Preface

Generalized Continua are in the focus of scientists from the end of the 19th century. A first summary was given in 1909 by the Cosserat brothers[1] and some previous works of such famous scientists like Lord Kelvin. All these contributions were focussed on the fact that in a continuum one has to define translations and rotations independently (or in other words, one has to establish force and moment actions as it was done by Euler).

After World War II a true renaissance in this field occurred with a publication of Ericksen & Truesdell in 1958. Further developments were connected with the fundamental contributions of, among others, Kröner (Germany), Aero and Palmov (Soviet Union), Nowacki (Poland), Eringen (USA), and Maugin (France). The reason for the revival was that some effects of the mechanical behavior of solids and fluids could not be explained by the available classical models. Examples of this are the turbulence of a fluid or the behavior of solids with a significant and very complex microstructure. The enthusiasm in this field was so great that the International Union of Theoretical and Applied Mechanics (IUTAM) in the mid 1960s decided to organize a special IUTAM-Symposium in 1967 in Stuttgart-Freudenstadt (Coordinator E. Kröner). The state of the art was then summarized and published by Springer[2].

Since the suggested models fulfill all requirements from Continuum Thermomechanics (the balance laws were formulated and the general representations of the constitutive equations were suggested) the scientific community was satisfied for a while but missed real applicative developments. Indeed, for practical applications the proposed models were not useful. The reason for this was a gap between the formulated constitutive equations and the possibilities to identify the material parameters. As often the case one had much more parameters compared to classical models. In addition, computational progress and available machines in these times

[1] E. et F. Cosserat: Cosserat, F.: Théorie des Corps Déformables, Hermann Editeurs, Paris, 1909 (Reprint, Gabay, Paris, 2008)

[2] E. Kröner (Ed.): Mechanics of Generalized Continua (Proceedings of the IUTAM-Symposium on the Continuum Theory of Dislocations with Applications, Freudenstadt and Stuttgart, Germany, 1967), Springer, Berlin/Heidelberg/New York, 1968

were limited. So from the end of the 1960s until the 1990s, there were only a few members of the scientific and engineering communities working in the field of Generalized Continua.

During the last ten years the situation has drastically changed. More and more researches emerged, being kindled by the partly forgotten models since now one has available much more computational possibilities and very complex problems can be simulated numerically. In addition, with the increased attention paid to a large number of materials with complex microstructure and a deeper understanding of the meaning of the material parameters (scale effects) the identification becomes much more well founded. We have thus contributions describing the micro- and macro-behavior, new existence and uniqueness theorems, the formulation of multi-scale problems, etc., and now it is time to ponder again the state of matter and to discuss new trends and applications. Strong interest in the field was checked and kindled by the two colloquia held in Paris in 2009 and celebrating the centennial of the Cosserats' book. The results of the first symposium were published again by Springer[3].

The present publication is a collection of papers of French, German and Russian scientists in field of *Generalized Continua*. France, Germany and Russia have a long tradition in the above mentioned research area. Under the leadership of Gérard Maugin new research directions were established within this topic. In Germany the research in this field was stimulated by Kröner, Lippmann, Besdo, and Rothert among others. Actual applications are directed to the modeling and simulation of continua with complex microstructure like foams or porous media. In Russia, starting with the pioneering works of Aero et al. and Palmov many new models for structural mechanics applications (rods, plates, and shells) were presented.

During the last years there were established a small number of common projects of these scientists (for example, Altenbach & Eremeyev worked out new models for plates made of foams based on the micro-polar elasticity and the Cosserat plate theory, Maugin & Porubov worked on nonlinear waves in micro-structured bodies; Maugin & Lazar worked on defects in generalized continua, Forest & Sievert worked on anelasticity in generalized continua). New research directions will be presented from the point of view of modeling and simulation, experimental identification, and numerical methods. The basics were discussed at the First trilateral French-German-Russian seminar held in Lutherstadt Wittenberg (Germany) August 9–11, 2010. The contributions to the present publication are focussed on the most recent research items, i.e.,

- new models,
- application of well-known models to new problems,
- micro-macro aspects,
- computational effort,
- possibilities to identify the constitutive equations, and

[3] G.A. Maugin, A.V. Metrikine (Eds): Mechanics of Generalized Continua: One Hundred Years After the Cosserats, Advances in Mathematics and Mechanics Vol. 21, Springer, Berlin, 2010

- old problems with incorrect or non-satisfying solutions based on the classical continua assumptions

During the Wittenberg seminar the following lectures were presented

- Gérard Maugin: An historical perspective of generalized continuum mechanics
- Patricio Neff: Subgrid interaction and micro-randomness. Novel invariance requirements in infinitesimal gradient elasticity
- Jean-François Ganghoffer: Construction of micropolar continua from the discrete homogenization of repetitive beam lattices
- Alexey Porubov: Nonlinear dynamic processes in media with internal structure
- Evgeny Lomakin: Constitutive models of mechanical behavior of media with stress state dependent material properties
- Anton Krivtsov: Modeling of media with microstructure at different scale levels using particles
- Wolfgang Ehlers: Coupling of discrete media and continuum mechanics: a computational approach towards micropolar continua
- Paul Fischer: Cahn-Hilliard generalized diffusion modeling using the C^1 natural element method
- Igor Shardakov: Couple stress effects in elastic materials (analytical and numerical solutions, experiments)
- Lalaonirina R. Rakotomanana: Some remarks on the invariance of Lagrangean function of higher gradient continuum
- Albrecht Bertram & Samuel Forest: An axiomatic framework for gradient materials
- Victor Eremeyev: On the application of generalized continua models to structural mechanics problems
- Elena Ivanova: On one model of generalized continuum and its thermodynamical interpretation
- Rasa Kazakevičiūtė-Makovska: Micromechanical basis of superelastic behavior of certain biopolymers
- Dmitry Indeitsev: Kinetics of chemical reactions in deformable solids with dynamic loading
- Stéphane Berbenni: Internal length scale effects on the local and overall behaviors of polycrystals
- Mikhail Karyakin: Theory of isolated and continuously distributed disclinations and dislocations in micropolar media
- Denis Sheydakov: Buckling of elastic composite rod of micropolar material subject to combined loads
- Céline Chesnais: Generalized media and structural dynamics
- Vladimir Erofeev: Nonlinear waves in the Cosserat Continuum with restricted rotation
- Rainer Glüge: Elastic modeling of deformation twinning
- Daniel Scharding: Parameter identification for extended continua
- Arthur Lebée: A full bending gradient theory for periodic plates homogenization

- Thomas Michelitsch: Wave propagation in quasi-continuous linear chains with self-similar harmonic interactions - towards a fractal mechanics
- Qi-Chang He: Symmetry classes of flexoelectricity
- Sergey Gerasimov: Visualization at studying hydrodynamic instability in strong media

Contributions in this book provide in print a large selection from these lectures.

Such a publication can be realized only with generous support of different people and organizations. So we have to acknowledge:

- Dipl.-Ing. Andreas Kutschke and Prof. Victor A. Eremeyev for fulfilling the organizational duties during the Trilateral seminar,
- Mrs. Dipl.-Ing. Barbara Renner, Mrs. MSc Oksana Ozhoga-Maslovskaja, MSc Adili Maimaiti, MSc Ivan Lvov, Dipl.-Ing. Andreas Kutschke and Prof. Victor A. Eremeyev for the assistance in the manuscript preparation,
- Dr. Christoph Baumann from Springer for supporting the project and solving a lot of difficulties, and last but not least
- the Leucorea administration for organizing the hosting in Wittenberg.

Finally, it should be noted that the Deutsche Forschungsgemeinschaft, the Russian Foundation of Basic Research and the French partner organization CNRS gave financial support for the realization of the project.

Halle, *Holm Altenbach*
Nizhny Novgorod, *Vladimir I. Erofeev*
Paris, *Gérard A. Maugin*
December 2010

http://www.springer.com/978-3-642-19218-0

Mechanics of Generalized Continua
Altenbach, H.; Maugin, G.A.; Verichev, N. (Eds.)
2011, XX, 352 p., Hardcover
ISBN: 978-3-642-19218-0