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### Guest Editorial: Sono Et Gravitass: The Legacy Of Robert Edmund Apfel

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## **Guest Editorial:** ***Sono et Gravitās* -- the Legacy of Robert Edmund Apfel**

In memory of Robert Edmund Apfel and in celebration of this past ASA president's contribution to rapid, online publishing of technically-oriented acoustics papers, this special edition of Acoustics Research Letters Online (ARLO) is entitled *Apfel's Acoustics Articulations*. Known as "Bob" by his friends and colleagues, "Rob" to his family, and "Apfel" by his students (who coined the word "Apfelian" to describe anything that is simultaneously clever and elegant), Robert E. Apfel's life and work continues to have a transformative effect on acoustics research and pedagogy. The Acoustical Society of America was his professional homeland, though he belonged to many other societies. The ASA awarded him the R. Bruce Lindsay Award at age 33, the Silver Medal in Physical Acoustics at 54, and its highest award, the Gold Medal, barely two months before his death at age 59. Robert Apfel's leadership in the Society is described in the encomium for his Gold Medal (J. Acoust. Soc. Am. 111(5), 2406 (2002)), including his term as President of the Society (1995-96) during which he set in motion the creation of ARLO.

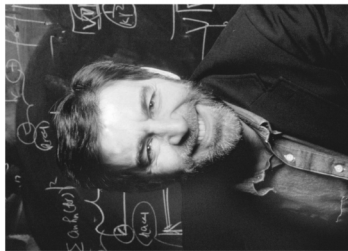
Born in New York City in 1943, Robert Apfel attended Tufts University, where he developed a fondness for both physics and his future wife, Nancy. After a summer spent working at Bolt, Beranek & Newman, in Cambridge, MA, he enrolled at Harvard University and served as a research assistant in F.V. Hunt's acoustics laboratory. Apfel was one of Hunt's last Ph.D. students and his dissertation work contributed to the understanding of the tensile strength of liquids by observing cavitation in superheated drops that were acoustically levitated. This research won Apfel his first award, the A.B. Wood Medal by the Institute of Physics (Great Britain) in 1971, after a year's postdoc in Hunt's lab. That same year, Apfel accepted a position in Engineering and Applied Science at Yale University, where he subsequently taught for 30 years. At that time, he had already published a dozen or so papers, on topics as diverse as auditorium acoustics, low-frequency noise reduction in spacecraft, and the role of impurities in cavitation nucleation.

At Yale, Robert Apfel attracted graduate students (see Fig. 1) whose research interests covered a wide range of topics, including neutron dosimetry, nonlinear properties of mixtures, the safety of diagnostic ultrasound, and control mechanisms of the human spine. Indeed, it is his excellence as a mentor that endeared Robert Apfel to generations of future acousticians. Striking a balance between micromanagement and benign neglect, Apfel would meet with students regularly to help "debug" their apparatus or derivations, often suggesting a very different approach or perspective from that which the student had adopted. His students thus learned to work independently and to collaborate with other laboratory members to create a fresh reformulation of the problem under Apfel's gentle guidance. Among his former students to contribute to this memorial edition of ARLO are Mike Bailey, Carr Everbach, Christy Holland, Glynn Holt, Sameer Madanshetty, and Ron Roy.

In keeping with his adherence to the Renaissance ideal, Apfel's students enjoyed what is becoming a rarity in engineering graduate academics: a full-featured education. As an experimentalist, Apfel understood the physical and mathematical basis for his work and he imparted this "big-picture" view on the next generation of experimentalists. Theorists were exposed to the joys and trials of experimentation and honed an intuitive feel for the physical processes they sought to model. Discussions around the lunch table focused on anything from acoustic levitation of grapes to a unified field theory in which the universe was enveloped in sound, particles took on a planetary scale and gravity was a cosmic Bjerknes force. Likewise, general discussions of politics, religion, or human nature were common, always interspersed with humorous anecdotes or observations. Students of acoustics were taught a quantitative appreciation for the essential scales and physical relationships that defined the discipline. This exposure and adherence to fundamentals produced graduates who were equally adept at dealing with architectural acoustics and biomedical ultrasound, with numerical modeling and precise physical measurement. For several summers in the 1980s, Robert Apfel asked all of his students to halt their scheduled research and undertake a three-week collaborative exploration of a particular topic. Each team member contributed a complementary skill, with the result that the project became a bonding experience whose echoes continue to this day.

# The Apfel Legacy

For over 30 years, Bob's impact on science has been enormous. During his career, he published over 120 articles, including 41 in the *Journal of the Acoustical Society of America*. The students and colleagues listed below are the most clearly linked to Bob because of their time at Yale but countless other students who may not have pursued a career in science also benefited from his guidance and encouragement.



**Robert E. Apfel**  
1943-2002  
Ph.D. Harvard '70  
B.A. Tufts '64



Frederick V. Hunt  
1905-1972  
Ph.D. Harvard 1934



Bob's Golden Anniversary celebration at Mason Lab, March 2002. Bob's students gathered at Yale to celebrate Bob's birthday, his 30 years at Yale, and his ASA Gold Medal.



## Students

1970's	1980's	1990's	2000's
Eugene H. Trinh '78 Ph.D. Robert D. Essert, Jr. '78 B.S.	Mary Ann Weiser '81 Ph.D. Wesley Cobb '82 Ph.D. Chaur-Jian Hsu '83 Ph.D. Mark S. Roos '83 Ph.D. Richard S. McGowan '85 Ph.D. John Morrell '86 B.S. Ye Yang Sun '87 Ph.D. Yuan-Chyuan Lo '87 Ph.D. Ronald A. Roy '87 Ph.D. Hui-Lan Lu '88 Ph.D. Joseph J. Crisco III '89 Ph.D. E. Carr Everbach '89 Ph.D. Christy K. Holland '89 Ph.D. Sameer I. Madanshetty '89 Ph.D.	Xucui Chen '91 Ph.D. Michael R. Bailey '91 B.S. Edward A. Gardner '92 Ph.D. Peng Jiang '93 Ph.D. Qihong (Eli) Xu '94 Ph.D. Yuren (Roger) Tian '94 Ph.D. Shermann Loyall Min '94 M.S. Cheri X. Deng '95 Ph.D. William T. Shi '96 Ph.D. Linglin Gao '96 M.Phil. Thomas R. Stottlmyer '96 Ph.D. Jeffrey A. Ketterling '99 Ph.D. Xiaohui Chen '99 Ph.D.	Joseph C. Jankovsky '00 Ph.D. Yibing Zheng '02 Ph.D. Ning Xu '02 M.S. Ping Yan '02 M.S. Juan Tu '02 M.S. Todd Brooks '03 Ph.D. Reinford G. Williamson '04 Ph.D.

## Post Docs

Philip Marston '76-'78	Anthony Atchley '85-'86 Zhermin Zhu '86-'87 Christy Holland '89-'91 Ronald A. Roy '87-'88 R. Glynn Holt '89-'91	Ning Qiu '93-'95 Yuren (Roger) Tian '94-'95 Wengwuang Li '97-'98 Kwanglin Song '98-'00 Jeffrey A. Ketterling '99	Anthony C. Khong '00-'02
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## Visiting Faculty

Leon Frizzell '85-'86	Nate Yen '94-'95 Richard Zahoranskyin '98-'99
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Compiled by Jeffrey A. Ketterling

Central to Robert Apfel's success was his notion of simple, elegant models that could be used to understand the fundamental mechanisms of phenomena. He was fond of order-of-magnitude calculations to see if an idea was worth pursuing, and he would keep a clear physical picture in mind as he worked toward deeper understanding. Apfel's famous Commandments of Cavitation Research are an example: 1. Know thy liquid; 2. Know thy sound field; and 3. Know when something happens. Another contribution is the Mechanical Index, an on-screen indicator of the likelihood of inertial cavitation that is found on ultrasound scanners worldwide. Apfel would frequently jot down ideas that occurred to him in a small spiral-bound notebook he kept in his pocket, and then use these notes as fodder for patents or later investigations. Robert Apfel's immense intellectual creativity led him to develop such concepts as a tetrahedral model of personality that explained much about human interactions, and ruminations on architecture, history, and pedagogy that were influential among his peers. Moreover, Apfel taught architectural acoustics to generations of architecture students at Yale, invented toys for children, and wrote passionately about innovation and exploration.

His intellectual legacy is reflected in contributions to this edition from colleagues or collaborators who used Robert Apfel's models or approaches to elucidate fundamental interactions in acoustics. Among the bubble-related papers herein are topics as diverse as bubble interactions near boundaries, gene transfection, HIFU cavitation, and low-frequency dispersion. Non-bubble articles include whispering waves in a wineglass, ultrasound-assisted thrombolysis and sound field determination. Missing are contributions pertaining to the Superheated Drop Radiation Detector, for which Robert Apfel formed a small company and received numerous patents, and his more humanistic pursuits, such as his poetry and songs. It is fitting, however, that this memorial issue be published in ARLO, Robert Apfel's brainchild, for he saw perhaps more clearly than others the benefits of a rapid-turnaround online journal to keep researchers abreast of current work in acoustics. ARLO is one of the most Apfelian components of his legacy.

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