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Guest Editorial

Special Issue: Innovations and Advancements in Heat & Mass Transfer: Celebrating the Legacy of Professor Ephraim M. Sparrow

Ephraim M. Sparrow

The passing of Professor Ephraim M. Sparrow on Aug. 1, 2019, left a large void in the worldwide heat and mass transfer community. To many in the field, he was an intellectual giant, who famously was the "most cited" mechanical engineering professor in the Science Citation Index for many decades. Many scholars, young and old, have encountered Professor Sparrow's multitude of works over a wide range of topics in standard academic textbooks, reference books, and eminent heat transfer journals. To his colleagues and students, "Eph" was more than a giant in the field of heat transfer, he was an incredible mentor and a lifelong friend who was passionate about the multifaceted area of thermal science and never stopped wanting to learn. To celebrate Eph's multitude of contributions, a memorial symposium was held at the University of Minnesota,[1] where he had spent his entire professional academic career.

Many of those who knew him can recall the technical evolution of Eph throughout the decades of his career. At the age of 19, in 1948, he obtained his B.S. degree from MIT. He then went on to receive his M.S. at MIT in 1949, followed by his M.A. in 1950 and Ph.D. in 1952 from Harvard University. In the 1950s, Eph began his early career by first working at Raytheon and then at the Lewis Flight Propulsion Laboratory of the National Advisory Committee on Aeronautics (NACA), which is now known as NASA. It was during this time that Eph started his professional research career working on a wide range of problems. These included fundamentals of heat transfer and fluid flow, electronics cooling, and nascent numerical methods, among others. Some of his work while at NASA was published in the very first volume[2] of the *Journal of Heat Transfer*.

Eph joined the faculty at the University of Minnesota in 1959, where he remained for a remarkable six decades, as a full professor to continue conducting research at the Mechanical Engineering Department's renowned Thermodynamics and Heat Transfer Laboratory. This research laboratory was founded by the notable Professor Ernst R. G. Eckert. The group of heat transfer faculty at that time became known as the "Heat Transfer Mafia." In the 1960s, Eph continued his dominance in the field, working on a wide range of heat transfer problems encompassing conduction, convection, and radiation, including publishing the first edition of an early classic textbook on radiation heat transfer [1].

During the 1970s energy crisis, Eph, among other things, was one of the pioneers of the enthalpy method for numerically modeling phase-change materials. Furthermore, it was during this decade that Eph served as the senior technical editor of the *Journal of Heat Transfer*. Subsequently, in the next couple of decades (1980–2000), he worked on numerous types of fundamental thermal engineering problems encompassing both numerical and experimental techniques. A 1988 publication is a quintessential snapshot of his interests and approach, where in his own words it is articulated as "… a highly personalized style of research characterized by intense human involvement and a minimum of material resources and exemplifies the notion that 'less is more'" [2]. During his illustrious academic career, Eph received all the major honors and awards, advised over 100 Ph.D. dissertations and 250 M.S. theses, and laid the foundational groundwork for much of the ongoing research today. A relatively recent paper [3] further highlights his sustained interests in addressing the resolution of persistent anomalies and "pesky" problems; in this instance, the work dealt with the uncertainty of predicting the heat transfer coefficient and friction factor in the entrance region of turbulent pipe-flow convection.

In the last two decades of his life, Eph shifted his academic and research philosophies from extremely fundamental work to applied, complex problems from industry—including problems outside of heat transfer. He even went as far as to rename his lab from the "Laboratory for Heat Transfer Practice" to the "Laboratory for Engineering Practice." Reflecting on the spectrum of complex industrial issues, he had this to say: "I seem to be interested in funky problems that others might eschew, such things as piezometer rings, annubars, thermometer wells, fan strangulation, etc. I bumped into fan strangulation when we were working on a FSI problem … with the too frequent breaking of fan blades in the field. My definition of fan strangulation is blocking of the space upstream of a fan from which it would normally draw air. Of course, the fan rotation must be considered, and the frame of reference must be chosen to achieve the simplest model" [4]. It is in this spirit that this special issue is dedicated to Eph's long history of performing research on a wide range of heat transfer problems. The invited papers in this issue carry on that legacy by representing both fundamental and applied research that collectively involve analytical, numerical, and experimental methods in addressing a spectrum of topical issues.

These contributions include four review articles that delve into a variety of issues and provide insightful commentaries: the current state-of-the-art and future directions in adopting the Monte Carlo method for resolving radiation heat transfer problems are discussed, a path-breaking treatise on surfactant-transport modulated interfacial processes and the hydrodynamics that resolve vascular gas embolism are delineated, the dynamic behavior associated with the growth, collapse, and coalescences of small-scale bubbles and their clusters is presented, and both fundamental thermal-hydrodynamics issues and practical applications of

[1] https://cse.umn.edu/me/remembering-ephraim-sparrow

[2] Note that the title *Journal of Heat Transfer* was adopted by ASME in 1959, and the first volume with this new name was published; prior to 1959 the journal was referred to as *Transactions of the ASME, Series C*.

pulsating heat pipes are addressed. A novel research investigation outlines the thresholds of boiling heat transfer enhancement by using structured surfaces that also have patterned biphilic surface treatments so as to change the surface energy and provide nucleating sites under subatmospheric pressure conditions. The effect of surface wettability has also been explored in adiabatic conditions and the influence it has on the bubble dynamics during ebullience from orifice plates submerged in liquid pools. In the biomedical realm, an insightful inquiry related to ophthalmic drug delivery has analyzed and simulated mass transfer in the vitreous humor from medicinal eye implants. Another elegant theoretical work highlights the influence of real gas radiation on the onset of buoyancy-induced flow and the eventual developed Bénard convection regime in a layer of participating media heated from below.

The very wide spectrum of unresolved problems and new excursions published in this special issue are further spotlighted by two briefs on topical issues of current interests: one on the impact of uncertainties in thermophysical property evaluations of supercritical CO_2 on Nusselt number predictions, and the other on the measurement of thermal conductivities of reactive magnesium manganese oxide porous beds at ultrahigh temperatures. An important study that has considerable significance for the use of energy piles, or another form of thermal energy storage, has developed an efficient method for modeling the dynamic response with a short time resolution. The onset of thermoconvective instability in a vertical porous media layer has been investigated, and the effects of anisotropy are considered in a computational effort. In another computational excursion, the gas diffusion-induced Cassie to Wenzel state transition has been analyzed in a two-dimensional system. Two other papers have delved into the chemical vapor deposition process. In one case, a roll-to-roll deposition of graphene on Ni and Cu foils is considered, whereas the other case deals with growing gallium nitride thin films. Modeling the response of a phase-change material under cyclical thermal conditions is considered in another study. Two papers report thermal management issues for electronic devices. Finally, an inspirational reflection on Eph's work on similarity solutions for laminar film condensation on a vertical plate is presented to roundoff and complement the gamut of different topics.

In closing, it should be reiterated that Professor Ephraim M. Sparrow had multifaceted interests in his research and academic endeavors. His contributions have shaped the current state of engineering science inquiry in a variety of ways that encompass both topics and investigative tools, such as visualization, analytical methods, computational simulations, and experimentation. The papers presented in this special issue celebrate this legacy in the hope of engendering high scholastic and more meaningful research in the generations to follow.

Sandra K. S. Boetcher
Fellow ASME
Department of Mechanical Engineering,
Embry-Riddle Aeronautical University,
Daytona Beach, FL 32114-3900
e-mail: sandra.boetcher@erau.edu

Raj M. Manglik
Fellow ASME
Department of Mechanical and Materials Engineering,
University of Cincinnati,
Cincinnati, OH 45221-0072
e-mail: Raj.Manglik@uc.edu

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[3] Sparrow, E. M., Gorman, J. M., and Bryant, D. B., 2018, *Journal of Heat Transfer*, **140**(6), p. 061702.
[4] Personal communication with SB.