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Randolph A. Nanna, Publisher

obituaries

can report the metabolic energy status in performing muscles, locate tumors and cancerous tissue in muscles and breast, and access cognition and injury in the brain. Chance's legacy is a burgeoning field of biomedical optics and biophotonics.

Recently Chance commented that he felt he had come full circle in applying microsecond microwave radar technology to picosecond optical ranging in the human frame. From his earliest days at MIT, he appreciated physicists' straightforwardness. Looking back over his career Chance reflected, "It's a good thing to have the physics community behind a biophysicist!"

P. Leslie Dutton

*Eldridge Reeves Johnson Foundation
Philadelphia*



**Steven
Alan
Orszag**

Steven Alan Orszag

The scientific community lost a brilliant and energetic thinker with the passing of Steven Alan Orszag from complications from chronic lymphocytic leukemia on 1 May 2011 in New Haven, Connecticut. Steve had a profound influence on fluid mechanics as he tackled daunting problems in turbulent flow using mathematical and computational methods.

Steve was born in New York City in 1943 and at 19 obtained his BS in mathematics from MIT. He spent 1962–63 taking part III of the Mathematical Tripos at St John's College of Cambridge University. Having obtained a strong mathematical foundation for the study of fluid flows, he went to Princeton University and completed his PhD in astrophysics in three years.

When Steve returned to the US from Cambridge, he realized that the style of research in fluid mechanics he'd learned there—the idea that fluid mechanics was, and is still, part of the mathematics curriculum—was distinct from that in North America. Here, it resided in application subareas of astrophysics, engineering, geophysics, and superfluidity. Steve fused the mathematical approach with numerical methods. Mentors Martin Kruskal, Lyman Spitzer, and Bengt Strömberg provided a blend of theory and observation into which Steve's approach of combining mathematical foundation and computational exposition dovetailed. His earliest paper on the atmospheres of neutron stars used state-of-the-art computing, but the evident intransigence of astrophysical flows quickly led him to examine the underlying mechanisms governed by the Navier–Stokes equations. His 1966 thesis, "Theory of turbu-

lence," led to his writing a series of papers with Kruskal and Robert Kraichnan both as a student and then later at the Institute for Advanced Study in New Jersey.

Steve's growing understanding of both the mathematical foundation and broad relevance of turbulent flow became the groundwork for his research at MIT, where he was an applied mathematics professor from 1967 to 1984. The widely used text *Advanced Mathematical Methods for Scientists and Engineers* (McGraw-Hill, 1978), which he wrote with Carl Bender, emerged from courses they developed there.

The tools of fluid mechanics are differential equations, scaling, and asymptotic methods. The Reynolds number Re commonly measures the degree of nonlinearity; when large, the flow is strongly turbulent and displays an enormous range of scales. Capturing that numerically is a major challenge. One needs both to store a great deal of information (scaling as $Re^{3/4}$) and to have efficient, high-precision algorithms. Those were major impediments until, beginning in 1969 while on a two-year leave at the National Center for Atmospheric Research in Colorado, Steve developed the transform methods, now called spectral methods, which exploit generalized Fourier decomposition and fast Fourier transforms.

Spectral methods provide the strongest evidence that the three-dimensional Navier–Stokes equations remain well posed and their solutions free of singularities for all times (real singularities could, of course, appear at Re far exceeding the capability of present-day computers). Spectral methods also make practicable many real-world flow problems. Some 40 years later, the

methods and codes Steve created are still central to progress.

When Steve returned to Princeton in 1984 as a professor in both applied mathematics and engineering, his interests broadened. He embraced the renormalization group in collaboration with Victor Yakhot; tested it against simulations and multiple scales analysis; and studied chaotic and unstable shear flows, cellular automata, boundary integral methods, the Rayleigh–Taylor instability, and electromagnetic theory with applications in photolithography. He developed turbulence closures that were not plagued by primal pathologies such as negative energies and that are still widely used. They were simultaneously sufficiently simple and versatile to allow many applications.

Steve arrived at Yale University in 1998 and became the Percy F. Smith Professor of Mathematics in 2000. For four years he directed the applied mathematics program. In close collaboration with Hudong Chen, Sauro Succi, and their students and colleagues, he studied and developed lattice Boltzmann models of turbulent fluids, which avoid solution of the full Navier–Stokes equations. Such an approach can be so powerful that many geometrically complex flows can be readily solved. Most recently Steve was involved in prob-

lems wherein solidification and fluid flow are coupled. Foremost on his mind was developing rigorous methods to quantify the processes of ice growth in the polar oceans, which underlies important issues in climate change.

Always keen on showcasing the power of computing, Steve recently began to teach calculus using computational pedagogy. He was a key intellectual framer for a company that uses lattice Boltzmann methods and very large eddy turbulence models as the core technology. It is a rare mathematician who creates engineering turbulence models, and Steve's became a part of a design cycle used everywhere in industry. Among his many accolades were the American Institute of Aeronautics and Astronautics's 1986 Fluids and Plasmadynamics Award, the American Physical Society's 1991 Otto Laporte Award, and the 1995 G. I. Taylor Medal from the Society of Engineering Science.

Steve's constant contact with computers and methods for improving scientific computing were an active love affair. For a PhD student, he recently built a GPU machine from the component parts. From mathematics to hardware, Steve was a constantly evolving renaissance man who did not care where someone came from but only what he or she brought to the discus-

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sion at hand. He cared immensely for his family, collaborators, students, and friends. With his passing, the landscape of science has lost one of its higher peaks, a wise adviser, and a cherished friend.

Carl Bender

*Washington University in Saint Louis
Saint Louis, Missouri*

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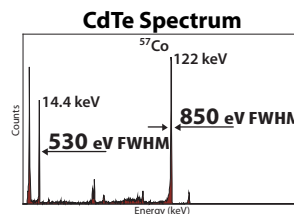
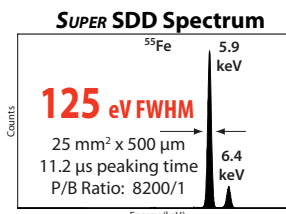
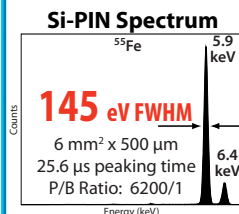
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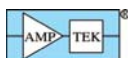
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