IMS DISTINGUISHED VISITOR LECTURE SERIES

2 and 3 February 2023
10.00am–12.30pm, GMT +8 (Singapore Time)
IMS Auditorium

Multiscale Analysis in Active Matter
Eitan Tadmor

In this four-tutorial lecture series, we discuss the multi-scale phenomena which arise in collective dynamics, aggregation and chemo-tactic dynamics.

1. Multi-flocks. We study the multiscale description of large-time collective behavior of agents driven by alignment. The resulting multi-flock dynamics arises naturally with realistic initial configurations consisting of multiple spatial scaling, which peak at different time scales. We derive a master-equation which describes the formation of multi-flocks and the related dynamics of multi-species.

2. Multi-species. We study the hydrodynamics of multi-species driven by alignment. What distinguishes the different species is the protocol of their interaction with the rest of the crowd: different species employ different communication kernels with members of other species. We show that flocking of the overall crowd emerges provided the communication array between species forms a connected graph. The same methodology applies to multi-species aggregation dynamics governed by first-order alignment: connectivity implies concentration around an emerging consensus.

3. p-alignment with pressure. We study the swarming behavior of hydrodynamic p-alignment, based on 2p-graph Laplacians and weighted by a general family of symmetric communication kernels. This extends the classical alignment model corresponding to p=1. The main new aspect here is the long time emergence behavior for a general class of pressure tensors without a closure assumption, beyond the mere requirement that they form an energy dissipative process. We refer to such pressure laws as `entropic', and prove the flocking of p-alignment hydrodynamics, driven by singular kernels with general class of entropic pressure tensors.

4. Multi-species with pressure. We extend these findings to systems of multi-species, proving their long-time flocking behavior for connected arrays of multi-species, with self-interactions governed by entropic pressure laws and driven by fractional p-alignment.

8 February 2023
9–10.00am, GMT +8 (Singapore Time)
IMS Auditorium

Swarm-Based Gradient Descent Method for Non-Convex Optimization
Eitan Tadmor

We introduce a new swarm-based gradient descent (SBGD) method for non-convex optimization. The swarm consists of agents, identified with positions x and masses m. The key to their dynamics is transition of mass from high to lower ground, and a time stepping protocol, h(x,m), which decreases with m. The interplay between positions and masses leads to dynamic distinction between `leaders' and `explorers'. Heavier agents lead the swarm near local minima with small time steps. Lighter agents, which explore the landscape by taking large time steps, are expected to encounter improved position for the swarm; if they do, then they assume the role of heavy swarm leaders and so on. Convergence analysis and numerical simulations demonstrate the effectiveness of SBGD method as a global optimizer.

Professor Eitan Tadmor
University of Maryland, USA

Eitan Tadmor is a Distinguished University Professor at the University of Maryland, College Park, with a joint appointment in the Department of Mathematics and the Institute for Physical Science and Technology. He received his Ph.D. in mathematics from Tel-Aviv University in 1978 and began his career as a Bateman Research Instructor at Caltech (1980-1982) before joining the faculties of Tel Aviv University (1983-1995) and UCLA (1995-2002). In 2002 he was recruited by the University of Maryland to lead the Center for Scientific Computation and Mathematical Modeling and served as CSCAMM Director (2002-2016). In 2016-2017 he was a Senior Fellow at the Institute for Theoretical Studies (ITS) at ETH-Zürich. Tadmor was a founding co-director of the NSF Institute for Pure and Applied Mathematics (IPAM) at UCLA (1999-2001) and the Principal Investigator of both an NSF Focus Research Group (2008-2012) and the NSF Kinetic Research Network (Ki-Net) at the University of Maryland (2012-2020).
Tadmor gave an invited lecture at the ICM (Beijing, 2002); the SIAM invited address at the JMM (Baltimore, 2014); the 2016 Leçons Jacques-Louis Lions (Paris); a Nachdiplom Lecture series at ETH (Zürich, 2017); and a plenary address at the ICIAM (Valencia, 2019). He is the recipient of the 2015 SIAM-ETH Peter Henrici Prize, the 2022 AMS-SIAM Wiener Prize and the 2022 AMS Gibbs lecturer. He is a fellow of the AMS and SIAM.

The mini courses and talk are part of the program on
Multiscale Analysis and Methods for Quantum and Kinetic Problems
30 January–10 March 2023

Program webpage
https://ims.nus.edu.sg/events/qkp2023/

Registration
https://tinyurl.com/multiscaleanalysisreg

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Contact information
Institute for Mathematical Sciences
National University of Singapore
3 Prince George's Park Singapore 118402
ims.nus.edu.sg