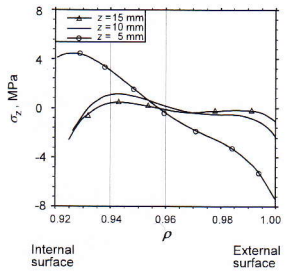
Axial stress field near the knuckle



Axial stress distribution on the surfaces

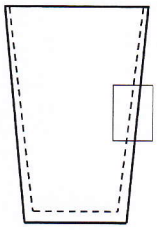


Axial stress distribution in the wall in three sections

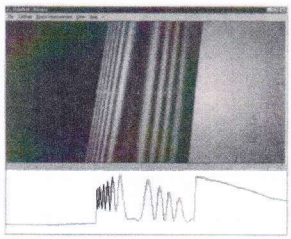


Stress measurement in a tempered tumbler

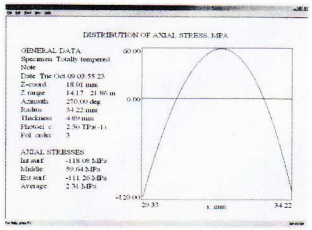
Geometry of the tumbler



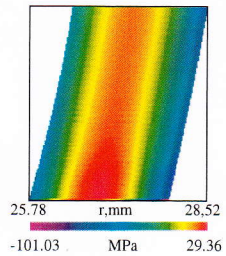
Physical and digitised fringe patterns



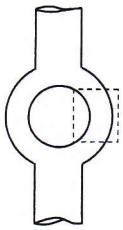
Axial stress distribution through the wall

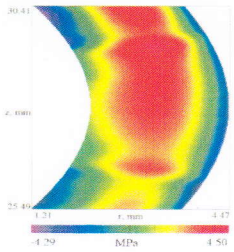


Axial stress field in the measurement area

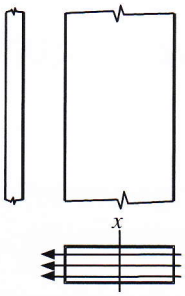


Stress field in a high-pressure lamp



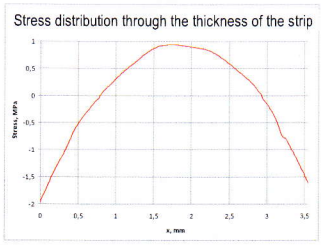


Stress measurement in a float glass strip



Schema of illumination in the polariscope

Stress distribution through the thickness of the strip



Literature

Fundamental theory, which lies behind the photoelastic measurement technology illustrated above, is described in the following two books:

1. Aben, H. Integrated Photoelasticity. McGraw-Hill, New York, 1979.
2. Aben, H., Guillemet, C. Photoelasticity of Glass. Springer, Berlin, 1993.

Two recent review papers on the photoelasticity of glass are:

1. Aben, H., Errapart, A., Ainola, L., Anton, J. Photoelastic tomography for residual stress measurement in glass. Optical Engineering, 2005, vol. 44, No., 9, 093601-1-8.
2. Aben, H., Anton, J., Errapart, A. Modern photoelasticity for residual stress measurement in glass. Strain, 2008, vol. 44, 40-48.

Technical services and training courses

Although our equipment is designed easy to handle, if any problems arise with its application, we are always ready to give any advice and consultations. Every spring we organise in Tallinn a Glass Stress Summer School. Please visit our website to learn when the next Summer School takes place. We are also ready to carry out glass stress measurement training courses at your premises.

Take the quality control a step ahead!

GlasStress Ltd.
GLASS STRESS MEASUREMENT EQUIPMENT

GlasStress Ltd.
21 Akadeemia tee
12618 Tallinn
Estonia

Tel: +372 655 5531
Fax: +372 655 5532
E-mail: info@glasstress.com
http://www.glasstress.com

NUMBER 7, OCTOBER 2011

BONUS briefing

SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

BALTICWAY

The potential of currents for environmental management of the Baltic Sea maritime industry

The ever increasing impact of the marine industry on vulnerable sea areas such as the Baltic Sea, and the increase in risks associated with potential oil pollution from ship traffic or oil platforms, calls for novel methods for mitigating beforehand the impact of risks on vulnerable areas. BALTICWAY develops methods for preventive reduction of offshore environmental risks caused by the maritime industry that are transported by surface currents to the coasts. The BALTICWAY scientists are characterising systematically the damaging potential of the Baltic Sea areas in terms of their potential transport to vulnerable regions if faced by an oil spill or other pollution. This way, by placing maritime activities in the safest offshore areas, the consequences of potential accidents can be minimised before they occur.

OVERVIEW

Traditionally risks of maritime industry are associated with possible accidents (ship collisions or grounding, etc.) that may lead to loss of lives or property, or to environmental pollution; the management of environmental risks in turn is typically focussed on small areas around the installation or the ship in question.

However, the technological progress has led to a new paradigm in the treatment of such risks. Namely, by-products such as exhaust emissions, external noise or dangerous waves are no more located in small areas. The amounts of oil spills or other harmful substances potentially released to the sea by some ships or specific offshore infrastructures have increased to a level that are of acute danger to the ecosystem and to society, even in seemingly remote and safe locations. Especially the currents can transport different impacts over hundreds of kilometres and may provide extremely large risks to some regions over a substantial time period, as demonstrated, for example, by the recent Gulf of Mexico oil spill. This component of environmental risk is exceptionally important in particularly vulnerable sea areas that host intense ship traffic such as the Baltic Sea (Figure 1).

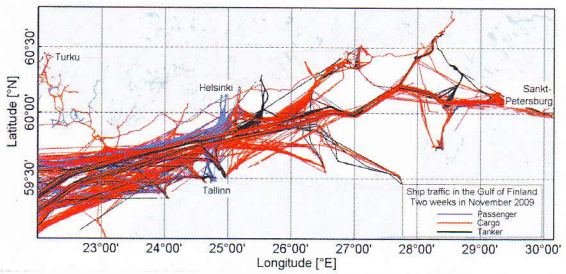


Figure 1. Sailing lines of ships in the Gulf of Finland in a two week period (Nov 2009).

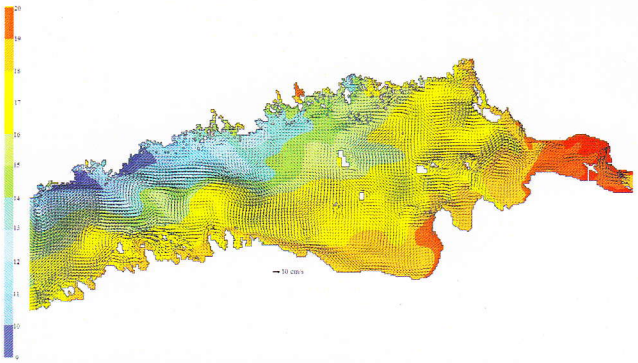


Figure 2. A snapshot of the current system (arrows) and sea surface temperature (color code) for the Gulf of Finland in 0.25 nautical mile (ca 470 m) resolution (O.Andrejev, Helsinki).

BALTICWAY's approach is based on a smart use of the existence of semi-persistent favourable current patterns which affect considerably pollution propagation as well as drift of various items such as vessels without propulsion, rescue boats or lost containers. These patterns make the probability of transport of dangerous substances or undesired items from different open sea areas to vulnerable sections (such as spawning, nursing or also tourist areas) highly variable. For certain areas of reduced risk this probability is relatively small and re- or directing activities to these areas would appear to be feasible as well with very limited additional costs. Hence, these areas are the best candidates for fairways and locations of high-risk offshore structures.

The core objective of BALTICWAY is to establish key components of a reliable, robust and low-cost technology for the environmental management of shipping, offshore, and coastal engineering activities. Integrating marine ecosystem management with other needs of society, and linking scientists, stakeholders and decision-makers in the process of elaborating a scientific base for political decisions is the key.

While addressing effectively and in a coherent and holistic manner the Baltic's transboundary environmental problems caused by industrial activities, it is also important for BALTICWAY not to be driven by the needs of scientific research alone; rather it is an initiative of the scientific community reflecting the cooperative research needs towards sustainable development and effective stewardship of the Baltic Sea.

The entire research under the BALTICWAY umbrella is highly interdisciplinary. The hydrodynamic studies have substantially improved our understanding of the patterns of currents in the Baltic Sea, thus leading to better knowledge of geophysical forcing of pollution transport and contributing to the predictive capacity of circulation and operational models. In parallel, the project has developed and applied knowledge systems for effectively tracking huge amounts of information concealed in current-driven transport. This knowledge is applied in a generalised form to assess environmental risks and to construct an optimum response strategy.

OUTLINE OF KEY RESULTS

The existence and location of areas of reduced risk have been established through the use of massive numerical simulations supported by specifically designed in situ experiments to verify their results. The method used contains four key components: (i) an eddy-resolving circulation model, (ii) a scheme for tracking of (Lagrangian) trajectories of water or pollution particles, (iii) a technique for the calculation of quantities characterising the potential of different sea areas to supply adverse impacts, and (iv) routines to construct the optimum fairway. The gain is expressed in terms of the probability of pollution transport to the vulnerable areas and the time pollution takes to reach these areas. As a first approximation, coastal areas are used as a generic model for valuable regions.

Computer simulations with a resolution necessary for adequately resolving the key features of current systems provide detailed information about the extreme complexity of water motions in natural current systems (Figure 2). This complexity calls for the use of non-traditional and novel mathematical methods to identify the persistence, properties, and potential effect of favourable current patterns, and to establish generic criteria for the existence of areas of reduced risk in different sea regions.

The quantification of the potential of different offshore domains to serve as a source of danger to the coastal environment through current-driven transport involves solving an inverse problem of pollution propagation. Such problems are frequently mathematically ill-posed and no universal method exists for solving them. An approximate solution to this problem can be obtained by means of statistical analysis of a large number of solutions of the associated direct problem of propagation of water particles (so-called Lagrangian trajectories, Figure 3).

The entire approach is intrinsically based on certain statistical features of current-induced transport. The importance of statistical methods in marine design and operation is now generally acknowledged. Since their outcome is not always explicit, one of the major challenges implicitly addressed by the BALTICWAY team consists in

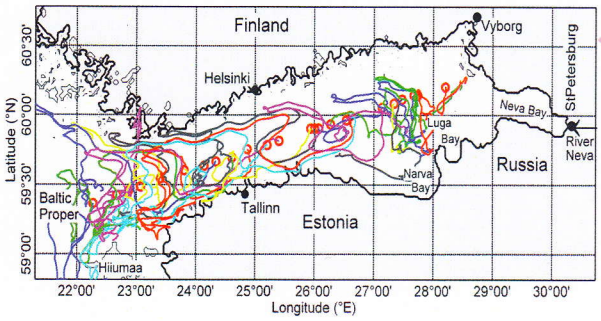


Figure 3. A selection of trajectories of water particles in the Gulf of Finland.

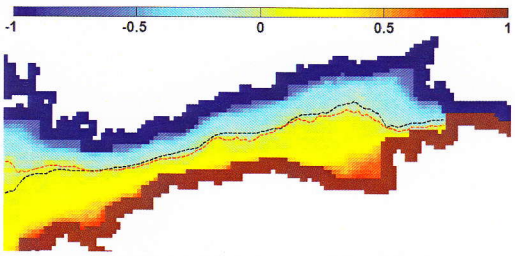


Figure 4. Distribution characterising the probability of hitting the northern and southern coasts of the Gulf of Finland for the years 1987–1991 based on simulations with the Rossby Centre model with a spatial resolution of 2 nautical miles (M.Meier, Norrköping) and the TRACMASS code for Lagrangian trajectories (K.Döös, Stockholm). Black and red lines indicate the equiprobability lines for two slightly different methods (B.Viikmäe, Tallinn).

further developing methods and technology for the use of statistical information in solving dynamical problems. These methods allow to identify a number of concealed features of transport which can be inferred neither from theoretical analysis nor from even massive measurements.

There is a variety of different approaches to define the optimum fairway or location of other potentially dangerous activities. The 'fair way' of dividing the risks equally between the opposite coasts is a local solution that does not normally provide the minimum level of risk for the entire water body (Figure 4).

Alternatively, better approximations to characterise the potential of each sea point in terms of its ability to create danger to the vulnerable regions are, for example, the average probability of the transport of pollution released at this point to a coast, or the time it takes for the impact to reach the vulnerable area (Figure 5).

The use of fairways roughly following the minima for probabilities of coastal hit or the maxima for the time it takes for the potential pollution to reach the coast (Figure 6) are most promising in the context of the optimisation of ship routes in terms of minimising the risk of coastal pollution. In the Gulf of Finland, as part of the Baltic Sea, the gain from the use of the optimum fairway is about 40% in terms of the decrease in probability of coastal pollution. In addition, the use of the optimum fairways may almost double the typical time it takes the released pollution to reach the coast.

NEXT STEPS AND FUTURE PLANS

The information derived using the developed technology is of vital importance for institutions responsible for environmental protection (national ministries of environment, national and regional environmental agencies) and maritime spatial planning. It is directly usable in the decision-making process in a crisis situation, e.g., about different search-and-rescue issues. The ultimate goal is to have the technology used by maritime boards for a new generation of fairway and ship routing services.

Practical implementation of the project results is expected to substantially decrease the impact of maritime transport and industry on biodiversity, particularly on fragile ecosystems.

The project will also indirectly contribute to sustainable fishing through better protection of key areas of fish stock reproduction. The method developed by BALTICWAY can also be used as a tool supporting decisions about how far the fairway for ships carrying dangerous cargo should be located from the coast (or from vulnerable areas) facing the open ocean.

Linking science and policy through the creation of the necessary societal, economical, legal and political framework for the real implementation of the research results is the key. For this reason, the consortium will strive for better synthesising and disseminating research outcomes at all levels for bridging the gap between science and users, for improved receptivity and utilisation in policy and decision making, and to increase the usability of research products.

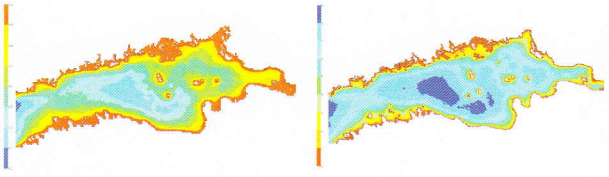


Figure 5. Probability for the beaching of the pollution within 10 days (left) and the time it takes for the pollution to reach the coast (right) in the Gulf of Finland simulated for the period of 1987–1991 (O.Andrejev, Helsinki)

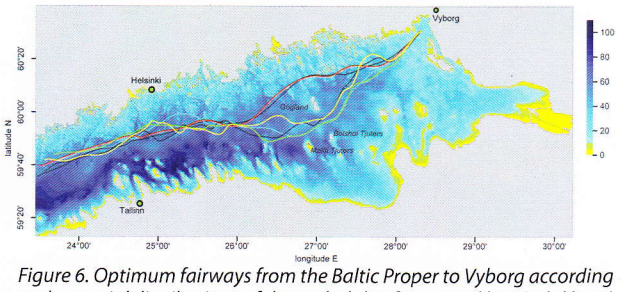


Figure 6. Optimum fairways from the Baltic Proper to Vyborg according to the spatial distributions of the probability for coastal hits (solid lines) and of the particle age (dashed lines) at resolutions of 2 nm (red and black), 1 nm (green and cyan) and 0.5 nm (yellow and white). The depth scale to the right of the map is given in metres.

IN BRIEF

BALTICWAY
The potential of currents for environmental management of the Baltic Sea maritime industry

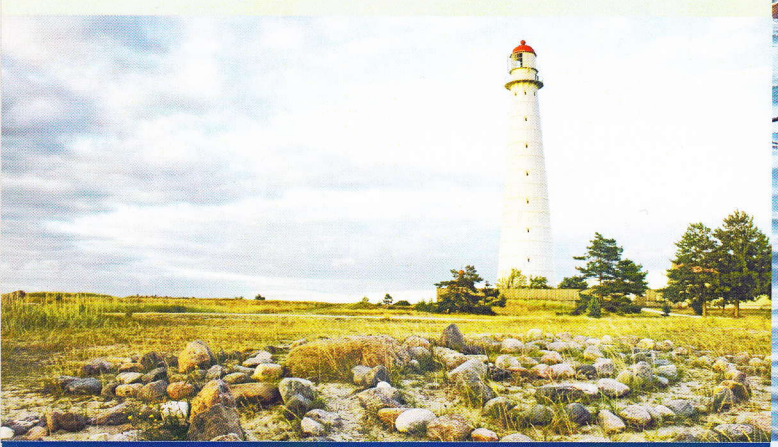
By studying surface currents in the Baltic Sea, BALTICWAY has developed a new method to determine how shipping as well as offshore and coastal engineering activities can be made environmentally safer. This research identifies areas that are safer to use, distinguishing them from those where marine activities are better avoided because dangerous substances (e.g. oil spills) are likely to be washed to the most vulnerable areas of the Baltic Sea.

KEY RESULTS

- Development of a technique for environmental management of offshore sea areas that minimises current-driven risks for coastal regions.
- Development of algorithms for the identification of the environmentally safest fairways.
- Mapping of long-term behaviour and dispersion properties of surface currents in the Baltic Sea with the use of autonomous drifters.
- Quantification of spatial and temporal variability of properties of the Baltic Sea wave fields.

WHO NEEDS THE INFORMATION

The derived information is of vital importance for institutions responsible for environmental protection (ministries of environment, national and regional environmental agencies) and maritime spatial planning. It is directly usable in the decision-making process in crisis situations, e.g., about different search-and-rescue issues. The ultimate goal is to have the technology used by maritime boards for a new generation of fairway and ship routing services.



PROJECT PARTNERS AND COORDINATOR

Estonia
Institute of Cybernetics at Tallinn University of Technology (Coordinating partner)
Laser Diagnostic Instruments, Tallinn

Denmark
Danish Meteorological Institute, Copenhagen

Finland
Finnish Environment Institute, Helsinki

Germany
Institute for Coastal Research, HZG Geesthacht
Leibniz Institute of Marine Sciences at the University of Kiel

Sweden
Department of Meteorology, University of Stockholm
Swedish Meteorological and Hydrological Institute, Norrköping

Project coordinator:
Professor Tarmo Soomere, email: soomere@cs.ioc.ee

wavelab.ioc.ee/bonus-balticway
www.bonusportal.org/balticway

Photos: iStock.com; BALTICWAY

SEVENTH FRAMEWORK PROGRAMME

BONUS is supported by the national research funding institutions in the eight EU member states around the Baltic Sea and the EU Commission's Research Framework Programme

More information about BONUS:
bonus@bonuseeig.fi
www.bonusportal.org

BONUS
SCIENCE FOR A BETTER FUTURE OF THE BALTIC SEA REGION

Legal Notice : The information in this website is subject to a disclaimer and a copyright notice

emerging ideas, techniques and tools

- Biology / Medicine
- Energy
- Environment
- IT-Telecommunications
- Industrial Technologies

Offers IT, Telecommunications

Dedicated centre for applied mathematics in Estonia

© *Shutterstock*

Mathematical models of complex problems have taken ever-increasing importance alongside experimental data collection. Although there has always been theory behind design, the development of faster and better computing technology has made implementation of these mathematical models more and more widespread, desirable and even necessary to ensure competitiveness.

The 'Educational, scientific, and technological aspects of splines' (Estspline) project was designed to given an edge in applied mathematics to the Tallinn University of Technology (TUT) in Estonia by providing funding to establish the Laboratory of Wave Engineering as a new part of the Center for Nonlinear Studies (CENS) within the Institute of Cybernetics (IoC).

Specifically, the EU-funded project enabled the recruitment of Dr Ewald Quak, a prominent researcher focused on industrial application of mathematical models to problems in geometry, computer-aided design, shape modelling and simulation, to develop the lab. Aside from his technical expertise, Dr Quak has been organising annual workshops on these topics since 2003 and thus was an excellent choice to develop the new lab in Estonia. The funding enabled establishment of a two-member administration team for the Wave Lab, critically important to its function as the researchers were freed from administrative tasks and able to focus on the research at hand.

The lab, formally established in January 2009, is focused on industrial application of three-dimensional (3D) geometric modelling to wave dynamics and coastal engineering. Dr Quak is the Senior Researcher among a team of 17 led by Professor Tarmo Soomere, a member of the Estonian Academy of Sciences. Among his scientific contributions and recognition, Dr Quak co-edited a book volume for Springer and was a guest editor of a special issue of the journal 'The Visual Computer'. Furthermore, he became a member of the Editorial Board of the newly established 'Journal of Mathematics in Industry'

In summary, EU funding enabled the realisation of an applied mathematics laboratory at the TUT in Estonia that has blossomed and whose team has already made significant contributions to mathematical modelling.

Country: ESTONIA

Information Source: Result from the EU funded FP7-PEOPLE programme

Date: 2011-12-21

Contact Details

ENGELBRECHT, Jüri (Prof.)

TALLINNA TEHNIKAUELIKOOLI KUEBERNEETIKA INSTITUUT
Centre for Nonlinear Studies
Head of Department
TALLINN
ESTONIA

Tel: +372-6204160
Fax: +372-6204151
Email: Contact
URL:

View printable page View related result

Offer ID: 7709

Back Previous offer Next offer

Top © email us About CORDIS

CENS

Institute of Cybernetics at TUT
Akadeemia tee 21
Tallinn 12618, Estonia
Phone: (+372) 620 4150
Fax: (+372) 620 4151
Prof. J. Engelbrecht, je@ioc.ee
Prof. H. Aben, aben@ioc.ee
Prof. T. Soomere, soomere@cs.ioc.ee
Dr. M. Vendelin, markov@sysbio.ioc.ee
Dr. Ü. Kotta, kotta@ioc.ee
Prof. P. Saari, peeter.saari@ut.ee

Internet: http://cens.ioc.ee

CENTRE FOR NONLINEAR STUDIES
Institute of Cybernetics at Tallinn University of Technology
Akadeemia 21
12618 Tallinn
ESTONIA

Phone: +372 620 4160
Fax: +372 620 4151
E-mail: je@ioc.ee
Web-site: http://cens.ioc.ee