XXXII Summer School – Conference
"Advanced Problems in Mechanics"

June 24 – July 1, 2004, St. Petersburg (Repino), Russia

APM 2004

BOOK OF ABSTRACTS

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NUMERICAL SIMULATION OF NONLINEAR WAVES DESCRIBED BY THE STOCHASTIC KURAMOTO - SIVASHINSKY EQUATION

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We consider nonlinear wave processes described by the stochastic Kuramoto - Sivascinsky equation. The Kuramoto - Sivashinsky equation is one of the known equations that is used at the description of the turbulence processes. This equation is applied at the description of nonlinear processes in liquid films flowing down an inclined surface, reactant concentration perturbations in chemical reactions, combustion, electrostatic potential waves in toroidal systems, etc. It takes the form

$$u_t + u\,u_x + \alpha\,u_{xx} + \beta\,u_{xxx} + \gamma\,u_{xxxx} = \chi(t)$$

Where $u(x,t)$ is a function characterizing the deviation from equilibrium of the displacement, concentration, temperature, potential, etc., α, β and γ are constant coefficients, x is a coordinate, t is time and $\chi(t)$ is the value of the white noise that depends on time. One can see that the term with the second derivative in equation corresponds to the increase in kinetic energy in the system, while the term with the fourth derivative characterizes its dissipation This equation is the well known example where dissipation, dispersion and instability are taken into account.

One can expect and we show in the work that the Kuramoto - Sivashinsky equation does not pass the Painleve test and this equation does not belong to the exactly solvable equation. The Cauchy problems for this equation can not be solved by the inverse scattering transform. However this equation at $\chi(t) = 0$ has some exact solutions. Some of these exact solutions were found before in works [1, 2, 3]. These exact solutions and some new exact solutions in the form of the periodic and solitary waves are given in this work. Some rational solutions of the Kuramoto - Sivashinsky model are presented as well.

It is shown that the travelling waves of the Kuramoto - Sivashinsky model are unstable taking the Sobolev space into account. However taking the boundary value problems one can have stable solutions. We present the investigation of this question in the work.

Stability of the exact solutions by the numerical simulation is considered taking the boundary value problems into account. With this aim the difference equation for the numerical simulation of different problems by the Kuramoto - Sivashinsky equation is written. The choice of the effective difference equation taking some criterion into account is presented. Comparison of the numerical solution for nonlinear wave processes with exact solutions of the Kuramoto - Sivashinsky equation is given.

Some exact solutions are shown to be stable at some parameter values. Form of the initial conditions and parameter values to be stable solutions are found by the numerical simulation. It is shown that the dispersion coefficient is very important for the stability of the numerical simulation.

Particular emphasis has been placed on the investigation of the nonlinear wave problems described by the stochastic Kuramoto - Sivashinsky equation in the media with dispersion. Some boundary value problems are considered. The middle value influence of white noise at the structure formation is studied. It is found that the white noise value affects on the structure formation velocity but does not destroy the structure at some values of the problem parameters.

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ESTIMATING ATTENUATION, PHASE AND GROUP VELOCITY OF SURFACE WAVES OBSERVED ON A 2D SHALLOW SEISMIC LINE USING CONTINUOUS WAVELET TRANSFORM

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This contribution is concerned with the estimate of attenuation and dispersion characteristics of surface waves observed on a shallow seismic record. The analysis is based on a initial parameterization of the phase and attenuation functions which are then estimated by minimizing a properly defined cost function via a Levenberg-Marquardt inversion procedure. To minimize the effect of random noise on the estimates of dispersion and attenuation we use cross-correlations (in Fourier domain) of preselected traces from some region of interest along the survey line. These cross-correlations are then expressed in terms of the parameterized attenuation and phase functions and the auto-correlation of the so-called source trace or reference traces. Cross-corelation that enter the optimization are selected so as to provide an average estimate of both the attenuation function and the phase (group) velocity of the area under investigation. As the phase velocity is derived from the phase, and the group velocity from the amplitude maxima in the wavelet spectrum, these two quantities are differently affect by noise. It is therefore important to extract them independently in order to avoid propagating errors from the phase velocity estimate to the group velocity or vice versa. Using the presented approach in conjunction with the wavelet propagation operator (Kulesh et al., 2003) one can simultaneously obtain the attenuation function, the phase and the group velocity. Results from the application of this dispersion and attenuation analysis method are shown for both synthetic and real 2D shallow seismic data sets.

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ELEMENTARY DESCRIPTION OF THE SNAKEBOARD DYNAMICS

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In this work we study an elementary mathematical model of a variant of the skateboard, known as the snakeboard. The snakeboard allows the rider to propel himself in the forward direction without having to make contact with the ground. The snakeboard consists of two wheel-based platforms upon which the rider is to place each of his feet. These platforms are connected by a rigid crossbar (or x-bar) with hinges at each platform to allow rotation about the vertical axis. The equation of motion of a model are written in the Chaplygin form. The control law for the forward motion of the model is obtained. The computer simulation is performed for all theoretical results.

The work was supported financially by the Russian Foundation for Basic Research (04-01-00398) and by the grants "Advanced Russian Scientific School" (AS-2000.2003.1) and "Young Scientists PhD" (YS-1393.2003.01).

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A NEW APPROACH TO COMPLEX AND CHAOTIC DYNAMICAL SYSTEMS

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It is accepted that regular deterministic dynamical systems satisfy the principle: the more exact is a solution algorithm the closer will its results (observables) be to reality (experiments).

We show that for chaotic (moderate-dim.) and complex (multi-dim.) systems, algorithms with a given order of precision are becoming intrinsic components of the systems. In particular, the measures of chaos and complexity are functionals of algorithms. In the talk, we demonstrate a possibility of constructive definitions and realizations of optimal computer algorithms (OCA) that minimize these measures. We consider 2 levels: local and global.

Local level: a chaotic system with one attractor (e.g. Lorenz system). Steps: 1) renormalization to a preferable form with the origin at an (unstable) fixed point; 2) spherical representation; 3) discretization defined by a given precision lattice with Pythagorean nodes; 4) realizing each step as transition from node to node ⇒ a system of 'generic' discrete cycles (discrete chaos).

Statement: small variations of the algorithm (modulo a given precision) permit to obtain one (simple) discrete limit cycle ↔ **no chaos** ↔ OCA.

A possible explanation of this result and its generalizations is based on number theory, discrete groups, geometries, and gauge fields.

Global level: a complex system is realized as a global lattice consisting of cells, each of which constitutes one of indicated above chaotic systems with prescribed laws of interaction ⇒ the corresponding global OCA. Analogies: galaxy and local solar systems; coupled map lattices, cellular automata.

Applications of the approach to engineering, mechanical, biological systems, etc., are presented at this mini-symposium.

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OPERATOR APPROACH TO NONLINEAR DYNAMICS AND STOCHASTIC CONTROL OF CHAOS

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The one goal of this talk is to review recent developments in nonlinear dynamics relying on reduction of nonlinear differential or deference equations to the study of linear operators in appropriate functional spaces. These operators are Perron-Frobenius, Koopman or Liouville ones depending on the type of dynamics. As any operator approach it is essentially based on spectral properties of mentioned above operators playing the role of the evolution generators for dynamical systems. The spectral analysis requires a proper choice of functional spaces. In frames of developed approach a choice of appropriate space for observable is defined by physics of the system. We illustrate the approach by several specific chaotic systems. Another goal of the talk is to develop synthesis of operator approach together with ideas of stochastic control for study of some low-dimensional system. In particular, some results on the stochastic control of two-dimensional chaotic map, i.e. baker map are presented. The approach is based on the probabilistic coupling of the controlled dynamics with a controlling system and subsequent lift of the coupled dynamics in a suitable functional space. The lifted dynamics is described in terms of probability densities and is governed by linear Perron-Frobenius and Koopman operators. Sufficient condition of controllability and estimation of time to achieve control for a given accuracy in terms of spectral decomposition of Perron-Frobenius operator are obtained.

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