Eitan TADMOR – Career Narrative

Eitan Tadmor is a Distinguished University Professor at the University of Maryland (UMd), College Park. He began his scientific career in 1980 as a Bateman Research Instructor in CalTech. He later chaired the Department of Applied Mathematics in his alma mater, Tel-Aviv University 1991–1993. In 1995 Tadmor was recruited by the UCLA Department of Mathematics where he was the Founding Co-Director of the NSF Institute for Pure and Applied Mathematics (IPAM) 1999–2001. He moved to UMd in 2002 where served as the Director of the University Center for Scientific Computation and Mathematical Modeling (CSCAMM) 2002–2016.

Synergistic activities include co-chairing International Conferences on Hyperbolic Problems, hosted at CalTech (Hyp2002) and at UMd (Hyp2008), and serving on numerous Scientific Committees, including the Abel Symposium on "Nonlinear PDEs" held in Oslo, 2010 and the program committee of the International Congress of Mathematicians (ICM2018). Tadmor was the Principal Investigator (PI) for an NSF Focus Research Group on "Kinetic Description of Multiscale Phenomena" (2008–2012). In 2012 he was the PI awarded the NSF Research network "Kinetic Description of Emerging Challenges in Natural Sciences" (Ki-Net) and served as Ki-Net Director (2012–2020).

Tadmor was a senior fellow at the Institute for Theoretical Studies (ITS), ETH-Zürich, 2016–2017. He also held numerous visiting positions, including longer visits at the universities of Michigan, Brown, the Courant Institute, the Weizmann Institute and at the Sorbonne (LJLL). He serves/served on the editorial boards of more than a dozen leading journals including European Math Surveys in Math. Sci. (2014–), Acta Numerica (2009–), SIAM J. Math. Analysis (2004–), J. Foundations of Computational Math. (2004–) and SIAM J. on Numerical Analysis (1990–2013). Notable addresses include an invited lecture at the 2002 ICM (Beijing), plenary addresses in the international conferences on hyperbolic problems (Zürich 1990 and Beijing 1998), the 2014 SIAM invited address at the Joint Mathematical Meeting (JMM) in Baltimore, the 2016 Leçons Jacques-Louis Lions at UPMC, Sorbonne University, the ETH-Zürich Nachdiplom lectures in spring 2017, and invited lecture at the 2019 ICIAM (Valencia) and the 2022 AMS Josiah Willard Gibbs lecture.

Tadmor was listed on the 2003 ISI most cited researchers in Mathematics. He is a Fellow of the American Mathematical Society (— inaugural class of 2012 AMS Fellows) and Fellow of SIAM. In 2015 he was awarded the SIAM-ETH Henrici prize for "*original, broad and fundamental contributions to the applied and numerical analysis of nonlinear differential equations and their applications ...*".

Research. The signature of Tadmor's work is the interplay between analytical theories and computational algorithms with diverse applications to shock waves, kinetic transport, incompressible flows, image processing, and self-organized collective dynamics. In particular, Tadmor made a series of fundamental contributions to the following.

• Development and analysis of high-resolution methods for nonlinear conservation laws. Tadmor introduced the classes of *central schemes*, *entropy conservative/stable schemes* and *spectral viscosity methods*.

Additional notable contributions include the analysis of scheme-independent stability criteria for translatory numetical boundary conditions, construction and analysis of Strong-Stability Preserving time-integration methods (the term SSP was in fact coined in the 2001 SiRev paper) and (the only existing) stability proof of ENO schemes.

• Kinetic formulation of nonlinear conservation laws and related problems. Tadmor carried out ground-breaking work on the rigorous derivation of transport models and their relation to *kinetic theories*, co-authored with P.-L. Lions, B. Perthame (1994) and T. Tao (2002), and a separate line of work on *critical thresholds phenomena* in such models.

• Spectral methods — stability and spectral recovery. Tadmor made a series of fundamental contributions to the development of stability theory for initial-boundary value problems, a rigorous study of spectral aliasing in linear and nonlinear problems, and the development of the concentration method for detection of edges towards the recovery of piece-wise smooth data from its spectral content.

• Signal and image processing: multiscale representations of imaging and PDEs. Tadmor introduced novel ideas of multi-scale *hierarchical decompositions* of images and solutions of PDEs in critical regularity spaces.

• Collective dynamics. Tadmor is leading an interdisciplinary research program in modeling and analysis of *social (hydro-)dynamics* with applications to flocking and opinion dynamics. He made a series of novel contributions, including the first mean-field description of Cucker-Smale model, introducing an adaptive alignment scaling (the so-called "Motsch-Tadmor model"), analysis of multi-species dynamics, the first proof or emeregnt behavior governed by short-range topologically-based alignment kernels, a unified paradigm based on anticipation and the first general paradigm for emergent behavior for short-range kernels, *independent of thermal equilibrium*.

Eitan TADMOR – 10 Principal Publications

1 Convergence of spectral methods for nonlinear conservation laws
SIAM J. Numerical Anal. 26 (1989) 30–44
The Spectral Viscosity method (SV) — the first systematic spectrally accurate method to treat shock discontinuities, which was followed by a large number of works on implementation of the SV method in a wide variety of applications.

2 Non-oscillatory central differencing for hyperbolic conservation laws
J. Computational Physics 87 (1990) 408–463 (with H. Nessyahu)
The Nessyahu-Tadmor scheme — the forerunner for the class of high-resolution "central schemes" which was followed by a large number of works on central black-box solvers in a wide variety of applications.

3 A kinetic formulation of multidimensional scalar conservation laws and related equations
J. Amer. Math. Soc. 7 (1994) 169–191 (with P.-L. Lions & B. Perthame)
This paper provides the first systematic treatment of regularizing effect of entropic solutions for nonlinear conservation laws and related convection-diffusion equations based on velocity averaging of their kinetic formulation.

4 Entropy stability theory for difference approximations of nonlinear conservation laws and related time dependent problems, Acta Numerica 12 (2003), 451–512
A general framework for studying entropy stability of difference approximations for nonlinear systems of conservation laws by comparison with a novel family of entropy conservative schemes.

5 A multiscale image representation using hierarchical (BV,L^2) decompositions
Multiscale Modeling & Simulation 2 (2004) 554–579 (with S. Nezzar and L. Vese)
A novel hierarchical decomposition of images in critical regularity spaces into multi-scale components.

6 A new model for self-organized dynamics and its flocking behavior
J. Statistical Physics 144(5) (2011) 923–947 (with S. Motsch)
The new model for self-organized dynamics far from equilibrium based on adaptive normalization.

7 ENO reconstruction and ENO interpolation are stable
Foundations Comput. Math. 13(2) (2012), 139–159 (with U. Fjordholm and S. Mishra)
First stability proof for the ENO reconstruction, indicating a remarkable rigidity for ENO procedure of arbitrary order of accuracy and on non-uniform meshes.

8 Hierarchical construction of bounded solutions in critical regularity spaces
Communications in Pure & Applied Math. 69(6) (2016) 1087–1109
A novel multi-scale constriction of uniformly bounded solutions of $LU = f$ for general f's in the critical regularity spaces $(U, f) \in (X, L^p)$ (motivated by results of Bourgain & Brezis). The intriguing critical aspect here is that although the problems are linear, the nonlinear *hierarchical* construction of their solution, $U = \sum_j u_j$, is not.

9 Construction of approximate entropy measure-valued solutions for hyperbolic systems of conservation laws
Foundations Comput. Math. 17 (2017) 763–827 (with U. Fjordholm, R. Kappeli and S. Mishra)
A first detailed numerical procedure which constructs stable approximations to entropy measure valued solutions together with sufficient conditions that guarantee their convergence for multiD *systems* of conservation laws.

10 Topologically-based fractional diffusion and emergent dynamics with short-range interactions
SIAM J. Math. Anal. 52(6) (2020) 5792–5839 (with R. Shvydkoy)
A new class of models for emergent dynamics based on a new communication protocol which incorporates short-range kernels adapted to the local density which form *topological neighborhoods*. We prove flocking behavior and (global) regularity by adapting a De Giorgi-type method for non-symmetric singular kernels.