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Editorial

Special issue of Wave Motion - "Nonlinear waves in solids: in memory of Alexander M. Samsonov"

This special issue of *Wave Motion* is dedicated to the memory of Professor Alexander M. Samsonov (30.09.1948 - 07.10.2017). Our aim is to present recent research in the area of *"Nonlinear Waves in Solids"*, where Professor Samsonov has made many pioneering contributions.

Alexander Samsonov was born on September 30, 1948 in St. Petersburg, Russia. He graduated from the Physics and Mechanics School of the Leningrad Polytechnic Institute (now the Peter the Great Saint Petersburg Polytechnic University) in 1972. Alexander obtained his PhD degree in 1979 for his work in Optimal Control Theory under the supervision of Prof. K.A. Lurie. In 2002 Alexander was awarded a Doctor of Science degree in Theoretical Physics for studies on the subject of "Nonlinear elastic waves theory for solid waveguides" in the Ioffe Institute of the Russian Academy of Sciences. He worked in this famous Institute from 1979, going through the ranks from a Junior Research Fellow to the Head of the Solid State Theory Division. From 2005 Alexander was also a Professor of Applied Mathematics at the Peter the Great St. Petersburg Polytechnic University.

Throughout his career Alexander's main research was in the area of nonlinear bulk strain solitary waves in solid waveguides. Alexander has initiated and developed, together with his students and collaborators, a new research direction which, eventually, formed the basis for the book [1]. His work included the development of mathematical models of Boussinesq type describing long nonlinear longitudinal bulk strain waves in various elastic waveguides (e.g., rods, plates, shells, etc.) within the scope of the Murnaghan model of nonlinear dynamic elasticity, and application of the derived model equations to the description of solitary waves and their evolution in various non-homogeneous waveguides (e.g. rods of variable cross-section, layered waveguides, etc.) using analytical approaches and direct numerical simulations. Alexander has inspired and guided some invaluable and detailed experimental work carried out in the Ioffe Institute. The experimental group originally included Yury Ostrovsky, Galina Dreiden and Irina Semenova. Together, they worked on the generation and observation of longitudinal bulk strain solitary waves in various solid waveguides.

Alexander had very broad research interests. In particular, he worked on application of methods of nonlinear mathematical physics to computational and systems biology, including, but not limited to, modelling of gene networks controlling early Drosophila embryogenesis [2], mechanistic aspect of molecular transport [3], as well as of the microRNA regulatory role in cells [4].

Alexander was a passionate and inspiring teacher for his students and younger colleagues, dedicating much of his time to their training, and challenging them to think creatively and independently. Many of these young scientists now also work on various waves-related problems. Alexander's ideas continue to influence researchers working in the area of nonlinear waves in solids.

Alexander was a very optimistic person loving travel, literature, photography, fine arts and music, of which German and Italian operas were his favourites. We will always remember him as a wonderful colleague and friend. We hope that this special issue will serve both as a reference for those who are already actively working on nonlinear waves in solids, and will help to engage a new generation of researchers.

The special issue includes 11 papers devoted to various aspects of nonlinear waves in solids, including analytical, numerical and experimental developments.

The paper by A. Pau and F. Vestroni [5] belongs to the classical area of acousto-elasticity, and is devoted to a detailed study of the individual effects of material and geometric nonlinearities on the changes in shear and longitudinal speeds of bulk waves, and their polarization as a function of the initial pre-stress. Three types of pre-stress are considered: hydrostatic, biaxial and uniaxial pre-stress. It is shown that material nonlinearity has a significant effect on the amount of speed change, and that pre-stress can lead to anisotropic behaviour and coupling between shear and pressure waves.

The derivations of model equations describing long weakly nonlinear longitudinal bulk strain waves in elastic rods are revisited within the scope of the Murnaghan model in the paper by F.E. Garbuzov et al. [6]. Two forced Boussinesq-type models are derived for a circular rod with axially symmetric loading and longitudinal pre-stretch from the full problem formulation using the presence of small parameters. Basic dynamical properties of the models are compared, and the equations are suggested as models for the related experimental research.

Soliton solutions of a Boussinesq-type equation with displacement-type nonlinearities linked to the Heimburg-Jackson model describing longitudinal waves (density charge) in biomembranes are investigated in the paper by T. Peets et al. [7]. The possibility of the existence of a soliton doublet, an ensemble of two co-existing

solitary waves moving with the same velocities but different amplitudes, is shown using phase plane analysis and numerical simulations.

M.R. Tranter considers the propagation of a solitary wave in non-homogeneous layered bars described by a system of coupled Boussinesq-type equations with piecewise-constant coefficients subject to continuity of displacement and stress on the boundaries with the help of numerical simulations [8]. The numerical scheme is applied to describe the transmission and reflection of longitudinal waves in layered waveguides with delamination, extending previous studies.

Numerical simulations are also used in the paper by A. Salupere and M. Rätsep [9] to study the formation and interaction of solitary waves within the scope of the so-called hyperelastic rod equation, earlier suggested as a model for waves with moderate wavelength. The model constitutes a modification of the Korteweg - de Vries equation and contains three arbitrary parameters. The authors are particularly concerned with the effect of these parameters on the nature of solutions.

The paper by O.V. Rudenko and C.M. Hedberg [10] is devoted to nonlinear waves in a lattice with holonomic constraints: atoms can move only along parallel lines. The dynamics of the lattice is studied in the continuum approximation, and a new equation is derived to describe the waves. It is shown that the structure exhibits anisotropic properties similar to a skeletal muscle with stretched fibres. Particular solitary wave solutions of the derived equation are studied in detail.

Nonlinear waves in a lattice are also studied in the paper by A.V. Porubov and A.E. Osokina [11]. Plane longitudinal waves in a 2D graphene-type hexagonal lattice are considered in the continuum approximation, and a Boussinesq-type equation similar to the equation describing longitudinal waves in a rod is obtained. The model is geometrically linear, but includes nonlinear terms in the potentials of interactions between the particles of the lattice.

Propagation of elastic waves in damaged media is modelled by H. Berjamin et al. [12]. A constitutive model combines Murnaghan model for hyperelasticity with an additional evolution of a scalar variable characterising the long-time softening of the material. The equations of motion are cast into the form of a nonlinear hyperbolic system of conservation laws and solved numerically using a finite-volume method. In particular, the generation of solitary waves in a periodic layered medium is described.

The paper by R. De Pascalis et al. [13] is devoted to the modelling of the shearing motions within the quasi-linear viscoelastic model widely used to investigate processes in soft tissues and bio-materials. Kink-type solitary waves are studied with the help of the derived nonlinear second-order ordinary differential equation. It is shown, for the stress relaxation function in the form of a Prony series, that kinks can exist for strongly elliptic strain energy, but not for the Mooney-Rivlin model. The Yeoh model is studied using numerical simulations.

P. Zhu and H.-H. Dai consider a 3D internal-variable formulation for a propagating phase boundary in a shape memory alloy bar in order to obtain an extra admissibility condition for the solution of the problem [14]. The derived condition is then used in the study of an impact problem, and the unique solution is constructed analytically for all possible values of the impact velocity. Comparison is made with the results obtained using the maximal dissipation rate criterion.

A.T. Il'ichev and V.Ja. Tomashpolskii [15] study the effect of a pre-stressed ice cover on the evolution of nonlinear surface envelope waves. The ice cover is modelled as a Kirchhoff-Love plate of considerable thickness. The fluid motion is described by the two-dimensional Euler equations including the additional pressure from the freely floating plate. The envelope solitary waves are studied in detail. The characteristic values of the wavelength and wave velocity are determined depending on the fluid depth and ice thickness.

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