Doctoral School of Information and Biomedical Technologies Polish Academy of Sciences

Supervisors, contact, place of research

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General subject

Theoretical and numerical modeling of phenomena used in ultrasound technologies

A series of biotechnologies, diagnostic methods of materials and tissues, including diagnostics and medical ultrasonography and therapeutic methods, uses devices that generate, receive and process acoustic and ultrasound disturbances. The advancement and quality of these methods depends on:

- skills in forming of the space-time characteristics of ultrasonic beams
- knowledge of phenomena accompanying propagation resulting, for example, from stochastic heterogeneity of the medium of its non-linearity or loss, formation of secondary thermomechanical effects (favorable or not beneficial for the state of biological tissue)
- skills of detecting the fields scattered on heterogeneities and proper analysis and processing of the received signal (searching for characteristic features).

In each of these ranges of activity, we observe constant progress despite the fact that their mathematical and physical foundations have been known for decades (electromechanical models of acoustic fields sources, linear and non-linear theory of the sound propagation, dispersion theory, generation and heat transfer in the acoustic field, information theory and signal processing). The decisive factors of this progress are and will remain own ingenuity, intuition and a degree of understanding of phenomena. However, these are qualitative and individually limited tools and, in the end, they must be quantified through experiment.

The process of constructing devices using ultrasounds (choosing the right initial concept or improving existing devices with the small changes method) for testing biological materials and tissues can be much more efficient if we can construct a numerical model of the phenomenon and research method, that is, before conducting the experiment, we can perform a numerical experiment. In the end, it can be a great fun "reinforcing" our intuitions and skills.

We have tools for numerical modeling of experiments - solvers of linear and non-linear wave equation with codes visualizing these solutions; solvers of a scattered field.

We have laboratories equipped with devices enabling: signal transmission and detection also in synthetic aperture (SA) technology, transmissions of coded ultrasonic pulses and signal filtration.

The proposed examples of specific topics:

- numerical and theoretical models of stochastic biological media (tissue and pathology of tissues) and ultrasound echoes from such materials.
- the acoustical radiation force in continuous heterogeneous medium, the phenomenon of streaming and the control of suspension flow.
- non-linear propagation and non-linear scattering of ultrasonic fields
- theoretical and numerical model of creating an acoustic image (signal) with a high signal/noise ratio.

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