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CENS

Centre for Nonlinear Studies

Estonian Centre of Excellence in Research

Annual Report

2007

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Contents

Abstract

The Report includes a brief overview on all the activities of CENS in 2007. Described are studies and results on: (i) dynamics of microstructured materials and solitons; (ii) water waves and coastal engineering; (iii) software development; (iv) biomechanics and biophysics; (v) fractality and econophysics; (vi) general nonlinear wave theory and inverse problems; (vii) optical nonlinearity and photoelasticity; (viii) geometric approach to nonlinear problems; (ix) EEG analysis and effects of microwave radiation. Described are also international programmes and projects. The Report presents the full list of published papers, reports, conferences, etc. The teaching activities are listed. The Summary includes a brief overview on results of CENS in 2002 – 2007 as a Centre of Excellence in Research.

Keywords: nonlinear dynamics, soft matter physics, microstructured solids, solitons, interaction solitons, acoustodiagnostics, photoelasticity, cardiac contraction, cell energetics, signal processing, water waves, extreme waves, coastal engineering, differential equations.

Sisukord

Lühikokkuvõte

Mittelineaarsete Protsesside Analüüsi Keskuse (CENS) tegevus 2007.a. on kirjeldatud järgmiste alateemade lõikes: (i) lainelevi mikrostruktuursetes materjalides ja solitonid; (ii) lained veepinnal ja rannikutehnika; (iii) tarkvara arendus; (iv) biomehaanika ja biofüüsika; (v) fraktaalsus ja ökonofüüsika; (vi) mittelineaarne laineleviteooria ja pöördülesanded; (vii) optiline mittelineaarsus ja fotoelastsus; (viii) diferentsiaalvõrrandite geomeetriline teooria; (ix) EEG analüüs ja mikrolainete radiatsioon. On antud ülevaade CENSi rahvusvahelistest programmidest ja projektidest. Esitatud on publikatsioonide, teeside, konverentside, välis külaliste, seminaride jm nimekirjad, sh. ka ülevaade kraadiõppest. Lühikokkuvõte CENSi tegevusest aastatel 2002 – 2007 haarab CENSi tööd tippkeskusena.

Võtmesõnad:
mittelineaarne dünaamika, pehmisefüüsika, mikrostruktuuriga materjalid, solitonid, interaktsioonisolitonid, akustodiagnostika, fotoelastsus, südamelihase kontraktsioon ja rakuenergeetika, signaalitöötlus, pinnalained, rannikutehnika, ekstreemlained, diferentsiaalvõrrandid.

1. Introduction

This report is the ninth Annual Report of CENS, following the previous Reports 1999 – 2006. The present CENS is one of the ten Estonian Centres of Excellence in Research. The period of holding this title with additional funding was initially granted for 2003 – 2006 and has been extended to 2007. This Report includes (see in Section 6) also a short overview on results of this 5-year period.

As before, the present Report includes a short summary on research fields (Section 2), an overview on current research in 2007 and co-operation projects (Section 3), an overview on funding (Section 4) followed by publication records, lists of conferences, seminars, etc. (Section 5). Conclusions, an overview on results of 2003–2007 and foresight ideas are presented in Section 6.

2. Overview on CENS

The present research of CENS involves as before:

- Nonlinear waves: complexity of wave motion in solids, coherent wave fields, solitonics and surface waves, phase-transformation fronts, acoustodiagnostics of material properties, microstructured materials, impact;
- Fractality and biophysics: complexity in biophysics, *in silico* modelling of cardiac mechanics and cell energetics, heart rate variability, turbulent diffusion, statistical topography and flooding, econophysics;
- Nonlinear integrated photoelasticity: stress field tomography (tensor tomography), complexity of interference fringes;
- Water waves and coastal engineering: marine physics, multimodal waves, wave-wave and soliton interactions, wind wave forecast, anomalies of wave fields, ship wakes, extreme waves, coastal processes;
- Geometric approach: Lie-Cartan methods, flows of vector fields on tensor fields;
- Nonlinear signal processing: analysis of physiological signals (EKG, EEG), and applications in cardiology and brain research (hypoxic states of the brain).

The activities of CENS are based on the following units:

- Department of Mechanics and Applied Mathematics, Institute of Cybernetics at Tallinn UT;
- Biomedical Engineering Centre, Tallinn UT;
- Chair of Geometry, Institute of Pure Mathematics, University of Tartu.

Within the Department of Mechanics and Applied Mathematics, IoC at TUT, there are the following subunits:

- Laboratory of Photoelasticity;
- Laboratory of Systems Biology.

The latter was founded in 2007 in order to concentrate the studies in this field, supported by the Wellcome Trust grant to Dr. M.Vendelin "Analysis of structural and functional aspects of compartmentation of adenine nucleotides in heart muscle cells". Presently there are also 5 PhD students beside the experienced supervisor.

The new computer cluster was installed in 2006 – 2007 with the support of the structural funds (Programme for Centres of Excellence in Research). The cluster consists of 49 nodes, each containing 2 CPUs (AMD Opteron 2216). The Sun Grid Engine is used to manage the jobs in the cluster. All nodes, except a server node, are diskless and keep the file system in memory and on the server's hard disk. Most of the nodes have 4 GB RAM, except one computation node that has 16 GB. The nodes are connected through 1 Gb/s network that is sufficient for present purposes. The nodes are build by a local computer dealer using Tyan motherboards (n3600B and h2000m). At present, up to 192 jobs can be run in parallel on the cluster.

3. Current results 2007

3.1 Institute of Cybernetics, Tallinn University of Technology

3.1.1 Dynamics of microstructured materials and solitons

Two types of models — the Mindlin–Engelbrecht–Pastrone (MEP) type and the Korteweg–de Vries (KdV) type — are used for analysing of the formation, propagation and interaction of solitary deformation waves in microstructured solids. MEP models include Mindlin theory and the concept of wave hierarchies and they are able to take into account nonlinear and dispersive effects on the micro- as well as on the macrolevel. Corresponding model equations, derived by Jüri Engelbrecht and Franco Pastrone, are so called two-wave equations and therefore they can be used for simulation of head-on interaction of solitary waves. On the contrary, KdV-type equations under consideration are evolution equations (one-wave equations) and they can be used for simulation of overtaking interaction of solitary waves. In 2007, like in previous years, the main attention was paid to numerical simulation of wave processes in microstructured materials by employing the pseudospectral method. However, analytical approach was applied in order to derive evolution equations for the MEP model (M.Randrüüt, J.Engelbrecht) and dispersion analysis (T.Peets, J.Engelbrecht).

Solitary waves in microstructured solids — MEP models.
Numerical experiments were carried out for (i) simulation of interactions of solitary waves over long time intervals (over high number of interaction) and (ii) simulation of emergence of trains of solitons from localised initial waves. Main attention was paid to the elucidation of the influence of different material parameters on the character of the solution and the long time behaviour of solitonic structures. The results are analysed in terms of space-time variables as well as spectral characteristics (K.Tamm, A.Salupere). The influence of external periodic (in time) force field on the propagation of deformation waves was analysed (M.Vallikivi, A.Salupere).

Solitary waves in microstructured solids — KdV-type models
The first part of studies here is related to the higher order KdV-type model equations that can include the fourth order elastic potential and the third an the fifth order dispersive terms. Numerical experiments were carried out in order to (i) simulate interaction of different solitonic structures and (ii) elucidate the contribution of different higher order terms on the character of the solution. The analysis of result is in progress (A.Salupere,

O.Ilison). The second part of studies is related to a new KdV-type evolution equation, derived from the MEP model (M.Randrüüt, J.Engelbrecht). This equation was numerically solved under harmonic initial conditions over a wide range of material parameters. Preliminary analysis of results demonstrates that 3–4 different solution types can be detected for this problem (M.Randrüüt, A.Salupere).

Solitary waves in granular materials — hierarchical KdV-type model.
Propagation of solitary waves in dilatant granular materials was studied by making use of the hierarchical Korteweg-de Vries type evolution equation. The model equation was solved numerically under localized initial conditions making use of the pseudospectral method. Preliminary analysis in previous year has demonstrated the existence of qualitatively different solution types (e.g. ensemble of KdV solitons, and coexistence of solitary waves and wave packages) for this problem as compared with the solitons of the KdV equation. In 2007 corresponding analysis over a wide range of material parameters (two dispersion parameters and one microstructure parameter) was finished and new numerical experiments were carried out in order to simulate interactions between different solitonic structures. Analysis of these results is in progress (L.Ilison, A.Salupere).

Wave hierarchies
From Mindlin-type theory several governing equations can be derived. The accuracy of the full and simplified models is studied by dispersion analysis. The ranges of velocity ratios of macro- and microstructure have been established where dispersion curves of different models coincide with 5% and 10% accuracy. Although the evolution equation (one - wave equation) is not able to grasp all the double-dispersion effects, it still follows the main patterns of normal and anomalous dispersion (M.Randrüüt, T.Peets, J.Engelbrecht).

3.1.2 Water waves

Long-term changes of wave activity based on visual observations
Wave conditions, their seasonal cycle and long-term variations in the northern part of the Baltic Sea Proper are studied based on visual wave observations at the Island of Vilsandi near the coast of Saaremaa in 1954-2005. The typical wave periods are 2-4 s. The monthly mean wave height follows the seasonal variation in wind speed and varies from about 0.4 m in April-July to almost 0.8 m in January. The annual mean wave height shows a quasiperiodic behaviour. The wave activity varied insignificantly in the 1960s and the 1970s, considerably increased in the 1980s, was at highest just before the turn of the century and is decreasing starting from about 1998 (T.Soomere, I.Zaitseva).

Nonlinear components of ship wake waves
The descriptions of origin, properties and evolution of nonlinear components of ship wakes are summarized in a systematic manner. The description focuses on nonlinear parts of large high-speed ships. The central topic is the generation of surface solitons in non-stratified water by ship motion both in channels and in unbounded sea areas. The optional nonlinear components of the ship wakes such as the very narrow V-like wake components, packets of monochromatic waves, ship-generated depression areas and supercritical bores are also discussed. Specific features of solitonic ship waves and their interactions have numerous applications in naval and coastal engineering, and in adjacent areas of applied mechanics. An overview of the practical use of and threats connected with certain properties of phase shifts and particularly high wave humps occurring during Mach reflection and nonlinear interaction of solitons in decreasing the wave resistance at supercritical speeds and in the freak wave theory is also presented. Description of the results of studies of far-field properties of nonlinear wakes and possible consequences of the increase of local

hydrodynamic activity completes the analysis (T.Soomere).

Coastal processes
The hydraulics theory and results of wind-wave modelling are used to model annual changes of a sand bar height at the mouth of the Narva River in 2002. The variations in the threshold height are attributed to two mechanisms: cross-shore sediment transport driven by the river flow that erodes the obstacle and long-shore transport forced by waves that increases the threshold height. It is shown that the flow stratification in the river mouth switches between one- and two-layer modes in different seasons, depending on variations of water level, river discharge and wave activity (T.Soomere, in cooperation with J.Laanearu, T.Koppel, and P.A.Davies). The basic factors affecting sediment supply for and transport processes at Pirita Beach, a sandy section of the south-eastern coast of Tallinn Bay, are analysed. Observations of bathymetry, sediment properties and sources, sediment transport processes and their changes arising from coastal engineering activities are reported. The mean grain size is about 0.12 mm, with the fine sand fraction (0.063-0.125 mm) accounting for about 77% of the sediments. Coarse sand dominates only along the waterline. The content of coarser sediments is greater in the northern part of the beach. A number of coastal engineering structures have blocked natural sediment supplies. The beach suffers from sediment deficit now and has lost about 400 m3 of sand annually from the dry beach between 1997 and 2005 (T.Soomere and A.Kask, in cooperation with J.Kask and R.Nerman).

On the potential of reducing coastal pollution by a proper choice of the fairway
Sea coasts located adjacent to fairways hosting intense ship traffic are frequently subject to major oil pollutions. The possibilities of the choice of the fairway (or smart re-routing of the ship traffic) so that a potential oil spill will stay in the open sea area as long as possible are analysed based on certain intrinsic properties of dynamics of water masses - specific patterns of subsurface currents in the Gulf of Finland. The experience of two pollution events in 2006 suggests that the propagation pattern of the pollution qualitatively matches the estimated current patterns. Perspectives and consequences connected with solutions of this type are discussed (T.Soomere, E.Quak).

Outlook for wind measurement at Estonian automatic weather stations
A preliminary analysis of the compatibility of wind properties obtained from continuous high-resolution recordings at automatic stations and traditional wind data has been carried out. Shown is that both data sets represent the same data population. The distribution of the differences between individual wind speed observations is non-Gaussian. The difference of estimates of the average wind speed is negligible for time scales of several weeks or longer. The scale parameter of the Weibull distribution for wind speeds depends on the threshold for calm situations (T. Soomere, in cooperation with S.Keevallik, R.Pärg, and V.Žukova).

Runup of solitary and nonlinear asymmetric waves on a plane beach
The problem of the long wave runup on a beach is discussed in the framework of the rigorous solutions of the nonlinear shallow-water theory. Shown is that the runup height increases when the relative face slope steepness increases whereas the rundown depression weakly depends on the steepness. The results partially explain why the tsunami waves with the steep front (as it was for the 2004 tsunami in the Indian Ocean) penetrate deeper into inland compared with symmetric waves of the same height and length (I.Didenkulova and T.Soomere, in cooperation with E.Pelinovsky and N.Zahibo).

Depending on the form of the incident wave, different formulas have been obtained for the height of wave run-up on a beach. A new development is the proof of the universality

of the formula for the maximum height of run-up of a solitary wave on a beach for a wide range of wave forms so that the effect of difference in form is eliminated. A semi-empirical formula suitable for applications, in particular, in problems related to tsunamis, has been proposed for the height of run-up of a solitary wave on a beach (I.Didenkulova, in cooperation with A.Kurkin, E.Pelinovsky).

The 1806 tsunami in Kozmodemyansk on Volga
The data of tsunami, observed on Volga River near Kozmodemyansk in 1806 are analysed. The most probable mechanism of the appearance of observed oscillations of water surface is the known effect of seaquake over the source of underwater earthquake, which is caused by parametric generation of waves at the water surface in the oscillation gravity field. The wave parameters within this theory are estimated. The numerical simulation of long wave propagation for this event is also performed (I.Didenkulova, in cooperation with A.Zaytsev and E.Pelinovsky).

Spectra of nonlinear shallow water waves
The process of the nonlinear shallow water wave transformation in a basin of a constant depth is studied. Characteristics of the first breaking of the wave are analyzed in details. The Fourier spectrum and steepness of the nonlinear wave are calculated. It is shown that the spectral amplitudes can be expressed using the wave front steepness. This feature is the basis of semi-empirical relation ships that can be used in practical estimations (I.Didenkulova, in cooperation with N.Zahibo, E.Pelinovsky).

3.1.3 Software development

Software development
The program "F2PY – Fortran to Python Interface Generator" (http://cens.ioc.ee/projects/f2py2e/) is being developed. The aim of F2PY is to provide an automatic connection between the high-level Python scripting language and high-performance Fortran/C libraries and programs.

The Third Generation F2PY compiler has been created. The aim is to extend F2PY to account for Fortran 90 specific features such as Fortran 90 type support. The G3 F2PY program has been implemented that can be used to wrap scalar F90 types to Python. The Fortran 2003 parser has been implemented (P.Peterson). See Annex 1 for the list of software.

The SciPy package (http://www.scipy.org/) that gathers a variety of high level science and engineering modules for Python is developed (P.Peterson).

A project SymPy Core (http://sympycore.googlecode.com/) has been started as a fork of SymPy project. The aim of SymPy Core is to develop a robust, efficient, and consistent core package of Computer Algebra System for Python. As a result of this work a package sympycore has been developed that is 10 to 100 times more efficient for various operation than the original SymPy. The work continues for seeking more efficient ways to perform symbolic operations in Python and eventually merge the results to the SymPy project (P. Peterson).

Matlab and Python programmes were composed and modified for numerical simulation of wave propagation in microstructured and granular materials and for analysis of numerical results (A.Salupere, K.Tamm, L.Ilison)

3.1.4 Biomechanics and biophysics

Cell energetics

We continued the analysis of functional interaction between mitochondria and surrounding ATPases. This interaction has been found from the experiments on permeabilized heart muscle fibers. According to our earlier analysis, such interaction can be induced by relatively local diffusion restrictions for adenine nucleotides. The specific causes of these restrictions are not known but intracellular structures are speculated to act as diffusion barriers. Based on the proximity of sarcoplasmic reticulum (SR) to mitochondria, we hypothesize that SR not only utilizes ATP but may also act as a diffusion barrier leading to functional coupling of ATPases and mitochondria. The diffusion barriers can be enhanced by cytoskeleton proteins localized near SR. With a 3D finite-element model, we attempted to explore, SR as the first candidate for diffusion barrier.

The geometry for the mathematical model was constructed using representative mitochondrial and SR structural organization from confocal and electron microscope images. SR and cytoskeleton proteins were assumed to induce the diffusion restrictions around mitochondria and in planes between neighboring mitochondria. Those restrictions were varied as well as a restriction induced by mitochondrial outer membrane to fit the following set of experimental data: mitochondrial respiration rate dependence on exogenous ADP and ATP; effects of pyruvate kinase and phosphoenolpyruvate additions on respiration. According to our simulations, there are many sets of model parameters that were able to reproduce all experiments considered in this work. However, in all the sets, the permeability of SR network and associated cytoskeleton proteins was very low indicating the importance of cytoskeleton proteins in formation of diffusion restrictions (M.Vendelin).

3.1.5 Fractality and econophysics

Soft matter physics

In collaboration with the Institute of Geology (TUT), migmatite formation process, together with the supposedly similar process of bubble formation in the sand-yeast mixture has been studied. Using the experimental data, it has been shown that there is a transition from the diffusional growth of the bubbles, to the Smoluchowski-type bubble merging. Numerical model for the second stage of the process has been developed (J.Kalda, M.Säkki).

Statistical topography

The evolution of material lines in nonsmooth turbulent velocity fields has been studied numerically. At the statistically stationary state, the fractal dimension of the material lines appears to be a non-monotonic function of the smoothness exponent of the velocity field. A qualitative explanation of this behaviour is provided. The maximal value of the fractal dimension 1.33 is achieved in the neighbourhood of the Kolmogorov spectrum smoothness exponent (J.Kalda, M.Kree).

Turbulent diffusion

Fully developed turbulence is known to be highly intermittent, characterized by non-Gaussian statistics and non-vanishing probabilities of extreme events. Such a behaviour is classically described by anomalous (nonlinear) structure function scaling exponents. In the case of passive tracers, there is another intriguing manifestation of the intermittency: the small-scale anisotropy. The reason for its appearance is that if the large-scale fluctuations of the tracer density are anisotropic, the anisotropy propagates along the turbulent cascade, down to the smallest dissipation scales. Thus far, theoretical studies have been unable to explain neither the anomalous scaling of the structure functions, nor

the small-scale anisotropy. We have developed a novel simple model for the evolution of passive tracers in turbulent flows. Based on that model, we have derived an expression for the structure function scaling exponent (which is in a good agreement with the existing numerical and experimental data), and have revealed the origin of the small-scale anisotropy (J.Kalda, A.Morozenko).

Econophysics
Nonlinear portfolio risk optimization and prediction methods based on the scaling laws of the low-variability periods have been implemented practically for Hansapank investment funds management. The main developments were presented to various audiences in Estonia (R.Kitt).

3.1.6 General nonlinear wave theory

Acoustodiagnostics of inhomogeneous and prestressed solids
Due to the complexity of the analytical basis and governing equations, inverse problems to identify inhomogeneous materials and their states on the basis of wave propagation data were solved resorting to the solutions of direct problems. The research was focused on the propagation and interaction of transient waves in following materials:
- nonlinear elastic material with significantly variable in space properties;
- nonlinear elastic materials with weakly variable properties.

The first topic is fundamental research with the aim to derive the analytical solution to describe the propagation of longitudinal waves with arbitrary smooth initial profiles. Several analytical solutions were obtained for the linear problem of wave propagation in special cases of material inhomogeneity. The problem to design materials that permit specific properties for wave propagation was studied. The analytical expressions for the properties of such materials where only one parameter of the wave changes in space by propagation were derived. Shown is that the wave frequency variation in the travelling wave type solution is not possible in the material with space dependent properties, but may occur in the material, properties of which change in time.

The basic effects of wave interaction in the nonlinear elastic material with significantly variable properties were clarified on the basis of numerical experiments. Nonlinear counter-propagation of longitudinal harmonic waves was considered in the material with polynomially varying in space properties. The main attention was paid to the oscillations on the parallel boundaries of the material (structural element). The interaction of counterpropagating waves was found to be very sensitive to the different laws of variation of material properties and to the values of the parameters of wave excitation. The resonance and the steady state of wave interaction were detected.

The second topic was addressed to the practical problem of nondestructive characterization of weakly inhomogeneous nonlinear elastic materials with exceptional external layers. Variation of the elastic properties and the density was described close to the boundaries like in the rolled metal profiles. The analytical solution describing the longitudinal wave propagation in the material was derived and the basic effects of wave propagation in this material were clarified.

All the considered problems are under further investigation. The obtained results are helpful in elaboration of new techniques for nondestructive evaluation of significantly variable properties of materials (A.Ravasoo, A.Braunbrück).

Multiscale dynamics in microstructured solids

Dual internal variables. A uniform approach is proposed for the treatment of internal variables and dynamic degrees of freedom. The basic suggestion requires dual internal variables and a generalization of the usual postulates of non-equilibrium thermodynamics: the satisfaction of the Onsagerian reciprocity relations is not required. With dual internal variables we are able to include inertial effects and to reproduce the evolution of dynamic degrees of freedom, a development which could be impossible with a single internal variable. This is the price we pay for the generalization.

The form of evolution equations depends on the mutual interrelations between the two internal variables. In the special case of internal degrees of freedom, the evolution of one variable is driven by the second one, and vice versa. This can be viewed as a duality between the two internal variables. In the case of pure internal variables of state, this duality is replaced by self-driven evolution for each internal variable. The general case includes all intermediate situations (A.Berezovski, J.Engelbrecht).

Influence of geometry and loading conditions on the martensitic front propagation. Damping capacity of shape memory alloys (SMA) damping devices is studied numerically under distinct geometry and loading conditions. Two-dimensional numerical simulations are performed on the basis of a phenomenological model of dynamics of martensite–austenite phase fronts. Results of the simulations predict the time delay and the value of the stress transferred to other parts of a construction by a damper device.

The dependence of the damping capacity of SMA damping devices on geometry and loading conditions is not simple. If we pay attention only for loading conditions, the geometry of damper with a hole looks like preferred. However, the energy dissipation is more efficient for dampers with simple geometry. Additionally, it is shown that the damping capacity is also material depending (A.Berezovski).

Scale separation in dynamics of microstructured solids. Scale separation cannot be directly applied to the canonical equations for energy and material momentum even if internal variables are introduced to describe the microstructure influence on the overall behavior. Nevertheless, the canonical equations show clearly that evolution equations for internal variables depend on the interactive force which is hidden in the standard formulation of continuum mechanics. This is a clear advantage of the approach over effective medium approximation.

It is shown that the evolution equation for an internal variable describing the influence of microstructure depends on representation of the internal variable as "internal variable of state"or "internal degree of freedom". A hyperbolic evolution equation for the internal variable provides the generalization of elastic wave equation, which covers all the models proposed on the basis of continualization and homogenization methods as well as on the second gradient elasticity theory (A.Berezovski, J.Engelbrecht).

Piano hammers - theoretical and experimental studies

The mathematical models describing the interaction of transverse waves in the string with the piano bridge are derived. The bridge is considered as an oscillating system consisting of the mass, spring and damper. The part of the string passing the bridge terminates at a point load on a damper. The influence of the piano bridge impedance on the fundamental natural vibrating frequency of the piano string is obtained. The influence of a stiffness of a string on amplitude of its vibration is also estimated. It is shown, that the growth of the string stiffness moves the spectrum of the string vibrations in direction of high frequencies.

It is shown that traveling waves carry energy and momentum with themselves, and for this reason the waves exert also the pressure on the piano bridge. It is found that the parameters of viscoelastic inertial support of the string can be varying under the action of the traveling wave pressure. This phenomenon, in turn, changes the amplitude-frequency response of the string vibrations, and in particular, the modulation of the natural frequency of the string may occur (A.Stulov).

Inverse problems

Inverse problems to determine five constant coefficients in a coupled system of equations describing the one-dimensional deformation of microstructured solid were studied. It was shown that measurements in macro-level enable to identify maximally four coefficients. It was proved that these four coefficients can be recovered from frequencies of four harmonic waves with different wave numbers uniquely in the case of normal dispersion and doubly in the case of anomalous dispersion. Possibilities to compute the coefficients in more general deformation processes, making use of the spectral decomposition into harmonic waves, were described. In addition, it was proved that the mentioned assertions about unique and double solvability hold in case when phase and group velocities of two wave packets are used instead of the harmonic waves.

The study of integral equations of nonlinearities of the convolution type was continued. In particular, the recent results for the equation of third kind were generalized to the case when the free term doesn't vanish at the initial point. This case comprises the well-known Benstein-Doetsch equation. In addition, an analogous equation of the second kind with Abel-type weak singularity was studied. For all these equations the existence of a family of solutions depending on an arbitrary real constant and an additional solution was proved (J.Janno, J.Engelbrecht).

Damage of materials

Damage of brittle materials caused by growth of microcracks is studied. Such microcracks are preexisting in the form of voids and defects in all realistic materials. In our model the cracks are penny-shaped with radius l and orientation of the surface normal $\overrightarrow{n}$ They can only enlarge, but not heal, a fact that is denoted as unilateral dynamics. For the single crack a Rice-Griffith growth law is assumed: There is crack growth only if tension is applied normal to the crack surface, exceeding a critical value. The cracks are moving together with the surrounding material. The aim was to investigate the effect of crack growth on macroscopic constitutive quantities.

A possible approach taking into account such an internal structure within continuum mechanics is the so called mesoscopic theory. A distribution of crack lengths and crack orientations within the continuum element is introduced. The macroscopic quantities are calculated as averages with the distribution function. A macroscopic measure of the progressing damage, i.e. a damage parameter, is the average crack length, which is a scalar parameter. For this damage parameter an evolution equation is derived. Due to the unilateral growth law for the single crack it turns out that the form of this *differential equation* depends explicitly on the initial crack length distribution. In order to treat biaxial loading, it is necessary to account for the anisotropic nature of crack growth, i.e. to introduce a tensorial damage parameter. A second order tensor damage parameter in terms of the crack length and orientation distribution function is defined (H.Herrmann et al.).

Heat conduction
Heat conduction close-to-Fourier means, that a minimal extension of heat conduction theory is constructed using the usual Fourier expression of the heat flux density and modifying that of the internal energy as minimal as possible by choosing the minimal state space. Applying Liu's procedure results in the class of materials and a differential equation both belonging to the close-to-Fourier case of heat conduction. A symbolic-numerical computing method is applied to approximate the numerical solutions of 2 special heat conduction equations belonging to the close-to-Fourier class (H.Herrmann et al.).

3.1.7 Optical nonlinearity and photoelasticity

Non-linear integrated photoelasticity
The aim of the research has been to make the algorithms of photoelastic tomography more efficient. Stress fields in some special glasses, loaded by an indenter, have been determined.

In photoelastic tomography the determination of the three-dimensional stress field is based on the measurement of the transformation of polarisation on many light rays that have passed the specimen. Since the specimen is optically both inhomogeneous and anisotropic, optical phenomena are nonlinear and solving of the inverse problem is complicated. Most of the methods, used to solve nonlinear inverse problems, need efficient algorithms for solving the direct problem, in our case for the calculation of the polarisation transformation matrix for a known stress field. It is suggested to use for that factorization of the transformation matrix. It has been shown that if the transformations of the polarisation are described through the characteristic parameters, the latter can be determined solving a single third-order ordinary differential equation. Since the characteristic parameters can be determined experimentally, iterative algorithms of photoelastic tomography can be based on the comparison of the calculated and measured characteristic parameters.

In the field of fracture mechanics of glass often glass specimens are loaded by an indenter until plastic deformations appear near the tip of the indenter. After the indenter is removed, a field of residual stresses remains in the glass. This stress field gives information about the elastic-plastic deformation of the glass. In the Laboratory of Photoelasticity an algorithm for calculating the residual stress field in the above case on the basis of experimental data has been elaborated and stress fields in specimens of silica glass and of soda-lime glass have been determined. Investigations showed that on the vertical axes the axial residual stress is tensile. That correlates well with theoretical investigations. This work was carried out in the framework of a cooperative investigation, headed by Prof. C.R.Kurkjian (University of Southern Maine, USA) (L.Ainola, H.Aben, J.Anton, A.Errapart).

3.2 Chair of Geometry, University of Tartu

Geometric approach to nonlinear problems
The concept of a q-connection and graded q-connection, which can be viewed as generalizations of connection and superconnection, are proposed and studied by means of a module over a graded q-differential algebra, where q is a primitive Nth root of unity. It is proved that the curvature of a (graded) q-connection satisfies the Bianchi identity, and the components of the curvature are expressed in terms of the coefficients of a q-connection provided that the module is a finitely generated free module (V.Abramov).

The formalism to study the equations of Lagrange mechanics is developed. We propose a scheme based on the tangent structures of Riemann and Finsler spaces which allows to conceive several different concepts introduced by Levi-Civita, Minkowski, Berwald, Kawaguchi, Kobayashi and Morimoto from a common point of view. The tangent functor of this scheme which allows to describe different gauge groups used in gauge field theory is also constructed and studied (M.Rahula).

3.3 Biomedical Engineering Centre, Tallinn University of Technology

The studies were aimed to investigation of brain electrical oscillations under influence of external periodic stressors or depressive disorders. The applied methods were based on detection of specific features in the resting electroencephalographic (EEG) signal and visual event-related potential (ERP).

3.3.1. Effect of the external periodic stressor (modulated microwave exposure) on the brain EEG rhythms

Effect of microwaves modulated at different frequencies on human EEG rhythms was evaluated. 13 healthy volunteers were exposed to microwaves (450 MHz) pulse-modulated at frequencies of 7, 14 and 21 Hz. The field power density at the scalp was 0.16 mW/cm^2. Our experimental protocol consisted of two five-cycle (1 min on and 1 min off) series of exposures at fixed modulation frequencies. A relative change in the EEG power with and without exposure was used as a quantitative measure. EEG frequencies recorded in the theta (4-6.8 Hz), alpha (8-13 Hz), beta1 (15-20 Hz), and beta2 (22-38 Hz) bands were analyzed.

The modulated microwaves caused an increase in the average EEG alpha (17%) and beta (7%) power but the theta rhythm remained unaffected. Increases in the EEG alpha and beta power were statistically significant at the modulation frequencies of 14 and 21 Hz. Our findings suggest that the effect of the 450 MHz microwave radiation modulated at 7, 14 and 21 Hz varies depending on the modulation frequency. The effect occurred at modulation frequencies higher or close to the EEG band frequency: microwave exposure modulated at 14 Hz enhanced the EEG power in the alpha and beta1, and modulated at 21 Hz in the alpha, beta1 and beta2 frequency bands whereas no enhancement occurred during exposure to the modulation frequency of 7 Hz. Such a finding indicates possibility of parametric excitation of the oscillations in the brain by the external periodic stimulation (H.Hinrikus, M.Bachmann, J.Lass, R.Tomson, V.Tuulik).

3.3.2. Effect of the external periodic stressor (modulated microwave exposure) on the visual ERP

The study was aimed to examination the effects of low level, modulated microwave radiation on human brain function utilizing the visual ERP. Thirty healthy volunteers were exposed and sham exposed to electromagnetic field (450 MHz, 0.16mW/cm^2) with 40Hz modulation frequency during visual oddball tasks. The task consisted of randomly appearing ball shape stimuli, of which the 25% were target and 75% were standard stimuli. There were always two same sequences of stimuli and the order was counterbalanced with expose and sham exposure conditions. One task lasted 10 minutes, during the expose task the electromagnetic field (EMF) was switched on and off in 1 minute intervals. Three-channel EEG (Fz, Pz, Cz) was recorded continuously during all the tasks using Neuroscan Syn Amps^2 amplifer and headbox.

The responses were grouped into different categories taking into account the EMF condition during the response and the response type and average responses with and without EMF were compared. There were no statistically significant differences in responses during sham exposure conditions, neither in standard nor in target response components. During expose task the group mean N100 amplitude measured from standard response had significant change ($p < 0.00009$), with EMF "ON"condition the N100 amplitude was lower compared to EMF "OFF"condition. Component latencies and average reaction time (RT) did not change. There was also no change in P300 parameters during the EMF "ON"condition. Results confirmed that EMF effects on visual cognitive processes are extremely weak and the detection of these effects is complicated. It can be concluded that modulated microwave effect has stronger impact on early (sensory) components of visual event related potentials compared with later stages of visual information processing during oddball task (J.Lass, K.Kruusing).

3.3.3. Evaluation of changes in the EEG in depression.
In this study we evaluated different electroencephalographic (EEG) measures for detection of major depressive disorder. Asymmetry in symmetric channels between hemispheres, coherence and spectral asymmetry were considered. The experiments were carried out on two groups of volunteers: a group of patients with major depressive disorder and a control group of healthy subjects. Each group consisted of 18 female persons. The 10 min resting EEG signals were used for analysis. The EEG asymmetry, coherence and the ratio of the EEG beta and theta power were calculated.

The results showed small statistically insignificant increase in asymmetry and coherence in frontal and temporal region within alpha frequency band for depressive patients. The calculated spectral asymmetry values were positive for patients with depressive disorder and negative for healthy subjects. Statistical differences between the depressive and healthy group was significant ($p < 0.0001$). The spectral asymmetry seems very promising as an EEG measure for detection of depression. The study was performed in cooperation with the Clinics of Psychiatry, North Estonia Regional Hospital (H.Hinrikus, M.Bachmann, J.Lass, K.Aadamsoo, Ü.Võhma, A.Suhhova, J.Rubljova, R.Tomson).

3.4 Research within international programmes

3.4.1 CENS - CMA Co-operation of Estonian and Norwegian Scientific Centres within Mathematics and its Applications. Contract: N 013909 (MTKO-CT-2004-013909).
Responsible scientist Prof. J.Engelbrecht, Technical Manager Dr. E.Quak.
The following researchers have used this project:
Prof. Tarmo Soomere (Tallinn) – senior researcher at CMA;
Prof. Andrus Salupere (Tallinn) – senior researcher at CMA;
Dr. Arvi Ravasoo (Tallinn) – senior researcher at CMA;
Dr. Jaan Kalda (Tallinn) – senior researcher at CMA;
Dr. Ewald Quak (Oslo) – senior researcher at CENS;
Dr. Andres Braunbrück (Tallinn) – post-doc at CMA;
Dr. Maksim Säkki (Tallinn) – post-doc at CMA;
Dr. Heiko Herrmann (Berlin) – post-doc at CENS;
Dr. Hena Ramay – post-doc at CENS;
Dr. Tomas Torsvik (Bergen) – post-doc at CENS.

The research results are described in other Sections. The 4rd CENS-CMA Annual Seminar was organized in Palmse, Oct. 12, 2007.

3.4.2 FP-6, Wide-range Non-intrusive Devices toward Conservation of Historical Monuments in the Mediterranean Area (WIND-CHIME). Contract: INCO-CT-2004-509805

Tasks worked on and achievements made by A.Berezovski:

1. Influence of geometry and loading conditions - WP3 *Dampers*
Objectives Design, implementation and validation of dampers exploiting SMA (shape memory alloys) properties.

Numerical simulations are performed in the two-dimensional case for different materials and distinct loading conditions. The main focus was on the propagation of phase-transition fronts from the impact end. The attention is paid to stress and displacement distributions in the transformation regions. Results of numerical simulations predict the time delay and the loading stress transferred to other parts of a construction by a damper device.

2. Damping capacity for Ni-Ti and Cu-based alloys - WP4 *Sewing devices*
Objectives Design, implementation and validation of sewing design based on SMA properties.

Numerical simulations of martensitic phase-transition front propagation in two-dimensional case show that the damping capacity of SMA damping devices depends on geometry and loading conditions. As we have seen, this dependence is not simple. If we pay attention only for loading conditions, the geometry of damper with a hole looks like preferred. However, the energy dissipation is more efficient for Cu-Al-Be dampers with simple geometry.

3.4.3 FP-6, Complexity - NET.

Complexity - NET unites partners from the UK (coordinator), Belgium, Denmark, Estonia, Greece, Hungary, Ireland, Italy, the Netherlands, Portugal, Spain with France and Germany as observers. Estonian representatives are J.Engelbrecht (CENS), L.Mõtus (CDC) and A.Pöitel (Foreign Dept. of the Estonian Academy of Sciences).

According to the rules of ERA-NETs, the coordination of national activities is supported that helps to plan further research.

3.4.4 FP-6, EU IST Network of Excellence AIM@SHAPE on shape modelling. Contract IST-506766

Dr. E.Quak, Senior Fellow of the CENS-CMA project, is the Technical Manager of this Network of Excellence.

3.4.5 FP-6, Marie Curie Research and Training Network "Applied stochastic models for ocean engineering, climate and safe transportation"(2005-2009) SEAMOCS. Contract MRTN-CT-2005 – 019374.

Main contractor: Lund University. The CENS group of water waves is leader of the work package 3 "Models on local scale". The responsible scientist is Prof. T.Soomere.

The partners are: University of Sheffield, Université Paul Sabatier (Toulouse), Katholieke Universiteit Leuven, Chalmers Technical University (Göteborg), Royal Netherlands Meteorological Institute (De Bilt), Swedish Meteorological and Hydrological Institute (Norrköping), Det Norske Veritas (Norway, Oslo).

The following young researchers were recruited in the framework of SEAMOCS:
1. Dr. Irina Didenkulova (Nižni Novgorod) as Experienced Researcher;
2. Loreta Kelpšaite (Klaipeda) as Early Stage Researcher.

3.4.6 NordPlus Neighbour Nordic–Baltic–Russian network

Cooperation of 9 partners from Finland, Sweden, Norway, Danemark, Estonia, Latvia and Russia within education and research (2005–2006/2008) "Boundary Layer Phenomena over Partially Ice Covered Arctic Seas: Impact on Weather, Climate, Ecology and Sustainable Economy."The responsible scientist of the CENS group is Prof. T.Soomere.

3.4.7 French-Estonian-Russian Eco–NET network "Wave Current Interaction in Coastal Environment" (2006–2007).

Cooperation of 3 partners in research and foresight studies. The responsible scientist of the CENS group is Prof. T.Soomere.

3.4.8 INNOVE (Estonia) project 1.0101–0208 "Inviting foreign experts in the framework of launching teaching of port and coastal engineering in Tallinn University of Technology"(2005–2008) financed from EU structural funds.

Project leader - Prof. T.Soomere.

This project largely supported the summer school "Waves and coastal processes"and its lecturers (see below).

4. Funding

4.1 Target funding through the Ministry of Education and Research

1. Long–term block grant SF0322521s03 "Nonlinear dynamics and stress analysis", supervisor J.Engelbrecht.

2. Long–term block grant SF0140027s07 "Biosignals interpretation in medicine", P.I.Fridolin, part of EEG analysis, supervisor H.Hinrikus.

4.2 Estonian grants (Estonian Science Foundation)

1. H.Aben, ETF grant 6881, "Photoelastic tomography", (2006–2008).

2. A.Berezovski, ETF grant 7037, "Multiscale dynamics in microstructured solids", (2007–2010).

3. P.Peterson, ETF grant 5767, "Extreme waves: analysis of free surface models", (2004–2008).

4. J.Kalda, ETF grant 6121, "Scale-invariant geometrical properties of turbulent diffusion", (2005–2008).

5. T.Soomere, ETF grant 5762, "Wind wave climate of the Baltic Sea and its dependence on nonlinear effects", (2004–2007);
   ETF grant 7000: "Real time optical measurements and modelling of wave-induced resuspension of bottom sediments", (2007–2010) (Ants Erm, Marine Systems Institute).

6. J.Janno, A.Ravasoo, ETF grant 6018, "Inverse problems for inhomogeneous and microstructured material identification", (2005–2008).
7. H.Hinrikus, ETF grant 6632, "Effect of electromagnetic radiation on brain oscillations", (2006–2009).
8. K.Meigas, ETF grant 5888, "Application of coherent photodetection in cardiovascular diagnostics: noninvasive monitoring of blood pressure and arterial elasticity", (2004–2007).
9. J.Lass, ETF grant 6173, "Microwave effects on cognitive functions", (2005–2008).
10. A.Salupere, ETF grant 7035, "Deformation waves in microstructured solids — multiscale models", (2007–2010).

4.3 International grants (see also 3.4)

1. FP-6 "Wide-range Non-intrusive Devices toward Conservation of Historical Monuments in the Mediterranean Area"(WIND-CHIME) – A.Berezovski.
2. Wellcome Trust International Senior Researcher Fellowship (M.Vendelin) "Analysis of structural and functional aspects of compartmentation of adenine nucleotides in heart muscle cells".
3. Marie Curie ToK – Transfer of Knowledge Scheme CENS-CMA – J.Engelbrecht, E.Quak.
4. Marie Curie Research and Training Network SEAMOCS – T.Soomere.
5. Humboldt Foundation, Feodor Lynen fellowship for H.Herrmann – starting in 2008.

4.4 Additional funding

1. Estonian Programme for Centre of Excellence in Research – block grant.
2. Institute of Cybernetics at TTU – basic funders.
3. Estonian Programme for Centres of Excellence in Research – infrastructure support (from the EU Structural funds).

4.5 National contracts

1. Calculations of sand transport and overfill factor for Pirita beach nourishment; Commissioned by Bureau R. Projekt – T.Soomere.
2. Analysis of rationality of thresholds for critical water level for the City of Tallinn. Suggestions for specification of adequate thresholds for critical water level. Commissioned by Municipal Engineering Services Department, City of Tallinn – T.Soomere.
3. Hydrometeorological conditions and transport of bottom sediments and suspended matter at Pirita – Environmental Impact Assessment of Pirita Beach protection measures: hydrometeorogy and hydrodynamics. Commissioned by OÜ Altakon Grupp – T.Soomere.

5. Publicity of Results

5.1 Research Reports

1.	Mech 287/07	L.Ilison, A.Salupere. Propagation of localized perturbations in granular materials.
2.	Mech 288/07	T.Soomere. Calculations of sand transport and overfill factor for Pirita beach nourishment.
3.	Mech 289/07	T.Soomere. Analysis of rationality of thresholds for critical water level for the City of Tallinn. Suggestions for specification of adequate thresholds for critical water level.
4.	Mech 290/07	T.Soomere. Hydrometeorological conditions and transport of bottom sediments and suspended matter at Pirita Beach.

5.1.1 Patent application

Patent application US60/957514 from 23.08.2007, Method and device for diagnosing a mental disorder by measuring bioelectromagnetic signals of the brain, authors Hiie Hinrikus, Maie Bachmann, Jaanus Lass, Anna Suhhova, Viiu Tuulik.

5.2 Publications

Books, proceedings and theses

1. Special issue on non-equilibrium dynamical phenomena in inhomogeneous solids EUROMECH Colloquium 478. Proc. Estonian Acad. Sci. Physics. Mathematics. (Eds.) J.Engelbrecht, G.A.Maugin, 2007, 56, 230 p.

2. Special issue on oceanography, meteorology and coastal engineering. Proc. Estonian Acad. Sci. Engineering. (Eds.) T.Soomere, S.Keevallik, 2007, 13, 3, pp. 185-272.

3. Geometric modelling, numerical simulation, and optimization: applied mathematics at SINTEF. (Eds.) G.Hasle, K.-A.Lie, E.Quak, Heidelberg: Springer, 2007. 558 p.

4. G.Atanasiu, M.Rahula. New Aspects in Differential Geometry of Second Order. About Theory of Connections. Tartu University Press, 2007, 212 p. (in Russian).

Papers (refereed)

1. H.Aben, A.Errapart. A non-linear algorithm of photoelastic tomography for the axisymmetric problem. Exp. Mech., 2007, 47, DOI 10.1007/s 11340-007-9057-5.

2. H.Aben. On the role of T. J. Seebeck in the discovery of the photoelastic effect in glass. Proc. Estonian Acad. Sci. Eng., 2007, 13, N 4, 283-294.

3. H.Aben, J.Anton, A.Errapart. Modern photoelasticity for residual stress measurement in glass. - In: Experimental Analysis of Nano and Engineering Materials and Structures: Proc. of the 13th Int. Conf. on Experimental Mechanics, Alexandroupolis, Greece, July 1–6, 2007, E.E.Gdoutos (Ed.), Dordrecht: Springer, 2007, 6p. (CD ROM).

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Abstracts

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2. H.Aben, J.Anton, A.Errapart. Modern photoelasticity for residual stress measurement in glass. - In: Experimental Analysis of Nano and Engineering Materials and Structures: Proc. of the 13th Int. Conf. on Experimental Mechanics, Alexandroupolis, Greece, July 1–6, E.E.Gdoutos (Ed.), Dordrecht: Springer, 2007, 3-4.

3. J.Anton, A.Errapart. Generalized onion-peeling method in integrated photoelasticity of axisymmetric problems. - In: Experimental Analysis of Nano and Engineering Materials and Structures: Proc. of the 13th Int. Conf. on Experimental Mechanics, Alexandroupolis, Greece, July 1–6, E.E.Gdoutos (Ed.), Dordrecht: Springer, 2007, 95-96.

4. J.Anton, A.Errapart. The generalized onion-peeling method in integrated photoelasticity of the axisymmetric stress field. Abstracts, 24th Danubia-Adria Symposium on Developments in Experimental Mechanics, Sibiu, Romania, 19–22 September 2007, 49-50.

5. A.Berezovski. Phase transition front propagation in thermoelastic solids. - In: 6th Spring 2007 MULTIMAT meeting, April 19–21, 2007 - Prague, Czech Republic, Abstracts book, 17.

6. A.Berezovski, G.A.Maugin. Macroscopic dynamics of straight brittle crack and phase-transition front. - In: Int. Conf. on Thermo-mechanical modelings for solids, Ecole Polytechnique, July 9–12, 2007 - Palaiseau, France, Abstracts book, 123-124.

7. A.Berezovski, J.Engelbrecht, G.A.Maugin. Internal variables and scale separation in dynamics of microstructured solids. - In: IUTAM Symp. on Scaling in Solid Mechanics, June 25–29, 2007 - Cardiff, UK, Abstracts book, 1p.

8. J.Engelbrecht, A.Berezovski, A.Salupere. Solitary waves in dispersive materials. - In: 14th Int. Conf. on Waves and Stability in Continuous Media, June 30 – July 7, 2007 - Ragusa, Sicili, Italy, Book of Abstracts, 5.

9. J.Janno. Inverse problems for microstructured materials. - In: "Direct, Inverse and Control Problems for PDE's - DICOP"- Conf. held in Rome: June 25–28, 2007, Abstracts, 8.

10. A.Braunbrück, A.Ravasoo. Nonlinear interaction and resonance of counterpropagating waves. - In: Fourth Int. Conf. of Applied Mathematics and Computing, FICAMC: August 12–18, 2007, Plovdiv, Bulgaria, Ed. S.Nenov, 2007, Volume 1, A-F, 56.

11. A.Salupere, K.Tamm and J.Engelbrecht. Interaction of solitary deformation waves in microstructured solids. - In: T.R.Taha (Ed.), Book of Abstracts, The Fifth IMACS Int. Conf. on Nonlinear Evolution Equations and Wave Phenomena: Computation and Theory, The University of Georgia, Athens, USA, April 16–19, 2007, p. 114.

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13. L.Ilison and A.Salupere. On the formation and interaction of solitons and solitary waves in granular media. In Book of Abstracts, 27th Dynamics Days Europe, Loughborough 9–13 July 2007, Loughborough University, p. 120.

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15. I.Didenkulova. Characteristics of the nonlinear shallow water wave: shape, steepness and spectrum. - Geophysical Research Abstracts, 2007, 9.

16. I.Didenkulova, E.Pelinovsky. Runup of solitary waves of different shapes on a beach. - Geophysical Research Abstracts, 2007, 9.

17. I.Didenkulova, E.Pelinovsky, A.Sergeeva. Runup of irregular waves with various statistics. - Geophysical Research Abstracts, 2007, 9.

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21. E.Pelinovsky, I.Didenkulova. Long wave runup on the plane beach. IUGG Abstracts, Perugia, Italy, 2–13 July 2007.

22. E.Pelinovsky, I.Didenkulova et al. A comparison of tsunamis in Caribbean and Mediterranean; history, possibility, reality. IUGG Abstracts, Perugia, Italy, 2–13 July 2007.

23. T.Lapimaa. Environmental Impact Assessments in Estonian coastal waters in 2001–2004. - In: Baltic Sea Science Congress, Rostock 2007, March 19–22, 2007 at Rostock University. Abstract volume. Part 2: Posters, Rostock University, 2007, 96.

24. A.Erm, A.Kask, T.Kõuts, T.Soomere. Optical detection of wave-induced resuspension of sediments. - In: Baltic Sea Science Congress Rostock 2007: March 19–22, 2007 at Rostock University: Abstract volume. Part 1: Lectures. Rostock: Rostock University, 2007, 96.

25. A.Kask, T.Soomere, J.Kask. Studies of composition of bottom sediments and bathymetric features of Pirita shore. - In: Baltic Sea Science Congress Rostock 2007: March 19–22, 2007 at Rostock University: Abstract volume. Part 2: Posters. Rostock: Rostock University, 2007, 116.

26. K.Myrberg, T.Soomere, M.Leppäranta, A.Nekrasov. Advances in the physical oceanography of the Gulf of Finland during the last decade. - In: Baltic Sea Science Congress Rostock 2007: March 19–22, 2007 at Rostock University: Abstract volume. Part 1: Lectures. Rostock: Rostock University, 2007, 58.

27. T.Soomere, E.Quak. On the potential of reducing coastal pollution by a proper choice of the fairway. - In: ICS 2007: 9th International Coastal Symposium 2007, Crown Plaza Hotel, Surfers Paradise, Gold Coast, Queensland, Australia, 16–20 April 2007, Book of Abstracts: Griffith School of Engineering, 2007, 77.

28. T.Soomere, I.Zaitseva. Long-term variations of wave properties in the northern Baltic Proper. - In: Baltic Sea Science Congress Rostock 2007: March 19–22, 2007 at Rostock University: Abstract volume. Part 1: Lectures. Rostock: Rostock University, 2007, 93.

29. T.Soomere. Modelling of sand transport at Pirita beach. - In: Baltic Sea Science Congress Rostock 2007: March 19–22, 2007 at Rostock University: Abstract volume. Part 1: Lectures. Rostock: Rostock University, 2007, 36.

30. A.Ravasoo. Characterization of variable material properties by nonlinear acoustic techniques. - In: 14th Int. Congress on Sound & Vibration ICSV14: Cairns Australia, 9–12 July 2007, Program and Abstracts. [S.l.]: International Institute of Acoustics and Vibration, 2007, 34.

31. A.Stulov, V.Erofeyev, E.Lissenkova. Action of traveling wave on the piano bridge. - In: ISMA 2007 Barcelona Program and Abstracts of Int. Symp. on Musical Acoustics 2007, Barcelona, Spain, 9–12 September, Barcelona: ISMA, 2007, 44.

32. A.Stulov, V.Erofeyev, E.Lissenkova. Piano string vibration and the role of the bridge. - In: 19th Int. Congress on Acoustics: Acoustics for the 21st Century, Madrid, Spain, 2–7 September 2007, Programme and Abstracts, Madrid ICA, 2007, 203.

33. M.Vendelin, T.Anmann, T.Käämbre, P.Sikk, V.Saks. Modeling of the coupled enzyme systems: model of mitochondrial creatine kinase (miCK) and adenine nucleotide translocase (ANT) coupling. - Biophysical Journal, 2007, Suppl. S, 660A.

34. M.Vendelin, H.R.Ramay, R.Birkedal. Three dimensional reaction-diffusion model of interaction between mitochondria and sarcoplasmic reticulum in heart muscle cells. - The FASEB Journal, 2007, 21, 6, A1351.

35. D.Beard, M.Vendelin. Special call on the Systems Biology of the Mitochondrion. - In: American Journal of Physiology-Cell Physiology, 2007, 292, 293.

36. A.Suhhova, M.Bachmann, K.Aadamsoo, Ü.Võhma, J.Lass, R.Tomson, V.Tuulik, and H.Hinrikus. EEG analysis in depression. COST B27 Meeting and Symposium: "Electrical brain oscillations along the life-span", Göttingen, October 12–14, 2007.

37. H.Hinrikus. Effect of modulated 450 MHz microwave on human EEG rhythms and cognitive processes. FGF Workshop "Sleep Disorders, EEG-Changes, Altered Cognitive Functions - Is there a Connection with the Exposure to a Connection with the Exposure to Mobile Communication RF Fields?", Stuttgart, Nov. 4–7, 20-21.

38. C.Papenfuss, T.Böhme, H.Herrmann, W.Muschik, and J.Verhás. Dynamics of the size and orientation distribution of microcracks and evolution of macroscopic damage parameters. Journal of Non-Equilibrium Thermodynamics, 2007, 32, 2, 1-14.

Submitted papers

1. J.Anton, H.Aben, L.Ainola, A.Errapart. A discrete algorithm of integrated photoelasticity for axisymmetric problems. Exp. Mech. (USA, accepted).

2. L.Ainola, H.Aben. Approximate solution of the inverse problem of axisymmetric thermoelasticity for residual stress measurement in glass. J. Thermal Stresses, 2008. DOI: 10.1080/01495701521843 (accepted).

3. L.Ainola, H.Aben. Integrated photoelasticity for axisymmetric thermal stress measurement using the stress function. J. Thermal Stresses (accepted).

4. A.Errapart. Technology of photoelastic tomography. Exp. Techniques (accepted).

5. H.Aben, J.Anton, A.Errapart. Modern photoelasticity for residual stress measurement in glass. Strain (accepted).

6. J.Janno, J.Engelbrecht. Inverse problems for a coupled system of microstructure. Inverse Problems (submitted).

7. L.v.Wolfersdorf, J.Janno. On the theory of convolution equations of the third kind II. J. Math. Anal. Appl. (indexed, abstracted: ISI Web of Science, Math. Rev, MathSciNet, Zentralblatt Math), electronically appeared: http://dx.doi.org/10.1016/j.jmaa.2007.12.042 (in print).

8. J.Janno, L.v.Wolfersdorf. Integro-differential equations of first order with autoconvolution integral. J. Int. Equ. Appl. (indexed, abstracted: Math. Rev, MathSciNet, Zentralblatt Math) (accepted).

9. A.Salupere, K.Tamm, J.Engelbrecht. Numerical simulation of interaction of solitary deformation waves in microstructured solids. Int. J. Non-Linear Mech (accepted).

10. L.Ilison and A.Salupere. Propagation of sech^2-type solitary waves in hierarchical KdV-type systems, Chaos Solitons & Fractals (submitted).

11. J.Engelbrecht, A.Berezovski, A.Salupere. Solitary waves in dispersive materials. Proc WASCOM 2007 (accepted).

12. P.Ván, A.Berezovski and J.Engelbrecht. Internal variables and dynamic degrees of freedom. - J. of Non-Equil. Thermodyn., 2008 (accepted).

13. A.Berezovski. Influence of geometry and loading conditions on the martensitic front propagation. - Smart Structures and Systems, 2008 (accepted).

14. G.A.Maugin, A.Berezovski. Introduction to the thermomechanics of configurational forces. Proc. of Thermocon '05 Conference (accepted).

15. A.Berezovski, J.Engelbrecht, G.A.Maugin. Internal variables and scale separation in dynamics of microstructured solids. Proc. of IUTAM Symp. on Scaling in Solid Mechanics, June 25–29, 2007, Cardiff, UK (accepted).

16. A.Braunbrück, A.Ravasoo. Nonlinear interaction and resonance of counterpropagating waves. - Int. J. of Pure and Appl. Math., 2008 (accepted).

17. T.Peets, M.Randrüüt, J.Engelbrecht. On modelling dispersion in microstructured solids. - Wave Motion, 2008 (accepted).

18. N.Zahibo, I.Didenkulova, A.Kurkin, E.Pelinovsky. Steepness and spectrum of nonlinear deformed shallow water wave. Ocean Engineering, 2008, 35, 1, 47-52 (in press).

19. I.Didenkulova, E.Pelinovsky. Runup of long waves on a beach: influence of the initial wave shape. Oceanology, 2008 (accepted).

20. T.Soomere, A.Behrens, L.Tuomi, J.W.Nielsen. Wave conditions in the Baltic Proper and in the Gulf of Finland during windstorm Erwin/Gudrun. Natural Hazards and Earth System Sciences (accepted).

21. Byung Ho Choi, E.Pelinovsky, Dong Chule Kim, I.Didenkulova. Two- and Three-dimensional Computation of Solitary Wave Runup on Non-plane Beach. Nonlinear Processes in Geophysics (submitted).

22. I.Didenkulova, E.Pelinovsky, N.Zahibo. Long wave reflection from a "non-reflected" bottom profile. Izvestiya, Mehanika Zhidkostej i Gazov (submitted).

23. N.Zahibo, I.Nikolkina, I.Didenkulova. Hurricane Dean in Guadeloupe: 16–17 August, 2007, Caribbean Journal of Science (submitted).

24. I.Didenkulova, E.Pelinovsky, A.Sergeeva. Runup of long irregular waves on a plane beach. Extreme Waves in the Ocean (Eds.) Efim Pelinovsky and Christian Kharif, Springer 2008 (accepted).

25. N.Zahibo, I.Nikolkina, I.Didenkulova. Extreme waves generated by cyclones in Guadeloupe. Extreme Waves in the Ocean (Eds.) Efim Pelinovsky and Christian Kharif, Springer 2008 (accepted).

26. T.Soomere. Extremes and decadal variations of the northern Baltic Sea wave conditions. Extreme Waves in the Ocean (Eds.) Efim Pelinovsky and Christian Kharif, Springer 2008 (accepted).

27. T.Soomere, T.Healy. Extreme wave and water level conditions in the Baltic Sea in January 2005 and their reflection in teaching of coastal engineering. BEAR 2008/CIB W89: International Conference in Building Education and Research, Kandalama, Sri Lanka 10–15 February 2008 (in print).

28. I.I.Didenkulova, E.Pelinovsky, T.Soomere. Influence of the initial wave shape on tsunami wave runup characteristics. Solutions to Coastal Disasters 2008 Conference, American Society of Civil Engineers (ASCE), April 13–16, 2008, Turtle Bay Resort on Oahu, Hawaii (submitted).

29. T.Soomere, T.Healy. Escalating extremes over descending trends of the northern Baltic Bea wave fields. Solutions to Coastal Disasters 2008 Conference, American Society of Civil Engineers (ASCE), April 13–16, 2008, Turtle Bay Resort on Oahu, Hawaii (submitted).

30. T.Soomere. Soliton interactions. Encyclopedia of Complexity and Systems Science, Springer, (to appear in 2008).

31. A.Stulov. Physical modelling of the piano string scale. - Applied Acoustics, 2007 (accepted).

32. K.Veski, J.Engelbrecht, T.Bountis. Emergence and propagation of nerve pulses: parameter analysis and response to forcing. J. Phys. Soc. Japan (submitted).

33. H.Hinrikus, M.Bachmann, J.Lass, and V.Tuulik. Effect of low frequency modulated microwave on human EEG: individual sensitivity. Bioelectromagnetics (submitted).

34. H.Hinrikus, M.Bachmann, J.Lass, and V.Tuulik. Effect of modulated microwave radiation on electroencephalographic rhythms and cognitive processes. Est. J. of Eng. (submitted).

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36. H.Herrmann, K.H.Hoffmann. Remarks around additional 56 lines of matlab: short parallel finite element implementation using pmatlab. J. Numerical Algorithms (submitted).

37. V.Abramov. q-connection and its matrix. Proc. of the AGMF Conference in Lund (submitted).

38. V.Abramov, O.Liivapuu. Connection on module over a graded q-differential algebra. Proc. of the AGMF Conference in Göteborg (submitted).

Popular science / Science policy

1. J.Engelbrecht, A.Salupere, A.Berezovski. Mikrostruktuursed materjalid ja deformatsioonilained. Küttner, Rein (Toim.). Teadusmõte Eestis (Science in Estonia) (IV) Tehnikateadused (Engineering) (II) (9 – 15). Tallinn: Eesti Teaduste Akadeemia, 2007 (in Estonian).

2. T.Soomere. Baltic Sea waves viewed from Estonia. Ibid. 133-142 (in Estonian).

3. J.Kalda. Competition of students. Horisont, 3, 2007, 92 (in Estonian).

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5. J.Kalda. Olympiad in Iran: Koran and physics. Horisont, 5, 2007, 44-45 (in Estonian).

6. T.Soomere. Estonia - in the mercy of sea and waves? Estonian Shipping Yearbook, 2007. E. Kreem (Ed.), Eesti Meremeeste Liit, Tallinn 2007, 51-57 (in Estonian).

7. T.Soomere. Rogue Waves: Do Ship Wakes Strike Back or Help Us? Coastal News (Newsletter of the New Zealand Coastal Society: a Technical Group of IPENZ), Issue 35, 19–20 June 2007.

8. T.Soomere. Towards better forecast of coastal floodings. Äripäev (Daily business newspaper), 149(3400) 22 August 2007, p. 26 (in Estonian).

9. T.Soomere. Up- and downwelling waters in the sea. Eesti Loodus, 8, 2007, 6-12 [398-404] (in Estonian).

Translations

H.Poincaré. Dernières pensées (Last Thoughts). Translation into Estonian by M.Rahula including an essay by the translator: Reading Henri Poincaré.
In: Akadeemia, 2006: N 8, 9, 10, 11; 2007: N 1, 2.

5.3 Conferences

1. 13th International Conference on Experimental Mechanics, July 1–6, Alexandroupolis.
   H.Aben, J.Anton, A.Errapart. Modern photoelasticity for residual stress measurement in glass.
   H.Aben, A.Errapart. Linear and non-linear algorithms of photoelastic tomography.
   J.Anton, A.Errapart. Generalized onion-peeling method in integrated photoelasticity of axisymmetric problems.

2. 24th Danubia-Adria Symposium on Developments in Experimental Mechanics, September 19–22, Sibiu, Rumeenia.
   J.Anton, A.Errapart. The generalized onion-peeling method in integrated photoelasticity of the axisymmetric stress field.

3. International Symposium on Defect and Material Mechanics, March 25–29, Aussois, France.
   A.Berezovski, G.A.Maugin. Moving discontinuities in thermoelastic solids.

4. 6th spring 2007 MULTIMAT meeting April 19–21, Prague, Czech Republic.
   A.Berezovski. Phase transition front propagation in thermoelastic solids.

5. FP6 European Research Project Wide-range Non-intrusive Devices toward Conservation of Historical Monuments in the Mediterranean Area, INCO-CT-2004-509085, final meeting, April 24–29, Larissa, Greece.
   A.Berezovski. Influence of geometry and loading conditions on the martensitic front propagation.

6. Continuum Physics and Engineering Applications June 2–10, Rackeve, Hungary.
   A.Berezovski. Moving discontinuities in solids. - invited lecture.

7. 10th European mechanics of materials conference (EMMC10): Multi-phases and multi-components materials under dynamic loading June 11–14, Kazimierz Dolny, Poland.
   A.Berezovski, M.Berezovski, J.Engelbrecht, G.A.Maugin. Numerical simulation of waves and fronts in inhomogeneous solids

8. IUTAM Symposium on Scaling in Solid Mechanics. June 25–29, Cardiff, UK.
   A.Berezovski, J.Engelbrecht, G.A.Maugin. Internal variables and scale separation in dynamics of microstructured solids.

9. 14th International Conference on Waves and Stability in Continuous Media June 30 – July 7, Ragusa, Sicili, Italy.
   J.Engelbrecht, A.Berezovski, A.Salupere. Solitary waves in dispersive materials.

10. The Fifth IMACS International Conference on Nonlinear Evolution Equations and Wave Phenomena: Computation and Theory, The University of Georgia, April 16–19, 2007, Athens, USA.
    A.Salupere, K.Tamm and J.Engelbrecht. Interaction of solitary deformation waves in microstructured solids.

11. XII International Workshop on Nonlinear Elasticity in Materials, June 3–9, 2007, Ajaccio, Corsica, France.
    A.Salupere, K.Tamm and J.Engelbrecht. Interaction of solitary deformation waves in microstructured solids.

12. Dynamics Days Europe 2007, Loughborough University, July 9–13, 2007, UK.
    L.Ilison and A.Salupere. On the formation and interaction of solitons and solitary waves in granular media.
    O.Ilison and A.Salupere On the formation of solitonic structures in microstructured solids.

13. The Ninth U.S. National Congress on Computational Mechanics (USNCCM IX), July 23–26, 2007, San Francisco, USA.
    A.Salupere, K.Tamm and J.Engelbrecht. Numerical simulation of propagation of solitary deformation waves in microstructured solids.

14. International Conference on Thermo-mechanical modelings for solids, Ecole Polytechnique July 9–12, Palaiseau, France.
    A.Berezovski, G.A.Maugin. Macroscopic dynamics of straight brittle crack and phase-transition front.

15. Direct, Inverse and Control Problems for PDE's DICOP June 25–28, Rome.
J.Janno. Inverse problems for microstructured materials.

16. Annual Biophysical Meeting, 2007, Baltimore, USA.
M.Vendelin. Modeling of the coupled enzyme systems: model of mitochondrial creatine kinase (miCK) and adenine nucleotide translocase (ANT) coupling.

17. Experimental Biology, 2007, Washington DC, USA.
M.Vendelin. Three dimensional reaction-diffusion model of interaction between mitochondria and sarcoplasmic reticulum in heart muscle cells.

18. Fifth Conference on Mitochondrial Physiology, 2007, Lake District, UK.
M.Vendelin. 3D reaction-diffusion model of interaction between mitochondria and sarcoplasmic reticulum/cytoskeleton proteins in heart muscle cells.
Participated: A.Illaste.

19. Baltic Sea Science Congress, Rostock, March 19–22, 2007.
T.Soomere. Modelling of sand transport at Pirita Beach (BSG, Baltic Sea Geology).
K.Myrberg, T.Soomere, M.Leppäranta, A.Nekrasov. Advances in the physical oceanography of the Gulf of Finland during the last decade (CBO, Conference of Baltic Oceanographers).
T.Soomere, I.Zaitseva. Long-term variations of wave properties in the northern Baltic Proper (CBO).
A.Erm, A.Kask, T.Kõuts, T.Soomere. Optical detection of wave-induced resuspension of sediments (CBO).
A.Kask, T.Soomere, J.Kask. Studies of composition of bottom sediments and bathymetric features (BSG), poster presentations.
T.Lapimaa. Environmental Impact Assessments in Estonian coastal waters in 2001-2004 (CBO), poster presentation.

20. European Geosciences Union General Assembly 2007, 15–20 April, Vienna, Austria.
I.Didenkulova. et al.:
Spectrum of the tide-gauge records in Pointe-a-Pitre bay, Guadeloupe,
Characteristics of the nonlinear shallow water wave: shape, steepness and spectrum,
Freak waves in 2006,
Runup of irregular waves with various statistics,
Runup of solitary waves of different shapes on a beach.

21. 9th International Coastal Symposium 2007, Crown Plaza Hotel, Surfers Paradise, Gold Coast, 16–20 April, Queensland, Australia.
T.Soomere, E.Quak, On the potential of reducing coastal pollution by a proper choice of the fairway.

22. Eco-NET Study Meeting, 21–22 May, Brest, IFREMER.
K.Rannat. Some GPS applications.
T.Soomere. Advances in the physical oceanography of the Gulf of Finland during the last decade.

23. International Symposium Tsunami Disaster Mitigation for East Korean Coast, 8 June, Suwon, Korea.
E.Pelinovsky, I.Didenkulova, N.Zahibo. Analytical expressions for runup characteristics of nonlinear long waves on a plane beach.

24. Fifth Study Conference on BALTEX, Kultuurivara, 4–8 June, Kuressaare, Saaremaa, Estonia.
K.Myrberg, T.Soomere, M.Leppäranta, A.Nekrasov. Recent advances in the physical oceanography of the Gulf of Finland.
T.Soomere. Trends, long-term variations and extremes of the Northern Baltic Proper wave fields.
S.Keevallik, T.Soomere. Examination of wind data from automatic weather stations (poster presentation).

25. XXIV General Assembly of the International Union of Geodesy and Geophysics, 2–13 July, IUGG 2007, Perugia, Italy.
I.Didenkulova, T.Soomere, N.Zahibo. Pointwise and distributed reflection of long waves from a beach.
Y.Ahmet Cevdet, E.Pelinovsky, T.Talipova, N.Zahibo, A.Zaitsev, I.Didenkulova, C.Ozer, I.Insel, H.Karakus, A.Kurkin, I.Nikolkina. A comparison of tsunamis in Caribbean and Mediterranean; history, possibility, reality.

26. International summer school "Waves and coastal processes", 25 August – 09 September 2007, Tallinn.
I.Didenkulova. Runup of nonlinear asymmetric shallow-water waves.
T.Soomere. Variability of marine winds.
T.Soomere. Applications of shallow-water soliton interactions in extreme wave theory.
T.Torsvik. Modelling of long ship waves.
T.Soomere. Overview of hydrodynamical and hydrogeological studies of potential locations of Saaremaa deep harbour.
T.Soomere. Trends, long-term variations and extremes of northern Baltic Proper wave fields.
J.Engelbrecht. Science and society.
E.Quak. Some things that went wrong due to bad numerical computing.
T.Soomere. On the potential of reducing coastal pollution by a proper choice of the fairway.
H.Herrmann. "Low Level"Software for Science.

27. Humboldtians's meeting (Alexander von Humboldt Foundation) (September 20–21, Tartu, Tallinn).
Participated: J.Engelbrecht, I.Didenkulova, T.Torsvik, T.Soomere.

28. 10th Polish — German Seminar Global Changes and Extreme Phenomena in the Baltic Sea, 19–23 September, Gdansk, Poland.
A.Behrens, L.Tuomi, J.W.Nielsen, T.Soomere. Unusual wave conditions in the Baltic Proper and in the Gulf of Finland during windstorm Gudrun.

29. Finnish-Estonian Humboldt-Kolleg "Wissenschaftliche Sprachpraxis, Kommunikation und die Effekte der Globalisierung", University of Jyväskylä, 29 September.
Participated: T.Soomere.

30. VI All-Russian conference on Atmospheric Electricity, October 1–7, Nizhny Novgorod, Russia.
I.Didenkulova. Applications of wave modeling.

31. 1st Colloquium Scientific and Fundamental Aspects of the Galileo Programme, 1–4 October, Toulouse, France.
Participated: K.Rannat.

32. Conference MAS2007, 4–6 October, Bergeggi, Italy.
Participated: K.Rannat.

33. "GAMIT for advanced users", 10–11 Dec. 2007, Pamplona, Spain.
Participated: K.Rannat.

34. Joint Workshops "Implications of climate change for marine and coastal safety"11–12 October, Palmse, Estonia, and "Applied Wave Mathematics"of Marie Curie networks SEAMOCS and CENS-CMA, and Eco-NET network"Wave Current Interaction in Coastal Environment", 12 October, Palmse, Estonia.
I.Didenkulova. Runup of long asymmetric waves.
T.Soomere. Climate change and shifts in the Baltic Sea.
T.Torsvik. Numerical Simulation of Long Ship Waves.
A.Kask. Large effects of small structures on coastal evolution.
J.Engelbrecht. Welcome and overview of CENS activities.
R.Winther, J.Engelbrecht, E.Quak. The status of the CENS-CMA project and its contributions to the organisations of CENS and CMA.
T.Soomere. Pirita Beach: changes and challenges.
E.Quak, K.-A.Lie. Simulations of 3D flows.
H.Herrmann. Mesoscopic description of complex fluids.

35. 3rd School on geology, 12–14 October, Pikajärve, Valgjärve vald, Põlvamaa, Estonia.
T.Soomere. Pirita ranna liivade liikumised - mudelid ja tegelikkus. (Motion of sand at Pirita beach: models and reality).

36. IoC Fall Seminar, November 8–9, Jäneda, Estonia.
I.Didenkulova. Mathematical modeling of long waves (tsunami waves).
T.Torsvik. Long Waves Generated by High Speed Vessels.

37. Meeting of the Coordination Action GSD — Global System Dynamics and Policies: simulation and visualisation technologies, 4 December, Brussels.
Participated: T.Soomere.

38. 19th International Congress on Acoustics : Acoustics for the 21st Century, 2–7 September, Madrid, Spain.
A.Stulov. Piano string vibration and the role of the bridge.

39. International Symposium on Musical Acoustics 2007, September 9–12, Barcelona, Spain.
A.Stulov. Action of traveling wave on the piano bridge.

40. 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society, August 23–26, Lyon.
H.Hinrikus. Adaptation of Human Brain Bioelectrical Activity to Modulated 450 MHz Microwave.

41. IFMBE 11th Mediterranean Conference on Medical and Biological Engineering and Computing, 26–30 June, Ljubljana.
R.Tomson, H.Hinrikus. Effect of Modulated 450 MHz Microwave on HumanEEG at Different Field Power Densities.

42. Workshop "Neuroscience today: neuronal functional diversity and collective behaviours", COST B27 meeting, 26–28 March, Firenze.
M.Bachmann, H.Hinrikus, V.Tuulik.

43. COST B27 Meeting and Symposium: "Electrical brain oscillations along the lifespan", October 12–14, Gõttingen.
A.Suhhova, H.Hinrikus. EEG analysis in depression.

44. FGF, EMF NET Workshop Sleep Disorders, EEG-Changes, Altered Cognitive Functions - Is there a Connection with the Exposure to a Connection with the Exposure to Mobile Communication RF Fields? Nov. 4–7, Stuttgart.
H.Hinrikus. Effect of modulated 450 MHz microwave on human EEG rhythms and cognitive processes.

45. 14th International Congress on Sound and Vibration ICSV14, 9–12 July 2007, Cairns, Australia.
A.Ravasoo. Characterization of variable material properties by nonlinear acoustic techniques.

46. Fourth International Conference of Applied Mathematics and Computing, FICAMC, 12–18 August 2007, Plovdiv, Bulgaria.
A.Braunbrück, A.Ravasoo. Nonlinear interaction and resonance of counterpropagating waves.

47. Workshop Turbulence and mixing, November 3-8, Eilat, Israel.
J.Kalda. Formation of tracer discontinuities by turbulent mixing: a simple model and scaling laws.
M.Kree. Fractal characteristics of fluid lines in 2D turbulence.

48. Conference STATPHYS-23, 9–13 July, Genova, Italy.
J.Kalda. Anomalous scaling behaviour of sticky particles in compressible turbulent flows.
M.Kree. On the fractal structure of the passive scalar fields in a fully developed turbulence.

49. XXXVII Estonian physics days, 15–17 March, Tartu.
J.Kalda. Physics beyond physics: complex systems and soft matter.

50. Workshop Software Issues in Computational Science and Engineering, Uppsala University, August 15–16, Sweden.
P.Peterson. The G3 F2PY for connecting Python and Fortran 90 programs.

51. Conference "Geometry in Odessa - 2007", 20–26 May, Odessa, Russia.
M.Rahula. Tangent structures and higher order movements.

52. Lecture, CPEA Conference, 2007.
H.Herrmann. Discretization of continuum physics a comparison of numerical methods from a physical point of view.

53. Workshop Networks of Excellence, FP7 in Motion Information Days, January 24, Luxemburg.
E.Quak. THE AIM@SHAPE Network of Excellence project and its results (with B.Falcidieno, IMATI, Genova, Italy).

54. Mini-workshop Industrial Geometry, CMA, March 20, Oslo, Norway.
E.Quak. The AIM@SHAPE Digital Shape Workbench as an eScience Collaboration Tool.

55. Workshop Industry Challenges in Geometric Modeling, CAD and Simulation 2007, March 22, Darmstadt, Germany.
E.Quak. THE AIM@SHAPE Network of Excellence project and its results.

56. Invited plenary presentation at the Launching Conference of the EU's Seventh Framework Programme (FP7) in Estonia, March 28, University of Tartu.
E.Quak. Research projects funded by the EU framework programmes: views of a practitioner.

57. Official Annual EU Project Review, March 29–30, Genova, Italy.
E.Quak. Presentation of the activity report of the EU IST Network of Excellence AIM@SHAPE.

58. Institute of Discrete Mathematics and Geometry, Vienna University of Technology, May 7, Austria.
E.Quak. THE AIM@SHAPE Network of Excellence project and its results.

59. Minisymposium The AIM@SHAPE Digital Shape Workbench as an eScience Collaboration Tool, ICIAM07 – 6th International Congress on Industrial and Applied Mathematics, July 16, Zürich, Switzerland.
E.Quak. THE AIM@SHAPE Network of Excellence project and its results.

60. Minisymposium Virtual Environments in Applied Mathematics, Finland, ICIAM07 – 6th International Congress on Industrial and Applied Mathematics, July 17, Zürich, Switzerland.
E.Quak. Multidimensional Digital Shapes for eLearning (with T. Dokken, SINTEF, Oslo, Norway).

61. Department of Mathematics, Texas A&M University, College Station, October 24, Texas, USA.
E.Quak. The AIM@SHAPE Digital Shape Workbench as an eScience Collaboration Tool & On the Potential of Reducing Coastal Pollution by a Proper Choice of the Fairway.

62. Official Annual EU Project Review Genova, Italy, December 3–7.
E.Quak. Presentation of the activity report of the EU IST Network of Excellence AIM@SHAPE, December 3.
E.Quak. Final project workshop NoE AIM@SHAPE: the semantic approach to digital shape modelling and reasoning, December 4.
E.Quak. 2nd International Conference on Semantic and Digital Media Technologies (SAMT 2007), December 5–7.

63. Conference: Algebra, Geometry and Mathematical Physics, 11–13 October, Göteborg.
V.Abramov. Algebra of q-Differental Forms on Quantum Plane.

64. CHiC startup meeting, 7 February, Chemnitz.
Participated: H.Herrmann.

65. Linux-Tag, 30 May – 2 June, Berlin.
Participated: H.Herrmann.

66. Mathematica Workshop, 16 November, WIAS Berlin.
    Participated: H.Herrmann.

67. Humboldt-Netzwerktagung, 26–29 November, Giessen.
    Participated: H.Herrmann.

5.4 Seminars

5.4.1 Tallinn Seminars on Mechanics (CENS)

1. 22.01. Dr. Heiko Herrmann: "Modern constitutive theory: 2 relativistic continuum thermodynamics".

2. 05.02. Dr. Hena R. Ramay: "Three dimensional reaction-diffusion model of interaction between mitohondria and sarcoplasmic reticulum in heart muscle cells".

3. 12.02. Prof. Jüri Engelbrecht, Prof. Leo Mõtus: "Complex systems (ERA-NET Complexity)".

4. 19.02. Prof. Gheorge Atanasiu (Transilvania University, Brasov):
   "Structure equations in differential geometry of order two".
   "The homogeneous prolongation to the second order tangent bundle of a finsler metric".
   Prof. Vladimir Balan (Bucharest University of Technology): "CMC Surfaces in euclidean and finsler spaces. Applications".
   Dr. Nicoleta Brinzei (Transilvania University, Brasov): "Variation problems of order two and geodesics of second order tangent bundle".

5. 21.02 Dr. Pearu Peterson: "New computer cluster of CENS".

6. 12.03. Prof. Tarmo Soomere: "Baltic Sea waves: extremes and long-term variability".

7. 19.03. Dr. Thomas Grandine (Boeing, Seattle, USA): "Contouring for fun and profit".

8. 02.04. Dr. Anatoli Stulov: "Piano string-bridge interaction and role of duplex scale".

9. 16.04. Dr. Maksim Säkki: "Migmatites, fermentation of paste".

10. 23.04. Päivo Simson: "Extremal solutions of free-surface problem".

11. 07.05. Prof. Hiie Hinrikus: "The influence of modulated microwaves on depression"; M.Bachmann "Changes caused by 40 and 70 MHz modulated microwaves".

12. 14.05. Dr. Jiři Plešek (Prague): "The influence of initial stress field on acoustic wave propagation";
    Dr. Gabriel Dušan (Prague): "Finite element and analytical solutions to the contact-impact problem of a long elastic cylinder".

13. 17.05. Prof. Vadim Lankin (Russian Research Centre of Cardiology, Moscow): "On molecular mechanisms of oxydative stress";
    Prof. Alla Tihase (Russian Research Centre of Cardiology, Moscow): "Treatment of aterosclerosis".

14. 21.05. Mihkel Kree: “Turbulent mixing of passive scalar: fractal structure of fronts”.

15. 28.05 Dr. Arvi Ravasoo: “Wave interaction in materials with variable properties”.

16. 30.05 Prof. Erwin Neher (MPI on Biophys. Chem., Göttingen): “On patch-clamp technique for analysis of Ca Signals in nerve fibres ”.

17. 14.06 Prof. Tsutomu Kambe (University of Tokyo): “Formation of vortices and its significance in fully developed turbulence”.

18. 25.06. Dr. Heiko Herrmann (Postdoc Research Fellow CENS-CMA): Modern constitutive theory: “3. Mesoscopic continuum physics”.

19. 13.09. Prof. Enrique Zuazua (Universidad Autónoma de Madrid): “An alternate descent method for the control of flows in the presence of shocks”.

20. 24.09. Dr. Andres Udal (TUT): “Semiconductor nanostructures with quantum holes: solutions of Schrödinger equations”.

21. 22.10. Dr. Arkadi Berezovski: “Finite volume method”.

22. 02.11. Prof. Dragan Savic (University of Exeter, Centre for Water Systems): “Water distribution system design and management: an optimization approach”.

23. 05.11. Prof. Richard Kerner (University of Paris 6): “Models of agglomeration and glass transition”.

24. 19.11. Dr. Jaan Kalda: “The model explaining intermittency and anomalous scaling of turbulent mixing”.

25. 26.11. Prof. Maarja Kruusmaa (TUT): “On modelling and control of electroactive materials”.

26. 03.12. Dr. Anatoli Stulov: “Echolocation of fish-eating bats ”.

5.4.2 Seminars outside the home Institute

1. J.Engelbrecht, seminar “Internal variables in biomechanics”, University of Turin, July 9–12.

2. J.Engelbrecht, short PhD course on Nonlinear Deformation Waves in Solids (3 lectures). University of Messina.
   Seminar “Mechanics and Complexity”- in Academia Peloritana dei Pericolanti, Messina, July 13–19.

3. J.Engelbrecht, seminar in the Xian Jiaotong University, “Striving for excellence in the European Research Area”, Xian, China, 22 August.

4. A.Ravasoo. Nonlinear effects of wave propagation for prestress evaluation. CMA Seminar, Oslo, Norway, 28 February.

5. M.Vendelin, Compartmentation in the cardiac muscle cells, University of Tartu, Nov., 2007, Tartu, Estonia.

6. A.Salupere, Solitary deformation waves in solids, seminar at Centre of Mathematics for Applications at University of Oslo (CMA Guest Lectures series), June 18, 2007.

7. T.Soomere, Waves from fast ferries: a new forcing factor and a model of freak waves. Lecture for the Det Norske Veritas; Oslo, 16 January 2007.

8. T.Soomere, Trends and extremes of wave properties in the Baltic Sea. Lecture Nansen Environmental Remote Sensing Centre, Bergen; 22 February 2007, Bergen.

9. T.Soomere, Possibilities of reducing coastal pollution by a proper choice of the fairway. Seminar for the Finnish Institute of Marine Research, 1 March 2007, Helsinki.

10. T.Soomere, Rogue waves: ship wakes strike back. Lecture to New Zealand Coastal Society, Hamilton Section; 3 April 2007, Hamilton, New Zealand.

11. T.Soomere, Nonlinear ship waves as a model of rogue waves and a source of danger to the coastal environment. Lecture to New Zealand Coastal Society, Auckland Section. 4 April 2007, Auckland, New Zealand.

12. T.Soomere, Lectures to the field trip team, Course of Prof. T.Healy, Waikato University: "Fast ferry traffic as a qualitatively new forcing factor of environmental processes in semi-enclosed sea areas".
"Lessons in linear wave theory from the Indian Ocean tsunami"11–12 April 2007, Mangawhai, New Zealand.

13. K.Rannat, Actual problems in GPS-meteorology. 2nd Workshop on monitoring of meteoparameters, Estonian Defence College, 18 October 2007.

14. I.Didenkulova, Long waves in a coastal zone. University of Lund, Sweden, December 20, 2007.

5.5. Meetings

5.5.1 Meetings in CENS

Summer school: International summer school "Waves and coastal processes", Tallinn, 25 August – 09 September 2007.
The event was co-organised with the Department of Mechanics, Tallinn University of Technology, and Institute of Cybernetics under financial co-support of EC structural funds (SA INNOVE) and Marie Curie project CENS–CMA, and Center of Excellence for Nonlinear Studies. The course consisted of 114 academic lecture hours (including 6 labs on wave dynamics), a two-day field trip to 7 different beaches containing 16 contact hours under supervision of experts, accompanied by 62 hours of individual work, written test and an individual examination of the participants. The key courses "Understanding coastal geomorphology as a basis for applications to coastal engineering and coastal management"and "Wave dynamics"were given by Prof. Terry Healy (University of Waikato) and Dr. Miguel Onorato (University of Turin). Total number of attendees: 70 (incl. 23 invited lecturers). The major lecture courses given by guest sciencists were as follows:

1. Prof. Terry Healy (University of Waikato), 20 August – 10 September 2007, course: *Understanding coastal geomorphology as a basis for applications to coastal engineering and coastal management.* (32 academic lectures), lead the field trip and present 6 supplementary lectures.

2. Dr. Miguel Onorato (University of Torino), 25 August – 6 September, course: *Wave dynamics* (17 academic lectures, 6 labs.).

3. Prof. Hubrecht de Vriend (Delft), 25–27 August, lectures: *New Orleans: what went wrong? 1,5D river modeling. Fighting floods.*

4. Dr. Kai Myrberg (Helsinki), 28–29 August, lectures: *Circulation and dynamics of the Baltic Sea and related processes.*

5. Prof. Jan Harff (Rostock), 29 August – 1 September, lectures: *The Baltic Sea - Introduction. The Baltic Sea - Geological development (Baltic sediments as climate records). The Baltic Sea - Coastal development. Sediment transport - An example from the western Baltic Sea.*

6. Dr. Heinz Günther (Geesthacht), 29 August – 1 September, lectures: *Numerical wave modeling. Assimilation of ocean wave parameters.*

7. Dr. Darya Ryabchuk (St. Petersburg), 4–7 September, lecture: *Litodynamics and modern sedimentation processes of the coastal zone of the eastern Gulf of Finland.*

8. Dr. Kimmo Kahma (Helsinki), 4–5 September, lecture: *Waves in the northern Baltic Sea.*

9. Prof. Matti Leppäranta (Helsinki), 5–6 September, lectures: *Sea ice dynamics. Optics of coastal waters.*

10. Prof. Sergej Zilitinkevich (Helsinki), 8–9 September, lecture: *Introduction to air-sea interaction processes.*

11. Dr. Alessandro Toffoli (DNV, Oslo), 3–7 September, presented invited lecture: *Surface gravity waves and their statistical properties in directional wave fields.*

The SEAMOCS Mid–term event — joint forum for wave and climate experts from three international networks

The SEAMOCS Mid–term meeting took place in the Palmse manor complex, at the heart of Lahemaa National Park about 70 km east from Tallinn. The scientific workshops of this four-day event developed into a forum hosting two Marie Curie projects (SEAMOCS and CENS–CMA) and French–Estonian–Russian Eco–NET network "Wave Current Interaction in Coastal Environment". The event attracted more than 40 experts in different aspects of theoretical and applied wave matters.

The central scientific event, two-day (11–12 October) SEAMOCS workshop on "Implications of climate change for marine and coastal safety", concentrated on three basic topics: climate change and its impact, determination of extreme wave heights, and coastal processes. Three invited talks from distinguished experts that described new perspectives in hurricane statistics (Richard Katz, NCAR, Boulder) and estimating wave extremes from models (Luigi Cavaleri, ISMAR, Venice) and satellites (Peter Challenor, NOC, Southampton) were accompanied by 13 presentations from the SEAMOCS community and two presentations by wave experts from Bergen and Saint Petersburg.

The CENS–CMA Workshop on Applied Wave Mathematics, organized in cooperation with the Eco–NET network, filled the 12 October until late evening. It started form overview of the content of CENS–CMA activities and a presentation of Dr. Marcela Groholova (European Commission, DG Research, Unit T3) about Marie Curie project opportunities in FP7. Six afternoon presentations were concentrated on wave mathematics and applications, and on mathematical description of flows and waves.

The final part of the event, a combination of sightseeing tour and field trip on 13 October, proceeded to eastern Estonia, an area which is relatively infrequently visited by classical tourist tours but which contains several highlights. The participants enjoyed visits to a couple of representative manor complexes, the limestone cliff along the northern coast of Estonia that is currently under review to be included into the UNESCO World Heritage list, the city of Sillamäe with its unique Stalin-time architecture, and Kuremäe orthodox monastery.

5.5.2 Meetings organized elsewhere

1. E.Quak, organizer: Full-day mini-symposium *The AIM@SHAPE Digital Shape Workbench as an eScience Collaboration Tool* with lectures from CENS, Institute for Applied Mathematics and Information Technology (IMATI, Italy), INRIA (France), Max-Planck Institute for Informatics (MPII, Germany), École Polytechnique Féderale Lausanne (EPFL, Switzerland), Université de Genève (MiraLab, Switzerland), Informatics and Telematics Institute (ITI, Greece), Fraunhofer Institute for Computer Graphics (IGD, Germany)
   ICIAM07 - 6th International Congress on Industrial and Applied Mathematics (ca. 3300 participants in total) Zürich, Switzerland, July 16–20.

2. E.Quak, co-organizer and moderator of a panel discussion: *Forward Looking Session* to suggest topics for future research, which are interesting and of practical industrial relevance 10th SIAM (Society for Industrial and Applied Mathematics) Conference on Geometric Design and Computing, San Antonio, Texas, USA, November 4–8.

3. E.Quak, member of the Program Committee: *2nd International Conference on Semantic and Digital Media Technologies (SAMT 2007)*, Genova, Italy, December 5–7.

4. E.Quak, organizer Mini-workshop *Industrial Geometry*, CMA, Oslo, Norway, March 20.

5. E.Quak, co-organizer Workshop *Industry Challenges in Geometric Modeling, CAD and Simulation 2007*, Darmstadt, Germany, March 22–23.

6. E.Quak, member of the Program Committee: Conference *IEEE Shape Modeling International 2007*, Lyon, France, June 13–15.

7. T.Soomere, convener of the CBO (Conference of Baltic Oceanographers) session *Physic of waves and interfaces*, Baltic Sea Science Conference, March 19–23, 2007, Rostock.

8. J.Engelbrecht, member of the Programme Commitee, *IUTAM Symposium on Scaling in Solid Mechanics*, June 25–29, 2007, Cardiff, UK.

5.6 Supportive grants (travel, etc.)

1. M.Bachmann, TTU Alumni Grant for PhD student.

2. A.Rodina, State Scholarships Foundation, Greece, grant for PhD study at University of Patras.

3. I.Didenkulova, grant from Russian Foundation for Basic Research for attending the EGU GA, April, 2007.

4. J.Engelbrecht, grant from Messina University for attending the Conference WASCOM 2007, Ragusa, Sicily, June 30 – July 7, 2007.

5. V.Abramov, French-Estonian science and technology collaboration program PARROT grant, Pierre et Marie Curie University, 22–30 October, France.

5.7 International cooperation

Within collaborative agreements:

Institute of Cybernetics:

- Laboratory for Mechanics of Materials of Helsinki University of Technology.
- Laboratory of Theoretical and Applied Mechanics of Helsinki University of Technology.
- Department of Mathematics of City University, Hong Kong.
- HAS-TUB Research Group for Continuum Mechanics, Hungarian Academy of Sciences.
- Stevin Centre for Computational and Experimental Engineering Science, Eindhoven, University of Technology, The Netherlands.
- Department of Mathematics, University of Turin, Italy.
- Laboratoire de Modelisation en Mecanique, Universite Pierre at Marie Curie, Paris, France.
- Department of Mathematical Sciences, Loughborough University, England.
- Fraunhofer Institute for Nondestructive Testing, Saarbrücken, Germany.
- Research and Development Department, Instrumental acoustics laboratory, IRCAM, Paris, France.
- Institut de Recherche et Coordination Acoustique Musique, Equipe Acoustique instrumentale, France.
- Ecole Nationale Superieure des Techniques Avancees, France.
- Finnish Marine Research Institute, Helsinki, Finland.
- GKSS Geesthacht, Germany
- Division of Atmospheric Sciences, Department of Physical Sciences, University of Helsinki, Finland.

Centre of Biomedical Engineering:

- COST 281 Potential Health Implications from Mobile Communication Systems.
- COST B27 Electric neuronal oscillations and cognition (ENOC).

5.8 Teaching activities

5.8.1 CENS Seminars for graduate students

Statistical thermodynamics of non-equilibrium process	– supervisors:	M.Vendelin, P.Peterson;
Bioenergetics	– supervisor:	M.Vendelin;
Waves in microstructured solids	– supervisor:	A.Salupere;
Wave dynamics	– supervisors:	I.Didenkulova, T.Soomere.

5.8.2 Courses:

1. A.Salupere – courses in TUT:
   - Dynamics
   - Statics
   - Continuum Mechanics
   - Seminars and Special Seminars for BSc, MSc and PhD students
2. M.Randrüüt – courses in TUT:
   - Technical Mechanics
3. K.Tamm – courses in TUT:
   - Technical Mechanics
4. T.Peets – courses in TUT:
   - Dynamics
5. J.Engelbrecht – courses in TUT:
   - Mathematical modelling
   - Nonlinear Dynamics
6. A.Braunbrück – courses in TUT:
   - Technical Mechanics
7. J.Kalda :
   - Training of the Estonian and Finnish teams for 38. International Physics Olympiad July 13–21, Isfahan, Iran. (Estonian students won one bronze medal and three honourable mentions).
   - Participation in the organization of 4th Estonian-Finnish Olympiad 30 April – 2 May 2007, Tallinn.
   - 6th Academic Olympiad in Physics 19 March 2007, University of Tartu.
   - 54th Estonian Physics Olympiad 17-18 March 2007.
8. R.Kitt – courses in TUT:
   - Financial Analysis
   - Security Analysis
9. T.Soomere – courses in TUT:
   - Coastal processes
   - Wave dynamics
10. J.Lass, R.Ferenets – courses in TUT:
    - Signal processing
    - Physiological signal processing
11. H.Hinrikus, M.Bachmann – courses in TUT:
    - Biological effects of electromagnetic field

12. I.Fridolin, H.Hinrikus – courses in TUT:
    - Electromagnetic fields and waves

13. I.Didenkulova:
    - lectures on computer science, Nijni Novgorod State Technical University

Participation in schools:

1. M.Berezovski. EPRSC Maths for Engineers Summer School "Mathematical Modelling and Computational Methods in Solid Mechanics", University of Glasgow, August 26 – September 1.

5.9. Visiting fellows

For shorter period

1. Dr. O.Andrejev (Finnish Institute of Marine Research, Helsinki), 28–30 May 2007.
2. Dr. T.Torsvik (University of Bergen, Norway), 24 August – 31 November 2007 in the framework of collaboration in fast ferry waves research.
3. Prof. M.Leppäranta, Dr. Kai Myrberg, 28–30 November 2007, in the framework of cooperation in the studies of the Gulf of Finland.
4. Prof. G.Atanasiu, Dr. Nicoleta Brînzei, University Transilvania, Braşov, Romania, Prof. Vladimir Balan (University Politehcnica of Bucharest, Romania), 15–22 February 2007.
5. Dr. A.Szekeres, Budapest Technical University. Join research project Estonian and Hungarian Academie of Sciences, 18 Sep. – 6 Oct.
6. R.Birkedal, University of Manchester, post-doc, 22June – 6 July.
7. N.Beraud, Joseph Fourie University of Grenoble, PhD student, 21 June – 5 July.
8. A.Stolin, University of Göteborg, "Classification of quantum groups". 19–22 March, 2007, University of Tartu.
9. R.Kerner, Universite Pierre at Marie Curie, Paris, France, 30 Oct. – 8 Nov., 2007, University of Tartu.
10. Dr. G.Gabriel, Dr. J.Plesek, 7–16 May, Institute of Thermomechanics of Czech Academy of Sciences, Prague, Czech Republic.

For longer periods

1. H.Herrmann (postdoc Research Fellow CENS-CMA).
2. I.Didenkulova. Experienced Researcher supported by the Marie Curie RTN network SEAMOCS, 1 September 2007 – 31 August 2008.
3. L.Kelpšaite, as Early Stage Researcher supported by the Marie Curie RTN network SEAMOCS, 15 November 2007 – 31 October 2009.

5.10 Theses
Institute of Cybernetics:
Promoted:

1. BSc:
   - D.Kartofelev. Action of traveling wave on a piano bridge (supervisor A.Stulov).
   - M.Vallikivi. Nonlinear waves in rods (supervisor A.Salupere).
   - R.Põder. On the interaction of cnoidal waves in the framework of Kadomtsev-Petviashvili equation (supervisor T.Soomere).
2. MSc:
   - M.Kalda. Interaction of waves in strongly inhomogeneous materials (supervisor A.Ravasoo).
   - T.Lapimaa. Methodology of monitoring of development activities in coastal waters and its implementation in Estonia (supervisor T.Soomere).
3. PhD:
   - K.Rannat. Long weakly nonlinear waves in geophysical applications (supervisors H.Ohvril, T.Soomere).

In progress:

1. PhD:
   - M.Berezovski. Numerical simulation of front tracking in inhomogeneous solids (supervisor J.Engelbrecht).
   - T.Peets. Dispersion in microstructured solids (supervisor J.Engelbrecht).
   - M.Randrüüt. Evolution and existence of nonlinear waves in microstructured solids (supervisor J.Engelbrecht).
   - 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).
   - K.Veski. Heterogeneity of energetic parameters in cardiomyocytes (supervisor M.Vendelin).
   - M.Sepp. Estimation of diffusion restrictions in cardiomyocytes using kinetic measurements (supervisor M.Vendelin).
   - K.Tamm. Deformation waves in microstructured solids (supervisor A.Salupere).
   - L.Ilison. Solitons and solitary waves in KdV-type hierarchical systems (supervisor A.Salupere).
   - A.Kask. Natural and anthropogenic morphodynamics caused by litohydrodynamical processes in the Estonian coastal sea (supervisor T.Soomere).
   - A.Räämet. Spatio-temporal variability of the Baltic Sea wave fields in changing climate conditions (supervisor T.Soomere).

I.I.Didenkulova. Runup of long waves on the sloping beach and analysis of real events (supervisors E.Pelinovsky, T.Soomere).

L.Kelpšaite. Sediment transport and wave influence to the ecosystem behavior near the Lithuanian sea shore (supervisors A.Razinkovas, Coastal Research and Planning Institute, Klaipeda University, Lithuania, T.Soomere).

2. MSc:

D.Kartofelev. Sound generation mechanisms in grand pianos (supervisor A.Stulov).

M.Vallikivi. Influence of a force field on the propagation of deformation waves (supervisor A.Salupere).

I.Zaitseva. Long-term variations of the northern Baltic Sea wave fields (supervisor T.Soomere).

Centre of Biomedical Engineering:

Promoted:

1. PhD:

R.Ferenets. EEg patterns and regularity properties during proüpofol induced anesthesia/sedation (supervisor T.Lipping).

2. MSc:

A.Suhhova. Changes in asymmetry and coherence of Human EEG caused by low-level microwave (supervisor M.Bachmann).

J.Rubljova. Adaptation of human brain bioelectrical activity to low-level microwave (supervisor M.Bachmann).

3. BSc:

K.Kruusing, R.Viidik, S.Telliskivi.

In progress:

1. PhD:

M.Bachmann (supervisor H.Hinrikus).
A.Anier (supervisor T.Lipping).
I.Hlimonenko (supervisor K.Meigas).

2. MSc:

K.Kruusing.

5.11 Distinctions

Fellows:

1. 2007 Baltic Assembly for Science Prize awarded to T.Soomere, for his cycle of research on ship waves in the Baltic Sea as a source of danger to the coastal environment.

2. T.Soomere – elected into Estonian Acad. Sci.

3. J.Engelbrecht – State Coat of Arms, III Cl.

4. J.Engelbrecht – elected into Bulgarian Acad. Sci.

5. J.Kalda – Prize of the Estonian Physics Society.

6. R.Kitt – Prize of the IPE - Investments and Pensions Europe.

7. A.Salupere: Estonian Acad. Sci. Diploma for supervising research students.

Students:

1. M.Vallikivi: student award of the Estonian Acad. Sci.

2. M.Vallikivi: student award of the Tallinn University of Technology.

5.12 Other activities

1. E.Quak – Technical Manager EU IST *Network of Excellence AIM@SHAPE on shape modelling*.

2. E.Quak – Vice-chair of the Mathematics-Engineering panel for the evaluation of Marie Curie *Industry-Academia Partnerships and Pathways* proposals in the EU FP7 People program.

3. E.Quak – External Examiner for diploma theses and written examinations in simulation and geometric modelling Narvik University College, Narvik, Norway.

4. E.Quak – Contact point *Special Interest Group on Geometric Modeling, CAD, Evolving Interfaces and Surfaces* of the European Consortium for Mathematics in Industry (ECMI).

5. T.Soomere – examiner to the PhD thesis of Tomas Torsvik "Long wave models with application to high speed vessels in shallow water", Department of Mathematics, University of Bergen, 23 February 2007.

6. T.Soomere – chair, Marine Board of the Estonian Acad. Sci. and Estonian representative in the Marine Board of the ESF.

7. J.Engelbrecht – chair, Estonian National Committee of Mechanics.

8. J.Engelbrecht – member of the IUTAM Bureau, Treasurer.

9. J.Engelbrecht – reviewer on funding applications of the EPSRC, UK.

5.13 Media reflections

5.13.1 About us in general

1. T.Kändler, Estonian Scientists looking for regularity in a complex world. Life in Estonia, Spring 2007, 23-25 (in Estonian).

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6. Summary

6.1. Current year 2007

In 2007, most active were groups in water waves and biophysics. The first organized successful meeting and attracted many guests and guest-researchers, so the group now is very international. The second got a celebrated Wellcome Trust grant that is now the basis for funding the new Laboratory of System Biology.

The evaluation for the next block grant 2008 – 2012 resulted in receiving the mark "outstanding". The application for the next stage of the Programme of Centres of Excellence is in progress with focus on complexity studies (see also Annual Report 2006).

6.2. Years 2002 – 2007

CENS had for this period the title "Centre of Excellence in Research", within the National Programme run by the Ministry of Education and Research. The short summary of studies in this period is the following.

Overview

CENS was founded in 1999 and got the title of a CoE in 2002. Research is directed by the working plan approved by the International Advisory Board. A number of studies are related to several international projects and direct contracts. Main research topics deal with the analysis of nonlinear processes involving wave motion, biophysics, fractality, signal processing, etc. Activities of CENS are focused on complexity and interdisciplinarity as within the studies of CENS as well as in relation to other fields.

Main results (more in CENS Annual Report 2003; ibid 2004, 2005, 2006, 2007):

Stress waves in microstructured materials. This is a hot topic in technology because of wide usage of new materials (functionally graded materials, metal-ceramic composites, etc). Based on the theory of continua with scale analysis, several mathematical models are formulated for describing the dynamical behaviour of such microstructured materials. Complicated dispersive and nonlinear effects and possible phase-transitions are taken into account. For martensitic-austenitic materials (i) the mechanism of phase transition fronts is described with specific thermodynamical consistency conditions and (ii) the types of solitary waves (solitons) including the plaited solitons are found. The emergence of such waves is shown to be dependent on a certain threshold. The existence of hierarchical waves is shown to be characteristic to cases when the scale factors exist (wave length vrs structural scale). The concepts of internal variables are introduced into the models of continua. A special formalism of dual internal variables is proposed. The emergence of solitons in granual materials is analysed. A composite wave-propagation algorithm is proposed based on the finite volume method for the calculation of phase-transition boundaries and wave fields in layered composites and functionally graded materials as well as for the propagation of Mode I cracks in brittle materials. It is shown that in case of the classical third-order dispersion and quadratic nonlinearity (the KdV model), the trajectories of emerging solitons form a certain pattern. It is also shown that the external force field may result in soliton ensembles where the mechanism is based on hidden solitons and resonance. In case of higher order dispersion (the Mindlin model) the emergence of counter-propagating soliton trains is analysed.

Surface waves in water. Modal structure of Rossby waves and basic parameters of their kinetic equation for 3-layer medium was established. An effective solver for the two-dimensional free surface problem is developed based on the conformal mapping technique. This approach permits to account for a changing depth profile. Properties of waves from fast ferries and their specific influence on marine and coastal environment was found in the context of typical and extreme parameters, and anisotropy of the Baltic Sea wind and wave-fields. Foundations of the theory and applications of nonlinear ship wake waves were systematically formulated. The decisive properties (amplitude, steepness, geometry, extension) and their extremes for structures created in interactions of shallow water solitons were found for counterparts with arbitrary amplitudes. Thorough description of related threats and potential applications of such interactions for studies of fast ferries' wakes and for the theory of rogue waves was presented. Observations of freak waves in 2005-2006 were comprehensively documented. Basic parameters of wave climate of Tallinn Bay and northern Baltic Proper were described based on simulations and long-term observations. The average wave intensity in the Baltic Proper exhibits substantial decadal variations. Main features of coastal processes in the Narva River mouth and at Pirita Beach were established. Shown was that the run-up height of asymmetric waves may several times

exceed the one for symmetric case. An express method for rapid estimates of the run-up parameters and a method for calculation of spectral amplitudes of approaching waves were derived.

Biophysics and biomechanics. Studies involve cell energetics related to cardiac contraction and are at the frontier of science. The contraction of a cardiac muscle depends essentially on the oxygen consumption and the ATP transfer. It is shown how diffusion limitations of adenosine phosphates influence the energetics in cells and how the creatin kinase (CK) and adenine nucleotide translocase (ANT) are coupled and localized in certain compartments of cardiac cells. The metabolic stability of cells is shown to be dependent on the feedback mechanism between the mitochondrial CK and ANT. A quantitative model is proposed for the description of mitochondrial arrangement in cardiac and skeletal muscle cells. The unidirectional fluxes of several reactions in energy transfer are analysed at different workloads. It is shown that the concept of internal variables permits effectively describe the behaviour of hierarchical bio-systems resp cells and muscles. The mathematical model for the contraction of the left ventricle is derived with three-layer fiber orientation taken into account. The mathematical models are verified by several experiments (NICPB, Grenoble University ao). All these studies including the studies of partners have laid the basis for one field of bio-complexity - molecular cell energetics. See also fractality.

Fractality. The scaling exponents for statistical topography of random surfaces are found and the fractal dimension of corresponding isolines are determined. An analytical relationship is derived for the exponents describing the light intensity distribution from rough self-affine surfaces including two-and three-dimensional cases. An approach for studying pair dispersion (Richardson law) in fully developed turbulence of compressible flows is proposed. The clustering of sticky particles in turbulent compressible velocity fields is described. It is shown that anisotropy of large-scale fluctuations can propagate along the turbulent cascade. The model of formation and merging of magmatic patches is analysed and the scale-distribution laws found. The scaling properties of the time series of asset prices and trading volumes of stock markets are analysed. The trading volume data obey multi-scaling length distribution of low-variability periods. Such a scaling behaviour can be used for risk forecasts. An analytical dependence is derived between the multifractal spectrum of intermittent heart rate time series and the multi-scaling exponent describing the length distribution of low-variability periods. The scaling exponenets for the EEG signals are found.

Acoustodiagnostics and inverse problems. The theoretical basis of the nonlinear acoustodiagnostics is elaborated and methods for Nondestructive Testing (NDT) are derived based on the informative properties of nonlinear wave fields for determining the prestress or the material properties. A resonance phenomenon is found based on two-wave method that enhances considerably the accuracy of NDT. Inverse problems are solved for determining the properties of microstructured materials. The novel ideas proposed are based on using of asymmetry of solitary waves and different phase velocities of harmonic waves.

Dynamics of piano hammers. A mathematical model for describing the behaviour of the piano hammer is derived, accounting with the hysteretic properties of the material (felt). An experimental device is constructed for determining the dynamical parameters of hammers. The experiments and the analysis prove the correctness and accuracy of this so-called Stulov model which has been used in many other labs. The description of the impact characteristics permits to analyse the hammer-string interaction and to find the

spectra of string vibrations (applied in the Tallinn Piano Factory).

Optical nonlinearity and photoelasticity. The method of photoelastic tomography is elaborated for the measurements of the three-dimensional stress fields in transparent objects. The idea is based in decomposing the tensor field tomography into the several problems of scalar field tomography for which the Radon inversion can be used. The method is realized by constructing the automatic polariscope AP-05 SM and implemented for several applications in practice. The developments include more exact analysis of the basic equations of electromagneticity by using the Pauli matrix formalism.

Signal processing. The studies are aimed to EEG analysis to distinguish the weak (microwave radiation) and strong (anesthetic drugs) stressors on human brain. The microwave stimulation effects are established influencing human EEG alpha and theta rhythms. It is shown that the instantaneous frequency estimate of propofol spindles is not stable during anesthesia.

Geometric approach to nonlinear problems. A consistent symmetry-based formalism is derived for vector fields. The tensor representation of linear groups uses the descriptions of algebraic invariants. This is the basis for deriving the universal structure of jet spaces and the corresponding differential operators. This formalism is used for solving the differential equations with a transparent geometrical description including the existence of singularities.

Software. The special tool F2Py has been developed for connecting Python and Fortran programs. Another special Python package SciPy has been developed in cooperation with other groups.

Activities of CoE.

CENS has stressed the co-operation between the teams, graduate studies, international networking and the dissemination of knowledge. In 2003-2007, the staff of CENS includes 26 fellows (PhD/DSc level) and 32 graduate/undergraduate students (22 PhD students, 9 PhD students have promoted, 15 PhD thesis are in progress), in addition three technical assistants. It must be stressed that CENS as a part of the Institute of Cybernetics at Tallinn UT has no formal obligation to supervise graduate studies. However, graduate studies are a part of CENS mission. Funding was through 4 target block grants from the Ministry (two fully, two partly), and 27 EstSF grants. International Programmes: ESF Programme NATEMIS, 6FP WIND-CHIME, Baltic Sea research network PAPA, SEAMOCS, French-Estonian PARROT (two programmes), COST 281, COST B27. Through the Ministry CENS is involved with its programme in the ERA-NET Complexity, first at the SSA stage, presently at the full stage of Complexity-NET. The ToK of Marie Curie scheme connects CENS with CMA in Oslo (exchange of fellows and post-docs). Since 2007 CENS has a Wellcome Trust Grant "Analysis of structural and functional aspects of compartmentation of adenine nucleotides in heart muscle cells". Based on that, the new Lab of Systems Biology was launched in 2007. The CENS members had Marie Curie post-doc grants, a Fulbright scholarship, grants from the Humboldt Foundation, study grants for graduate students, etc., several research contracts in Estonia.

The conferences/meetings/schools:
Advanced Study School "Nonlinear Processes in Marine Sciences", 2003; Intensive Graduate Week "Nonlinear Waves and Applications", 2004; Workshop on Biomedical Engineering, 2004; Glass Summer Schools, 2003, 2004, 2005, 2006, 2007; Parrot Workshop, 2003; Estonian Colloquium of Mechanics, 2005; Euromech Colloquium 478 "Non-Equilibrium Dynamical Phenomena in Inhomogeneous Solids", 2006; Summer School on Applications of 3D Shapes, 2006; Advanced Study School in Waves and Coastal Processes, 2007; SEAMOCS - CENS CMA Workshop, 2007. The number of guest-lecturers over five years was 59. CENS runs the courses and seminars related to mechanics for TUT technical physics. The graduate students attended also international schools and meetings.

The number of guest-researchers and PhD students from other countries in CENS in 2007 is about 10. Regular seminars are run with a special series of seminars on complex systems. Research networking with over 20 countries, close contacts with several international organisations.

Publications and conferences:

Altogether 266 peer-reviewed publications, published 3 books and edited 5 special issues of journals. Conference talks - 243, seminars outside the home institute - 65. Stressed should be the attendance in the World Congress ICTAM04 in Warsaw, where CENS gave 7 presentations (out of 1200). Published are also popular overviews on mechanics and CENS. Detailed overview is in Centres of Excellence in Estonian Science, 2004, 45-57. Published are many science-popular articles and a book "The Beauty of Complex World", which was also distributed to all the Estonian Secondary Schools.

Summary:

The studies and results of CENS unite several fields from soft matter physics to biology, from mechanics to econophysics, which all bear similar features due to nonlinearities and interactions resulting in The whole is more than the sum of the parts. Nowadays this symbiosis is called complexity science. CENS is actually a Centre for Complexity Studies in Estonia and a node in the corresponding international network - CENS is a member in Complex Systems Society and active in the EU Complexity-NET.

The following results place CENS to the frontier of science:

- a novel approach to calculating the stress-driven phase-transitions fronts based on elaborated thermodynamically consistent finite volume method;
- hierarchical mathematical models for describing the wave propagation in micro-structured materials (FGMs, composites, granular materials);
- mechanisms of soliton emergence for complicated dispersion and long-time behaviour with establishing the patterns of trajectories;
- properties of interaction for surface waves in shallow water, with possible extension to extreme waves, and experiments with ship wake waves (fast ferries);
- novel mathematical models for cardiac contraction and related cell energetics with testing in Grenoble, Paris and Tallinn have resulted in molecular cell energetics - a new field in biocomplexity;
- fractal analysis of heart rate variability and the properties of multi-scaling;
- theoretical explanation of the multi-fractality of the passive scalar field in smooth chaotic flows;
- fractal analysis of geological landscapes (four-vertex model) and the scaling exponents;
- novel scaling models for the time series of asset prices and stock markets with specific multi-scaling properties;
- algorithms for nonlinear acousto-diagnostics for stress analysis and NDT of material properties;
- novel mathematical model for the impact of piano hammers and spectral analysis of strings;
- method of photoelastic tomography for 3D stress analysis in transparent specimen;
- microwave effects on EEG established with special attention to low-level radiation on human alpha and theta rhythms;
- methods of mathematical physics derived by using the tensor representations of linear groups and the universal structure of jet space.

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