Preface

In this book three different areas of modern science are joined together and studied: two quite recent topics:

- micro- and nano-mechanics of composite materials, and
- the wavelet analysis as applied to physical problems

(both started to be deeply investigated at the end of the 1980s), and a third new one

- propagation of a new type of dispersive waves (solitary ones) in composite materials.

Dispersive waves, i.e. waves with phase velocity depending on the phase, were actively explored in the last ten years within the classical theory of elastic waves propagation. They are nonlinear waves and show some unpredictable and outstanding nonlinear effects in the propagation. We found, as a common link of these three topics, the ability of wavelet analysis to perfectly describe some of the many nonlinear physical phenomena which arise in problems on composite materials, with micro- and nano-structure (and propagation therein).

We begin by presenting each of the three parts in the simple and easily understood form, because the new area of the application of wavelet analysis, nano-materials and waves in nano-composites, can be very interesting for specialists working with wavelets, as well as the techniques from wavelet analysis can be useful for specialists working in mechanics of materials. The three parts concern with quite new fields of science and research and for this reason many conceptual facts are still in progress and under assessment.

Thus we figure out a wide circle of readers and form the structure of the book in the understanding that some readers, maybe unprepared on all subjects, can nevertheless obtain a sufficient preliminary information. The specialists in each topic will find, instead, a full description of open problems and many suggestions for further new investigations. Our goal is to prepare readers to a

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clear understanding of the procedures and techniques, which unify three different scientific areas into a new one and to inspire some readers to explore the more advanced aspects of this new promising scientific direction.

The book consists of five chapters (Chapters 2 – 6).

Chapter 2 has 11 sections and is thought by the authors as primary and introductory information about wavelet analysis. Two facts are shown as having a key role in wavelet theory: the link (similarities and distinctions) of wavelet analysis with Fourier analysis and the notion of frames, as in classical functional analysis.

Chapter 3 presents the updated established understanding of materials with internal structure. Eight sections contain the primary information about materials from the notion of the internal structure of macro-, meso-, micro-, and nano-levels till the useful computer modeling data on real micro- and nano-composites. We paid special attention to composite materials as the main representatives of materials having an internal structure. The basic models used in the modern studies of composite materials are shown and commented on.

Chapter 4 is devoted to the analysis of waves in materials. It includes five sections, which cover fully the topic under consideration. The main purpose of this chapter is to give a sufficiently clear and simple representation of linear and nonlinear processes of elastic wave propagation in materials.

Chapter 5 deals with the solitary waves in structured elastic materials. From this chapter we start with applications and form the skeleton of a new field in the analysis of material where: i) the object is defined as solitary waves, ii) the model is taken from wave analysis and mechanics of materials, and iii) the tools of analysis combine techniques from wave analysis and elastic wavelet analysis.

Chapter 6 is the closest chapter to applications and computer simulation. It consists of six sections representing different stages of computer modeling. The regularities of propagation of solitary waves with different initial profiles are studied, by using the elastic wavelet technique. The main attempt is to show the ability of elastic wavelet technique to describe adequately the evolution of the wave initial profile as the fundamental phenomenon accompanying the solitary wave propagation. The mentioned technique is described in the most clear and open form, which ensures using all procedures in the new more advanced problems.

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