

In Memoriam

Janusz Wójcik Professor of the IPPT PAN



1957–2023

Janusz Wójcik was born in the heart of Poland near Czarnolas in August 1957. He obtained an M.Sc. Eng. degree at the Warsaw University of Technology in 1983. From 1984 until the last days of his life, he worked at the Institute of Fundamental Technological Research Polish Academy of Sciences in Warsaw. He received his doctoral degree on the basis of the dissertation “Non-linear Envelope Waves in The Vlasov-Maxwell Plasma” in 1990. In 2004, he was given a permanent position of IPPT PAN professor and a year later he was appointed Head of the Ultrasound Introscopy Laboratory at the Department of Ultrasound.

From the beginning of his work his scientific activity was focused on the thermodynamics of ultrasonic waves in tissues modeled as fluids. The theoretical description of thermal effects occurring under the influence of ultrasonic waves on tissues is of fundamental importance not only in planning thermal therapies (hyperthermia) used in medicine but also in the elucidation of attenuation phenomena to improve the quality of medical ultrasonography.

Among the many issues addressed by Professor Janusz Wójcik, one included, e.g., the quantitative determination of the transient temperature increase in lithotripsy (1991), the temperature increase in focused Gaussian ultrasonic beams at various insonation times (1993), the temperature increase for three-layer and

four-layer two-layer model of obstetric tissue in cases of non-linear and linear ultrasonic propagation (1999). He computed also possible temperature effects for acoustic microscopy used for living cells (2004), analyzed the phenomena related to the nonlinear reflection and transmission of plane acoustic waves (2001), and solved theoretically and numerically the aspects of nonlinear reflection–transmission phenomena in acoustics (2018).

The most important scientific achievement of Professor Janusz Wójcik was the introduction, for the first time in the world, of non-local equations for a liquid lossy medium, published in the article “Conservation of energy and absorption in acoustic fields for linear and nonlinear propagation”, *JASA*, 1998.

In 2000, he completed his habilitation thesis “Energy Transport in the Field of Ultrasonic Waves”, which summarized the above results.

In the following years, Professor Wójcik studied the scattering of scalar waves in complex media, modeled systems processing scalar waves in stochastic media, and built a numerical solver for such calculations. He developed a numerical environment for modeling stochastic tissue structures and determining echoes of scattered scalar ultrasonic waves in tissues to search and study the correlation of structure features with the statistical characteristics of echoes. These studies

were focused on improving diagnostic tools for pathological changes in the structure of spongy bone and in arterial walls, and heart tissue dynamics.

Professor Janusz Wójcik was the author and co-author of nearly 100 scientific papers published in the best acoustics journals and several dozen papers presented at international conferences. His works constitute an important contribution to the foundations of understanding the phenomena of nonlinear fluid dynamics; in particular, they allowed the study of the influence of nonlinearity on the thermal effects of sonication and ultrasonic streaming phenomena in fluids.

The center of Janusz Wójcik's interests has always been the fundamentals of physics and mathematics in applied acoustics. He was passionate about them until the end of his life, even in poor health, he was discovering new paths and scientific truths, his two recent publications are the best proof of this. The first of these publications, "Analytical Solution of the Nonlinear Equations of Acoustic in the Form of Gaussian Beam" (2022) makes a significant contribution to applied mathematics by proposing an analytical form of solving nonlinear acoustic equations in the form of a Gaussian beam, and the second publication, "Derivation of Acoustical Streaming Equations for Nonlinear and Dispersive Fluids" (2023) constitutes a theoretical basis for explaining and modeling the physical phe-

nomenon of the so-called acoustic streaming. In the second paper, he obtained formulas that generalize the known descriptions of the form of forces driving streaming and extend their application to the case of nonlinear propagation.

It should be emphasized that Professor Janusz Wójcik was able to cooperate with other scientists, he was always full of enthusiasm and willing to help in solving problems. He passed on his knowledge and made his numerical software available to both his colleagues and younger science students, for whom he lectured during their doctoral studies at IPPT PAN.

Professor Janusz Wójcik was the Deputy Editor-in-Chief of *Archives of Acoustics*.

His scientific contribution to the nonlinear acoustic allows us to remember the Horatian *non omnis moriar*.

We will remember Janusz Wójcik not only as a great scientist, but as a man with a big heart, cheerful, kind to everyone, and, above all, incredibly heroic in the last months of his serious illness, working until the last days of his life.

Janusz Wójcik passed away on September 4, 2023.

We have lost a dear colleague and sincere friend.

Barbara Gambin, Andrzej Nowicki,
and the Editorial Board of *Archives of Acoustics*