iW-RTA 2022

International e-Workshop on Radiation Transport and Applications

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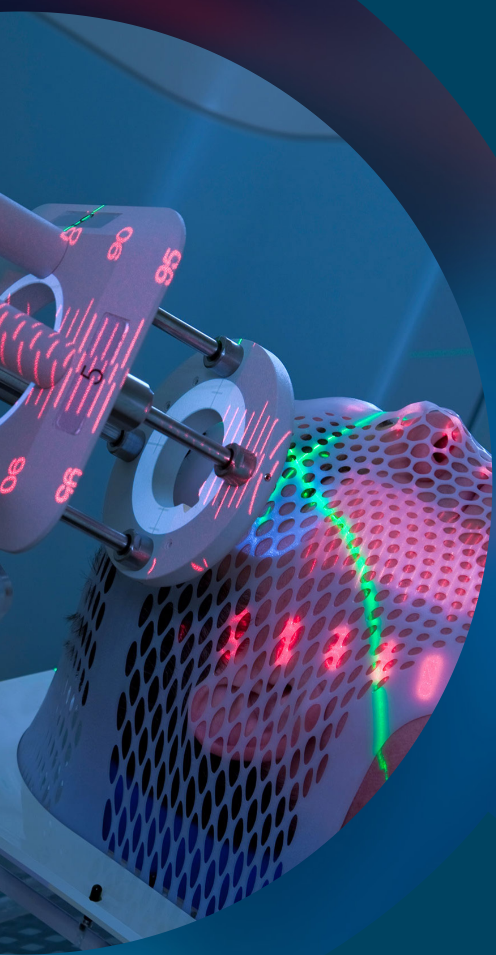
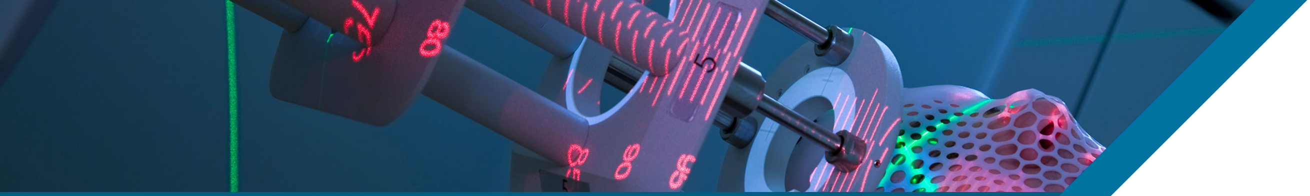
January 21-22, 2022



Organized Virtually by
Indian Institute of Technology
Bhubaneswar

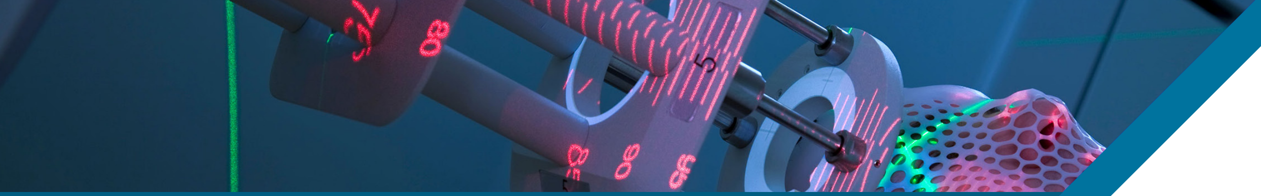
Sponsored by
Scheme for Promotion of Academic
and Research Collaboration (SPARC),
Ministry of Education, Government of India.



About the Virtual Workshop

The main objective of the workshop is to bring together scientists, engineers, and doctors involved in radiation transport and its interaction with other modes of heat transfer research, and to provide a relaxed atmosphere for in-depth discussion of theory, experiments, and applications.

A special focus is placed on sharing the research ideas on radiation in biomedical applications for tumor diagnosis and therapy which serves as guidepost for treatment modalities and clinical trials.



Workshop Coordinators

Prof. Swarup K. Mahapatra
Indian Institute of Technology
Bhubaneswar, Odisha, India

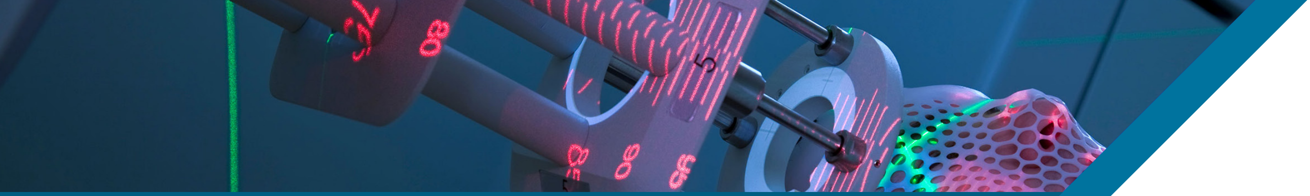
Dr. Prasenjit Rath
Indian Institute of Technology
Bhubaneswar, Odisha, India

Prof. Sunil Kumar
New York University
Brooklyn, New York, USA

Prof. Zhixiong (James) Guo
Rutgers University
New Brunswick, New Jersey, USA

Prof. Kunal Mitra
Florida Institute of Technology
Melbourne, Florida, USA

Prof. Dilip K. Parida
All India Institute of Medical Science,
Bhubaneswar, Odisha, India



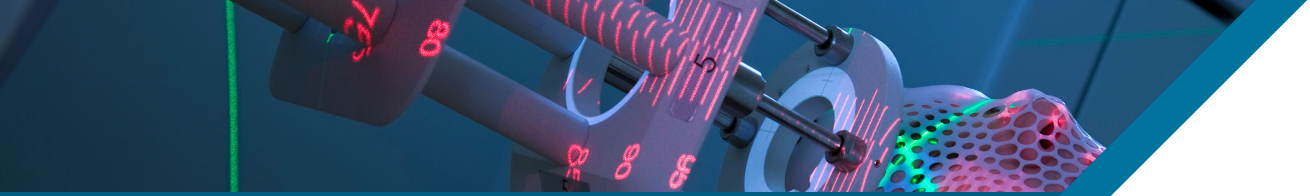
Administration and Volunteers

Jacqueline Menezes

Sajina Lal

Ronak Yadav

Prabodh Panindre



Message
From Director, IIT Bhubaneswar

Greetings from IIT Bhubaneswar!

Dear Participants,

It gives me immense pleasure to join the organizing team in welcoming you all to the International e-Workshop on "Radiation Transport and Applications", which is scheduled to be conducted during Jan 21-22, 2022, under the aegis of the Scheme for Promotion of Academic and Research (SPARC), a flagship program of the Ministry of Education, Govt. of India. It also gives me a great pleasure to note that this e-Workshop comprises of addresses by 32 eminent speakers, including 18 renowned professors from USA, Australia, UK, France, Turkey, Canada, China etc. and 14 from India.

The participation of Prof. Sunil Kumar from New York University, USA, Prof. Zhixiong (James) Guo, (Rutgers University, USA) and Prof. Kunal Mitra, (Florida Institute of Technology, USA) who have undertaken the collaborative research SPARC project with the School of Mechanical Sciences, IIT Bhubaneswar, would certainly be complementary to the strength of the program and I express my gratitude for the same. I am happy to note that this e-Workshop on radiation transport mainly aims at its biomedical applications for tumor diagnosis and therapy, besides other spectrum of radiation transfer applications.

I notice that the event is an initiative towards providing a common platform for engineering and medical professionals to jointly work and would like to place my appreciation. I do hope that the association of eminent professors of medical institutes in this endeavor will certainly be helpful in achieving the targeted outcome of the project.
I wish the e-platform provided to the scholars, researchers and the medical professionals to exchange their ideas and develop a model that will be rewarding to the participants.
I would also like to congratulate Prof. Swarup Kumar Mahapatra and his team for promoting this research activity through this e-Workshop.

Thanking you.

Prof. R. V. Raja Kumar

Message
From the Local Coordinators

With immense pleasure we take this opportunity of extending a warm welcome to all the beloved participants, eminent speakers joining the **Virtual International-Workshop** on **"Radiation Transport and Applications** being **organized by Indian Institute of Technology Bhubaneswar, India**, during **21st – 22nd January 2022 under the aegis of SPARC, MoE, Govt. of India**. It is significant to note that the workshop comprises of thirty (32) lectures of the distinguished professors including more than fifteen (15) International professors. The e-workshop is organized with an aspiration to create a forum of the scientists, engineers, national and international professors of engineering institutes, research scholars and medical professors associated with the radiation transport applications. The discussions will be primarily aimed at on the topics of Novel numerical and analytical techniques for the solution of radiation transfer equation which are applied for simulating complex phenomena in the field of Conjugate heat transfer, Atmospheric radiation, Radiation in multiphase heat transfer, Nano- and micro-scale radiation transfer, Solar radiation etc. It is pertinent to mention here that a special emphasis will be given for exchanging the ideas between the engineering and medical professionals on the biomedical applications of radiation transport models for tumor diagnosis and therapy.

The organizers are very much grateful to the Ministry of Education, Govt. of India, which has provided an opportunity to IIT Bhubaneswar to be a part of the Scheme for Promotion of Academic and Research (SPARC) by approving and sanctioning funds for the research project **"Computationally Guided Laser Based Tumor Diagnosis and Therapy".** It is anticipated that the outcome of this international virtual workshop will be very much beneficial with respect to meeting the objective of the SPARC sponsored research project.

We are very much thankful to Prof. R. V. Raja Kumar, Director, IIT Bhubaneswar for his staunch administrative and moral support with respect to conductance of the workshop.

We express our sincere gratitude to the International PIs of the project Prof. Sunil Kumar from New York University, USA, Prof. Zhixiong (James) Guo from Rutgers University, USA and Prof. Kunal Mitra, Florida Institute of Technology, USA for their research input to the project and sharing their expertise and experience through lectures. The initiative taken by the Indian investigator Prof. Dillip Kumar Parida, AIIMS Bhubaneswar for arranging the special lectures by professors of medical Institutes on tumor diagnosis and therapy is highly appreciated.

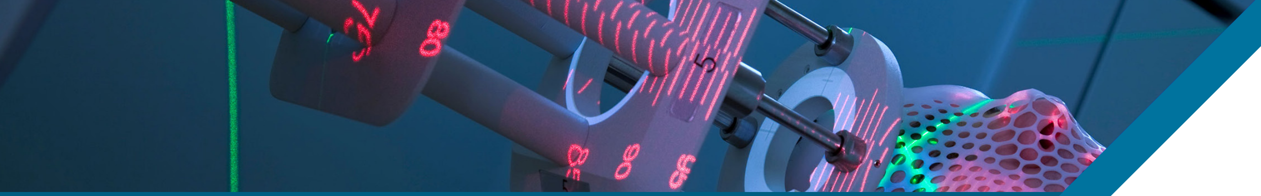
At the end, we would like to thank profusely all particularly the organizing committee members and others who are directly and indirectly associated with the workshop for making it grand success.

Stay safe stay Healthy,
Regards

Swarup K. Mahapatra

Prasenjit Rath

Dilip K. Parida



Message
From the International Collaborators

It gives us great pleasure to welcome you to the International e-Workshop on Radiation Transport and Applications 2022, a special workshop sponsored by the Scheme for Promotion of Academic and Research Collaboration, or SPARC, program of the Ministry of Education of India through a grant to the Indian Institute of Technology at Bhubaneswar.

The Workshop was originally envisioned to be a multi-day symposium at the campus of IIT Bhubaneswar, with travel and attendance partially sponsored by the grant. However, the pandemic disrupted these plans, and we are holding this virtual event with shorter presentations and extended hours to accommodate speakers from different time zones. It is indeed unfortunate that we will not be able to meet in person and enjoy the face-to-face in-depth discussions and exchange ideas in the relaxed atmosphere of the IIT campus, but we hope that this will be possible in the future.

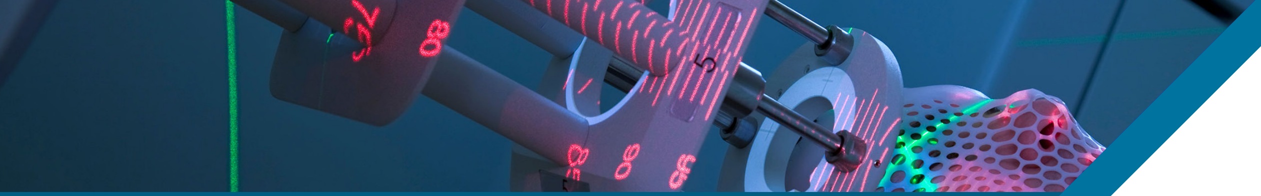
We trust that you will be stimulated by the presentations of the leading researchers from across the globe who are creating new conceptual, theoretical, methodological, and translational frameworks and innovations in radiation transport and applications. We thank you for taking the time to present your research, and for graciously accommodating the challenges of presenting across time zones.

With regards,

Sunil Kumar

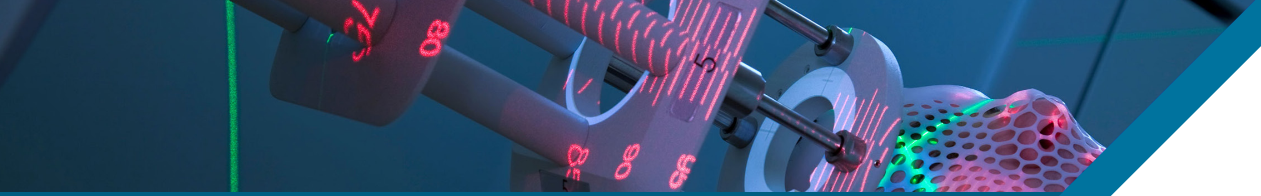
Zhixiong Guo

Kunal Mitra



Workshop Topics

- Novel numerical, analytical and hybrid techniques for the solution of radiation transfer equation in multidimensional and complex geometries
- Conjugate heat transfer
- Atmospheric radiation
- Radiation in multiphase heat transfer
- Radiative transfer in participating media
- Fundamentals and applications of radiative transfer in bio-medical science
- Nano- and micro-scale radiative transfer
- Radiative transfer-based diagnostic systems
- Far and nearfield radiation
- Radiative heat transfer in combustion
- Solar radiation
- Radiation in planetary systems
- Gas radiation
- Optical imaging and optical tomography
- Radiation properties



Program Schedule

Friday, 21 January 2022 (Virtual)

Session I (Presentation I-1 to I-8)

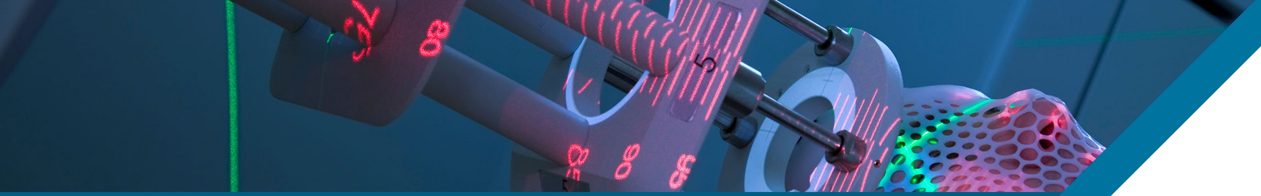
TIME	SPEAKER	TITLE
9:00-9:30 AM	Brent W. Webb, PhD Department of Mechanical Engineering, Brigham Young University	**Presentation I - 1** The Spectral Line Weighted-sum-of-gray-gases (SLW) Model for Prediction of Radiative Transfer in High Temperature Gases
9:30-10:00 AM	Michael F. Modest, PhD Prof. Emeritus of Engg, Dept. of Mechanical Engg, University of California, Merced	**Presentation I - 2** State-of-the Art of Global Spectral Models in Radiative Transfer
10:00-10:30 AM	Laurent Pilon, PhD Mechanical and Aerospace Engg Dept., University of California, Los Angeles	**Presentation I - 3** Light Transfer in Photobioreactors for CO2 Capture and Biofuel Production
10:30-11:00 AM	Himanshu Tyagi, PhD Dept. of Mechanical Engg., Indian Institute of Technology Ropar, Punjab	**Presentation I - 4** Radiative Heat Transfer Applications: Solar Thermal Collector
11:00-11:30 AM	Wojciech Lipinski Polna 1a, 05-600 Grójec, Poland	**Presentation I - 5** Radiative Transfer in Multiphase Reactive Flows for Concentrated Solar Energy Applications
11:30-12:00 PM	M. Pinar Mengüç, PhD Center for Energy, Environment & Economy Ozyegin University	**Presentation I - 6** Radiation Transfer and EM Waves: From Theory to Applications
12:00-12:30 PM	Prabal Talukdar, PhD Department of Mechanical Engineering, Indian Institute of Technology, Delhi	**Presentation I - 7** Pore Scale Radiative Heat Transfer Modelling through Foams at High Temperature
12:30-1:00 PM	Sunil Kumar, PhD Division of Engineering New York University Abu Dhabi	**Presentation I - 8** Machine Learning for Inverse Radiative Transfer: Preliminary Results

Program Schedule

Friday, 21 January 2022 (Virtual)

Session II (Presentation II-1 to II-8)

TIME	SPEAKER	TITLE
4:00-4:30 PM	Denis Lemonnier, PhD. Institut Pprime, Dept. Fluid, Thermal &Combustion Science CNRS– ENSMA–Univ. Poitiers	**Presentation II - 1** Coupling of natural convection and radiation in semitransparent gaseous media
4:30-5:00 PM	Dr.Sanat Kumar Bhuyan (MDS) Prof., Dept. of Oral Medicine, Siksha O Anusandhan University, Odisha.	**Presentation II - 2** Current concept of Laser – Oral Tissue Interaction
5:00-5:30 PM	Pedro J. Coelho, PhD Mechanical Engineering Department, Instituto Superior Técnico, University of Lisbon	**Presentation II - 3** An improved model to account for turbulenceradiation interaction in the numerical simulation of turbulent reactive flows
5:30-6:00 PM	Kunal Mitra, PhD Biomedical Engineering Florida Tech	**Presentation II - 4** Bio-Heat Transfer Analysis for Laser Based Therapeutic Applications
6:00-6:30 PM	Zhixiong Guo, PhD Department of Mechanical and Aerospace Engineering Rutgers University	**Presentation II - 5** Near-field radiation and detection in integrated sensor combining whispering-gallery mode and surface plasmonic resonance
6:30-7:00 PM	Zhuomin Zhang Jr. Professor, Mechanical Engg Georgia Institute of Technology, Atlanta	**Presentation II - 6** Thermal Radiation: from Nanoscale and Microscale to Macroscale
7:00-7:30 PM	Kyle Daun, PhD Department of Mechanical and Mechatronics Engineering University of Waterloo	**Presentation II - 7** Flare emissions quantification using hyperspectral and multispectral imaging
7:30-8:00 PM	Srinivasa Ramanujam Kannan, PhD., School of Mechanical Sciences, IIT Bhubaneswar, Odisha	**Presentation II - 8** Retrieval of multi-parameters from passive microwave remote sensing observations of a raining atmosphere

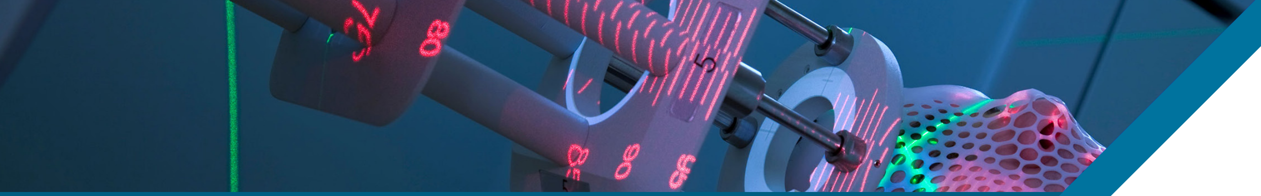


Program Schedule

Saturday, 22 January 2022 (Virtual)

Session III (Presentation III-1 to III-8)

TIME	SPEAKER	TITLE
9:00-9:30 AM	Andreas H. Hielscher, Department of Biomedical Engg, Tandon School of Engg, New York University	**Presentation III - 1** Radiative-Transfer-Based Optical Tomographic Imaging for Clinical and Pre-Clinical Applications
9:30-10:00 AM	Swarup K Mahapatra Professor, School of Mechanical Sciences IIT Bhubaneswar, Odisha	**Presentation III - 2** Introduction to Bio-Heat Transfer
10:00-10:30 AM	Dr. Sucheta Parija MS HOD of Ophthalmology, All India Institute of Medical Sciences Bhubaneswar	**Presentation III - 3** Lasers in Ophthalmology- Diagnostic and Therapeutic Applications
10:30-11:00 AM	John C. Chai, PhD Innovative Technology Research Center Shenzhen Envicool Technology	**Presentation III - 4** The Development of Finite-Volume Method for Radiation Heat Transfer
11:00-11:30 AM	Ramjee Repaka, PhD Department of Mechanical Engg, Indian Institute of Technology Ropar, Punjab	**Presentation III - 5** Radiofrequency Ablation of Breast Cancerous Tissue: A Computational Approach
11:30-12:00 PM	Dillip Kumar Parida, MD Professor & HOD of Radiation Oncology, All India Institute of Medical Science Bhubaneswar	**Presentation III - 6** Use of Thermal Energy for the Management of Cancer
12:00-12:30 PM	Dr. Paramdeep Singh Dept of Radiology, All India Institute of Medical Sciences, Punjab	**Presentation III - 7** Radiation Safety and Protection for Medical professionals
12:30-1:00 PM	S. P. Venkatesan, PhD, Professor (Emeritus) Department of Mechanical Engineering, Indian Institute of Technology Madras	**Presentation III - 8** Conjugate heat transfer involving thermal radiatio



Program Schedule

Saturday, 22 January 2022 (Virtual)

Session IV (Presentation IV-1 to IV-8)

TIME	SPEAKER	TITLE
4:00-4:30 PM	Dr Suprava Naik, Associate Prof. Dept of Radiodiagnosis, All India Institute of Medical Sciences, Bhubaneswar	**Presentation IV - 1** Radiation in Diagnostic Imaging
4:30-5:00 PM	Sumit Kumar, PhD Department of Mechanical Engg, National Institute of Technology Rourkela	**Presentation IV - 2** Modeling of laser irradiated biological tissue during photo-thermal therapy
5:00-5:30 PM	Pradeep Kumar, PhD School of Engineering, Indian Institute of Technology Himachal Pradesh	**Presentation IV - 3** Challenges in the computing of the gaseous radiation in engineering problems
5:30-6:00 PM	Prasenjit Rath, PhD School of Mechanical Sciences, Indian Institute of Technology Bhubaneswar	**Presentation IV - 4** Radiation Heat Transfer and its Interaction with other Modes of Heat Transfer at short time scale
6:00-6:30 PM	Fengshan Liu, PhD Black Carbon Metrology, Metrology Research Centre, National Research Council, Ottawa, Ontario	**Presentation IV - 5** Development of non-gray wall emissivity models to improve the accuracy of FSCK method for problems involving non-grey walls
6:30-7:00 PM	Arvind Narayanaswamy Department of Mechanical Engineering, Columbia University	**Presentation IV - 6** On thermal radiation, small and large
7:00-7:30 PM	Sandip Mazumder Department of Mechanical and Aerospace Engineering, The Ohio State University	**Presentation IV - 7** Hybrid Solver for the Radiative Transport Equation in Nongray Combustion Gases
7:30-8:00 PM	J. Robert Mahan, PhD Department of Mechanical Engineering, Virginia Tech, Blacksburg	**Presentation IV - 8** Confronting Large-Scale Combined-Mode Radiation/ Conduction Modeling Problems

Session I

Presentation I-1 to I-8

Friday, 21 January 2022
9:00 AM to 1:00 PM

Brent W. Webb, PhD

Department of Mechanical Engineering, Brigham Young University

The Spectral Line Weighted-sum-of-gray-gases (SLW) Model for Prediction of Radiative Transfer in High Temperature Gases

Abstract:

Prediction of radiative transfer in gas mixtures at high temperature is extraordinary complex, since the absorption/emission characteristics of real gases include many thousands of ultra-narrow spectral lines which depend on local temperature and concentrations of the participating gases. This makes spectral integration of the Radiative Transfer Equation (RTE) for gases particularly challenging. In the past three decades, so-called global methods have been developed for engineering approaches to the prediction of radiative heat transfer in high-temperature gases. The first such global method to be proposed was the Spectral Line Weighted-sum-of-gray-gases (SLW) model. In short, this model replaces integration of the RTE over wavenumber (or wavelength) by an integration over absorption cross-section. As a result, the number of integrations may be reduced from millions to just a handful. The SLW model has been extended, refined, and its accuracy assessed rigorously in hundreds of radiation-only example problems by comparison with rigorous line-by-line benchmark integrations of the RTE. SLW model predictions yield accuracy within a few percent of the line-by-line solution, but with computation time on the order of 10-5 that of the LBL solution.

This presentation will briefly introduce the complexities associated with radiation in real gases. The fundamental theoretical concept behind the SLW model will then be presented for scenarios of increasing difficulty ranging from single-component isothermal systems to multi-component systems with locally varying species concentrations and temperature. Sample predictions will be shown in each case. Finally, sample coupled cases involving radiation and other transport modes will be presented.

Bio:

Prof. Brent Webb received his PhD from Purdue University in 1986. He joined the faculty in the Department of Mechanical Engineering at Brigham Young University immediately thereafter. He has served the university as Executive Director of the Research Office, Vice President for Research, and Academic Vice President. He now enjoys teaching and research in the department.

Professor Webb has been past Associate Technical Editor of the ASME Journal of Heat Transfer, and is currently Associate Technical Editor of the Journal of Quantitative Spectroscopy and Radiative Transfer. He is an ICHMT Fellow, and he received the ASME Heat Transfer Memorial Award in 2016. He served as co-chair of the past five International Symposia on Radiative Transfer. He is author of over 250 technical publications, including 140 archival papers and 8 invited reviews. His work has been cited over 10,000 times (Google Scholar).

Michael F. Modest, PhD

Distinguished Professor Emeritus of Engineering, Department of Mechanical Engineering University of California, Merced

State-of-the Art of Global Spectral Models in Radiative Transfer

Abstract:

Radiative heat transfer in emitting/absorbing gases is immensely complicated due to the millions of spectral lines exhibited by such molecular gases, and its exact treatment by so-called line-by-line calculations is prohibitively expensive in combined-mode heat transfer, such as combustion, atmospheric reentry, etc. Consequently, spectral models have been developed approximating small (narrow band models) or larger parts of the spectrum (wide band models), or the entire spectrum (global models).

A brief history of spectral models will be given, with particular emphasis on global models. The state-of-the art of the three most important global models, the Weighted Sum of Gray Gases (WSGG), the Spectral line based WSGG (SLW), and the Full Spectrum k-Distribution (FSK) will be presented, and their capabilities, accuracies and computational efforts will be compared.

Bio:

Michael F. Modest received his Dipl.-Ing. degree from the Technical University in Munich, and in 1972 obtained his M.S. and Ph.D. in Mechanical Engineering from the University of California at Berkeley. He has carried out many research projects in all areas of radiative heat transfer (measurement of surface, liquid, and gas properties; theoretical modeling of surface and participating media transfer).

Professor Modest spent the majority of his career at the Pennsylvania State University, followed by 8 years at the University of California, Merced. He is the author of the internationally acclaimed textbook Radiative Heat Transfer (Academic Press, now in its 4th ed 2021) and also of a research monograph Radiative Heat Transfer in Turbulent Combustion Systems (Springer, 2015). He is the recipient of many awards, among them the ASME Heat Transfer Memorial Award (2005), Germany's Humboldt Research Award (2007), and the AIAA Thermophysics Award (2008); he is an honorary member of the ASME, and an associate fellow of the AIAA.

Laurent Pilon, PhD

Mechanical and Aerospace Engineering Department
University of California, Los Angeles

Light Transfer in Photobioreactors for CO2 Capture and Biofuel Production

Abstract:

Industrial and developing nations face the formidable challenge to meet ever expanding energy needs without further impacting climate and the environment. These conditions call for much greater reliance on a combination of fossil fuel-free energy sources and on new technologies for capturing and converting CO2.

This seminar will present how photosynthetic microalgae and cyanobacteria, grown in photobioreactors, can be used to mitigate CO2 emissions and produce biofuels and other added-value products in a sustainable manner. It will emphasize the importance of light transfer in designing and controlling the photobiological process. It will also present experimental measurements and electromagnetic wave simulations of the spectral absorption and scattering cross-sections and scattering phase function of selected microalgae in the photosynthetically active radiation region. The seminar will also discuss experimental demonstrations on control incident light intensity and spectra to maximize microalgae CO2 capture and biomass production.

Bio:

Laurent Pilon is Full Professor of Mechanical and Aerospace Engineering at the University of California, Los Angeles with expertise in radiative transfer, thermal sciences, transport and interfacial phenomena, and materials for energy applications. He has authored more than 180 archival journal publications in major physical chemistry and engineering archival journals. He is the recipient of the National Science Foundation CAREER Award, the Bergles-Rohsenow Young Investigator Award in Heat Transfer (2008) and the Heat Transfer Memorial Award (2021) from the American Society of Mechanical Engineers (ASME), among others. He was elected ASME Fellow and a member of the Scientific Council of the International Center for Heat and Mass Transfer (ICHMT). He is Associate Editor of the Journal of Quantitative Spectroscopy and Radiative Transfer.

Himanshu Tyagi, PhD

Department of Mechanical Engineering
Indian Institute of Technology Ropar, Punjab

Radiative Heat Transfer Applications: Solar Thermal Collector

Abstract:

Radiative heat transfer plays a very important role in the overall performance of a solar thermal collector. There are several components within the solar collector which participate in radiative transport. Each of these components performance influences the overall efficiency of the collector, and hence is a very important design consideration. This is even more important for concentrated solar collectors, where the temperatures of various surfaces reached a very high value.

Solar energy can be utilized for various applications ranging from process heat, to water purification, order to reduce the reliance on electricity generated from fossil fuels. Thermal processes as well as heat transfer play a very critical role in improving the efficiency of solar thermal systems. Recently, several new techniques have been proposed to improve efficiency of conventional solar collectors, for instance, by the use of nanoparticle-laden fluids which are able to directly absorb the sunlight. Such improvements require fundamental understanding of the underlying physical processes, and could offer great efficiencies for solar thermal systems, as well as other processes which may rely on supply of low-grade heat, such as thermal-based water purification techniques.

Bio:

Dr. Himanshu Tyagi is currently working as Associate Professor in the Department of Mechanical Engineering at IIT Ropar. He has previously worked in the Steam Turbine Design Division of Siemens (in Germany and India) and in the Thermal and Fluids Core Competency group of Intel Corp (in USA). He obtained his PhD from Arizona State University, USA in the field of heat transfer, and specifically looked at the radiative and ignition properties of nanofluids.

He and his co-workers proposed the concept of direct absorption solar collectors using nanofluids which won the Best paper award at the ASME Energy Sustainability Conference at Long Beach, CA. At present he is working to develop nanotechnology based clean and sustainable energy sources as well as water purification techniques with a team of several PhD, masters, and undergraduate students.

Wojciech Lipinski

Polna 1a, 05-600 Grójec,
Poland

Radiative Transfer in Multiphase Reactive Flows for Concentrated Solar Energy Applications

Abstract:

High-flux solar irradiation obtained with optical concentrators is an excellent source of clean process heat for high-temperature physical and chemical processing. Solar thermal power, the area that has traditionally driven developments in concentrating solar technologies, experiences renewed research interests, primarily in the context of large-scale dispatchable power generation.

The area of solar thermochemistry aims at direct thermochemical production of chemical fuels and commodity materials. These high-temperature energy conversion systems involve multi-scale radiative transfer, multiphase flows and chemical reactions in complex geometrical configurations. Understanding radiative transfer in heterogeneous media undergoing chemical transformations is the key challenge to designing efficient thermochemical systems for solar energy conversion.

Bio:

Wojciech Lipinski obtained his MSc Eng degree from Warsaw University of Technology (2000), and doctorate (2004) and habilitation (2009) from ETH Zurich. He held positions of Research Associate (2004–2006) and Senior Research Associate (2006–2009) at ETH Zurich, Assistant Professor at the University of Minnesota (2009–2013), and Associate Professor (2013–2015) and Professor (2016–2021) at the Australian National University. He has published over 180 articles in peer-reviewed journals and conference proceedings, and contributed to several books, edited books and e-books.

He is Associate Editor of Solar Energy and Journal of Quantitative Spectroscopy and Radiative Transfer, and serves on the editorial board of Computational Thermal Sciences. He is a member of the Scientific Council and the Executive Committee of the International Centre for Heat and Mass Transfer, as well as a member of ASME, AIChE, AIAA, and several other professional societies. His work has been recognized by several honours and awards including the 2013 Elsevier/JQSRT Raymond Viskanta Award in Radiative Transfer and the 2020 ASME Yellot Award. He is Fellow of the ASME.

M. Pinar Mengüç, PhD

Center for Energy, Environment and Economy
Ozyegin University, Istanbul

Radiation Transfer and EM Waves: From Theory to Applications

Abstract:

A review of theoretical studies and applications of radiative transfer and electromagnetic light scattering will be presented. This will be a personal research journey which, over the years, coupled these two areas to allow our groups' to work on state-of-the-art applications and instrumentation development. Starting from the importance of particulate matter in combustion systems, we will outline the development of elliptically-polarized-light scattering systems for characterization of size and structure of particles.

The presentation will continue with the work carried out for the characterization of particles at nano-scales, and extension to nano-scale manufacturing and energy harvesting. Importance of understanding of plasmonics for near-field energy transfer will be highlighted.

Bio:

M. Pinar Mengüç received his PhD from Purdue University, in 1985, and then he joined the University of Kentucky. In 2008 he became UK Engineering Alumni Association Chair Professor. He is the author of more than 160 articles published in SCI journals, has more than 220 conference papers, four books, and six patents. He has worked with more than 65 MS, PhD and Post-Doc researchers. He joined Özye in University, Istanbul in 2009 as the founding Head of ME. The same year, he established the Centre for Energy, Environment and Economy, which he is still directing.

His research areas include radiative transfer, nano-scale transport phenomena, applied optics and sustainable energy applications. He is an elected member of Science Academy of Turkey. He is one of the Editors-in-Chief Journal of Quantitative Spectroscopy and Radiative Transfer (JQSRT) and the recipient of the 2018 ASME Heat Transfer Memorial Award and the 2020 Purdue Outstanding Mechanical Engineering Award.

Prabal Talukdar, PhD

Department of Mechanical Engineering,
Indian Institute of Technology, Delhi

Pore Scale Radiative Heat Transfer Modelling through Foams at High Temperature

Abstract:

Open cell ceramic/metallic foams find a lot of applications in volumetric solar receivers, porous media combustion, heat exchanger etc., because of its high surface area to volume ration and excellent radiative properties. Pore scale modelling of these foams are complex and a lot of numerical work with various degrees of assumptions have been reported in the recent past to model fluid flow and heat transfer characteristics through these foams. Finite volume method (FVM) is one of the popular methods used for radiation modelling because of its conservative nature and compatibility with the other numerical fluid flow and heat transfer models.

In the current presentation, a novel approach will be demonstrated where FVM is integrated with blocked-off region approach to model radiative transport through foams. Basic FVM will be discussed first, followed by the blocked off region approach to handle the solid and void of porous media. It will be demonstrated how the voxel based information of a foam obtained from tomographic images is utilized to carry out a pore scale simulation. The FVM is modelled in a Cartesian coordinate frame and does not require any grid construction for a complex porous media like foams making it a suitable candidate for such pore level simulations. The simulations are carried out for determination of radiative properties like extinction coefficient, scattering albedo and also for finding out the effective thermal conductivity when used in conjunction with conduction heat transfer. Experimental validation of the data shows the reliability/accuracy of the numerical model.

Bio:

Dr. Prabal Talukdar is currently a CEA chair Professor in the Department of Mechanical Engineering of IIT Delhi. Prior to this Dr. Talukdar worked as a Post-Doctoral fellow at the University of Saskatchewan (2005-2006), Canada and University of Erlangen-Nuremberg (2002-2005), Germany. He did his MTech and PhD from IIT Guwahati and B.E. from Assam Engineering College. He has been working as a Visiting Professor/Scientists at the Technical university of Freiberg, Germany, and University of Saskatchewan, Canada in the past several years.

His research areas are radiative heat transfer, heat and mass transfer in porous media, convective drying, continuous casting, Inverse heat transfer, heat transfer through thermal protective fabric etc. He has authored about 160 international journal and conference papers. Nine students successfully defended their PhD thesis under his supervision and currently, 10 PhD students are working with him. He is currently the Associate Editor of ASME Journal of Thermal Science and Engineering Applications and Journal of Enhanced Heat Transfer.

Sunil Kumar, PhD

Division of Engineering
New York University Abu Dhabi

Machine Learning for Inverse Radiative Transfer: Preliminary Results

Abstract:

Inverse radiative transfer problems typically take the form of ascertaining the distribution of radiative properties within the scattering-absorbing medium from a limited set of observations. Most common observations are those that are made at the boundaries of the medium, such as the local intensity or flux leaving the medium. Due to the ill-posed nature of the inverse problem the mathematical techniques to obtain a solution require sophisticated mathematics, regularization, and cost function minimization to arrive a possible distribution.

Typically a unique inverse solution is not guaranteed. In our method we take a machine learning approach where neural networks are trained to solve the inverse problem. In a step-by-step approach we have tackled cases of increasing complexity, starting with a single inhomogeneity in an otherwise homogenous scattering-absorbing medium, and increasing their number, size, and property distributions. Although the preliminary results are encouraging, there are bottlenecks that could become intractable as the complexity increases. We are exploring integrating physics based modeling with machine learning – a nascent idea in the literature. Neural networks are purely data driven, agnostic to the physics of the underlying problem. Introducing the mathematical model of the underlying physics in the minimization process has the promise of yielding more accurate results.

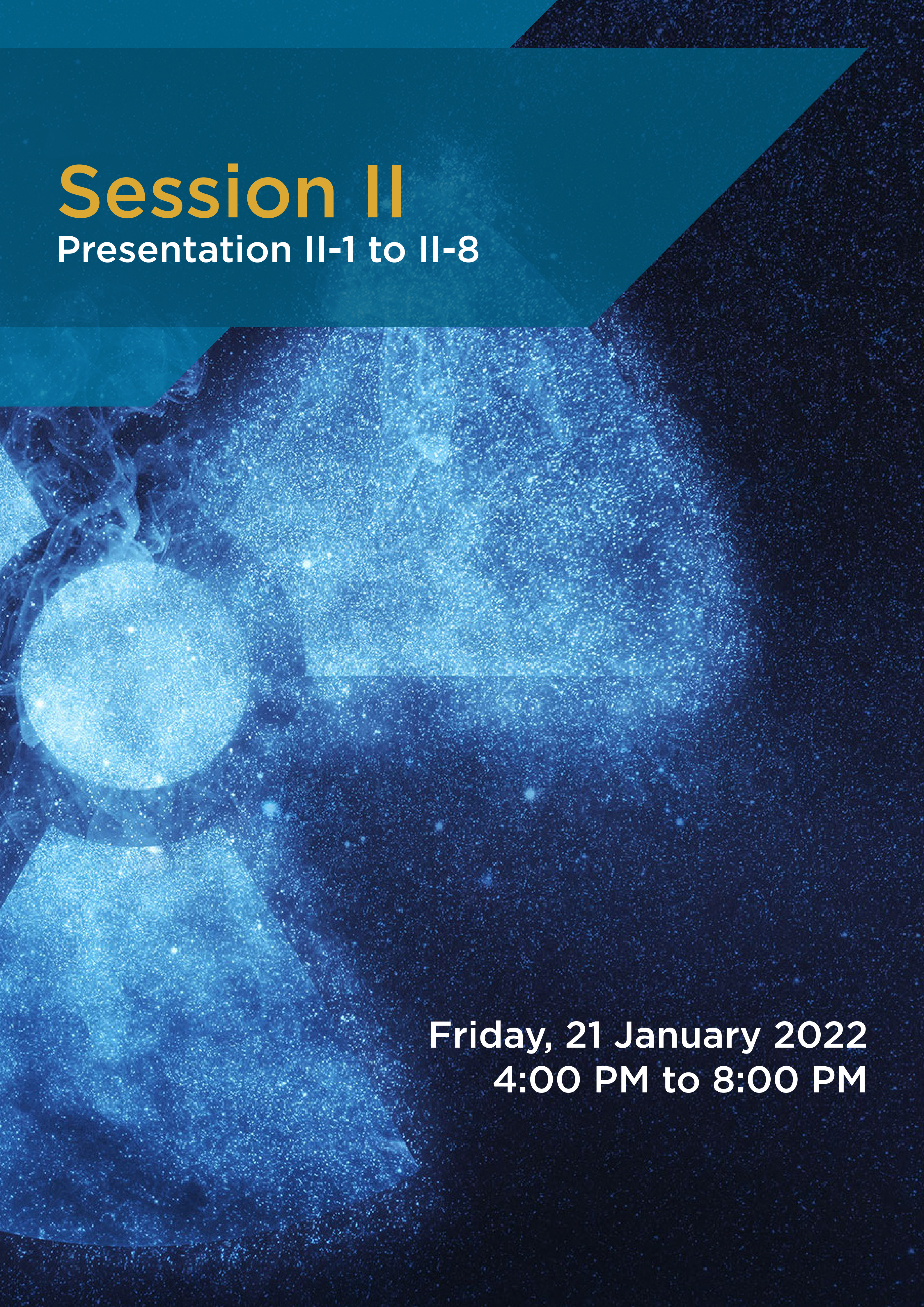
Bio:

Sunil Kumar is Professor of Mechanical Engineering at New York University Abu Dhabi (NYU-AD). He was the founding Dean of Engineering at NYUAD since 2009 until 2015, and from 2015 to 2020 the inaugural Vice Provost for Graduate and Postdoctoral Programs. Before joining NYUAD he was a Professor of Mechanical Engineering and the Dean of the Graduate School at New York University Tandon School of Engineering.

Sunil Kumar received his PhD in Mechanical Engineering from the University of California at Berkeley, MS in Mechanical Engineering and MA in Mathematics from the State University of New York at Buffalo, and a BTech (Hons) from the Indian Institute of Technology at Kharagpur. He is a Fellow of the American Society of Mechanical Engineers and a member of The UAE Mohammed bin Rashid Academy of Scientists.

Session II

Presentation II-1 to II-8



Friday, 21 January 2022
4:00 PM to 8:00 PM

Denis Lemonnier, PhD

Institut Pprime, Dept. Fluid, Thermal and Combustion Science
CNRS – ENSMA – Univ. Poitiers

Coupling of natural convection and radiation in semitransparent gaseous media

Abstract:

Natural convection in large enclosures may be very sensitive to any type of perturbation, and especially to gas radiation. Complex couplings arise, that influence the flow regimes, the transition limits to unsteadiness or turbulence, or more generally, the stability of the flow. This problem is of primary interest in many aspects linked to air-filled closed domains, as in buildings, where even at room temperature, the water vapor contained in air plays a significant role either in a static way (it changes the thermal stratification, with an impact on comfort) or in a dynamic way by its influence on the onset of turbulence and its main characteristics (intensities, energy spectra). Even more complex situations occur in mixtures where the absorbing specie diffuse into another gas. This leads to the so-called double-diffusive convection flows (with simultaneous thermal and mass gradient driving the buoyancy forces) and, depending on the configuration, gas radiation may either stabilize the flow or promote instabilities in the flow.

The main challenges faced by numerical simulations of this type of flow lies in a reliable description of the turbulent regime, even without any radiative effect. When radiation is included, the challenge is to find an accurate gas absorption model. In that frame, the most recent versions of the global models based on k-distributions (SLW, FSK, ADF) provide reliable tools. A short survey of some typical case studies in coupled natural convection and gas radiation will be presented in many different configurations involving differentially heated cavities, thermal plumes or point heat sources.

Bio:

Denis LEMONNIER is a Senior Scientist at the French National Council for Scientific Research (CNRS). His research activities take place at Institut Pprime, Poitiers: they mainly concern radiation in absorbing dense or gaseous media and simulation of coupled transfers in convective flows. He is Associate Editor of the Journal of Quantitative Spectroscopy and Radiative Transfer, as well as permanent chair of a EUROTHERM seminar series devoted to thermal radiation.

He also chaired, with Brent W. Webb, the last four symposia on radiative transfer organized by the International Center for Heat and Mass Transfer (ICHMT). He is a member of the directorate of the French Society of Heat Transfer (SFT), French delegate at the EUROTHERM Committee and member of the Scientific and Executive Committees of ICHMT.

Dr.Sanat Kumar Bhuyan, MDS

Professor, Dept. of Oral Medicine, Institute of Dental Sciences, Siksha O Anusandhan (Deemed to be) University, Bhubaneswar, Odisha

Current concept of Laser – Oral Tissue Interaction

Abstract:

The common dental lasers that are used today are erbium, Nd:YAG(Neodymium Yttrium AluminiumGarnet) , diode, and CO2. Each type of laser has specific biological effects and procedures associated with them. Lasers have been used to perform oral soft tissue dental procedures as it is beneficial in treating a wide range of dental complications and also in therapeutic treatments that aims in the management of tissues.

There are three types of lasers used in dentistry mainly, Soft, Hard tissue and Non-surgical lasers. Lasers are also used for diagnosis purposes such as, detection of pulp vitality; Doppler flowcytometry; laser fluorescence (i.e. Detection of caries, bacteria, changes in the diagnosis of cancer). Lasers also has an impact on restorations, bleaching agents and as a laser-induced analgesics. Soft tissue lasers have been successfully used in periodontal surgical procedures. This Includes, Periodontal Flap Surgery, Oasis Resuscitation, gingivectomy, gingivoplasty, frenectomies, ablation of Wounds, excisional and incisional biopsy, tuberculosis Soft Tissue Deficiency, Periodontal Pocket Treatment, Laser treatment can be a useful method Obtaining biopsy samples without tissue destruction. This presentation includes mainly the evidence based application of laser in diagnosis and management of various oral tissues related disease.

Bio:

Dr. Sanat Kumar Bhuyan is a renowned clinician, with a state of art dental hospital equipped with all latest gadgets. He graduated as BDS (SCB Dental College, Cuttack, Odisha in1991), post-graduation in Oral Medicine and Radiology (University of Nagpur in 1996), worked as a faculty member (University of Utkal(SCB),Cuttack, Odisha).He actively participated in a course in Endodontic and Implant Radiology in NEW YORK,USA .Presently working as professor and Head of the Dept. of Oral Medicine and Radiology, SOA UNIVERSITY.

He has conducted various hands-on programs on CT and CBCT and conventional radiology. Invited as keynote speaker in DMFR conf .Taiwan .Received and honored with many awards and certificate of appreciation in various National and International conferences. He is a member and reviewer in many journals in Indian academy of Oral Medicine and Radiology. He Conducts workshop in weekends in his state of art dental hospital for young practitioners in microscopic endodontic and implants and lasers. He has 15 patents, 3 books and 45 publications on his credit.

Pedro J. Coelho, PhD

Mechanical Engineering Department, Instituto Superior Técnico, University of Lisbon

An improved model to account for turbulence-radiation interaction in the numerical simulation of turbulent reactive flows

Abstract:

It is presently well-established that turbulence enhances radiative emission in reactive flows. The radiative emission depends on the temperature, pressure and chemical composition of the medium. Different approaches are available to account for the effect of turbulence on radiative emission, which are closely related to the employed combustion model. In the case of combustion models that assume the shape of the probability density function (pdf) of mixture fraction or models that solve an equation for the joint pdf of temperature and chemical composition, the assumed or computed pdf allows also the calculation of the mean radiative emission without additional assumptions besides those already used in the combustion model. In the case of other models, as for example when the eddy dissipation concept is used, a different approach is required to determine the mean radiative emission.

The classical one is to determine the mean radiative emission by expanding the temperature and absorption coefficient into their mean and fluctuating components, followed by neglecting the correlations of order higher than two, whose contribution is lumped into two coefficients. It turns out that, in general, the higher order correlations are not negligible. Accordingly, the relative importance of the higher order terms was investigated using numerical data from large eddy simulation of a large-scale pool fire, and then an improved model was developed. It was found that the improved model performs better than the classical one, especially in the flame region.

Bio:

Professor Pedro Coelho graduated in Mechanical Engineering in 1984 and received his Ph.D. in 1992 from Instituto Superior Técnico (IST), University of Lisbon, Portugal. He is professor at the Department of Mechanical Engineering of IST, being currently the head of the Department. He has about 100 papers published in international journals, and more than 120 papers presented at international conferences. He is co-author of a book on Combustion (in Portuguese) for undergraduate and master students.

His research is in the field of numerical simulation of heat transfer and combustion problems. Specific areas of interest are radiation models, turbulence-radiation interaction, computational heat transfer, turbulent diffusion flames, mild combustion and industrial combustion equipment. He is member of several international heat transfer organizations (e.g., Eurotherm Committee, International Centre of Heat and Mass Transfer), associate editor of the J. Quantitative Spectroscopy and Radiative Transfer, Int. J. Thermal Sciences, and member of several international journals.

Kunal Mitra, PhD

Biomedical Engineering
Florida Tech

Bio-Heat Transfer Analysis for Laser Based Therapeutic Applications

Abstract:

The objective of this presentation is to provide an overview of bio-heat transfer analysis for various laser-based applications. The first topic focuses on the experimental and numerical analysis of axial and radial temperature distributions and heat affected zone in layered tissue media when irradiated with a focused beam from a short pulse laser source. The next topic will focus on the use of lasers for dental applications. Most tooth decay occurs in the enamel (outer surface) and the dentin, which is the region between the enamel and inner region of the tooth containing the nerve endings (pulp). In order to utilize lasers for caries therapy (removal of tooth decay), it is crucial to minimize the amount of heat diffusion to the surrounding tooth due to thermal energy produced by the laser irradiation.

The following topic focuses on laser surgery LASIK to correct the refractive error. The LASIK procedure is done with nanosecond laser pulses that may generate cavitation bubbles during ablation and excessive heating of corneal tissue left behind. The collapse of cavitation bubbles can damage tissue. The procedure requires a mechanical keratome to make a flap in the corneal surface that is folded back during corrective ablation. This flap never heals and remains a danger to correct vision if it moves or wrinkles. The introduction of femtosecond pulse lasers for refractive surgery may solve some of the LASIK problems. The talk will conclude with the laser ablation of brain tumors using laser interstitial thermal therapy.

Bio:

Dr. Kunal Mitra is currently a Tenured Professor of Biomedical Engineering with joint appointment in Mechanical Engineering at Florida Tech. He is also the Director of Laser, Optics, and Instrumentation laboratory which he established at Florida Tech in 2000. He earned his BSME degree from Jadavpur University, Calcutta, India in 1991. He then earned his M.S. and Ph.D. degree in Mechanical Engineering from NYU School of Engineering in 1993 and 1996 respectively. He is a Fellow of American Society of Mechanical Engineers (ASME), American Society for Laser Medicine and Surgery (ASLMS), and Senior Member of Society of Photo-Optical Instrumentation Engineers (SPIE).

He serves on the Board of Florida Photonics Cluster. He also serves on Research Strategy Committee of NASA-New Organ Alliance and Steering Committee of Regenerative Medicine Engineering Society. He is also Associate Editor of four journal in the areas of heat transfer, medical device, and tissue engineering.

Zhixiong Guo, PhD (co-author Yihua Hao)

Department of Mechanical and Aerospace Engineering
Rutgers University

Near-field radiation and detection in integrated sensor combining whispering-gallery mode and surface plasmonic resonance

Abstract:

Surface plasmonic resonance (SPR) is integrated into a whispering-gallery mode (WGM) optical microsensor to augment sensitivity and evanescent radiation in this study. The performance of such WGM silica ring sensors was evaluated for detection of small respiratory viruses such as COVID-19 via the finite-element modeling.

Compared with traditional WGM sensors, the integration with SPR enhances sensitivity by 3-5 times and facilitates combination with the polymerase chain reaction method to achieve fast, accurate, and specific virus detection. A fundamental enhancement factor based on relative electric energy ratio is introduced and defined to analyze and quantify sensitivity enhancement for the first time.

Bio:

Dr. Zhixiong "James" Guo is a Professor of Mechanical and Aerospace Engineering at Rutgers University-New Brunswick, NJ, USA, since 2001. He received his B.S., M.S., and Doctorate, all in Engineering Physics, from Tsinghua University, Beijing. From 1999 to 2001, he was a research staff member in NYU-Tandon School of Engineering, where he completed his Ph.D. in Mechanical Engineering.

He is a recognized expert in heat transfer, with notable expertise in radiation transport, heat transfer enhancement, and nanoscale heat transfer. He has authored over 260 articles/editorials in archival journals and conference proceedings. He is the Editor-in-Chief for Journal of Enhanced Heat Transfer, a Managing Editor for Heat Transfer Research, and editorial board member for Applied Thermal Engineering and Frontiers in Energy. Dr. Guo is an elected Fellow of ASME and ASTFE. He was awarded a JSPS Invitation Fellowship, a K.C. Wong Education Foundation Fellowship, and Rutgers the Board of Trustee's Award for Excellence in Research, the university's highest honor for outstanding research contributions to a discipline or to society.

Zhuomin Zhang

J. Erskine Love, Jr. Professor
George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology, Atlanta

Thermal Radiation: from Nanoscale and Microscale to Macroscale

Abstract:

Radiative heat transfer between objects can be greatly enhanced at nanoscale separation distances due to photon tunneling and surface plasmon or phonon polaritons. Nanoscale thermal radiation has promising applications in advanced energy harvesting, nanomanufacturing, thermal control and management, and high-resolution thermal mapping.

This presentation will give an overview of nanoscale thermal radiation and related applications, including tailoring the spectral radiative properties using micro/nanostructured surfaces and two-dimensional materials (such as graphene and hexagonal-boron-nitride films). At the macroscale, solid particle receivers have been actively investigated for use as the thermal energy storage materials for concentrated solar power plant. Characterization of the thermal properties of promising solid particles such as sintered bauxite particles and silica particles is imperative. We have developed several techniques to study the thermal radiative properties of particles and particle beds. The second part of this presentation will focus on the spectral, directional thermal radiative properties of bauxite and silica particles and particle beds.

Bio:

Dr. Zhuomin Zhang is the J. Erskine Love, Jr. Professor in Mechanical Engineering at Georgia Institute of Technology. He earned his B.S. and M.S. degrees from the University of Science and Technology of China and Ph.D. degree from MIT. He worked at the National Institute of Standards and Technology and University of Florida before joining Georgia Tech. Professor Zhang's research interests are in nanoscale thermal radiation and radiative properties for energy harvesting.

He has written a book on Nano/Microscale Heat Transfer (1st ed. 2007, 2nd ed. 2020). Dr. Zhang has co-authored more than 200 journal papers and given over 400 invited and contributed presentations and seminars. Dr. Zhang is a Fellow of ASME, AAAS, and APS. He was a recipient of the 1999 PECASE award, 2015 ASME Heat Transfer Memorial Award, 2021 ASME Yeram S. Touloukian Award, and the 2021 AIAA Thermophysics Award.

Kyle Daun, PhD

Department of Mechanical and Mechatronics Engineering
University of Waterloo

Flare emissions quantification using hyperspectral and multispectral imaging

Abstract:

The impact of methane released from upstream oil and gas processing on climate change is mitigated through flaring, which converts the methane into carbon dioxide. Under ideal conditions this process is highly effective, but cross-winds and smoke suppression through air and steam injection may significantly reduce flare combustion efficiency. Understanding how these phenomena impact flare emissions is challenging, however, due to the highly transient and diffuse nature of gaseous emissions.

Hyperspectral and multispectral imaging offers a unique capability to provide reliable, temporally-resolved field measurements of flare combustion efficiency through fenceline monitoring. The technique combines species column densities inferred from emission spectroscopy with intensity-weighted velocities found from an optical flow algorithm to obtain the mass fluxes needed to define combustion efficiency. This talk reviews recent progress and some of the remaining challenges that must be resolved to develop a robust tool for monitoring flare combustion efficiency.

Bio:

Kyle Daun is Professor in the Department of Mechanical and Mechatronics Engineering at the University of Waterloo. He received his PhD from the University of Texas at Austin (2003) in the area of radiative heat transfer. He then worked at the National Research Council (NRC) Canada as an NSERC postdoctoral fellow and later as a research officer, working in the area of optical combustion diagnostics, before moving to Waterloo in 2007. Professor Daun's current research interests include: optical gas diagnostics, laser-based nanoparticle diagnostics, and heat transfer in automotive manufacturing. He is a Fellow of the American Society of Mechanical Engineers.

Srinivasa Ramanujam Kannan, PhD

School of Mechanical Sciences,
IIT Bhubaneswar, Jatani, Khorda, Odisha

Retrieval of multi-parameters from passive microwave remote sensing observations of a raining atmosphere.

Abstract:

In this talk, the schematic of layered non-homogeneous raining atmosphere will be discussed from radiative transfer equation perspective. The raining atmosphere is often sensed with passive microwave instruments due to its ability to penetrate through cloud and rain, allowing us to measure total cloud, rain, ice, and water vapour content. However, the instrument typically senses the atmosphere in a few select frequencies and polarization. Hence, the multi-parameters of a raining atmosphere has to be retrieved from fewer observations, which mathematically comes under ill-posed problems.

The talk details about the sensitivity of water particles present in atmosphere in different phase to the frequency and polarization aspect of radiation, and the algorithms applied to retrieve the parameters using a non-parametric function inversion.

Bio:

Dr Kannan completed his Ph.D from IIT Madras and was a postdoc researcher from Colorado State University, U.S.A. He has worked in inter-disciplinary problems involving active and passive microwave remote sensing of raining atmosphere based on which he has published over 25 peer reviewed Journal and Conference articles.

Session III

Presentation III-1 to III-8

Saturday, 22 January 2022
9:00 AM to 1:00 PM

Andreas H. Hielscher, PhD

Department of Biomedical Engineering,
Tandon School of Engineering, New York University

Radiative-Transfer-Based Optical Tomographic Imaging for Clinical and Pre-Clinical Applications

Abstract:

Optical tomography (OT) is a biomedical imaging modality that employs visible and near-infrared light to probe biological tissues. Unlike many other medical imaging modalities, such as X-ray imaging or positron emission tomography, OT does not relay on potentially harmful radiation. Furthermore, the high contrast of many optical markers promises disease detection on the molecular level. It is well established that reconstruction algorithms that employ the equation of radiative transfer (ERT) provide the most accurate reconstruction results in OT. However, these ERT codes require large amounts of memory and are usually slowly converging. To overcome these problems, we have developed algorithms that employ so-called partial-differential-equation (PDE) constrained methods. In this approach the forward and inverse problem are solved simultaneously in each iteration step by using the ERT as a Lagrangian constrained on the generalized inverse problem. The performances of these codes have been evaluated with numerical and experimental data. We found that the computation and memory requirement can be considerably reduced without affecting the accuracy of the solutions. Employing ERT-based codes in preclinical studies involving tumor-bearing mice we were able to predict responses and treatment outcome to anti-angiogenic drugs.

Furthermore, we have demonstrated utility of these codes in clinical studies involving patients with arthritis, peripheral artery diseases (PAD), and breast cancer. For example, high sensitivities and specificities were found in diagnosing arthritic joint diseases and PAD. Most recently we have implemented first deep-learning based neural network to achieve sub-second, real-time read-out of human brain activity.

Bio:

Professor Andreas H. Hielscher received his PhD degree in Electrical and Computer Engineering from Rice University, Houston, Texas. After a postdoctoral fellowship at the Los Alamos National Laboratory in New Mexico, he moved to Columbia University in New York City, where he became the Director of the Biophotonics and Optical Radiology Laboratory. In 2020, he moved across town to head the newly formed Department of Biomedical Engineering at New York University.

His work focuses on the development of state-of-the-art systems for optical tomographic imaging that make use of the equation of radiative transfer. He applies this technology to diagnose and monitor arthritis, vascular diseases, breast cancer, brain activity, and more. He has published over 250 scientific articles, several book chapters, and holds over 20 patents. His work has been funded by various institutes at National Institutes of Health (NIAMS, NIBIB, and NCI), DARPA, and other national and international funding agencies.

Swarup K Mahapatra

Professor, School of Mechanical Sciences
IIT Bhubaneswar, Odisha

Introduction to Bio-Heat Transfer

Abstract:

Bioheat transfer is the study of the transport of thermal energy in living systems. Understanding the heat transfer in biological tissues is a necessity for many therapeutic practices involving either raising or lowering temperature such as cancer hyperthermia, burn injury, brain hypothermia resuscitation, disease diagnostics, thermal comfort analysis, cryosurgery and cryopreservation, and so on. The conventional Fourier heat conduction law sometimes fails to predict the accurate tissue temperature due to larger relaxation time, which invites non-Fourier heat conduction model as the application tool to biological tissues. Similarly, tissue medium is highly scattering in nature because of which internal volumetric radiation involving emission, absorption and scattering is considered for accurate description of the thermal behaviour of living tissues. The prescribed talk will address these issues in order to introduce the complexities and the development of bio heat transfer models.

Bio:

Dr.Swarup Kumar Mahapatra is currently working as a professor (Ex-head), School of Mechanical Sciences, Indian Institute of Technology Bhubaneswar, India. He has more than 30 years of teaching and research experience. He has been conferred with teaching excellence award at IIT Bhubaneswar. In addition to teaching and research, he is acting as Dean (Continuing Education) and Dean(Alumni Affairs & International Relations) at IIT Bhubaneswar. He received his Ph.D. from Jadavpur University, India, in 2000. He is involved in many research projects. His research interests are radiative heat transfer modeling computational fluid dynamics and conjugate heat transfer. He has also organized many conferences and short-term courses in his field of research. He has already published more than 55 papers in reputed International Journals.

Dr. Sucheta Parija, MS (Ophthalmology)

**Additional Professor and Head of Department of Ophthalmology,
All India Institute of Medical Sciences Bhubaneswar**

Lasers in Ophthalmology- Diagnostic and Therapeutic Applications

Abstract:

Laser technology continues to progress with the addition of new lasers, new delivery systems, and new applications. Ophthalmology was the first medical specialty to adopt lasers right after their invention more than 60 years ago, and they gradually revolutionized ocular imaging, diagnostics, therapy, and surgery. Challenging precision, safety, and selectivity requirements for ocular therapeutic and surgical procedures keep advancing the laser technologies, which in turn continue enabling novel applications for the preservation and restoration of sight.

Lasers used in ophthalmology use wavelengths from the near infrared to the ultraviolet and pulse durations that are measured in femtoseconds to seconds. Modern lasers can provide single-cell-layer selectivity in therapy, sub-micrometer precision in three-dimensional image-guided surgery, and nondamaging retinal therapy under optoacoustic temperature control. The laser radiations interact with the living tissue mainly by biological, thermal, electrical and mechanical effect. The main areas of therapeutic use of lasers are in treatment of diabetic retinopathy, retinal tears and retinal detachment, intraocular tumors, refractive surgeries etc. Lasers are also used in diagnosis and prognosis of diseases.

This lecture reviews the evolution of laser technologies; progress in understanding of the laser–tissue interactions; and concepts, and therapeutic and surgical applications of lasers in ophthalmology.

Bio:

Dr. Sucheta Parija is Additional Professor and Head of Ophthalmology at All India Institute of Medical Sciences Bhubaneswar. She did her medical undergraduate and post-graduate training in Ophthalmology from S.C. B Medical College, Cuttack and VSS Medical College, Burla as a Gold medalist. She did her long-term fellowship training in Paediatric Ophthalmology and Strabismus from Aravind Eye Hospital, Madurai; Microsurgery training from Sankara Netralaya Eye Institute, Chennai and short term training in Medical Retina at Shroff's Eye Hospital and Retina Eye Hospital, New Delhi.

She is also trained by eminent national and international teachers in Ophthalmology in her career growth. She has many national and international awards for paper and poster presentations to her credit. She has more than 55 paper publication in Pubmed and indexed journals and written few book chapters. She has reviewed many papers and has been the editorial member in few renowned journals such as BMJ, PLOS ONE and IJO.

John C. Chai, PhD

Innovative Technology Research Center
Shenzhen Envicool Technology

The Development of Finite-Volume Method for Radiation Heat Transfer

Abstract:

The talk discusses the development of a numerical method for radiation heat transfer which is called a finite-volume method for radiation heat transfer at the University of Minnesota. The talk will present some of the events that lead to some of the “discoveries”. These include the removal of the intensity of interest from the source term, the effects of mesh (angular and spatial) on spatial differencing schemes and the resulting intensity distributions. Some issues which are still unresolved will be discussed.

Bio:

John Chai is currently the chief scientist of the Innovative Technology Research Center at Shenzhen Envicool Technology (a listed company with annual revenue > US$260M) Co. Ltd. He is an elected Fellow of ASME, an ex-Editorial Board member of Computational Thermal Sciences, an Associate Editor of the ASME Journal of Thermal Science and Engineering Applications (2014 – 2018) and Heat Transfer Engineering (2014 – 2019).

He was an adjunct professor at the Xi’an Jiaotong University, Shanxi, China and China University of Petroleum (East China), Qingdao, China. Prior to his current position, he was a Professor and the Subject Area Leader (Head) of Mechanical Engineering at the University of Huddersfield, UK. In Oct. 2009, he joined the Petroleum Institute (PI) as professor and Chairman of Mechanical Engineering. Prior to joining the PI, he was a Principal Engineer at Amoeba Technologies Inc., a start-up CFD company. He also held faculty positions in Singapore and Tennessee, USA.

Ramjee Repaka, PhD

Department of Mechanical Engineering,
Indian Institute of Technology Ropar, Punjab

Radiofrequency Ablation of Breast Cancerous Tissue: A Computational Approach

Abstract:

Radiofrequency ablation (RFA) is the most extensively studied and widely applied minimally invasive thermal ablative technique in clinical practices. Earlier studies have demonstrated that, RFA is not only an effective treatment modality for primary hepatocellular carcinoma and colorectal metastases to the liver, but has also gained interest in the treatment of tumours in lung, brain, kidney, prostate and bone. Most importantly, RFA is a faster technique that exhibits relatively fewer complications with improved cosmesis and low treatment cost as compared to the other techniques. In this presentation the effect of temperature controlled RFA with monopolar multi-tine electrode in different body sites, viz., liver, kidney, lung and breast (with different density levels), is going to be delineated.

The variations in predicted input voltage, temperature distribution, ablation volume and treatment time during RFA of tumour in these parts will be presented. The effect of temperature-dependent changes in electrical and thermal conductivity along with damage-dependent changes in local tissue perfusion has been accounted in this study. A thermo-electric analysis has been done to obtain the temperature distribution and the ablation volume by incorporating the coupled electric field distribution, the Pennes bioheat and the first-order Arrhenius rate equations. It will be presented that, the surrounding tissue environment significantly affects the ablation volume produced during RFA in different organs and also the breast density compositions significantly affect the treatment outcomes.

Bio:

Dr. Ramjee Repaka is an Associate Professor in the Department of Mechanical Engineering and Center for Biomedical Engineering at IIT Ropar. He received his Bachelor degree in Mechanical Engineering from Andhra University, Master degree in Mechanical Engineering from Jadavpur University, Kolkata and Ph.D. in Mechanical Engineering from IIT Kharagpur.

He worked as Assistant Professor in the Department of Mechanical Engineering at NIT Rourkela before joining IIT Ropar. Dr Ramjee Repaka is also an Associate Editor for ASME Journal of Engineering and Science in Medical Diagnostics and Therapy. His research areas include Heat Transfer, Applied Thermal Engineering, Bioheat Transfer, Cancer Diagnosis and Therapy (RFA and MWA), Biofluid Mechanics and Refrigeration and Air Conditioning.

Dillip Kumar Parida, MD

Professor & Head, Department of Radiation Oncology
All India Institute of Medical Science, Bhubaneswar

Use of Thermal Energy for the Management of Cancer

Abstract:

Since ages heat is being used for various use of mankind including therapeutics. The use of thermal energy for oncological management dates back to 3000BC. Hippocrates once mentioned that "What medicines to not heal, the lance will; what the lance does not heal, fire will." The process of hyperthermia refers to increasing of body temperature or selected tissue beyond 44 C in order to achieve a precise therapeutic effect. The discovery of ionizing radiation in 1895 by German physicist Wilhelm C. Röntgen and Radium by Marie Curie in 1896 led to the use of X-rays and ionizing radiation to treat cancer and temporarily reduce the interest in hyperthermia.

However, already in 1910, G. Schwarz found that hyperthermia combined with radiotherapy gives good therapeutic results. Hyperthermia treatment is delivered as both systemic as well as local. The development of new technologies allow for better options in the local heating of tumors, including those located deep in the human body (local-regional hyperthermia). In 1988, by combining hyperthermia with modern knowledge of bioelectromagnetism and human physiology, a new direction in the fight against cancer called "Oncothermia" was created. Technical difficulties did not allow Hyperthermia as a modality to come to the forefront. Nevertheless hope still remain on recent use of nanotechnology and magnetic fluid hyperthermia.

Bio:

Dr. Dillip Kumar Parida is Professor and Head of Department of Radiation Oncology at AIIMS Bhubaneswar. He received his MBBS from MKCG Medical College in Berhampur, and MD in radiation oncology from SCB Medical College, Cuttack. He established the department of radiation oncology in the newly formed AIIMS Bhubaneswar. Previously he was at AIIMS New Delhi and NEIGRIHMS Shillong, a regional cancer center of the government of India. He has been a visiting professor at National Institute of Biomedical Innovation, Japan, and Erasmus University, Netherlands. He is a member of the editorial board of Journal of Oncology and Hematology and the Indian Journal of Cancer Education and Research.

Dr. Paramdeep Singh, MD

Department of Radiology, All India Institute of Medical Sciences (AIIMS), Bathinda, Punjab

Radiation Safety and Protection for Medical professionals

Abstract:

The units of measurement for radiation have changed from Rads and Rems to Grays and Sieverts. Radiation's biological impacts are divided into two categories: deterministic and stochastic effects. Organ or gene alterations can occur as a result of both deterministic and stochastic influences. Radiation doses from medical exposure are currently the most common type of man-made radiation exposure, thanks to the fast development of medical technology. Controlling medical radiation exposure necessitates regulation.

At the international and national levels, there are a number of regulatory bodies that set radiation safety standards such as the International Commission for Radiation Protection (ICRP), the National Commission for Radiation Protection (NCRP) in the United States, and the Atomic Energy Regulatory Board (AERB) in India. Three important terms that summarise the general concepts of radiation protection against the dangers of ionising radiation are the justification, optimization, and dose limit. Physicians and the general public must be aware of the hazards and advantages of medical radiation exposure, as well as comprehend and use radiation protection guidelines.

Bio:

Dr Paramdeep Singh is working as an Additional Professor of Radiology at AIIMS Bathinda. Besides Medical Imaging, he has received certifications on Global Health, Biomedical Research and Evidence Synthesis from reputed Institutions. He has been nominated as the Focal point for the United Nations (UN) Sustainable Development Solutions Network (SDSN) and has been appointed as the Ambassador to the Asian Council of Science Editors. While maintaining a healthy balance between teaching, research and clinical service, Dr. Singh has authored numerous peer-reviewed publications, apart from having many presentations at National and International scientific meetings.

Dr. Singh is the recipient of many awards, scholarships and recognitions such as the Young Investigator award by World Stroke Organization and has been identified as an outstanding Young Physician Leader (YPL) by the Inter Academy Partnership (IAP). He is member of the Indian National Young Academy of Science (C/O Indian National Science Academy (INSA)), National Academy of Medical Sciences (India) and Punjab Academy of Sciences (India).

S. P. Venkatesan, PhD, Professor (Emeritus)

Department of Mechanical Engineering,
Indian Institute of Technology Madras

Conjugate heat transfer involving thermal radiation

Abstract:

Seldom do practical problems occur that involve only one mode of heat transfer. Invariably radiation is a process that is always present, but usually ignored because of the complexity of this mode of heat transfer.

This talk focuses on the importance or otherwise of radiation heat transfer in a few typical problems encountered in practice. Analysis and results are presented that highlight the role played by radiation in problems involving all three modes of heat transfer viz. conduction, convection and radiation. Both theoretical and experimental results are presented and discussed.

Bio:

Dr. S.P. Venkateshan received his PhD from IISc Bangalore in 1977. He worked as a post doctoral fellow at Yale University, USA from 1979 to 1981. He joined IIT Madras as Assistant Professor in 1981 and was promoted as Professor in 1990.

He retired as Professor of Mechanical Engineering in 2011. He has been Professor Emeritus in the department until December 2016. His areas of research are: radiation heat transfer, interaction of radiation and convection, thermal conductivity of anisotropic materials, Heat transfer in space applications.

Session IV

Presentation IV-1 to IV-8

Saturday, 22 January 2022
4:00 PM to 8:00 PM

Dr Suprava Naik, MD Radiodiagnosis

Associate Professor, Department of Radiodiagnosis
All India Institute of Medical Sciences, Bhubaneswar

Radiation in Diagnostic Imaging

Abstract:

Radiation involves X-rays and gamma rays that forms a part of electromagnetic spectrum. Ability of radiation to penetrate the human body and other objects offers multiple day to day applications including medical imaging.

The invent of X-rays have revolutionized the field of medical imaging. Many innovations have been added to X-ray since its discovery like fluoroscopy, Digital Subtraction Angiography (DSA) and CT scan. Imaging techniques are usually supplement to the clinical diagnosis, however with the advancement of newer modalities it has become the diagnostic and therapeutic modality of choice in stroke, aneurysms and vascular malformations. Apart from this, imaging is also essential to plan the surgical management in cancer patients and in follow up. Many fold increase in the frequency of CT scan examinations being requested because of the technological improvement that have resulted in higher spatial and temporal resolution and shorter scanning times. Guided biopsy and percutaneous interventional procedures have become easy under CT guidance.

To the common man the word radiation always raises a question of concern for safety. There are potential risks associated with radiation exposure however these are seen predominantly at high dose. But even then, it is advised to assess the risk versus benefit and opt for that imaging examination which delivers the lowest possible radiation exposure to the patient and at the same time offers diagnostic benefit.

Scan should be performed with minimal possible radiation dose by Dose optimization and shielding the unexposed parts of the body with lead apron. Adequate measures should be taken by the staff involved in radiation related procedures for protecting themselves. There are bodies like International Commission on Radiological Protection (ICRP) and The Atomic Energy Regulatory Board (AERB) for formulating guidelines and regulating the same within all the hospitals and scan centers under them.

In summary it is impossible to imagine the current way of medical practice without the availability of imaging modalities. However clinical decision and justification is always essential prior to imaging examination.

Bio:

> Associate Professor, Department of Radiodiagnosis,
All India Institute of Medical Sciences, Bhubaneswar
> Publications: 56 publications in Pubmed Indexed journals
> Reviewer of many reputed journals

Sumit Kumar, PhD

**Department of Mechanical Engineering,
National Institute of Technology Rourkela**

Modeling of laser irradiated biological tissue during photo-thermal therapy

Abstract:

The laser-based photo-thermal therapy is a noninvasive technique wherein the tissue temperature is raised using the laser to destroy the cancerous cell with minimal damage to the surrounding healthy tissue. So, the laser's energy acts as the source term in the bio-heat transfer equation. Therefore, the challenge is to accurately determine this source term which depends on the absorption of light intensity. So, various models such as Beer-Lambert law, diffusion approximation, radiative transfer equation, etc., have been developed under some approximation in the past. Among all the available models, the radiative transfer equation is more appropriate for modeling short-pulse laser-irradiated biological tissue because of its turbid nature.

The time scale is used for solving the radiative transfer equation is the order of picoseconds, and it is challenging to capture the diffusion process in such a time scale because it is a slow process. Therefore, modeling the short-pulse laser propagation through the biological tissue is a multi-time scale problem. So, the coupling of the radiative transfer equation with the non-Fourier model-based bio-heat transfer equation will be discussed during the virtual workshop. The analytical solution of the non-Fourier-model-based bio-heat transfer equation using the finite integral transform technique will also be addressed.

Bio:

I am currently working as Assistant Professor at the National Institute of Technology Rourkela Odisha. Prior to joining NIT Rourkela, I worked at Galgotias College of Engineering and Technology, Greater Noida. I pursued my Ph.D. in Mechanical Engineering from IIT Bombay. I pursued my B.Tech in Mechanical Engineering and M.Tech in Thermal Engineering from the University of Rajasthan and NIT Rourkela, respectively.

My research areas are CFD, bio-heat transfer, radiation. I published 12 international journals and 8 papers in peer-reviewed international conferences. I got Financial Assistance from the Science and Engineering Research Board, Department of Science and Technology, Government of India, to attend the International Conference, USA.

Pradeep Kumar, PhD

**Numerical Experiment Laboratory (Radiation & Fluid Flow Physics)
School of Engineering, Indian Institute of Technology Mandi,
Mandi, Himachal Pradesh**

Challenges in the computing of the gaseous radiation in engineering problems

Abstract:

In any scenario of heat transfer in a flow condition, all modes of heat transfer, i.e., conduction, convection and radiation, exist, however, radiation mode of heat transfer poses a major challenge in computing because of its additional dependency on directions and spectrum. Further, the emissions from gaseous medium happen at discrete spectrum unlike the emissions from solid bodies. These emissions depend on the thermodynamic state of gases, i.e., temperature, pressure and composition. In order to estimate accurate emission from the gaseous medium, it is required to solve the radiative transfer equation (RTE) for each transition line of the spectrum.

The literature reveals that such computations take more than 95% computational resources in a Direct Numerical Simulation (DNS) analysis. This situation is further complicated when there exists numerous thermodynamic states of the gases in the system. Numerous methods such as Full Spectrum Scaled k-distribution (FSSK), Full Spectrum Correlated k-distribution (FSCK), Spectral Line Weighted Sum of Gray Gases (SLW), Look-up table based Full Spectrum k-distribution methods etc., have been devised to reduce the requirement of the computations resources. With these methods, the requirement of the computational cost for the computing of the gaseous radiation has reduced drastically and are able to perform some of the critical applications like, estimation of radiation loss in combustion, thermal load on the rocket base plate etc., whereas, the spectral information of emitted radiation, which is of strategic importance, is lost with these methods, however, it can be reconstructed, once the thermodynamic state of gases is obtained by above methods in conjunction with Computational Fluid Dynamics.

Bio:

Dr. Pradeep Kumar is currently Assistant Professor in School of Engineering at Indian Institute of Technology Mandi (IIT Mandi), Mandi, Himachal Pradesh, India. After completing his PhD from Indian Institute of Technology Kanpur (IIT Kanpur), Kanpur, Uttar Pradesh, India, he worked with ANSYS Fluent India Pvt Ltd in the development department for six and half years. He is currently working in the area of radiative heat transfer, fluid mechanics, solar devices, etc., and uses computational tools for his research purposes.

He is extremely interested in exploring and developing open-source software. His team is currently developing various features of radiative heat transfer like, collimated beam radiation, non-gray radiation model, etc. in OpenFOAM - an open-source CFD software for the applications of solar receiver cavity, combustion, thermal load on rocket base plate, etc.

Prasenjit Rath, PhD

School of Mechanical Sciences,
Indian Institute of Technology Bhubaneswar

Radiation Heat Transfer and its Interaction with other Modes of Heat Transfer at short time scale

Abstract:

Radiation heat transfer at short time scale has potential applications in laser materials processing and biomedical engineering. At extremely short time scale (sub picoseconds), only radiation heat transfer is the dominant mode of energy transfer. Divergence of radiative heat flux is a measure of the energy deposition due to volumetric radiation in a participating medium. At extremely short time scale, the conventional steady form of divergence of radiative heat flux is modified and a new term called as the "propagation term" evolve. The inclusion of this new propagation term results in a non-zero radiation energy deposition even for a purely scattering medium.

Effect of the modified radiation energy deposition on the temperature of the medium is studied at extremely short time scale. Further, a conduction-radiation axisymmetric bioheat transfer is studied in a short time scale where radiation is steady and conduction shows wave behavior (non-Fourier). A finite volume numerical methodology is developed to solve the governing set of equations.

Bio:

P. Rath received his PhD from NTU Singapore in 2007 where he worked under the supervision of Professor John Chai from School of Mechanical and Aerospace Engineering. Soon after completing his PhD, he joined NIT Rourkela as Assistant Professor in 2006. In 2009, he moved to IIT Bhubaneswar and working as Assistant Professor in the School of Mechanical Sciences.

He worked as a Teaching and Research Associate at Khalifa University of Science and Technology (formerly known as Petroleum Institute), Abu Dhabi during 2014-15. He published more than 30 international journal articles and several conference articles. His areas of research are: ultrafast radiation heat transfer, Microfabrication, bioheat transfer, electronic cooling and energy storage. His major research includes the development of numerical methodology for moving boundary problems involving heat and mass transfer.

Fengshan Liu, PhD

Black Carbon Metrology, Metrology Research Centre, National Research Council, Ottawa, Ontario

Development of non-gray wall emissivity models to improve the accuracy of FSCK method for problems involving non-grey walls

Abstract:

Accurate calculations of gas radiative heat transfer in combustion systems are challenging due to not only the strong spatial and directional dependence of radiative intensity but also the very rapid spectral variations of radiative property of combustion products (mainly CO2 and H2O). As a result, simplified treatments of non-grey walls have often been made in gas radiation heat transfer calculations to save computing time. The importance of properly modeling the non-grey wall emissivity to the accuracy of calculations within the framework of FSCK method has received increasing attention.

In this presentation, the development and evaluation of non-grey wall emissivity models for the FSCK method are discussed. The spectral radiative transfer equation (RTE) and the spectral boundary condition were first reordered. Then the analytical solution of net radiative flux between two parallel-plates containing a uniform medium under optically thick condition was used to derive the non-grey wall emissivity and absorptivity. The accuracy of non-grey wall emissivity models and the commonly used Planck-function-weighted gray-wall emissivity model is evaluated in several 1D parallel-plate cases containing isothermal and homogeneous as well as non-isothermal and inhomogeneous media and 3D flames bounded by walls coated with fly-ash deposit or soot deposit. The results show that the non-grey wall models offer better accuracy without losing computational efficiency of grey wall models. Non-grey wall models are recommended for use with the FSCK method for accurate calculations of gas radiation heat transfer in combustion systems.

Bio:

Dr. Fengshan Liu received his Bachelor degree in from Tsinghua University in 1986 and PhD degree from The University of Sheffield in 1990. After a two-year postdoctoral fellowship in Leeds University, he joined the Queen's University in Canada as a Research Assistant Professor from 1992 to 1996. He joined the National Research Council Canada in 1996 and has remained at NRC.

Dr. Liu has conducted research in modeling radiative heat transfer, modeling soot formation in hydrocarbon flames, development and implementation of the laser-induced incandescence technique for soot diagnostics. Dr. Liu holds two patents in the LII technique. Dr. Liu's recent research focused on measurements of black carbon emitted from combustion systems and radiative properties of soot particles and other ultrafine fractal aggregates. Dr. Liu is an Associate Editor of Journal of Quantitative Spectroscopy and Radiative Transfer and a Fellow of Combustion Institute.

Arvind Narayanaswamy

**Department of Mechanical Engineering,
Columbia University**

On thermal radiation, small and large

Abstract:

In this talk, I will touch upon two aspects of thermal radiation, one at the small length scales (nanometer scale) and one at large length scale (meters). The fluctuational-electrodynamical description of thermal radiation is necessary, especially at length scales comparable to or lower than the dominant thermal wavelength. Less well-known, perhaps, to researchers focused on thermal radiation is the concurrent phenomenon of dispersion forces between macroscopic objects, van der Waals forces and Casimir forces being the most well-known. In the first part, I will address topics relevant to the phenomena of dispersion forces between macroscopic objects but with a small twist – what happens when the two objects are not solids but fluids, especially fluids approaching the critical point? Can we link the optical properties of the media to the surface energies or surface tension?

In the second part, I will address the importance of vegetation in reducing building energy consumption and talk about the interaction between solar radiation and vegetation. Specifically, I will address the importance of green walls – vertically grown vegetation that can shade the building walls from incoming solar radiation. In a country like India, where fraction of urban land purposed for vegetation is abysmally low, this could be a great way of increasing urban vegetation.

Bio:

Arvind Narayanaswamy received his PhD in mechanical engineering from Massachusetts Institute of Technology in 2007, a MS in mechanical engineering from University of Delaware in 1999, and a B. Tech in mechanical engineering from Indian Institute of Technology (Madras) in 1997.

As a graduate student at MIT, he worked with Prof. Gang Chen mainly on the topic of nanoscale thermal radiative transport. He joined the faculty in the Department of Mechanical Engineering at Columbia University in 2007, and is now an Associate Professor. His research interests include theoretical and experimental investigations in nanoscale thermal transport, radiative transfer in gas turbines, selective emitters for building energy applications, nanoscale thermal metrology with bi-material cantilevers, influence of intermolecular forces on phase change heat transfer, and friction.

Sandip Mazumder, PhD (Co-author Nehal Jajal)

**Department of Mechanical and Aerospace Engineering,
The Ohio State University**

Hybrid Solver for the Radiative Transport Equation in Nongray Combustion Gases

Abstract:

The Radiative Transfer Equation (RTE) is a five-dimensional integro-differential equation, and is challenging to solve. The Discrete Ordinates Method (DOM) or its variant, the Finite Angle Method (FAM), yields accurate solutions when used with sufficient angular resolution, especially when the medium is optically thin. However, this can be computationally expensive. On the other hand, the Spherical Harmonic Method (PN approximation) with its lowest order approximation (P1) yields a single elliptic partial differential equation and is efficient to solve.

The P1 method is accurate only when the intensity field is more or less isotropic, as in optically thick media. In this study, the nongray RTE is solved using a hybrid approach that utilizes the efficiency of the P1 method in optically thick spectral bands while maintaining its accuracy with FAM in the optically thin bands with a cut-off optical thickness for switching. Using the statistical narrow band (SNB) model for CO_2 and H_2O, homogeneous and inhomogeneous mixtures enclosed in multidimensional media are tested to assess the hybrid solver. The governing equations were discretized using the unstructured finite volume procedure and solved using iterative Krylov subspace based solvers. Overall, the hybrid solver was found to be a good compromise between accuracy and efficiency. A novel filtered approach showed higher computational efficiency than the initial cut-off idea.

Bio:

Dr. Mazumder obtained his B. Tech. (Honors) from IIT-Kharagpur in 1991 and his Ph.D. from Penn State University in 1997. He joined the Ohio State University (OSU) in March of 2004. Prior to joining OSU, he was employed at CFD Research Corporation in Huntsville, AL for 7 years. He is one of the architects and early developers of the commercial code CFD-ACE+™.

Dr. Mazumder is the author of two graduate-level textbooks (Numerical Methods for Partial Differential Equations and Radiative Heat Transfer), 60+ journal papers, and 50+ peer-reviewed conference publications. He is the recipient of the McCarthy award for teaching and the Lumley award for research from the OSU College of Engineering among other awards, and is a Fellow of the American Society of Mechanical Engineers (ASME) since 2011. Currently, he also serves as the Associate Editor of three different journals in the heat transfer area.

J. Robert Mahan, PhD

(Co-authors: Mehran Yarahmadi and Brian Vick)

Department of Mechanical Engineering
Virginia Tech, Blacksburg

Confronting Large-Scale Combined-Mode Radiation/ Conduction Modeling Problems

Abstract:

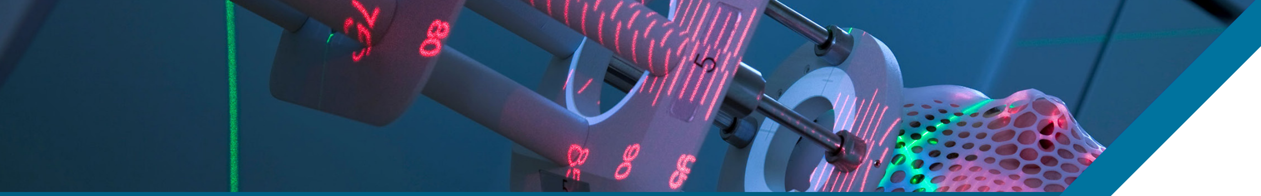
Ray-trace schemes for describing radiation transport are replacing earlier net-exchange formulations. This is mainly because they can represent surface-to-surface radiation and transport within a participating medium equally well. In addition, they easily describe wavelength and directional dependence of transport properties while conforming to complex geometries. The presentation emphasizes a further, often overlooked, advantage of the Monte Carlo ray-trace (MCRT) method: viz., its compatibility with the finite-volume approach to large-scale transient heat conduction formulations.

The MCRT method is used to populate a radiation distribution factor (RDF) matrix which distributes heat emitted from a surface or volume element to other surface or volume elements of an enclosure, while the discrete Green's function (DGF) distributes heat released in a finite volume element to other volume elements during a time increment. Together, these two factors are used in a global first-law statement to formulate a system of equations that characterize combined-mode radiation and conduction. The resulting system is solved using standard techniques. The advantage of the approach is that, once the RDF and DGF matrices have been computed, transient solutions can be obtained to problems involving thousands of surface and volume elements in a relatively short period of time on a laptop computer. As a demonstration of this combined-mode approach we consider the transient thermal analysis of an infrared telescope of the type used to monitor the planetary energy budget from low Earth orbit.

Bio:

J. Robert (Bob) Mahan is currently emeritus professor of mechanical engineering at the Virginia Polytechnic Institute & State University (Virginia Tech) in Blacksburg, Virginia (USA), where he leads the NASA-funded Thermal Radiation Group. The author of two radiation heat transfer textbooks and numerous other contributions to the technical literature, he has previously held professorships at Georgia Tech and West Virginia University, and served as a visiting professor at the U.S. Naval Academy.

In addition to his degrees in electrical (BS) and mechanical (MS, Ph.D.) engineering from the University of Kentucky, he also holds a degree in French Language and Literature and has served in various research and teaching capacities at several French engineering schools, including service as Director of Studies at Georgia Tech Lorraine (France). His many former doctoral students hold prminent positions in government, academe, and industry throughout the world.



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