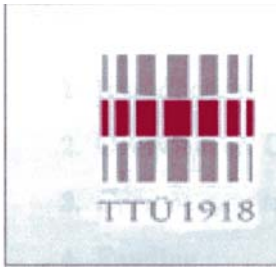



Institute of Cybernetics at Tallinn University of Technology
Chair of Geometry, University of Tartu
Biomedical Engineering Centre, Tallinn University of Technology

CENS

Centre for Nonlinear Studies

Estonian Centre of Excellence in Research

Annual Report

2005

Tallinn, Estonia

Contents

Abstract

The Report includes a brief overview on all the activities of CENS in 2005. Described are studies and results in: (i) dynamics of microstructured solids and solitons; (ii) water waves; (iii) optical waves and softvare development; (iv) biomechanics and biophysics; (v) fractality and econophysics; (vi) general nonlinear wave theory; (vii) optical nonlinearity and photoelasticity; (viii) geometric approach to nonlinear problems; (ix) biosignals interpretation and EEG. The international programmes and projects are described. The full records of papers, reports, abstracts, conferences, etc are all included.

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

See also: Centres of Excellence of Estonian Science, Tallinn, 2004, 45-57.

Sisukord

Lühikokkuvõte

Käesolev aruanne on ülevaade Mittelineaarsete Protsesside Analüüsi Keskuse (CENS) tegevusest 2005.a. Kirjeldatud on tulemused järgmistes suundades: (i) lainelevi mikrostruktuursetes materjalides ja solitonid; (ii) lained vees; (iii) optilised lained ja tarkvara arendus; (iv) biomehaanika ja biofüüsika; (v) fraktaalsus ja ökonofüüsika; (vi) mittelineaarne lainelevi ja rakendused; (vii) optiline mittelineaarsus ja fotoelastsus; (viii) mittelineaarsete protsesside geomeetriline teooria; (ix) biosignaalid ja EEG analüüs. Esitatud on publikatsioonide, aruannete, konverentside, jm nimekirjad.

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

Vaata: Eesti teaduse tippkeskused, Tallinn, 2004, 45-57.

1. Introduction

This Report is the seventh Annual Report of CENS, following the previous Reports 1999 – 2004. The present CENS is one of the Estonian Centres of Excellence in Research (the whole number of such Centres is 10). The period of awarding this title with the additional funding is 2003 – 2006. The general overview on all Centres is published in 2004 "Centres of Excellence of Estonian Science", Association of Centres, Tallinn, 2004, 163 pp., see CENS, (pp. 45-57); see also a short summary in CENS Annual Report 2004.

The present Report includes a short summary of research fields (Section 2), the description of current results in 2005 and research cooperation (Section 3), an overview on funding (Section 4), and then the publications records, lists of conferences together with all the publicity of results (Section 5). The last Section 6 gives conclusions and foresight ideas.

2. Overview on CENS

The present research of CENS involves:

- 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: marine physics, multimodal waves, wind wave forecast, anomalies of wave fields, extreme waves;
- 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 main aim of CENS is to be at the frontier of science in all these fields and also react to national interests.

The International Advisory Board:

Prof. Josef Ballmann, RWTH Aachen; Prof. Bengt Lundberg, Uppsala University; Prof. Gérard A. Maugin, University of Paris 6; Prof. H.Keith Moffat, Cambridge University; Prof. Valdur Saks, University of Grenoble; Dr. Andras Szekeres, Budapest Technical University; Prof. Dick van Campen, Eindhoven University of Technology; Prof. Embrecht van Groesen, Twente University

has approved this aim and the main results of recent years.

3. Current results 2005

3.1 Institute of Cybernetics, Tallinn University of Technology

3.1.1 Dynamics of microstructured materials and solitons

Solitary waves in microstructured solids

A KdV-type evolution equation, including the third- and the fifth- order dispersive and the fourth order nonlinear terms, is used for modelling the wave propagation in microstructured solids like martensitic-austenitic alloys. In 2005 the main attention was paid to the analysis of the formation of solitary waves from the localized initial excitation. New numerical results were obtained and analyzed in the case of mixed dispersion. Beside the latter, results from earlier years were generalized and summed up. One should bring out main results: (i) for the harmonic initial conditions solution is a train of negative solitons, i.e., there exists a certain balance between higher order dispersion and quartic nonlinearity that results in solitonic solution; (ii) for the localized initial conditions with normal dispersion there exists a threshold for the initial amplitude above what solitary waves can travel with minimal disturbances; (iii) for the localized initial conditions with mixed dispersion "plaited" solitons can be found if value of the initial amplitude is higher than a certain threshold. PhD thesis by Olari Ilison "Solitons and solitary waves in media with higher order dispersive and nonlinear effects" was promoted in September. Further studies will be carried out for simulating various interactions of solitary waves in order to detect their solitonic behaviour (O.Ilison, A.Salupere)

Numerical experiments are initiated making use of Mindlin-Engelbrecht-Pastrone (MEP) model

The MEP model describes wave propagation in microstructured solids. However, compared with KdV-type models, it allows to present right-going as well as left-going waves. In order to study the formation of solitary waves and their interactions one has to integrate the model equation under different initial conditions. Numerical algorithm is worked out, test problems are solved and pilot study is performed. Simulation of interactions of solitary waves (overtaking as well as head on collision are considered) is in the progress (A.Salupere, K.Tamm).

Solitary waves in granular materials

The studies of wave propagation in granular materials are continued by making use of a hierarchical KdV equation. The model equation involves three material parameters (two different dispersion parameters and one microstructure parameter). Numerical solutions are found under localised initial conditions by making use of pseudospectral method. Three solution types are detected: (i) one solitary wave solution; (ii) KdV-type ensemble of interacting solitons and an ensemble of equal amplitude solitary waves; (iii) single solitary wave together with wave-packets. Cases (ii) and (iii) are the most interesting: our numerical experiments show that under certain conditions (defined by micro- and macro level dispersion parameters) two different wave structures can exist simultaneously. The analysis of the behaviour of the solutions in the three-dimensional space of material parameters is in progress (A.Salupere, L.Ilison).

Periodicity and hidden solitons for the KdV model
An overview on the long-time behaviour of a KdV-soliton train emerging from a harmonic excitation is presented. It is shown that in the physical plane, the left-going and right-going trajectories form a regular pattern. In the case of an harmonic external force several resonance schemes are revealed where both visible and hidden solitons have important roles. The hidden solitons may turn out to be also hidden "energy pockets" (J.Engelbrecht, A.Salupere).

Wave hierarchies
New problems have been formulated on the basis of mathematical models derived earlier and published in 2005. The main idea is to distinguish between the usual equations of motion and evolution equations. This is in consistency with the detailed dispersion analysis (J.Engelbrecht, M.Randrüüt, T.Peets).

3.1.2 Water waves

Surface Waves
An efficient and accurate solver for 2D free surface problem using half analytical/half numerical approach based on conformal mapping technique is being developed, with extensions to nonstationary bottom (P.Peterson).

Perturbation theory has been applied to free surface problem with fixed bottom in conformal variables. A general scheme has been found for solving given problem iteratively and a method is developed to solve a recurrent system of pseudo-differential equations (P.Simson, P.Peterson).

Interaction of solitary waves
Studies of various nonlinear phenomena occurring in the framework of the Kadomtsev-Petviashvili equation when two solitonic waves travel in slightly different directions were mostly focused on certain mathematical aspects of the relatively well known phenomena such as amplitude amplification, forming of very steep wave fronts, and bending of the wave crests. Analytical expressions for the maximum surface elevation and the slope of the wave front were derived in a consistent manner for arbitrary combinations of the parameters of the solitonic waves, the only restriction being that the phase shift parameter must be positive. The crests of the composite structure arising during an interaction of such waves form a complex pattern. For equal amplitude solitons, this pattern has two bifurcation points. In the case of solitons of unequal amplitude it may consist of three separated branches. The point of bifurcation of the crests always lies outside of the area when surface elevation twice or more exceeds the amplitudes of the incoming solitons, therefore always a single particularly high hump is formed. Exact conditions for the amplitude of the composite structure to exceed the double amplitude of the incoming solitons are established (T.Soomere, in cooperation with J.Engelbrecht). The outcome of the studies into properties of soliton inteactions in this framework have been generalized and summarized together with results of research in certain adjacent areas, including estimates of the role of such interactions in forming of freak waves in realistic conditions and their potential environmental influence, in the form of an overview paper.

Cnoidal and solitonic properties of long waves from fast ferries in coastal area
Solitonic waves occur relatively seldom in natural conditions. However, a substantial part of energy of wake waves from high-speed ships sailing in shallow water is concentrated in nonlinear components which at times have solitonic nature. The shape and

properties of long ship-generated waves approaching shallow coastal areas of Tallinn Bay are studied based on recordings of water surface time series. For typical leading wake waves nonlinear effects become significant at depths of 10 - 15 m. A large part of waves (with the height of > 0.4 m) have the shape of cnoidal waves in shallow areas with depths of 4 - 5 m. The shapes of the largest wake waves are close to the solitary wave solutions of the Korteweg de Vries equation. Such waves excite considerably larger velocities of water particles than sinusoidal waves of the equal height and length. Also, the above-described interactions of solitonic waves may become evident in coastal areas adjacent to ship lanes hosting intense fast ferry traffic (T.Soomere, R.Põder, K.Rannat, in cooperation with A.Kask, MSI).

Waves from fast ferries as a qualitatively new forcing factor in certain sea areas

The impact of wake wash from high-speed ferries on the coastal environment in non-tidal seas has been systematically analysed based on relevant studies in Tallinn Bay and outcome from analogous studies in other parts of the world. Shown is that hydrodynamic loads caused by heavy high-speed traffic may play a decisive role not only in low-energy coasts but also in certain areas with high wind wave activity. For example, ship-generated waves form, at least, about 5-8% from the total wave energy and about 18-35% from the wave power in the coastal areas of Tallinn Bay exposed to dominating winds. The periods of wake waves from high-speed ships frequently are much larger than dominating periods of wind waves. The leading waves typically have a height of about 1 m and a period of 10-15 s. Such waves extremely seldom occur in natural conditions in many regions of semi-enclosed seas. They cause unusually high hydrodynamic loads in the deeper part of the nearshore. The fast ferry traffic thus is a qualitatively new forcing component of vital impact on the local ecosystem. Wakes from high-speed ferries may trigger considerable changes of the existing balance of coastal processes. Owing to their low decay rates combined with their exceptional compactness after crossing many kilometres of the sea surface, such wakes may cause considerable remote impact of the ship traffic. This feature has to be addressed in the analysis of the impact of harbours and associated ship traffic in the neighbourhood of vulnerable areas (T.Soomere).

GPS-methods in meteorology

In collaboration with Tartu University (The Institute of Applied Mathematics) and the Estonian Defence College, the possibilities of GPS-signal usage are investigated as a complimentary and independent method to obtain information on atmospheric water content (K.Rannat, in cooperation with P.Miidla, P.Uba). The goal is to get 3D distribution of water vapor in the lower troposphere. At the current phase of research the computer simulation is used to obtain information on the optimal instrumental and spatial setup and tomographic methods to convert the measured delays (GPS-signal carrier phase delays) to precipitable water. The instrumentation of the experiments can be enhanced to special needs of wave height measurements in the sea (floating buoys equipped with GPS receiver, capable to process L1 carrier phase data).

Local wave climate estimates based on high-resolution spectral wave models

The wind wave regime of Tallinn Bay, Gulf of Finland, is analysed with the use of a simplified method of long-term computations of wave fields based on a high-resolution nested WAM model, Kalbådagrund (1991-2000) wind data and on a specific technique of splitting of long-term wave calculations into short independent slices. The distributions of probabilities for wave heights, annual and seasonal mean wave heights, density

of wave energy and its flux (wave power), and 1-year return wave heights as well as the wave field properties in extreme storms are computed. The average wave properties exhibit a significant seasonal and spatial variability. The highest waves occur in the vicinity of the Tallinn-Helsinki ship lane where the significant wave height exceeds 2 m each year and may reach 4 m in extreme NNW storms (T.Soomere).

3.1.3 Optical waves and software development

Stability analysis of nonlinear periodic structures
The study of propagation properties of coherent optical waves in a stratified medium with Kerr nonlinearity is continuing. With the application to photopolymers with dispersed CdSe-nanoparticles and laser-written holograms, the stability of stationary waves in such materials has been investigated (M.Sepp, L.Rebane, P.Peterson).

Digital spiral imagining
Spiral spectrum of optical waves due to the orbital momentum of light has been measured (L.Rebane, ICFO, Spain) and analyzed (L.Rebane, P.Peterson). It is proved experimentally that the orbital angular momentum spectrum can be used to image phase dislocations.

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 high-level Python scripting language and high-performance Fortran/C libraries and programs (P.Peterson).

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

3.1.4 Biomechanics and biophysics

Cell energetics
Recent studies have shown the existence of multiple specific functional interactions between mitochondria, sarcoplasmic reticulum (SR) and myofibrils in permeabilized muscle fibers. Namely, endogenous ATP has been shown to be more efficient in maintaining calcium uptake into SR than exogenous ATP. Additionally, kinetic studies have shown direct supply of endogenous ADP from ATPases to mitochondria. Such interaction can be explained by existence of localized intracellular diffusion restrictions. A mild treatment of the fibers with trypsin leads to the removal of these diffusion restrictions and, at the same time, distribution of mitochondria in the fiber is changed from regular arrangement in control to random distribution after the treatment. Similarly, in ischemic hearts, various alterations in mitochondrial function such as the significant decrease in maximal respiration rate and half-saturation constant for ADP were observed in parallel with the changes in structural organization of the cardiac muscle cells. These experimental results suggest that there is a direct link between regulation of muscle cell energetics and structural organization of the cell.

The aim of our work was to characterize quantitatively the arrangement of mitochondria in heart and skeletal muscles. We studied confocal images of mitochondria in nonfixed cardiomyocytes and fibers from soleus and white gastrocnemius muscles of adult rats. The arrangement of intermyofibrillar mitochondria was analyzed by estimating the densities of distribution of mitochondrial centers relative to each other (probability density function). In cardiomyocytes (1,820 mitochondrial centers marked),

neighboring mitochondria are aligned along a rectangle, with distance between the centers equal to $1.97+/-0.43$ and $1.43+/-0.43$ microm in the longitudinal and transverse directions, respectively. In soleus (1,659 mitochondrial centers marked) and white gastrocnemius (621 pairs of mitochondria marked), mitochondria are mainly organized in pairs at the I-band level. Because of this organization, there are two distances characterizing mitochondrial distribution in the longitudinal direction in these muscles. The distance between mitochondrial centers in the longitudinal direction within the same I band is $0.91 + / - 0.11$ and $0.61 + / - 0.07$ microm in soleus and white gastrocnemius, respectively. The distance between mitochondrial centers in different I bands is approximately 3.7 and approximately 3.3 microm in soleus and gastrocnemius, respectively. In the transverse direction, the mitochondria are packed considerably closer to each other in soleus than in white gastrocnemius, with the distance equal to $0.75 + / - 0.22$ microm in soleus and $1.09 + / - 0.41$ microm in gastrocnemius. Our results show that intermyofibrillar mitochondria are arranged in a highly ordered crystal-like pattern in a muscle-specific manner with relatively small deviation in the distances between neighboring mitochondria. This is consistent with the concept of the unitary nature of the organization of the muscle energy metabolism (M.Vendelin).

Heart rate variability (HRV)
The analytic relationship between the multifractal spectrum of intermittent time series (such as sequences of heart interbeat intervals) and the multi-scaling exponent describing the length-distribution of low-variability periods has been tested using synthetic multi-fractal time-series. Also, a PhD-thesis has been prepared and defended by Maksim Säkki (J.Kalda, M.Säkki).

3.1.5 Fractality and econophysics

Statistical topography
We have studied numerically and analytically the statistical topography of fluid lines, which are transported (and continuously being reconnected) by a fully developed turbulent velocity field. We have calculated numerically the fractal dimension of a single line, and the full set of lines (including small loops). We have studied the applicability of these result to the discontinuity fronts of a passive scalar in fully developed turbulence (J.Kalda).

Turbulent diffusion
We have studied the pair dispersion of passive tracer particles in compressible flows (e.g. free-slip surface flows). We have shown that the classical definition of compressibility needs to be modified in order to characterize adequately the time-correlated (non-Kraichnan) flows, and suggested a suitable substitution. We have shown that the dispersion depends on the stickiness of the tracer particles and derived the pair-dispersion exponents for sticky particles (J.Kalda).

Econophysics
A multi-factor scaling analysis is proposed and motivated. It has been shown that such method is simpler and more intuitive than multi-factor wavelet analysis that can be also employed. The portfolio construction problem is addressed. The Leptokurtic Portfolio Theory is proposed that optimises the portfolio against the large, non-Gaussian, drawdowns. The method devised, separates two types of asset price changes: Gaussian, fluctuations and non-Gaussian drawdowns. The theory is tested also empirically with simple, two-factor model. The results found, confirmed the theory. Finally, the first doctoral thesis in econophysics was prepared and succesfully defended by Robert Kitt.

3.1.6 General nonlinear wave theory

Acoustodiagnostics of inhomogeneous and prestressed solids
The theoretical research to elaborate the nondestructive methods for evaluation of strongly variable properties of the nonlinear elastic material started. The theoretical basis of nonlinear propagation and interaction of deformation waves (ultrasound) in the material was developed. The possibility to solve the derived equation of motion analytically was investigated by making use of the software for symbolic computations MAPLE 9. It was concluded that the hyperbolic second order nonlinear equation of motion with smoothly variable arbitrary coefficients has no explicit analytical solution. Several analytical solutions were derived for the special cases of linear propagation of dispersive waves in strongly inhomogeneous materials. The analyses of the obtained solutions verifies the fact that the solutions are very cumbersome even in the linear special cases and are composed of transcendent and special functions. In these cases it is better to apply to the numerical methods. The implemented numerical experiments with MAPLE 9 affirm the effectiveness of numerical simulations in investigation of nonlinear wave propagation and interaction in strongly inhomogeneous nonlinear elastic material.

The resonance method elaborated for nondestructive evaluation of the properties of weakly inhomogeneous nonlinear elastic material was improved. The assumption that the resonance points in the cascade of two-parametric weakly inhomogeneous material can be roughly determined as a vectorial sum of vectors that determine the corresponding points in the cascades of related one-parametric weakly inhomogeneous materials was studied in detail. The results of numerous numerical experiments enabled to conclude that the accuracy of this assumption is sufficient for the solutions of the practical problems of acoustodiagnostics (A.Ravasoo, A.Braunbrück).

Wave propagation in materials with internal interfaces
A kinetic relation is derived for the determination of the velocity of moving discontinuity in solids. It follows from non-equilibrium jump relations at the discontinuity. The non-equilibrium jump relations are formulated in terms of contact quantities and entropy production. It is shown that simple assumption of continuity of contact stresses allows to determine the stress jump across the discontinuity and, therefore, to derive kinetic relation.

The obtained kinetic relation is successfully applied in the case of Mode I brittle crack. The driving force in this case is proportional to the energy release rate at the crack tip. The energy release rate is calculated by means of dynamic J-integral in the domain representation. Numerical simulations of crack propagation show a good agreement with available experimental data.

Numerical simulations of the phase transition front propagation in one-dimensional bar under impact loading allow us to explain the decrease in displacement for Ni-Ti shape-memory alloy due to the martensitic phase transformation.

Numerical simulations of nonlinear one-dimensional wave propagation in layered heterogeneous media show that the experimentally observed response of laminated composites subjected to high velocity impact loadings can be reproduced by means of nonlinear stress-strain relation for the constituents (A.Berezovski).

Piano hammers - theoretical and experimental studies
The main goal is optimization of piano scale that was carried out by comparison of the simulated spectra of the neighbour string vibrations excited by the hammer. The string is assumed to be perfectly flexible, and the nonlinear hysteretic models of the piano hammer were used for this purpose. The computer modeling was used for the systematical approach of the structure of piano scale to its optimum value. The main attention is devoted to choosing of suitable linear mass density and tension of piano strings, and determination of position of the striking point. The problem of a choice of a tension for the neighbour strings terminated on the separate bass and treble bridges is considered in detail.

This study is realized in frame of French-Estonian programme PARROT in collaboration with the Institut de Recherche et Coordination Acoustique Musique (IRCAM, France), Ecole Nationale Supérieure des Techniques Avancées (ENSTA, France), and Tallinn Piano Factory (A.Stulov).

Inverse problems
Last year we established existence conditions and properties of solitary wave solutions of 1D hierarchical nonlinear wave equation of microstructured materials. This year we took into consideration an inverse problem to determine five unknown coefficients of this equation. The idea was to to use solitary waves in the inverse problem. It turned out that a single solitary wave doesn't contain enough information to recover all five coefficients. Therefore we focused our interest to an inverse problem which uses measurements of two solitary waves propagating with different velocities. We showed that two coefficients of the equation related to the macrolevel are uniquely recovered by amplitudes of these waves, and three coefficients of the equation which are related to the microlevel are uniquely recovered by three independent half-lengths of the waves. In addition, we proved that the solution of the inverse problem is stable with respect to small measurement errors of the data (J.Janno, J.Engelbrecht).

3.1.7 Optical nonlinearity and photoelasticity

Non-linear integrated photoelasticity
The well-known first-order system of differential equations of integrated photoelasticity has been transformed to a single fourth-order differential equation. For that, in the direction of light propagation a transformed coordinate has been used, which depends on the distribution of stress along the light ray. The coefficients of the new equation depend on the first three derivatives of the principal stress directions. With different initial conditions, this equation holds for all the components of the polarization transformation matrix. If the direction of the principal stresses is a linear function of the difference of the principal stresses then the coefficients of the equation are constant. In this case the equation has a closed form solution.

By residual stress measurement in axisymmetric glassware two methods can be used: 1) the fringe counting and 2) phase unwrapping. A systematic comparison of these methods has been carried out by measuring stresses experimentally in a number of specimens. It has been shown that in case of a suitable fringe unwrapping procedure both methods give the same results.

In cooperation with the University of Valenciennes, tempering stresses in a number of glass plates have been measured with the scattered light method and the results are compared with calculations (L.Ainola, H.Aben, J.Anton, A.Errapart).

3.2 Chair of Geometry, University of Tartu

Geometric approach to nonlinear problems

We propose a notion of a Z_N-connection, where N any integer equal or greater than 2, which can be viewed as a generalization of a notion of Z_2-connection or superconnection. We use the algebraic approach to the theory of connections to give the definition of a Z_N-connection and to explore its structure. It is well known that one of the basic structures of the algebraic approach to the theory of connections is a graded differential algebra with differential d satisfying the condition d to power 2 equals zero. In order to construct a Z_N-generalization of a superconnection for any $N > 2$ we make use of a Z_N-graded q-differential algebra, where q is a primitive $N - th$ root of unity, with N-differential d satisfying d to power N equals zero. The concept of a graded q-differential algebra arises naturally within the framework of the non-commutative geometry and the use of this algebra in our construction involves the appearance of q-deformed structures such as graded q-commutator, graded q-Leibniz rule, q-binomial coefficients. Particularly if $N = 2, q = -1$ then the notion of a Z_N-connection coincides with the notion of a superconnection. We define the curvature of a Z_N - connection and prove that it satisfies the Bianchi identity (V.Abramov).

Supplementary chapters for the completely revised reprint of the monograph "Vector fields and symmetries" have been prepared. New chapters are: f-connected tensors and tensor fields, Lie-Cartan calculus, tangent group; Equivalence of differential equations and differential operators; Exponential law and representations of linear group and the Lie algebra; Connections in fibre bundles (M.Rahula). V.Retšnoi is preparing his PhD thesis "Vector fields and infinite jets".

3.3 Biomedical Engineering Centre, Tallinn University of Technology

3.3.1. Biosignals interpretation

The main attention was aimed to EEG analyses to distinguish effects and possible interaction mechanisms of weak (microwave radiation) and strong (anesthetic drugs) stressors on human brain.

Studies on analysis of pulse wave parameters were aimed to noninvasive indirect estimation of elastic properties of blood vessels. Analysis of pulse wave shape is promising as a measure of arterial elasticity and stiffness.

Digital analysis of the spectrophotometrical signal and on-line processing of its components during hemodialysis was aimed to develop a method for monitoring of dialysis treatment and improve dialysis adequacy and quality.

3.3.2. Microwave effects on EEG

1. Modulated microwave radiation at low non-thermal level of field power density can affect human central nervous system in a sensible way. During this year, the study continued on discrimination of changes, produced by low-level microwave exposure in intensity and time variability of the human EEG at rest. The power spectral density (PSD) method and nonlinear scaling analysis of the length distribution of low variability periods (LDLVP) were selected for analysis of the EEG signal. During the experiment, 19 healthy volunteers were exposed to a microwave (450 MHz) of 217 Hz frequency (as most characteristic for mobile phones) on-off modulation. The field power density at the scalp was 0.16 mW/cm^2. The experimental protocol consisted of ten cycles of repetitive microwave exposure. Signals from frontal, temporal, parietal and occipital EEG channels on EEG theta, alpha and beta rhythms were analysed.

Exposure to microwave causes average increase of EEG activity. LDLVP analysis

discriminated significant effect in time variability for 2 subjects. PSD method detected significant changes in intensity for 4 subjects. The effect of low-level microwave exposure is stronger on EEG beta rhythm in temporal and parietal regions of the human brain. The analysis by the LDLVP and PSD methods detected the effect of exposure for about 11% and 21 % of subjects respectively. For instance, the rate of multiple chemical sensitivity (MCS) occurrence is estimated to be between 2 and 10 % in the general population. Taking this into consideration, low-level microwave exposure can influence even higher part of population than multiple chemically unrelated compounds (M.Bachmann, J.Kalda, M.Säkki, J.Lass, V.Tuulik, H.Hinrikus).
2. A possible origin of interaction mechanism of microwave radiation with nervous system - quasi-thermal field effect - was investigated. The high frequency microwave field cannot cause any regular changes in the ions movement due to their small absorption cross-section as well as inertial properties and viscosity of the liquid medium. However, the microwave field can cause fluctuations and vibration of the charged particles and membranes in tissues. This phenomenon is similar to the effect caused by Brown motion initiated by temperature and results in the same effects without rise in temperature. The electric field of 1 V/cm can introduce disturbance of the thermal equilibrium inside a cell of 10 m radius, which is equivalent to disturbance produced by temperature rise of 1 K. The hypothesis, that microwave heating should cause an effect independent of the microwave modulation frequency, while non-thermal field effect depends on modulation frequency, was examined experimentally. The 450 MHz microwave radiation, modulated at 7, 14 and 21 Hz frequencies, power density at the skin 0.16 mW/cm2, was applied. The experimental protocol consisted of two series of five cycles of the repetitive microwave exposure at fixed modulation frequencies. Relative changes in EEG theta, alpha and beta rhythms of the group of 13 healthy volunteers were analysed. Analysis of the experimental data shows that: 1) statistically significant changes in EEG rhythms depend on modulation frequency of the microwave field; 2) microwave stimulation causes an increase of the EEG energy level; 3) the effect is most intense at beta1 rhythm and higher modulation frequencies. These findings confirm the quasi-thermal origin of the effect, different from average heating (H.Hinrikus, M.Bachmann, J.Lass, R.Tomson).

3.3.3. EEG in anesthesia

Our interest has recently been to compare the behavior of the various entropy/complexity measures at different levels of sedation in the intensive care unit (ICU). We have found that the various ways of quantifying signal entropy/complexity depend on different signal properties causing sometimes their contradictory behavior. Main problem we met in comparing the entropy/complexity measures of the EEG signal was the dependence of spectral entropy on the length of the signal window. During this year, our aim was to test if this dependence was due to added information when incorporating more data or if it was due to the algorithm.

The EEG data recorded from 12 ICU patients were analyzed using four different schemes of power spectrum estimation for obtaining spectral entropy. Two of the schemes comprise the Welch periodogram averaging method, one scheme is based on the estimation of the autocorrelation function and one on the autoregressive modelling. The results show that spectral entropy values depend highly on the smoothness of the power spectrum estimate. Spectral entropy correlates significantly with data length only if FFT is used for power spectrum estimation and the FFT size varies together with the data length.

The conclusions can be drawn from the analysis presented:

- the ability of the estimate of EEG spectral entropy to differentiate between various levels of sedation does not depend on the method used for power spectrum estimation in general. However, spectral entropy values achieved using different methods for power spectrum estimation are not comparable with each other;
- in the case of periodogram averaging, higher spectral entropy estimates for longer data windows are not due to the additional information contained in the data but rather comes from high variance of the power spectrum estimate typical to this method;
- in general, smoother power spectrum estimates (using AR-model coefficients, for example) give higher values of spectral entropy (R.Ferenets, A.Anier).

3.3.4. Noninvasive monitoring of arterial elasticity

Impaired vascular compliance and a concurrent rise in vascular rigidity are the central pathogenetic processes and the first step leading to fatal cardiovascular events in many cases of hypertension and hyperlipidaemia patients. Among the noninvasive methods of evaluating arteries, pulse wave shape analysis can be used as an index of arterial elasticity and stiffness. The goal of the study was twofold: 1) to evaluate whether pulse wave shape is modified by cold pressure test (CPT), and 2) compare the changes in the radial arterial pulse shape during CPT in normotensive patients and in patients with borderline hypertension.

During this study the changes in arterial pulse wave shape for 21 patients (aged 22 to 64 years) were investigated. Measurements of pulse wave shape were performed in normal conditions and with applying CPT. The results showed that pulse wave shape was significantly changed with increasing of blood pressure. The CPT caused statistically significant changes in pulse wave shape in the case of patients with normal blood pressure and did not induced significant change for the patients with hypertension. The preliminary results show that it is possible to use pulse wave shape analysis for noninvasive indirect estimation of elastic properties of blood vessels. Cooperation with North Estonia Regional Hospital (I.Hlimonenko, K.Meigas, R.Vahisalu).

3.3.5. Analysis of the spectrophotometrical signal in hemodialysis

The aim of the research is to develop a new technique to estimate dialysis adequacy and quality. The method is based on UV-absorption phenomena enabling on-line monitoring of solutes in the spent dialysate. The technique offers a possibility to follow haemodialysis session continuously, monitor deviations in dialysis efficiency, and estimate the quality and adequacy of the dialysis.

During this year, a preliminary validation of the method was performed. The study was aimed to compare the total removed uric acid obtained from the on-line UV-absorbance measurements in the spent dialysate (*TRua*) and the total dialysate collection (*TDC*) as reference method. Six uremic patients, two females and four males, on chronic thrice-weekly hemodialysis were included in the study. All spent dialysate during dialysis was collected in a tank that gave the *TDC* value. A double-beam spectrophotometer was used for the determination of UV-absorbance. Regression line from the first in week sessions was assessed to transform UV-absorbance into uric acid concentration. This relationship was used for the subsequent treatments' TRua calculations for each patient (method UV1). Also, *TRua* based on the transformation using the regression line from the total material was calculated (method UV2). *TRua* from the three methods was finally compared. *TRua* obtained using *TDC* and two different transformations for UV-absorbance (mean $\pm$ SD) in μmol were: 5277 $\pm$ 897 from *TDC* ($N = 23$), 5150 $\pm$ 882 from UV1 ($N = 23$), and 5422 $\pm$ 1112 from UV2 ($N = 23$) transformation. None of the mean TRua values were significantly different ($P > 0.05$).

The results show the possibility to estimate total removed uric acid by using UV-absorbance. Still a larger material is needed to draw more general conclusions. Co-operation with Institute of Biomedical Engineering, Linköping University, and North Estonia Regional Hospital (I.Fridolin, M.Luman).

3.4 Research within international programmes

3.4.1 NATEMIS
ESF programme (2000 – 2005)

The term of the programme was extended until July 31, 2005. The final NATEMIS report will be published by Springer in the form of the book "The universality of nonclassical nonlinearity". Three following chapters of the CENS members were submitted, revised on the basis of the reviewers remarks and accepted for publication:

(i) J.Engelbrecht, F.Pastrone, M.Braun and A.Berezovski: Hierarchy of waves in non-classical materials,

(ii) A.Berezovski, J.Engelbrecht and G.A.Maugin: Modelling and numerical simulation of non- classical effects of waves, including phase transition fronts,

(iii) A.Ravasoo and A.Braunbrück: Nonlinear acoustic techniques for NDE of materials with variable properties.

Activities:

- A.Braunbrück participated at the NATEMIS Workshop in Lisbon, Portugal during 11-14 July with the talk "Influence of material inhomogeneity on nonlinear interaction".
- A.Braunbrück took part at the Steering Committee Meeting in Lisbon, Portugal on July 11.
- J.Engelbrecht attended a seminar in Turin, 4-5 May.

3.4.2 PARROT

French-Estonian science and technology collaboration program PARROT "Experimental and Theoretical Study of Sound Generation Mechanisms in Grand Piano — 2005 – 2006"

In frame of French-Estonian programme PARROT the Tallinn Piano Factory has build and presented to the Institute of Cybernetics the special sample of a grand piano. This instrument is specially prepared for experimental measurements and testing of the various parts of the piano. Using their own experimental arrangement two French researchers René Caussé and Philippe Zelmar from IRCAM carried out the experimental measurements of the piano bridge vibrations excited by the special B&K impact hammer. The results of this test will give the clear understanding of the process of the wave transmission through the bridge and the way of the piano soundboard excitation.

3.4.3 CENS - CMA

Co-operation of Estonian and Norwegian Scientific Centres within Mathematics and its Applications

This Marie Curie Transfer of Knowledge project started on May 1st, 2005. Dr. Ewald Quak is the Senior Research Fellow in Tallinn. The Annual seminar of CENS-CMA was held in Oslo, May 24-25, 2005. Prof. Tarmo Soomere is the Senior Research Fellow in Oslo since Nov. 2005 for three months.

3.4.4. Renewal of Alexander von Humboldt fellowship in GKSS Institute of Coastal Research

T.Soomere (March 15 - June 15, 2005). Preliminary analysis of unique wave conditions in the northern Baltic Proper during windstorm Erwin/Gudrun (January 2005) was carried out. The measured significant wave height in the central area of the northern Baltic Proper reached 7.2 m. Based on output from three independent operational wave models, it may be hypothesized that the significant wave heights most probably exceeded 10 m.

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

Workpackage progress:

WP1 Ni-Ti alloys

Objectives: Identification and characterization of a Ni-Ti SMA alloy with optimal properties toward cultural heritage retrofitting

WP2 Alternative Shape Memory Alloys

Objectives: Identification and characterization of other shape memory alloys, with emphasis on Cu-based SMA alloys, with optimal properties toward cultural heritage retrofitting.

A thermomechanical description of the phase-transition front propagation it is developed on the basis of the material formulation of continuum mechanics and non-equilibrium jump relations at the phase boundary. A general relationship between the driving force and the velocity of a moving phase boundary in thermoelastic solids is established. The one-dimensional problem of impact-induced phase transformation front propagation in a Ni-Ti bar is solved numerically in the correspondence with the above mentioned description. The attention is paid to stress and displacement distributions in transformation regions. In the case of pulse loading, the local stress-strain relation at a fixed point, which was initially in austenitic state, is calculated and compared with experimental data by McKelvey and Ritchie (2000) for the quasi-static loading of Ni-Ti bar. Numerical simulations of the phase transition front propagation in a Ni-Ti bar under impact loading show that even in the simple isothermal one-dimensional case the developed description demonstrates a good agreement with experimental measurements. The numerical simulations allow us also to explain the decrease in displacement due to the martensitic phase transformation in the case of quasi-static loading. This displacement decrease is proposed to be considered as a characteristic damping property in the design of seismic resistant SMA devices (A.Berezovski).

3.4.6 FP-6, ERA-NET Complexity. Contract ERAS-CT-2004-011810

Specific Support Action (SSA) is completed from 1 August 2004 – 30 April 2005. (J.Engelbrecht).
The SSA has influenced the consolidation of complexity studies in Estonia. Beside CENS, the computer scientists (Profs. E.Tõugu, L.Mõtus) joined the Scheme. For the next application the following themes are included:

- nonlinearity and fractality of natural processes;
- biocomplexity;
- complexity of dynamical processes;
- software complexity;
- complexity in software - intensive systems.

The application for the years 2006 – 2009 has successfully passed the first round of evaluation. Presently, the contract is to be prepared with 13 research councils or ministries taking part.

3.4.7 Marie-Curie return grant ERG 6, N14826, "Cardiac energetics"

Requested project start date: 1.01.2006
Full title: Cardiac energetics in silico: microcompartmentation of adenine nucleotides and the crosstalk between organelles. Marie Curie Fellow: Marko Vendelin.

3.4.8 FP-6, New and Emerging Science and Technology (NEST). Contract NEST-CT-2003-002513

Project: New and Emerging Themes in Industrial and Applied Mathematics is a Specific Support Action (SSA).
CENS-CMA fellow Dr. E.Quak participated in the final strategy workshop, Oxford, UK, July 4-5. As a result of the workshop, the brochure Unleashing Mathematics - A Driving Force for Industry and Society in Europe was produced to start an initiative to identify the best way of coordinating interdisciplinary mathematics in Europe and to construct an Action Plan for Mathematics in Industry and Society.

3.4.9 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.

3.4.10 Special Interest Group on Geometric Modeling, CAD. Evolving Interfaces and Surfaces of the European Consortium of Mathematics in Industry (ECMI).

Contact person: Dr. E.Quak.

3.4.11 Marie Curie Research and Training Network SEAMOCS

Marie Curie Research and Training Network SEAMOCS "Applied stochastic models for ocean engineering, climate and safe transportation (2005 – 2009; leaded by Lund University. Group of water waves is leader of the work package 3 "Models on local scale").
The partners are: The University of Sheffield (UK), 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).

3.4.12 NordPlus Neighbour network.

NordPlus Neighbour Nordic-Baltic-Russian network cooperation within education and research (2005 – 2006/2008) "Boundary Layer Phenomena Over Partially Ice Covered Arctic Seas: Impact on Weather, Climate, Ecology and Sustainable Economy".
Division of Atmospheric Sciences, Dept. of Physical Sciences, Univ. of Helsinki, Finland, Nansen Environ. Remote Sensing Centre, Bergen, Norway, Wind Energy Dept., Risø National Laboratory, Denmark, Danish Meteorological Institute, Copenhagen, Denmark, Nils Bohr Institute, University of Copenhagen, Denmark, Dept. of Meteorology, Stockholm University, Sweden, Arctic and Antarctic Research Institute, St. Peterburg, Russia, Russian Hydrometeorological State University, St. Peterburg, Russia, Nansen Internat. Environ. Remote Sensing Centre, St.Petersburg, Russia, Laboratory of Mathematical Modelling, University of Latvia, Riga, Latvia.

4. Funding

4.1 Target funding through the Ministry of Education

1. Long-term block grant "Nonlinear dynamics and stress analysis", supervisor J.Engelbrecht.
2. Long-term block grant "Bioelectrical signal interpretation", supervisor H.Hinrikus.

4.2 Estonian grants (Estonian Science Foundation)

1. H.Aben, ETF grant 4972, "Nonlinear integrated photo-elasticity", (2001–2005).
2. A.Berezovski, J.Engelbrecht, M.Berezovski, T.Peets, ETF grant 5765, "Numerical simulation of wave propagation in materials with internal interfaces", (2004–2006).
3. A.Stulov, ETF grant 5566, "Sound generation mechanisms in grand pianos", (2003–2006).
4. P.Peterson, ETF grant 5767, "Extreme waves: analysis of free surface models", (2004–2007).
5. A.Salupere, ETF grant 5565, "Wave dynamics and wave hierarchy in microstructured materials", (2003–2006).
6. J.Kalda, ETF grant 6121, "Scale-invariant geometrical properties of turbulent diffusion", (2005–2008).

7. T.Soomere, ETF grant 5762, "Wind wave climate of the Baltic Sea and its dependence on nonlinear effects", (2004–2007).
8. H.Hinrikus, ETF grant 5143, "Mechanisms of biological interaction of the EMF", (2002–2005).
9. V.Tuulik, ETF grant 5625, "Analysis and monitoring of EEG patterns during propofol anesthesia", (2003–2005).
10. I.Fridolin, ETF grant 5871 "Novel optical technique for monitoring and evaluation of quality of hemodialysis".
11. K.Meigas. ETF grant 5888, "Application of coherent photodetection in cardiovascular diagnostics: noninvasive monitoring of blood pressure and arterial elasticity".
12. J.Lass. ETF grant 6173, "Microwave effects on cognitive functions".
13. J.Janno, A.Ravasoo, ETF grant 6018, "Inverse problems for inhomogeneous and microstructured material identification", (2005–2008).

4.3 International grants (see also 3.4)

1. A.Berezovski. FP-6 "Wide-range Non-intrusive devices toward Conservation of Historical Monuments in the Mediterranean Area (WIND-CHIME) – see 3.5.3.
2. A.Ravasoo. European Science Foundation Programme "Nonlinear Acoustic Techniques for Micro-Scale Damage Diagnostics" (NATEMIS) – see 3.5.1.
3. M.Vendelin. INSERM postdoctoral fellowship, INSERM Unit 446, Paris, France. 2005.

4.4 Additional funding

1. Estonian Programme for Centre of Excellence in Research - block grant.
2. Institute of Cybernetics at TTU – infrastructure.

5. Publicity of Results

5.1.1 Research Reports

1.	Mech 271/05	V.A.Saks, M.Vendelin, M.K.Aliev, T.Kekelidze, J.Engelbrecht. Mechanisms and modeling of energy transfer between and among intracellular compartments.
2.	Mech 272/05	A.Berezovski, G.A.Maugin. On the velocity of moving singularities in solids – I.
3.	Mech 273/05	A.Berezovski, G.A.Maugin. On the velocity of moving singularities in solids – II.
4.	Mech 274/05	A.Berezovski. Macroscopic description of stress-induced phase transition front propagation. Part I. Theoretical background.
5.	Mech 275/05	A.Berezovski. Macroscopic description of stress-induced phase transition front propagation. Part II. Impact-induced phase transition front propagation in a bar.
6.	Mech 276/05	O.Ilison, A.Salupere. On the propagation of solitary pulses in microstructured materials.
7.	Mech 277/05	T.Soomere, A.Kask, J.Kask. Environmental studies of coastal zone of Pirita Beach and formulation of technical conditions of beach protection (in Estonian).
8.	Mech 278/05	A.Berezovski, M.Berezovski, G.A.Maugin. Impact-induced phase transition front propagation in an adiabatic bar.
9.	Mech 279/05	A.Stulov. A spectral approach to the problem of piano string scale optimization.
10.	Mech 280/05	A.Ravasoo, A.Braunbrück. Nonlinear acoustic techniques for NDE of materials with variable properties.
11.	Mech 281/05	A.Braunbrück, A.Ravasoo. Wave interaction resonance in weakly inhomogeneous nonlinear elastic material.
12.	Mech 282/05	A.Braunbrück, A.Ravasoo. Application of counterpropagating nonlinear waves to material characterization.
13.	(no number)	J.Kask, T.Soomere, A.Kask, J.Kotta, I.Kotta, G.Martin, R.Eschbaum, M.Vetemaa, A.Verliin, M.Kesler, T.Saat. Post-mining environmental monitoring of the area of sand mining near the south-western coast of Naissaar (in Estonian).
14.	(no number)	T.Soomere. Wind and wave regime in the neighbourhood of Toila Harbour. Recommendations for planning of the harbour extension (in Estonian).

5.1.2 Lecture Notes

1.	Mech 05/05	P.Peterson. Hamiltonian Mechanics. http://cens.ioc.ee/cens/Members/pearu/hamiltoni-mehaanika

5.2 Publications

Books, proceedings and theses

1. Proc. Estonian Academy of Sciences, Engineering, 2005, 11, No 2. Special Issue on Interaction Phenomena in Multiphase Flows (Euromech Coll. 447) - J.Engelbrecht and Ü.Rudi (guest editors).

2. A.Braunbrück. Wave Interaction in Weakly Inhomogeneous Materials. PhD Theses, Tallinn University of Tehnology, 2005, ISBN 9985-59-531-9.

3. R.Kitt. Generalised Scale-Invariance in Financial Time Series. PhD Theses, Tallinn University of Technology, 2005, ISBN 9985-59-532-7.

4. M.Säkki. Intermittency and Long-Range Structurization of Heart Rate. PhD Theses, Tallinn University of Technology, 2005, ISBN 9985-59-572-6.

5. O.Ilison. Solitons and Solitary Waves in Media with Higher Order Dispersive and Nonlinear Effects. PhD Thesis, Tallinn University of Technology, 2005, ISBN 9985-59-557-2.

Papers (refereed)

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2. L.Ainola, H.Aben. Principal formulas of integrated photoelasticity in terms of characteristic parameters. J. Opt. Soc. Am. A, v. 22, 2005, 1181-1186.

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Abstracts

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4. A.Salupere, J.Engelbrecht, L.Ilison, K.Tamm. On solitary waves and solitons in hierarchical systems. In: T.R.Taha (Ed.). The Fourth International Conf. on Nonlinear Evolution Equations and Wave Phenomena: Computation and Theory, Athens, Georgia, April 10-14, 2005, The University of Georgia, Book of Abstracts, p. 158

5. A.Salupere, J.Engelbrecht, O.Ilison, L.Ilison. Propagation of solitary waves in microstructured media. Finno-Ugric International Conf. of Mechanics, 29 May - 4 June, 2005, Rackeve, Hungary, Book of Abstracts, 1 p.

6. A.Salupere, J.Engelbrecht, O.Ilison, L.Ilison. Solitary waves governed by complicated nonlinearity and dispersion. FPU+50: Nonlinear Waves 50 Years After Fermi-Pasta-Ulam, Rouen, June 21-25, 2005, INSA de Rouen, France, List of abstracts, 16-17.

7. A.Salupere, J.Engelbrecht, O.Ilison, L.Ilison. On solitary waves and solitons in microstructured media. E.Pavlovskaja, M.Wiercigroch, and Xu Xu (Eds), IMA International Conf., Resent Advances in Nonlinear Mechanics, 30 Aug. - 1 Sept., 2005, Aberdeen, Scotland, University of Aberdeen, Book of Abstracts, p. 144.

8. A.Berezovski, G.A.Maugin. Thermomechanics of moving phase boundaries in solids. The XI International Conf. of Fracture, March 20-25, 2005, Turin, Italy, Book of Abstracts, p. 70.

9. A.Berezovski, G.A.Maugin. Numerical simulation of phase-transition front propagation in thermoelastic solids. The Sixth European Conf. on Numerical Mathematics and Advanced Applications, Santiago de Compostela, Spain, July 18-22, 2005, Book of Abstracts, p. 56.

10. A.Berezovski, M.Berezovski, J.Engelbrecht. Numerical simulation of nonlinear elastic wave propagation in piecewise homogeneous media. EUROMECH Colloquium 466, Computational and Experimental Mechanics of Advanced Materials, Loughborough, UK, July 20-22, 2005, Book of Abstracts, 9-10.

11. A.Berezovski, G.A.Maugin. Moving fronts in solids: a non-equilibrium description. The International Conf. and Summerschool Thermocon'05, Messina, Italy, September 25-30, 2005, Summary Book, 2 p.

12. A.Stulov. Piano string scale optimization on the basis of dynamic modeling of process of the sound formation. Twelfth International Congress on Sound and Vibration, Lisbon, Portugal, July 11-14, 2005, (Eds) J.L.Bento Coelho, M.Boubezari, D.Alarcão and M.Neves, Programme and Book of Abstracts, p. 136.

13. A.Stulov, A spectral approach to the problem of piano string scale optimization. Finno-Ugric International Conf. of Mechanics, 29 May - 4 June, 2005, Rackeve, Hungary, Book of Abstracts, 1 p.

14. M.Kutser. Integration of Estonian mechanics into the European networking. Finno-Ugric International Conf. of Mechanics, 29 May - 4 June, 2005, Rackeve, Hungary, Book of Abstracts, 1 p.

15. T.Soomere, J.Engelbrecht, Geometry of soliton interactions in shallow water. 5th Baltic Sea Science Congress, The Baltic Sea Changing Ecosystems, Sopot, Poland, June 20-24, 2005, Sopot, CBO, BMB, BSG, Book of Abstract, 59-60.

16. T.Soomere. A simple model of wind wave climate in semi-enclosed sea areas. 5th Baltic Sea Science Congress, The Baltic Sea Changing Ecosystems, Sopot, Poland, June 20-24, 2005, Sopot, CBO, BMB, BSG, Book of Abstract, 70-71.

17. K.Rannat, A.Kask, R.Põder, T.Soomere. The shape of wake waves from high-speed ferries in the coastal area. 5th Baltic Sea Science Congress, The Baltic Sea Changing Ecosystems, Sopot, Poland, June 20-24, 2005, Sopot, CBO, BMB, BSG, Book of Abstract, 99-100.

18. A.Erm, T.Soomere. The impact of fast ferry traffic on the underwater optics and sediment resuspension. 5th Baltic Sea Science Congress, The Baltic Sea Changing Ecosystems, Sopot, Poland, June 20-24, 2005, Sopot, CBO, BMB, BSG, Book of Abstract, 101-102.

19. T.Soomere. Lessons in wave theory from the Indian Ocean Tsunami of Millennium and from the Baltic Sea Storm Surge of Century. J. of Structural Mechanics, 2005, 38, 3, p. 31.

20. A.Ravasoo. Counterpropagating waves and prestress characterization. Finno-Ugric International Conf. of Mechanics, 29 May - 4 June, 2005, Rackeve, Hungary, Book of Abstracts, 1 p.

21. A.Braunbrück, A.Ravasoo. Influence of material inhomogeneity on nonlinear wave interaction. 12th Congress on Sound and Vibration, July 11-14, 2005, Lisbon, Portugal, Book of Abstracts, p. 156.

22. P.Peterson. Building user-friendly interfaces to high-quality Fortran libraries. SIAM Conference on Computational Science & Engineering, Orlando, Florida, USA.

23. F.Uhlin, I.Fridolin, et al. On-line monitoring of the spent dialysate during haemodialysis using UV-absorbance. 34th International Conf. of EDTNA/ERCA, Wien, Austria, ERCA Abstracts Journal XXXI 2, 2005, Suppl. 1, p. 46.

Popular Science / Science policy

1. J.Engelbrecht. Interview - Why I think in such a way. Horisont 5, 2005, 20-26 (in Estonian).
2. J.Engelbrecht. Chancen einer wissensbasierten Gesellschaft. In: Wissenschaft und wissensbasierte Gesellschaft. Universität Tartu. Academica, 2005, 47-55 (in Estnisch), 323-329 (in Deutsch).
3. J.Engelbrecht. Kommentare. Ibid, 152-154 (in Deutsch), 412-414 (in Estnisch).
4. J.Engelbrecht. Knowledge based Estonia. Teachers Gazette. 2005, 35.
5. J.Engelbrecht. Fractals for the European research area. RDT info. Magazine on European Research, 2005, 46, 14-15.
6. J.Engelbrecht (ed). Quality assessment in Estonian higher education. Min. of Educ. & Res., 2005 (in Estonian).
7. J.Engelbrecht. Report on activities of the Estonian Acad. Sci. Yearbook of the Estonian Acad. Sci., 2005 (in Estonian).
8. J.Engelbrecht. Estonian Acad. Sci. in 1994-2004. Ibid, 2005, 91-101 (in Estonian).
9. J.Engelbrecht. Thoughts from fellows. Ibid, 2005, 205-206 (in Estonian).
10. J.Engelbrecht. Heart and mathematics. Yearbook of the Estonian Sci. Foundation 2004. ETF, 2005, 17 (in Estonian).
11. T.Soomere. The sea does not behave in an unexpected manner. Postimees, 7 (4281), 10.01.2005, p. 15 (in Estonian).
12. T.Soomere. Estonia got storm warning from newspaper. The Scandinavian Shipping Gazette, No 4, 25.02.2005, 26-29.
13. T.Soomere. Mechanisms for giant wave generation in the Baltic Sea. Eesti Teadusfondi Aastaraamat 2004, Sihtasutus Eesti Teadusfond, Tallinn 2005, p. 16 (in Estonian).
14. T.Soomere. Furious sea: lessons from the Indian Ocean tsunami. Horisont, 2/2005, 10-17 (in Estonian).
15. T.Soomere. On the possibilities and needs of operational marine forecast. Meremees 1(274) 2005, 4-8 (in Estonian).
16. T.Soomere. Furious sea II: when water attacks. Horisont 3/2005, 32-38 (in Estonian).
17. T.Soomere. Operational marine forecast must be provided by professionals. Postimees, 266 (4540), 16.11.2005, p. 21 (in Estonian).

18. T.Soomere. Coastal flooding - painful reaction of sea to storms. Universum IV, Tallinn 2005, 243-255 (in Estonian).

Submitted papers

1. J.Engelbrecht, F.Pastrone, M.Braun, A.Berezovski. Hierarchies of waves in non-classical materials. In: P.-P.Delsanto, Ed., The Universality of Non-classical Nonlinearity with Applications to NDE and Ultrasonics. Springer, (accepted).

2. A.Berezovski, G.A.Maugin, J.Engelbrecht. Modelling and numerical simulation of non-classical effects of waves including phase transition fronts. Ibid, (accepted).

3. J.Engelbrecht, M.Vendelin. Mathematical modelling of cardiac mechanoenergetics. In: Proc. IUTAM Symp on Mechanics of Biological Tissues, ed. by G.Holzapfel. Kluwer, (accepted).

4. A.Berezovski, M.Berezovski, J.Engelbrecht. Numerical simulation of nonlinear elastic wave propagation in piecewise homogeneous media. Materials Sci. and Engng., A, (accepted).

5. J.Engelbrecht, A.Berezovski, F.Pastrone, M.Braun. Deformation waves in microstructured solids and dispersion. In: Proc WASCOM 2005, ed. by R.Monaco world Scientific, Singapore, (accepted).

6. V.Saks, K.Guerrero, M.Vendelin, J.Engelbrecht, E.Seppet. The creatine kinase isoenzymes in organized metabolic networks and regulation of cellular respiration: a new role for Maxwell demon. In: Molecular Anatomy and Physiology of Proteins, ed. by C.Vial, Novascience Publ., NY, (in press).

7. V.Saks, M.Vendelin, M.K.Aliev, T.Kekelidze, J.Engelbrecht. Mechanisms and modeling of energy transfer between and among intracellular compartments. In: Handbook of Neurochemistry & Molecular Neurobiology: Neural Energy Utilization. Kluwer, NY, (in press).

8. J.Engelbrecht, J.Janno. Microstructured solids and inverse problems. Rendicorti Sem. Mat. Univ. Pol. Torino, (accepted).

9. T.Soomere, J.Engelbrecht. Weakly two-dimensional interaction of solitons in shallow water. Eur. J. Mechanics B / Fluids, (accepted).

10. A.Berezovski, G.A.Maugin. On the propagation velocity of a straight brittle crack. Int. J. Fracture, (submitted).

11. A.Berezovski, G.A.Maugin. Numerical simulation of phase-transition front propagation in thermoelastic solids. Proc. of ENUMATH 2005 - Springer, (submitted).

12. A.Stulov. Application of mathematical models to the problem of piano string scale optimization. International Journal of Sound and Vibration, (in preparation).

13. A.Stulov. Mathematical model of echolocation of fish-eating bats. In preparation to the Journal of Acoustical Society of America, (in preparation).

14. O.Ilison, A.Salupere. On the propagation of solitary pulses in microstructured materials. Chaos, Solitons and Fractals, (accepted, in press).

15. T.Soomere, A.Behrens, L.Tuomi, J.W.Nielsen. Unusual wave conditions in the Baltic Proper and in the Gulf of Finland during windstorm Erwin/Gudrun, submitted to Boreal Environment Research.

16. T.Soomere. Nonlinear components of ship wake waves. Applied Mechanics Reviews, (submitted).

17. T.Lapimaa, T.Soomere. Some observations of environmental impact assessments in Estonian coastal waters. Proc. Estonian Maritime Academy, (submitted).

18. T.Soomere. Nonlinear ship wake waves as a model of rogue waves and a source of danger to coastal environment. Oceanologia, (submitted).

19. T.Soomere. Fast ferries as wavemakers in a natural laboratory of rogue waves. Rendiconti del Seminario Matematico Università Politecnico di Torino, (submitted).

20. A.Braunbrück and A.Ravasoo. Wave interaction resonances in weakly inhomogeneous materials. Wave Motion, (accepted).

21. A.Ravasoo and A.Braunbrück. Nonlinear acoustic techniques for NDE of materials with variable properties. In P.P.Delsanto (Ed.) The universality of nonclassical nonlinearity, with applications to NDE and Ultrasonics, (accepted).

22. A.Braunbrück and A.Ravasoo. Resonance of counterpropagating waves in weakly inhomogeneous material. 6th European Solid Mechanics Conference ESMC 2006. 28 August - 1 September, 2006, Budapest, Hungary, (submitted).

23. A.Ravasoo. Application of counterpropagating nonlinear waves to inhomogeneous prestress characterization. The Thirteenth International Congress on Sound and Vibration, ICSV13, 2-6 July, 2006, Vienna, Austria, (submitted).

24. R.Kitt and J.Kalda. Leptokurtic Portfolio Theory. Eur. Phys. J. B, (accepted).

25. P.Peterson. A decomposition of multi-soliton solutions for (2+1)-dimensional KdV type equations to describe multi-soliton interactions. Journal of Nonlinear Mathematical Physics, (submitted).

26. R.Ferenets, T.Lipping, A.Anier, V.Jäntti, S.Melto, S.Hovilehto. Comparison of entropy and complexity measures for the assessment of depth of sedation, IEEE Transactions on BME, (accepted).

27. V.Abramov. Generalization of superconnection in non-commutative geometry. Proceedings of the Est. Acad. of Sci.: Physics, Mathematics, (accepted).

28. V.Abramov. On a graded q-differential algebra, arXiv:math.QA (Quantum Algebra)/0509481. J. of Nonlinear Mathematical Physics, (Ed.) Norbert Euler, (submitted).

29. V.Abramov. Geometric approach to BRST-symmetry of Lagrangian of Donaldson-Witten theory. Advances in Applied Clifford Algebras, (submitted).

5.3 Conferences

1. ISASUT Intensive Seminar on Non Linear Waves, Generalized Continua and Complex Studies, Torino, 4-6 May, 2005.
   J.Engelbrecht. Waves in microstructured solids and dispersion.
   J.Engelbrecht. Microstructure and inverse problems. Ibid.
   T.Soomere. Fast ferries as wake-makers in a natural laboratory of rogue waves.

2. XII International Conference on Waves and Stability in Continuous Media, Acireale, 19-25 June, 2005.
   J.Engelbrecht, F.Pastrone, M.Braun, A.Berezovski. Deformation waves in microstructured solids and dispersion.

3. FUDoM, Rackeve (Budapest), Hungary, 29 May - 5 June, 2005.
   J.Engelbrecht. Dispersive waves in microstructured solids.
   A.Salupere, J.Engelbrecht, O.Ilison, L.Ilison. Propagation of solitary waves in microstructured media.
   A.Ravasoo. Counterpropagating waves and prestress characterization.
   A.Stulov. A spectral approach to the problem of piano string scale optimization.

4. IMACS 2005, The Fourth International Conference on Nonlinear Evolution Equations and Wave Phenomena: Computation and Theory, The University of Georgia, Athens, USA, 10-14 April, 2005.
   O.Ilison, A.Salupere. On the propagation of solitary pulses in microstructured media.
   A.Salupere, J.Engelbrecht, L.Ilison, K.Tamm. On solitary waves and solitons in hierarchical systems.

5. FPU+50: Nonlinear Waves 50 Years After Fermi-Pasta-Ulam, INSA de Rouen, France, 21-25 June, 2005.
   A.Salupere, J.Engelbrecht, O.Ilison, L.Ilison. Solitary waves governed by complicated nonlinearity and dispersion.

6. RANM 2005, Recent Advances in Nonlinear Mechanics, University of Aberdeen, Scotland, UK, 30 Aug. - 1 Sept., 2005.
   A.Salupere, J.Engelbrecht, O.Ilison, L.Ilison. On solitary waves and solitons in microstructured media.

7. The XI International Conference of Fracture, Turin, Italy, 20-25 March, 2005.
   A.Berezovski, G.A.Maugin. Thermomechanics of moving phase boundaries in solids.

8. The Sixth European Conference on Numerical Mathematics and Advanced Applications, Santiago de Compostela, Spain, 18-22 July, 2005.
   A.Berezovski, G.A.Maugin. Numerical simulation of phase-transition front propagation in thermoelastic solids.

9. EUROMECH Colloquium 466, Computational and Experimental Mechanics of Advanced Materials, Loughborough, UK, 20-22 July, 2005.
   A.Berezovski, M.Berezovski, J.Engelbrecht. Numerical simulation of nonlinear elastic wave propagation in piecewise homogeneous media.

10. The International Conference and Summer School Thermocon'05, Messina, Italy, 25-30 Sept., 2005.
    A.Berezovski, G.A.Maugin. Moving fronts in solids: a non-equilibrium description.

11. International Conference "Glass Processing Days", Tampere, 17-20 June, 2005.
    D.Lochegnies, E.Romero, J.Anton, A.Errapart, H.Aben. Measurement of complete residual stress fields in tempered glass plates.

12. International Conference on Experimental Mechanics ICEM05, New Delhi, 12-14 Sept., 2005.
    A.Errapart, J.Anton, H.Aben. On data processing in photoelastic residual stress measurement in glass.

13. General Assembly of European Geosciences Union (EGU), Vienna, 24-29 April, 2005.
    T.Soomere, J.Engelbrecht. Weakly two-dimensional interaction of solitons in shallow water.
    T.Soomere. Fast ferry traffic as a qualitatively new forcing factor of environmental processes in non-tidal areas (poster).
    K.Rannat, T.Soomere, R.Põder, A.Erm. The shape of wake waves from high-speed ferries and their influence in the coastal area (poster).

14. CENS-CMA 2. seminar, Oslo, 24-25 May, 2005.
    E.Quak. About the CENS-CMA project.
    J.Engelbrecht. CENS and complexity.
    T.Soomere. Fast ferries as wake-makers in a natural laboratory of rogue waves.
    J.Kalda. Intermittend geometry of turbulent diffusion.
    A.Ravasoo. Relaxation in nonlinear viscoelasticity.

15. Fifth Baltic Sea Science Congress, The Baltic Sea Changing Ecosystems, Sopot, Poland, 20-24 June, 2005.
    T.Soomere, J.Engelbrecht. Geometry of soliton interactions in shallow water.
    T.Soomere. A simple model of wind wave climate in semi-enclosed sea areas.
    T.Soomere, A.Behrens, L.Tuomi, J.W.Nielsen. Unusual wave conditions in the Baltic Proper and the Gulf of Finland during windstorm Gudrun.
    K.Rannat, A.Kask, R.Põder, T.Soomere. The shape of wake waves from high-speed ferries in the coastal area.
    A.Erm, T.Soomere. The impact of fast ferry traffic on the underwater optics and sediment resuspension.

16. I3M International Mediterranean Modeling Multiconference, Marseille, France, 20-22 Oct., 2005.
    K.Rannat, P.Miidla, P.Uba. Simulation of the tropospheric water vapor distribution monitoring.

17. Kick-off meeting of the Nordplus Neighbour project "Boundary-layer phenomena over partially ice covered arctic seas: impact on weather, climate, ecology and sustainable economy" Bergen, Nansen Environmental and Remote Sensing Centre, 10-11 Oct., 2005.
    T.Soomere. Partial ice cover: influence on boundary-layer processes through changes in wind and wave fields.

18. Kick-off meeting of Marie Curie Research and Training Network SEAMOCS, Lund, 22-23 Oct., 2005.
T.Soomere. On extreme wave conditions on the Baltic Sea.

19. 18th Nordic Seminar in Computational Mechanics, NSCM18, Helsinki/Stockholm, 27-30 0ct., 2005.
T.Soomere. Lessons in wave theory from the Indian Ocean Tsunami of Millennium and from the Baltic Sea Storm Surge of Century.

20. METOBS140 - Estonian Geophysics 2005, Tartu/Tõravere, 10-11 Dec., 2005.
T.Soomere. Unique wave conditions on the Baltic Sea on 8-9 January 2005 (in Estonian).
R.Põder. Fast ferry waves in the coastal area of Tallinn modelled by the theory of cnoidal waves (in Estonian).

21. Workshop Rogue Waves, Edinburgh, 12-15 Dec., 2005 (by invitations only).
T.Soomere, J.Engelbrecht. Interaction of shallow-water solitons as a possible model for freak waves.

22. Twelfth Congress on Sound and Vibration, Lisbon, Portugal, 11-14 July, 2005.
A.Braunbrück, A.Ravasoo. Influence of material inhomogeneity on nonlinear wave interaction.
A.Stulov. Piano string scale optimization on the basis of dynamic modeling of process of the sound formation.

23. In SIAM Conference on Computational Science & Engineering, Orlando, Florida, USA.
P.Peterson. Building user-friendly interfaces to high-quality Fortran libraries.

24. Third NEXT-SigmaPhi (News, Expectations and Trends in Statistical Physics), Crete, Greece, 13-18 August, 2005.
R.Kitt. Leptokurtic Portfolio Theory.

25. 13th Nordic Baltic Conference on Biomedical Engineering and Medical Physics, Umeå, Sweden, 13-17 June, 2005.
K.Meigas, J.Lass, D.Karai, R.Kattai, J.Kaik. Device for continuous blood pressure measurements.
F.Uhlin, I.Fridolin, et al. Response to clearance reduction during haemodialysis by online UV-absorbance monitoring.
I.Hlimonenko, K.Meigas, R.Vahisalu. Change of arterial pulse wave in patients with hyperlipidaemia.

26. 5th International Workshop on Biosignal Interpretation, Tokyo, Japan, 6-8 Sept., 2005.
R.Ferenets. Comparing Entropy/Complexity of EEG during Propofol and Sevoflurane Anesthesia at Burst-Suppression Level.

27. 3rd European Medical & Biological Engineering Conference EMBEC05, Prague, Czech Republic, 20-25 Nov., 2005.
R.Tomson, H.Hinrikus, M.Bachmann, J.Lass, and V.Tuulik. Sensitivity of human EEG to modulation frequency of microwave radiation.
T.Lipping, R.Ferenets, A.Anier, S.Melto, S.Hovilehto. Power spectrum estimation in the calculations of spectral entropy to assess depth of sedation.

K.Meigas. J.Lass, D.Karai, R.Kattai, J.Kaik. Method and device for beat-to-beat blood pressure measurements.
I.Hlimonenko, K.Meigas, R.Vahisalu. Arterial pulse wave analysis during cold pressor test in patients with borderline hypertension.
F.Uhlin, L.G.Lindberg, I.Fridolin. Total removed uric acid during dialysis estimated by on-line ultra violet absorbance in the spent dialysate.
H.Hinrikus, M.Bachmann, J.Lass, V.Tuulik. Effect of modulated at 7Hz, 14Hz and21 Hz microwaves on human EEG rhythms.

28. International Conference on High Energy and Mathematical Physics, Marrakech, Marocco, 4-9 April, 2005.
V.Abramov. On a graded q-differential algebra.

29. Differential Geometry and Physics, Budapest, 29 Aug - 4 Sept., 2005.
V.Abramov. Ternary structures and generalization of exterior calculus.

30. Algebra, geometry and mathematical physics, Baltic-Nordic Workshop, Tallinn, 8-9 Oct., 2005.
V.Abramov. Graded q-differential algebra and reduced quantum plane.

31. Geometry in Odessa-2005, Differential Geometry and Its Applications, Odessa, 23-29 May, 2005.
V.Retšnoi. Prolongation of total differentiation operators under jet composition.

32. Communicating European Research (CER) 2005, Brussels, Belgium, 14-15 Nov., 2005.
E.Quak. Part of the AIM@SHAPE project stand team.

33. Workshop Industry Challenges in Geometric Modeling and CAD 2005, Darmstadt, Germany, 10-11 March.
E.Quak. Co-organizer.

5.4 Seminars / meetings

5.4.1 XII Estonian Days of Mechanics, September 12-13, 2005, Tallinn (year of Physics 2005)

1. J.Engelbrecht. Complexity and physics.
N.Alumäe medal lecture.

2. A.Berezovski. Thermomechanics of moving interfaces in solids.

3. T.Soomere. Giant waves in shallow water.

4. P.Peterson. Modelling extreme waves.

5. L.Rebane, M.Sepp. Propagation of optical waves in stratified nonlinear medium.

6. A.Ravasoo. Interaction of ultrasonic waves in prestressed materials.

7. A.Braunbrück. Effects of material inhomogeneity on wave interaction.

8. A.Salupere. Solitons and solitary waves in microstructured materials.

5.4.2 The 5th Glass Stress Summer School

Tallinn, June 1-3, 2005. An intensive three-day course containing lectures, equipment demonstrations, practical stress measurements and informal discussions.

5.4.3 Tallinn Seminars on Mechanics

1. 17.01. Dr. A.Erm: "Optically active substances in ice - origin, influence, problems".
2. 7.02.2005: Prof. J.Engelbrecht, Prof. E.Tõugu, Prof. L.Mõtus. ERA-NET Complexity. CENS seminar.
3. 14.02. Prof. T.Soomere: "Lessons in wave theory from the Indian Ocean tsunami and from the Baltic Sea storm surge of century".
4. 21.02. MSc. A.Braunbrück: "Resonances of longitudinal waves interaction".
5. 28.02. Dr. A.Berezovski: "Mode I straight crack velocity in brittle solids".
6. 7.03. Dr. M.Eerme: "Simulation in mechanical engineering".
7. 14.03. MSc. R.Kitt: "Generalised scale-invariance in financial time-series".
8. 21.03. Prof. H.Hinrikus: "Electromagnetic processes in brain".
9. 25.04. Prof. T.Puu, Umeå University: "Complex dynamics in oligopoly models".
10. 15.06. Prof. C.Hedberg (Blekinge Institute of Technology, University of Karlskruna-Ronneby): "Nonlinear acoustic testing of diverse materrials".
11. 5.09. Prof. Karl-Hans Laermann, (Bergische Universität, Wuppertal): "Inverse problems in experimental solid mechanics".
12. 14.09. Prof. Nobumasa Sugimoto (Department of Mechanical Science, Graduate School of Engineering Science, Osaka University): "Experiments and simulations of the acoustic solitary waves".
13. 3.10. Prof. T.Soomere: "Unique wave conditions on the Baltic Sea on 8-9 January 2005."
14. 10.10. MSc. M.Säkki: "Intermittency and long-range structurization of heart rate".
15. 17.10. Dr. A.Stulov: "Grand piano string scale and its optimization".
16. 21.10. MSc. Elzbieta Olejarczyk, (Institute of Biocybernetics and Biomedical Engineering, Poland) "Applications of higuchi's fractal dimension method in anaesthesia".
17. 10.11. Dr. Wael Hassan, (Twente University, Holland): "Towards a better prediction of sand transport in oscillatory sheet-flows".
18. 14.11. MSc. R.Ferenets: "Entropy and complexity of EEG at anesthesia".

19. 17.11. Dr. Shu Qing Yang, (Korea Maritime University, Pusan): "Analytical solutions of Reynolds equations".

20. 29.11. Dr. René Caussé, MSc. Philippe Zelmar, (Institut de Recherche et Coordination Acoustique Musique, Equipe Acoustique instrumentale), and A.Stulov (IOC): "Musical acoustics and grand piano".

21. 12.12. Dr. Aleksei Chechkin (Kharkov, Institute of Physics and Technology): "Wave and front propagation in inhomogeneous solids".

5.5 Seminars outside the home Institute

1. J.Engelbrecht. Activities of CENS. CENS-CMA seminar, Oslo, Norway, 24 May.

2. A.Ravasoo. Relaxation in nonlinear viscoelasticity. CENS-CMA seminar, Oslo, Norway, May 24-25.

3. J.Engelbrecht. Research in Nonlinear Science. Seminar in the Institute of Mechanics, Bulgarian Academy of Sciences, Sofia , 12 Oct.

4. J.Engelbrecht. Waves in microstructured solids carry information about the microstructure. Seminar in the Dept of Mathematics, Messina University, 21 Nov.

5. A.Stulov. Mathematical modelling of piano scale. Institut de Recherche et Coordination Acoustique Musique, Equipe Acoustique instrumentale, Paris, France, 18 May.

6. A.Stulov. Grand piano and experiments. Ecole Nationale Supérieure des Techniques Avancées, Palaiseau, Paris, France, 24 May.

7. A.Stulov. Measurements of piano bridge acceleration. Institut de Recherche et Coordination Acoustique Musique, Equipe Acoustique instrumentale, Paris, France, 13 Dec.

8. T.Soomere. Unusual wave conditions in the Baltic Proper and the Gulf of Finland during windstorm Gudrun 7-9 January 2005. GKSS Geesthacht, Institute of Coastal Research, 16 May.

9. K.Rannat. Simulation of water vapor in the troposphere. University of Tartu, 15 Nov.

10. T.Soomere. Simple math and geometry of nonlinear interactions of shallow-water waves. CMA, Dept. of Mathematics, University of Oslo, 28 Nov.

11. T.Soomere. CNR / Politecnico di Torino, Italy. Lessons from the Indian Ocean Tsunami, 09 May.

12. T.Soomere. Lecture in the Estonian Mathematical Society, Tartu. Simple mathematical problems in marine sciences, 14 Nov.

13. K.Rannat. Lecture in the Institute of Environmental Physics, University of Tartu. On the applications of th GPS monitoring.

14. T.Soomere. Lecture in Centre of Mathematics for Applications, University of Oslo, Lessons in linear wave theory from the Indian Ocean Tsunami, 20 Dec.

15. E.Quak. Presentation of the EU AIM@SHAPE and CENS-CMA projects Nokia Research Center Helsinki, Finland, 9 June.

5.6. Science and Society - Flooding of Western Coast of Estonia, Jan. 2005 – voice of a scientist

1. T.Soomere, Interview to newspaper "Linnaleht" (Tallinn City Paper) about specific features of tsunami waves (in connection with the Indian Ocean Tsunami); published 7.01.2005.

2. T.Soomere, Interview to daily newspaper "Postimees" about approaching of a dangerous storm flood and rough seas expected to occur 8-9.01.2005, excerpts published 8.01.2005.

3. T.Soomere, Comments to Radio Kuku, Marine Hour, about dangers of the approaching storm, live on air in the morning of 8.01.2005.

4. T.Soomere, Comments to the public radio service "Vikerraadio" about dangers in the approaching storm, 8.01.2005.

5. T.Soomere, Comments to the main news block of TV channel TV3 about the approaching storm, 8.01.2005.

6. T.Soomere, Comments to the national TV channel "Eesti Televisioon" about specific features of the 8-9 January storm, Osoon, broadcasted 12.01.2005.

7. T.Soomere, Comments to daily newspaper "Postimees" about a storm expected to arrive on 13.01.2005, excerpts published 13.01.2005.

8. T.Soomere, Comments to Tallinn City Paper about potential black scenarios of the exceptional storm on 8-9 January, published 14.01.2005.

9. T.Soomere, Comments to the national TV channel "Eesti Televisioon" about specific features of the 8-9 January storm, Tasakaal, broadcasted 14.01.2005.

10. T.Soomere, Interview to daily newspaper "Postimees" about possibilities of forecasting of reaction of sea surface to various storms, excerpts published 14.01.2005.

11. T.Soomere, Comments to the national TV channel "Eesti Televisioon" about documental movie "The wave that struck the world", broadcasted 21.02.2005.

12. T.Soomere, Information to daily newspaper "Postimees" about specific properties of wave fields in the Gulf of Finland on 9 January 2005, excerpts published 25.02.2005.

13. T.Soomere, Interview to newspaper "Pärnu Postimees" about potential scenarios of future storms, published 10.03.2005.

14. T.Soomere, Comments to the national TV channel "Eesti Televisioon" about strong earthquake near Sumatra and possibilities of emerging another tsunami, live on air 28.03.2005.

15. T.Soomere, Interview to Tallinn City Paper about education in marine matters and marine scientists, excerpts published 30.03.2005.

16. T.Lapimaa, Interview to national television channel "Eesti Televisioon": TV project about young scientists introducing science to 14-17 years old children. In association with www.vedur.ee and Haridusmeedia OÜ. Project manager Anne Lill, 2.08.2005.

17. T.Soomere, Interview to weekly newspaper "Eesti Ekspress" about potential increase of storminess owing to climate changes and about extreme wave conditions in the Baltic Sea; excerpts published 29.09 and 6.10.2005.

18. T.Soomere, Interview to BONUS Newsletter about the role of scientists in popularization of science, excerpts published in BONUS Newsletter 2.11.2005.

19. T.Soomere, Comments to Radio Kuku, Marine Hour, about specific features of the storm on 14-15 November 2005, broadcasted 19.11.2005.

20. T.Soomere, Interview to TV channel TV2 on the case of election as the Person of the year, broadcasted in Reporter, 7.12.2005.

21. T.Soomere, Interview to journalists of daily newspaper "Postimees" on the case of election as the Person of the year, published 8.12.2005.

22. T.Soomere, Comments to Radio Kuku, Marine Hour, on the case of election as the Person of the year, by phone live on air in the morning of 10.12.2005.

5.7 Supportive grants (travel, etc.)

1. European Science Foundation Grant through the NATEMIS programme for participating the NATEMIS Workshop in Lisbon, Portugal during 11-14 July and the Steering Committee Meeting in Lisbon, Portugal on July 11, A.Braunbrück.

2. French-Estonian science and technology collaboration program PARROT "Experimental and theoretical study of sound generation mechanisms in grand piano" grant for research visit the Institut de Recherche et Coordination Acoustique Musique, Equipe Acoustique instrumentale and Ecole Nationale Supérieure des Techniques Avancées, Paris, May 17-26, and Dec. 7-16, A.Stulov.

3. Estonian Ministry of Education and Research - R.Tomson.
   Grant for MSc study at Mälardalen University, Sweden, Sept. 15 - Dec. 31, K.Jaak.

4. Estonian Ministry of Education and Research - R.Ferenets.
   Grant for doctoral study and research at Tampere University of Technology, April 01 - Dec. 31, K.Jaak.

5. State Scholarships Foundation, Greece, grant for PhD study at University of Patras, Oct. 2005-2006, A.Rodina.

6. Erasmus grant for graduate study at Universitat Polytecnica de Catalunya, Febr. 5 - July 5, L.Rebane.

7. Erasmus grant for graduate study at University of Patras, Greece, Oct. 2005 - April 2006, K.Veski.

8. NATO grant Optical methods for diagnosis and monitoring of clinical parameters, I.Fridolin.

5.8 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).

5.9 Research programmes (national)

1. Estonian Programme on Mechanics.
2. Estonian Programme on Biomedical Engineering.

5.10 Teaching activities

1. A.Salupere – courses in TUT:
   - Dynamics
   - Statics
   - Continuum Mechanics
   - Theory of Elasticity
   - Seminars and Special Seminars for BSc, MSc and PhD students
2. J.Engelbrecht – courses in TUT:
   - Mathematical modelling
   - Biomechanics (together with T.Sillat)
   - Nonlinear Dynamics

3. A.Braunbrück – courses in TUT:
   - Engineering Mechanics

4. J.Kalda :
   - Training of the Estonian and Finnish teams for 36th International Physics Olympiad, July 3-12, Salamanca, Spain. Estonian students won one bronze medal and four honourable mentions. Overview by J.Kalda: Magazine "Horisont", No 6, 2005, 46-47 (in Estonian).
   - Participation in the organization of 3rd Estonian-Finnish Olympiad, 28-30 April, 2005, Tallinn. Overview by J.Kalda: Magazine "Horisont", No 4, 2005.
   - 3rd Academic Olympiad in Physics, 21 March 2005, University of Tartu.
   - 52nd Estonian Physics Olympiad, 9 April 2005.

5. P.Peterson – courses in TUT:
   - Hamiltonian mechanics (graduate)
   - Linux applications (graduate)

6. R.Kitt – courses in TUT:
   - Financial Analysis
   - Security Analysis

7. T.Soomere – intense courses:
   - Wave dynamics (TUT)
   - Coastal hydrodynamics (Estonian Marine Academy)

8. J.Lass, R.Ferenets – courses in TUT:
   - Signal processing
   - Physiological signal processing

9. H.Hinrikus, M.Bachmann – courses in TUT:
   - Biological effects of electromagnetic field

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

11. M.Randrüüt – courses in TUT:
    - Statics

Participation in schools:

1. T.Lapimaa: participated in Fourth GKSS School of Environmental Research. Environmental Crises: Science and Policy (Helgoland, Germany), 2-11 Nov., 2005.

2. K.Veski: participated in the BEST school on biophysics, Lissabon New University, 28 Aug. - 10 Sept., 2005.

3. L.Rebane: graduate study at Universitat Polytechnica de Catalunya, 5 Feb. - 5 July, 2005.

5.11 Visiting fellows and students (longer periods)
Students:

1. Pantelis Theocharakis, University of Patras, Greece, 4 Oct., 2004 - 5 Jan., 2005.
2. Giovanni Nolli, Italy, MSc student, Sept.-Dec., 2005.
3. Fernando Perez, Spain, PhD student, Sept.-Dec., 2005.

Visiting scholars

1. Prof. Jaakko Malmivuo, Ragnar Granit Institute, Tampere University of Technology, Finland, Intensive course "Bioelectromagnetism", April 18-22, 2005.
2. Prof. Tarmo Lipping, Sen. Res. Ville Jäntti, Tampere University of Technology, workshop "EEG in intensive care unit", March 3, 2005.

5.12 Theses

Institute of Cybernetics:
Promoted:

1. BSc:
   - M.Kalda: Interaction of waves in inhomogeneous elastic materials (supervisor A.Ravasoo)
   - T.Lapimaa: Methodology of environmental impact assessment in coastal waters and its implementation in Estonia (supervisor T.Soomere)
   - K.Veski: Modelling of nerve pulse propagation (supervisor J.Engelbrecht)
2. MSc:
   - A.Kask: Distribution of sand resources in the coastal area of Northern Estonia (MSI, supervisor T.Soomere)
   - R.Randmeri: Description of wave climate of the Gulf of Riga with the WAM model (MSI, supervisor T.Soomere)
3. PhD:
   - A.Braunbrück: Wave interaction in weakly inhomogeneous materials (supervisor A.Ravasoo)
   - O.Ilison: Solitons and solitary waves in media with higher order dispersive and nonlinear effects (supervisor A.Salupere)
   - R.Kitt: Generalised scale-invariance in financial time series (supervisor J.Kalda)
   - M.Säkki: Intermittency and long-range structurization of heart rate (supervisor J.Kalda)

In progress:

1. PhD:

L.Ilison:	Solitons and solitary waves in hierarchical Korteweg-de Vries type systems (supervisor A.Salupere)
A.Kask	Natural and anthropogenic morphodynamics caused by lito-hydrodynamical processes in the Estonian coastal sea (supervisor T.Soomere)
K.Rannat	Long weakly nonlinear waves in geophysical applications (supervisor T.Soomere)

2. MSc:

M.Berezovski:	Numerical simulation of elastic wave propagation in layered nonlinear media (supervisor J.Engelbrecht)
M.Kalda:	Interaction of waves in strongly inhomogeneous materials (supervisor A.Ravasoo)
K.Tamm:	Wave dynamics in hierarchical systems (supervisor A.Salupere)
T.Lapimaa	Methodology of monitoring of development activities in coastal waters and its implementation in Estonia (supervisor T.Soomere)
T.Peets	Dispersion analysis of waves in microstructured solids (supervisor J.Engelbrecht)
M.Randrüüt	Modelling of deformation waves in microstructured solids (supervisor J.Engelbrecht)
K.Veski	Studies in nerve pulse dynamics - preliminary title (supervisor J.Engelbrecht)
L.Rebane	Orbital momentum of light (supervisor P.Peterson)
M.Sepp	Nonstationary coherent optical waves in stratified medium with Kerr nonlinearity (supervisor P.Peterson)

Chair of Geometry, University of Tartu:

In progress:

1. PhD:

V.Retšnoi	Vector fields and infinite jets (supervisor M.Rahula)

Centre of Biomedical Engineering:

Promoted:

1. MSc:

I.Hlimonenko	Pulse wave analysis in patients with hypertension and hyperlipidaemia (supervisor K.Meigas)

2. BSc: R.Kala, A.Vaiser, J.Rubljova, K.Ilau, J.Jerotskaja, I.Krotova, M.Tšukardina, A.Suhhova, A.Suik, A.Janson

In progress:

1. MSc:
   R.Tomson (supervisor H.Hinrikus)
   A.Suhhova, J.Rubljova (supervisor M.Bachmann)
   L.Berkis, A.Suik (supervisor K.Meigas)
   J.Jerotskaja, A.Štšerbakov, G.Vaik, K.Lauri (supervisor I.Fridolin)
   A.Kaasik, K.Temitski (supervisor J.Lass)
   I.Krotova (supervisor V.Tuulik)

2. PhD:
   M.Bachmann (supervisor H.Hinrikus)
   R.Ferenets, A.Anier (supervisor T.Lipping)
   I.Hlimonenko (supervisor K.Meigas)
   E.Suurküla (supervisor I.Fridolin)

5.13 Distinctions
Fellows:

1. J.Engelbrecht: Chevalier, Order of Merit, Poland.

2. J.Engelbrecht: N.Alumäe medal, Estonian Academy of Sciences.

3. J.Engelbrecht: M.Drinov medal, Bulgarian Academy of Sciences.

4. T.Soomere: Person of the Year by the daily newspaper
   "Postimees" (The Postman).

Students:

1. R.Ferenets. Young scientist award at IEEE EMBS 5th International Workshop on Biosignal Interpretation, September 6-8, Tokyo, Japan.

6. Summary

Current year 2005

First, the structural changes. Although the Research Group "Water Waves" has been in CENS from the very beginning of the Centre, it has moved from the Institute of Marine Systems under the umbrella of the Institute of Cybernetics. This move has consolidated the frontier research in water waves.

In 2005, the Programme for improving the infrastructure for Centres of Excellence was launched based in the EU Structural funds. As a result, CENS got funding in 2006 for a new computer cluster and for biomedical devices, meant for the Research Group "Nonlinear Signal Processing". The small lab was founded in musical acoustics by a generous gift (a concert piano) from Tallinn Piano Factory (A.Mägi).

Second, the research. In 2005, research in CENS has progressed well. The highlights were 4 new PhD's (A.Braunbrück, O.Ilison, R.Kitt, M.Säkki) who have completed their theses fully in CENS. New impetus for research was initiated by several cooperation projects. In May, 2005 the Marie Curie Transfer of Knowledge project CENS-CMA started. Dr. E.Quak is a senior research fellow in Tallinn for two years,

Prof. T.Soomere was the first CENS fellow to spend 3 months in Oslo. There are several positions both in CENS and in Oslo open for senior researchers and for post-docs (see Annex). The Estonian Programme for Centres of Excellence was the part of the ERA-NET Complexity first stage (SSA) and the application for the full ERA-NET was successful being now under final formulation. The MC Research and Training Network SEAMOCS, with CENS being the leader of one of the 4 work packages, was launched in November. Two INTAS projects with CENS participation were successful and now at their final stage of approval.

Research-based education is an important part of activities in CENS. In 2005, the curriculum "Technical physics" was accredited by an international team for all the studies, i.e. for BSc, MSc and PhD levels. This accreditation is for next 7 years. There is one part of education, initiated by CENS and now getting followers in EU. Namely, in 2004, an intensive week of tutorials and seminars was organized by CENS (see Annual Report 2004). In 2005, a similar intensive week was organized by our partners in Turin (Prof. F.Pastrone, University of Turin) and in 2006 it has moved to Nancy (Prof. J.Ganghoffer, University of Nancy). This is an excellent format for distributing knowledge on the graduate level together with research seminars.

In science - society direct relations year 2005 was very special for CENS. The January flooding at Western Coast of Estonia has brought the importance of knowledge clearly to the focus of the society and the media. Prof. T.Soomere was the main figure in it stressing the importance of forecasting based on research. The triple combination of high-level research, science-popular description and nerve for societal life has brought him the title "Person of the Year" by the Estonian daily newspaper "Postimees". This is not a research award, but it is a society award to a scientist for his message (see also Section 5.6).

Coming year 2006

Within the application for structural funds, the work plan for 2006 was specified. The main challenge for 2006 is to make a new application for the next Estonian Centres of Excellence Programme (the present one runs for 2003-2006). There are several summing up meetings or publications planned for 2006:

- the Proceedings of the ESF Programme NATEMIS will be published by Springer under the title "The Universality of Nonclassical Nonlinearity"; three chapters are authored by CENS fellows;
- the Euromech Colloquium 478 "Non-equilibrium Dynamical Phenomena in Inhomogeneous Solids" will be organized by CENS in Tallinn, June 13-16, 2005 (Co-Chairmen J.Engelbrecht and G.A.Maugin, Scientific Secretary A.Berezovski) - see also Annex;
- a special issue of the American Journal of Physiology - Cell Physiology will be edited by Dr. M.Vendelin under the title "Systems Biology of the Mitochondria".

In short, CENS follows simple principles:

- quality not quantity matters;
- graduate studies are linked to research;
- international co-operation is important.

Annexes:

- ◇ **Euromech Colloquium 478 – Call for papers**
- ◇ **Marie Curie ToK, CENS–CMA – Call for post-docs and fellows**
- ◇ **New and Emerging Themes in Industrial and Applied Mathematics – NETIAM**
- ◇ **Grand piano dynamics – experiments in CENS**

EUROMECH Colloquium 478

Non-equilibrium Dynamical Phenomena in Inhomogeneous Solids

Tallinn University of Technology, June 13 - 16, 2006, Tallinn, Estonia

Chairmen

Professor Jüri Engelbrecht
Centre for Nonlinear Studies
Institute of Cybernetics
Tallinn University of Technology
Akadeemia tee 21
12618 Tallinn
ESTONIA

Professor Gerard A. Maugin
Laboratoire de Modélisation en Mécanique
Université Pierre et Marie Curie
4 place Jussieu, case 162
75252 Paris Cedex 05
FRANCE

Scope of the Colloquium

Dynamic problems in the general area of deformation, damage initiation and growth, and failure of materials and structures require the effective prediction of material's properties and performance. Few materials are used solely in their ideal equilibrium state. Non-equilibrium phases can be associated with inherent abilities to undergo structural changes, which are manifested in rearrangement of particles, crack propagation, phase transformation, and inhomogeneities of various kinds.

The objective of the Colloquium is to present and critically discuss the state of the art, various mathematical formulations, constitutive modeling, and numerical simulations in the prediction of the response of such materials to various types of dynamic loading.

The goal of the Colloquium is to promote advances in the formulation and solution of real-life problems, with an emphasis on dynamical aspects, and with a multidisciplinary vision accounting for all the complex dynamics involved in the physical description.

Topics of the Colloquium include:

- Material-configurational forces at evolving singularities
- Phenomenology and numerical simulation of the non-equilibrium evolution of inhomogeneities
- Phase-transition front propagation
- Growth propagation in biological structures
- Crack dynamics

Several visiting positions for Experienced Researchers (4-10 years experience) and Senior Researchers (> 10 years experience) available at the

Centre for Nonlinear Studies (CENS)
http://cens.ioc.ee
Institute of Cybernetics
Tallinn University of Technology
Tallinn, Estonia

As part of the Transfer of Knowledge project CENS-CMA funded by the European Commission's Marie Curie Programme from May 2005 to April 2009, the Centre for Nonlinear Studies is looking for visiting researchers, typically for six-month appointments of Experienced Researchers (4-10 years experience, counted from the Master or Diploma degree) and for three-month appointments of Senior Researchers (more than 10 years experience, usually for a sabbatical term).

The interdisciplinary CENS-CMA project is carried out by CENS together with the Centre of Mathematics for Applications (CMA, http://www.cma.uio.no) at the University of Oslo, Norway, integrating modelling, theoretical and computational aspects and focussing on research related to biomechanics and nonlinear wave modelling.

The expectations on a research fellow are twofold: on one hand the visiting researcher should add to the research activities of CENS by contributing knowledge from subject areas that are not strongly represented there, but that complement the existing strengths of CENS. On the other hand an essential feature is also to take part in the training of young researchers and students through seminars and by contributing teaching material, also in electronic form. To further the popularisation of science, at least one presentation for a general audience is expected as well. Senior fellows are also expected to share their experience in the acquisition and management of large research projects, also in collaboration with industrial partners.

An electronic application should consist of a CV and a suggested work plan for a specified time period that addresses how the applicant intends to contribute in all the above-mentioned aspects. To demonstrate the opportunities for female researchers to young researchers and students, women are especially encouraged to apply.

Interested researchers are asked to contact the Chairman of the Steering Committee of the CENS-CMA project, Prof. Jüri Engelbrecht, at je@ioc.ee for further inquiries and more details concerning the opportunities within this project.

Unleashing Mathematics

A Driving Force for Industry and Society in Europe

Mathematics offers unique power and flexibility for exploiting opportunities for innovation across a broad spectrum of industry and society: its use will be crucial in achieving the European Union's ambition to become the world's most dynamic knowledge-based economy

NETIAM

The proposals in this document are the result of a meeting held at St Catherine's College, Oxford in July 2005 and are endorsed by the following participants.

Prof Jean-Pierre Bourguignon	Director, Institut des Hautes Études Scientifiques, Paris
Dr Melvin Brown	Technology Translator, Smith Institute
Prof Heinz Engl	Director, Johann Radon Institute, Austrian Academy of Sciences President, Austrian Mathematical Society
Prof Peter Grindrod	Chief Mathematician, Lawson Software
Prof Helge Holden	Norwegian University of Science and Technology President, European Consortium for Mathematics in Industry
Prof Julian Hunt	University College London Director, Lighthill Institute of Mathematical Sciences
Prof Rolf Jeltsch	ETH Zürich President, Gesellschaft für Angewandte Mathematik und Mechanik
Dr Philippe Lacour-Gayet	Chief Scientist, Schlumberger
Dr Robert Leese	Director, Smith Institute
Prof Robert Mattheij	Technische Universiteit Eindhoven
Prof Helmut Neunzert	Fraunhofer-ITWM, Kaiserslautern
Dr Hilary Ockendon	Oxford Centre for Industrial and Applied Mathematics
Dr John Ockendon	Research Director, Oxford Centre for Industrial and Applied Mathematics
Prof Mario Primicerio	Universitá degli Studi di Firenze President, Societá Italiana di Matematica Applicata e Industriale
Dr Ewald Quak	Tallinn University of Technology
Dr Mike Sheppard	Schlumberger Fellow, Schlumberger Cambridge Research
Prof Martin Taylor	University of Manchester Physical Secretary, Royal Society of London
Dr Bernardus Tubbing	DG Research, European Commission
Dr Aivars Zemitis	University College, Ventspils

This initiative is a direct result of the NETIAM project, coordinated by the Smith Institute and carried out as a Support Action under the European Commission's Framework 6 programme. If you would like to contribute to stimulating the wider use of mathematics in Europe please register your interest on the NETIAM website: www.netiam.net/Unleashing.

"Mathematics in the formulation of unexplored multidisciplinary challenges"

New and Emerging Themes in Industrial and Applied Mathematics

NETIAM

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Within the framework of the Estonian-French programme PARROT, the Tallinn Piano Factory built a special sample of a grand piano and presented it to the Institute of Cybernetics. Using their own experimental arrangements, Rene Causse and Philippe Zelmar from IRCAM (Paris) measured the piano bridge vibrations excited by the special B&K impact hammer. The results of these measurements are expected to clarify the process of wave transmission through the bridge to the excitation of the piano soundboard.

CENS

Institute of Cybernetics at TUT
Akadeemia tee 21
Tallinn 12618, Estonia
Phone: (+372) 620 4150
Fax: (+372) 620 4151
Prof. J.Engelbrecht, je@ioc.ee
Prof. H.Aben, aben@ioc.ee
Prof. M.Rahula (Tartu), rahula@math.ut.ee
Prof. H.Hinrikus, hiie@bmt.cb.ttu.ee
Prof. T.Soomere, tarmo.soomere@cs.ioc.ee

Internet: http://cens.ioc.ee