

Kinetic theory of non-equilibrium gas flows: theory and computations

Overview

Accurate and efficient modeling of non-equilibrium processes in rarefied gases is a very challenging. Non-equilibrium arises in rarefied situations when the mean-free-path of a gas becomes comparable to the macroscopic length scale of the system. In rarefied situations, the conventional fluid dynamics—e.g. Euler equations and Navier-Stokes and Fourier equations—usually fails to describe processes accurately and, therefore more refined models are required. Rarefied gas flows are commonly encountered, for instance, in micro- and nano-scale electronic devices, in re-entry flows, in high-altitude flights, etc. The main objectives of the course are to learn classical and modern methods for developing efficient models for modelling non-equilibrium rarefied gas flows, and to learn numerical techniques for solving practical problems with them. Various methods—in particular, BGK model, Chapman-Enskog expansion, Grad’s moment method and regularized moment method—along with their advantages and shortcomings will be explained. Furthermore, boundary conditions, numerical techniques and their implementation for studying physical problems with moment equations will be demonstrated. The participants will be guided step-by-step about the modelling of rarefied gas flows and will be given hands-on experience for numerical implementation. The course will have a format of recitation and discussion with individual assignments and readings that focus on strengthening covered topics.

Date of the Course	December 10 - December 14, 2018 Number of participants for the course will be limited to fifty.
Host Institute	IIT Madras
No of Credits	2
You Should Attend If...	<ul style="list-style-type: none"> ▪ you are a mathematician, physicist, engineer or research scientist dealing with fluid mechanics, particularly with kinetic theory, rarefied gas flows or related topics. ▪ you are a mechanical/chemical engineer interested to learn theory and computation behind micro- and nano-scale flows and interested to extend the application of these methods to other areas, such as granular matter, active matter, etc. ▪ you are a person from industry/research organization, and are applying or interested to apply beyond hydrodynamics methods in your research work.
Fees	<p>The participation fees for taking the course is as follows: Participants from abroad : US \$ 500 Student participants: Rs. 1000.00 Faculty participants: 5000.00 Industry: Rs. 10000.00 Research Organizations: Rs. 10000.00</p> <p>The above fee includes all instructional materials, computer use for tutorials and assignments, laboratory equipment usage charges.</p> <p>Modes of payment: <u>Online transfer:</u> Account Name: CCE IIT Madras Acc. No: 3640111110 Branch: SBI, IIT Madras Branch, Chennai IFSC Code: SBIN0001055 Swift Code: SBININBB453</p> <p>Note: The participants should mention the purpose of GIAN while the transaction.</p> <p style="text-align: center;">OR</p> <p>Demand draft in favour of “CCE IIT Madras” payable at Chennai. The demand draft is to be sent to the course coordinator at the address given below.</p>
Accommodation	The participants may be provided with hostel accommodation, depending on availability, on payment basis. Request for hostel accommodation may be submitted through the link: http://hosteldine.iitm.ac.in/iitmhostel/

The Faculty



[Prof. Dr. Manuel Torrilhon](#), born in Berlin (Germany) in 1975, earned Ph.D. in Applied Mathematics from ETH Zürich, Switzerland in 2003, and continued there as a Lecturer in the department of Mathematics until 2004. Later, he was a research associate in the Department of Mathematics, Hong Kong University of Technology,

Hong Kong (2004-2005) and a postdoc in the Department of Applied Mathematics, Princeton University, USA (2005-2006). Subsequently, he held the position of Assistant Professor in the Seminar for Applied Mathematics, ETH Zürich, Switzerland during 2007-2010 along with the position of Visiting Professor in Applied Mathematics, University of Washington, Seattle, USA in 2009. Since 2010, he is a full Professor in the Department of Mathematics, RWTH Aachen University, Germany and also holds Chair position of the Center for Computational Engineering Sciences in this university. He works on diverse research areas which include mathematical modelling of rarefied gases, numerical methods for nonlinear hyperbolic systems, kinetic theory of gases, magnetohydrodynamics for plasmas and multiscale methods. He is well-known for developing regularized moment method for rarefied gas flows. He has published more than 100 scientific papers and his works have received close to 2500 citations so far. He is also a recipient of the prestigious *European Young Investigator award of European Science Foundation* in 2006. Currently, he is a member of editorial boards of [SIAM Journal on Numerical Analysis](#) and [Continuum Mechanics and Thermodynamics](#).



[Dr. Vinay Kumar Gupta](#) is currently a Commonwealth Rutherford Fellow in the Mathematics Institute of the University of Warwick, UK while being on leave from the SRM Institute of Science and Technology Chennai, where he holds the position of Assistant professor in the Department of Mathematics and in the SRM

Research Institute. Prior to the current positions, he was a postdoc at Max Planck Institute for Dynamics and Self-Organization, Germany after earning his doctoral degree from the RWTH Aachen University, Germany in 2015 under the supervision of Prof. Dr. Manuel Torrilhon. He also earned a M.S. (Engineering) degree from Jawaharlal Nehru Centre for Advanced Scientific Research, Bengaluru in 2011 and a M.Sc. (Applied Mathematics) degree from Indian Institute of Technology Roorkee in 2007. His research interests include kinetic theory of molecular and granular gases and their mixtures, mathematical modelling and fluid mechanics.



[Dr. Priyanka Shukla](#) is an Assistant Professor in the Department of Mathematics, Indian Institute of Technology Madras since 2015. Prior to her current position, she was a postdoc in the Université libre de Bruxelles, Belgium (2014-15) and an Assistant Professor in the Department of Mathematics and Statistics, Indian

Institute of Science Education and Research Kolkata (2011-14). Her research interests include fluid mechanics, hydrodynamic stability, kinetic theory of gases, granular flows and Pattern formation.

Course Co-ordinator

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