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Acoustical Society of America Silver Medal In Physical Acoustics 2017: Evgenia Zabolotskaya FREE

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ACOUSTICAL SOCIETY OF AMERICA

Silver Medal in

Physical Acoustics

Evgenia Zabolotskaya

2017

The Silver Medal is presented to individuals, without age limitation, for contributions to the advancement of science, engineering, or human welfare through the application of acoustic principles, or through research accomplishment in acoustics.

PREVIOUS RECIPIENTS

Isadore Rudnick	1975	Robert E. Apfel	1997
Martin Greenspan	1977	Gregory W. Swift	2000
Herbert J. McSkimin	1979	Philip L. Marston	2003
David T. Blackstock	1985	Henry E. Bass	2006
Mack A. Breazeale	1988	Peter J. Westervelt	2008
Allan D. Pierce	1991	Andrea Prosperetti	2012
Julian D. Maynard	1994		

CITATION FOR EVGENIA ANDREEVNA ZABOLOTSKAYA

". . . for contributions to nonlinear acoustics and bubble dynamics"

NEW ORLEANS, LOUISIANA • 6 DECEMBER 2017

Evgenia (Zhenia) Andreevna Zabolotskaya was born and raised in Moscow. Her grandfather worked as a janitor in the Kremlin and lived there with his family before and after the Russian Revolution, and during the 1930s the Soviet secret police took her mother away from their home for several days because she was active in her church. Zhenia demonstrated a proclivity for math and physics at a young age, so it was no surprise that she was admitted to the prestigious Physics Department at Moscow State University (MSU), where some of her classes were taught by none other than Lev Landau, who received the Nobel Prize in Physics in 1962. She still recalls Landau's intimidating challenge on the first day his electrodynamics class, "If you do not understand quantum mechanics, you should think about whether you have chosen the right path in life."

While at MSU, Zhenia met Yurii (Yura) Ilinskii, a remarkable young theoretical physicist. After Zhenia and Yura graduated, she with her bachelor's degree and he with his PhD, both were employed at the Electro-Mechanics Institute in Moscow, where they started dating, and in 1963 they married. That same year Zhenia returned to MSU to pursue a PhD in the Wave Processes Chair under Rem Khokhlov in the Physics Department. By the 1970s, the work conducted in Khokhlov's chair made MSU a leading international center for theoretical nonlinear acoustics and, even more influentially, for nonlinear optics.

Zhenia was among the first graduate students in Khokhlov's nonlinear acoustics group. Other members of the group at that time included Stepan Soluyan, Oleg Rudenko, Vyacheslav Kuznetsov, and Nellie Pushkina. One of Zhenia's four papers that culminated in her PhD in 1968 contained nothing less than a model equation for nonlinear bubble dynamics that became widely used in the former Soviet Union instead of the Rayleigh-Plesset equation that was used extensively in the West [Sov. Phys. Acoust. 13, 254 (1967)]. The same paper also contained the first effective medium theory for nonlinear propagation of sound in bubbly liquid.

In 1966, while still a doctoral student, Zhenia joined the Acoustics Institute in Moscow, sharing an office with other Khokhlov protégés Anna Polyakova and Konstantin Naugolnykh. After receiving her PhD, her continued collaboration with Khokhlov produced one of the most famous advances in twentieth-century nonlinear acoustics: the Khokhlov-Zabolotskaya equation for nonlinear sound beams [Sov. Phys. Acoust. 15, 35 (1969)]. The KZ equation became known as the KZK equation after Kuznetsov added a term accounting for losses in 1970.

The impact of the KZK equation on practical applications of nonlinear acoustics, whether biomedical, industrial, or sonar related, cannot be overstated. Originally important for describing nonlinear effects in sonar (1970s and 80s), for the past two decades the KZK equation has provided the main theoretical basis for modeling HIFU (High Intensity Focused Ultrasound), a therapeutic procedure for treating cancer. Reports of modeling HIFU using the KZK equation are now presented routinely at ASA meetings. Subsequent work by Zhenia with mathematicians Nikolai Bakhvalov and Yakov Zhileikin was published in 1982 in their book *Nonlinear Theory of Sound Beams*, which was deemed so groundbreaking that it was translated into English by Robert Beyer for the American Institute of Physics.

Zhenia returned to MSU in 1971 where she was appointed not in the Physics Department but, interestingly, in the Biology Department, and in 1982 she joined the General Physics Institute of the USSR Academy of Sciences. In 1985 she was awarded the USSR State Prize for her overall contributions to nonlinear acoustics, a level of recognition that today is bestowed in the Kremlin and accompanied by personal congratulations from the Russian president.

Zhenia's path to the United States began unwittingly in 1982 in Tallinn, Estonia, where she encountered David Blackstock from the University of Texas at Austin (UT), basically

Khokhlov's American counterpart in nonlinear acoustics, at a symposium on nonlinear deformation waves. Blackstock maintained contact with Zhenia following that symposium, and in 1987 he encouraged her to meet his UT faculty colleague and former graduate student Mark Hamilton at the International Symposium on Nonlinear Acoustics to be held that August in Novosibirsk, in the heart of Siberia. Zhenia and Mark hit it off, because his research at the time was based largely on the KZK equation, and in 1988 he returned to the USSR specifically to visit her.

Zhenia then visited Hamilton in the Mechanical Engineering Department at UT for several months in both 1989 and 1990, and in 1991 she moved to Austin with Yura and their two daughters. She immediately published a theoretical model for nonlinear Rayleigh waves [J. Acoust. Soc. Am. 91, 2569 (1992)], a type of interface wave in solids, initiating a line of research that continued for over a decade. In collaboration with UT students, her fundamental theory was extended to include Scholte and Stoneley waves, and also surface waves in anisotropic and piezoelectric materials. Nonlinear interface waves are generated on very large scales by earthquakes and on very small scales by piezoelectric actuators in microfluidic and SAW (Surface Acoustic Wave) devices.

In 1997 Zhenia and Yura took a position at a startup company in Virginia at which two former UT doctoral students hired them to develop theoretical models for nonlinear sound fields in resonators. Zhenia and Yura returned to UT's Mechanical Engineering Department in 2000 to work on nonlinear phenomena in thermoacoustic engines. Then in 2003 UT's Applied Research Laboratories hired Zhenia and Yura to initiate a research program in biomedical acoustics. This appointment enabled Zhenia to return to one of her original research interests, nonlinear bubble dynamics, but this time for medical applications such as shock-wave lithotripsy.

Zhenia and Yura retired from their research staff positions at UT in February 2015. They continue to live in Austin where they remain engaged in acoustics research at UT, as well as consult for a startup company in Massachusetts for which they model particle manipulation with acoustic radiation force.

Zhenia's contributions to theoretical nonlinear acoustics are prolific and foundational. Her publications are not only exclusively on nonlinear acoustics but equally divided between *Soviet Physics-Acoustics* in the first half of her career and the *Journal of the Acoustical Society of America* in the second half. The name Zabolotskaya is justifiably iconic in the history of nonlinear acoustics.

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