Radiative Transfer and Computational Challenges

M. Pinar Mengüç, CEEE/EÇEM, Özyeğin University, İstanbul

This talk focuses on computational methods used for the far- and near-field radiative transfer phenomena and the computational challenges need to be tackled for its future applications. Radiative transfer equation (RTE) is an integro-differential equation by nature, and its solution is not trivial. It has to be modeled based on the difficulty of the geometry and the physical system considered. Over the years, a number of methods have been developed to account for the spatial and directional nature of RTE, including spherical harmonics, moment and discrete ordinates methods and their combinations, and several versions of Monte Carlo techniques. MC approaches used extensively for thermal transport applications can also be extended to electron-transport problems for electron-machining applications, and to phonon-transport applications which allow the modeling of nano-micro scale conduction problems. The computational details behind these approaches, their similarities and differences will be highlighted.

At nano-scales, the computational methods differ from the far-field calculations carried out for common thermal phenomena problems. The coupling of the equations of electro-magnetic light propagation (Maxwell equations) and fluctuating electrodynamics equation allows the analysis of near-field radiation transfer, which lead the way to design of new nano-scale systems and devices. The use of Maxwell equations is also necessary to determine the properties of particulate matter in combustion systems and in atmosphere. The variations in shape, size and size distribution of such particles present significant complexity, which require intricate applications of computational methodologies.

In the second part of this talk, different solution methodologies for near-field radiative transfer phenomena and the use of electromagnetic light scattering concepts for particle characterization will be mentioned. Use of different computational techniques to design new type of sensors and filters will be discussed. The challenges for the future far-and near-field radiative transfer problems will also be presented.

Prof. Dr. M. Pınar Mengüç

Biography
Director of the Center for Energy, Environment and Economy (CEEE)

M. Pinar Mengüç, after graduating from Ankara Science High School, received his BS and MS degrees from ODTU/METU in Ankara, Turkey, and his PhD from Purdue University, USA in 1985. He joined to the University of Kentucky in Lexington, KY and promoted to the ranks of associate professor and professor in 1988 and 1993, respectively. He was appointed as the Engineering Alumni Association Chair Professor in 2008. He was a visiting professor at Harvard University, Cambridge, Massachusetts, during 1998-99 academic year and at UCLA, California, in 2022.

He joined Özyeğin University, Istanbul in 2009 as the founding Head of Mechanical Engineering. The same year, he established the Centre for Energy, Environment and Economy (CEEE/EÇEM). Currently he holds the FYE (Fiba Holding Renewable Energy) Chair Professor position at Ozyegin University.

Mengüç's research areas include radiative transfer, nanoscale transport phenomena, applied optics and sustainable energy applications. Over the years, he has guided more than 70 MS and PhD students, and post-docs researchers. He is the author/co-author of more than 150 archival research papers, 230 conference publications, six books, seven patents. He has established a start-up company with his former PhD student and received a prestigious R&D100 Award in 2005 based on an innovative particle characterization technique.

In 2018 he received the ASME Heat Transfer Memorial Award in the category of Art, and in 2020 he was chosen as an Outstanding Mechanical Engineer by the Purdue University School of Mechanical Engineering. He received Michael Mishchenko medal from Elsevier/JQSRT in 2023. Mengüç is an elected member of Science Academy of Turkey and the Chair of the Executive Board of International Center for Heat and Mass Transfer.