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STEPHEN H. DAVIS

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"For contributions to the mathematics of hydrodynamic stability theory and interfacial phenomena."

BY JULIO M. OTTINO AND MICHAEL J. MIKSIS

STEPHEN HOWARD DAVIS, McCormick Institute Professor and Walter P. Murphy Professor Emeritus of Engineering Sciences and Applied Mathematics at Northwestern University, passed away November 12, 2021, at the age of 82. His elegant research in the fundamentals of interfacial flows won him international recognition and honors in multiple fields.

Steve, the first son of Eva (née Axelrod) and Harry Davis, was born in New York City on September 7, 1939. He lived in Brooklyn until he was three years old, when the family moved to Long Island, partly because of his asthma. At age 16 he was offered a full scholarship to Brooklyn Polytechnic but decided to attend the Rensselaer Polytechnic Institute (RPI), where he graduated with a major in electrical engineering in 1960. He stayed at RPI for

his graduate study but switched to mathematics, receiving an MS in 1962 and a PhD in 1964 while working with Lee Segel. His PhD thesis, titled "The Effects of Property Variations and Surface Curvature on Bénard Convection," began what became a storied career in interfacial fluid dynamics.

Steve's first job was at the RAND Corporation in Santa Monica, and it was in California that he met the love of his life, Suellen Lewis, formerly of Dallas, Texas. They married January 15, 1966.

Also in 1966, Steve left RAND to join the Department of Mathematics at Imperial College London as a lecturer. Two years later he returned to the United States and took a position as assistant professor in the Department of Mechanics at Johns Hopkins University, rising to associate professor in 1970 and professor in 1975.

At the time, Johns Hopkins was well-known for fluid mechanics and its faculty included, among others, the formidable Stan Corrsin (NAE 1980) as well as Les Kovasznay, Bill Schwarz, Bob Long, Owen Phillips (NAE 1996), and Francis Bretherton. The university also had a strong rational mechanics component, led by the equally formidable Clifford Truesdell. These two worlds could have connected, but at Hopkins they remained separate.

In 1979, Davis moved to Northwestern University's recently formed Department of Engineering Sciences and Applied Mathematics (ESAM)—he was the department's first faculty hire, and eventually became its chair (1988–91). Bernie Matkowsky and Ed Olmstead were in the process of building a Department of Applied Mathematics. At the time there were few such departments in the United States, and even fewer housed in an engineering school. Northwestern's formula worked, and it created one of the most recognized departments in the world for applied mathematics and, because of Davis, fluid dynamics as well.

Davis became possibly the most prominent fluid mechanician in interfacial dynamics in the world. He produced fundamental results in small-scale hydrodynamic systems, in which interfaces between fluids are important. These phenomena include the modeling of moving contact lines, van der Waals instabilities, thermocapillary effects, and phase transformations. His introduction and development of long-scale evolution equations to examine transport and breakup of thin films underlie much of the recent explosion in theories of micro- and nanoscale fluid flows. Such approaches make the examination of complex interactions among various force fields transparent.

He was also a worldwide leader in interfacial dynamics in crystal growth, with particular contributions to rapid solidification, anisotropic-material effects, mushy-zone convection, and nonlinear evolution of cellular growth. His 2011 Cambridge University Press monograph, *The Theory of Solidification*, stands as the gateway for mathematicians into the field of crystal growth.

He also elucidated the evolution of quantum dots from the instability of continuous crystalline films, and he predicted the scaling laws for coarsening of the instability, the final pattern and spacing of the dots, and the shapes of these dots for any material. These dots are being examined by scientists worldwide as logical elements in a new generation of computing, quantum computers.

Davis' physical insights were brilliantly displayed when he attacked solidification in a system with a faceted solid-liquid interface. Because of the nonsmooth nature of the energies of facets, theories for such situations were exceedingly difficult to formulate. The breakthrough was to account for the energy of corners that connect facets in a dynamical context and to derive nonlinear evolution equations for the interface shape. The addition of corner

energy regularizes the evolution equations, leading to important predictions on the way solidification occurs in these systems.

The common threads through all of Steve's work are his ability to focus on the essential physics of nonlinear phenomena using asymptotic mathematical methods and his strong interest in developing and supporting the careers of younger scientists. Fluid interfaces are everywhere, and solidification is relevant to myriad problems in processing and engineering; therefore, it is difficult to list the ramification of impacts that can be traced to Davis' work. It is clear, however, that his impact has been felt in many diverse applications, from flow in the lung to dynamics in foams to heat and mass transfer associated with paints, adhesives, and membranes and lab-on-a-chip applications.

Steve's profound contributions to both fluid mechanics and materials science earned him election to the National Academy of Engineering (1994), the American Academy of Arts and Sciences (1995), and the National Academy of Sciences (2004). Among his other honors were the 1994 Fluid Dynamics Prize from the American Physical Society (APS), "For his profound contributions in a diversity of areas [including]...both linear and non-linear hydrodynamics instabilities, bifurcation phenomena, and directional solidification. His impact on the fluid dynamics scene stems not only from his superb ability to apply an optimum combination of physical and mathematical analyses to significant problems, but also from his talented and sympathetic mentoring of a succession of bright research students who are now full-fledged researchers and/or teachers in their own right"; and the G.I. Taylor Medal from the Society of Engineering Science (2001), a Royal Academy of Engineering Distinguished Visiting Fellowship

(2014–15), and election to the Academia Europaea (2017).

Steve was involved with many professional activities throughout his career. These included the US National Committee on Theoretical and Applied Mechanics (1979–87), the NAE's Mechanical Engineering Peer Committee (1998–2001) and Committee on Membership (2009–12), and NASA activities such as the Discipline Working Group on Fluid Dynamics and Transport Phenomena (chair, 1991–97; member, 1997–2005) and the Microgravity Science and Applications Subcommittee (member, 1991–97) of the Space Science and Applications Advisory Committee. He also provided leadership of the US fluid dynamics community through his service as APS Division of Fluid Dynamics chair (1978–79 and 1987–88), council member (1980–81), and member of its executive committee (1977–80 and 1987–90) and fellowship committee (1981–86).

Over his six-decade career, he authored four books and more than 200 academic publications, including 58 papers in the *Journal of Fluid Mechanics* (*JFM*) with nearly 60 coauthors. And, in a first, he was simultaneously the editor of both *JFM* and the *Annual Review of Fluid Mechanics*.

He was widely appreciated as a mentor of more than 80 PhD students, postdoctoral fellows, and senior visitors. Many former students are now leading figures in academia (mathematics, biomedical engineering, chemical engineering, and mechanical engineering), and in industrial and research laboratories worldwide.

Two events honoring him required broad participation of the scientific community, illustrating the very high regard in which he was held and his scientific connectivity. The first was a 2001 workshop held to celebrate his 60th birthday. The proceedings, published in the monograph *Interfaces*

for the 21st Century (Imperial College Press, 2002), contains 16 invited papers and 63 contributed abstracts. The list of attendees and contributors, all of whom were influenced by Steve Davis, was remarkable.

The second was the March 25, 2010, *JFM* issue dedicated in honor of Davis' 70th birthday, featuring 24 papers involving 60 authors. Of the three people thus honored in the history of *JFM*, Steve was the only US scientist and the only one for whom the issue was assembled independent of a conference.

Steve Davis is survived by his wife of 55 years, Suellen; a brother, Jeffrey; and an academic family of scores of former graduate students and postdoctoral fellows. He will always be remembered for his friendly and cordial manner, his love of travel and fine dining, and an impeccably understated sense of humor.