ME Seminar

New reduced mathematical models explain energy transfers in wave turbulence

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ABSTRACT

Wave turbulence, driven by nonlinear interactions among dispersive waves, mediates energy transfer in diverse systems such as ocean-atmosphere flows, plasmas, lattice vibrations, quantum fluids, and more. Despite its importance, the pathways by which energy cascades from large-scale forcing to small-scale dissipation remain largely unexplored. To address this, I will discuss novel reduced one dimensional dispersive nonlinear models designed to systematically explore these pathways. I will present case studies involving four dispersion relations and two nonlinear models across five nonlinear regimes, yielding 40 distinct flow regimes. These regimes capture transitions from strong to weak nonlinearity and varying resonant pathways induced by contrasting dispersion relations in a finite domain. Furthermore, the models uncover energy transfer mechanisms—including exact, quasi-, and non-resonant interactions—that govern the behavior of wave turbulence in different scenarios, underscoring the complex and rich dynamics of wave turbulence. Qualitative insights gained from studies such as this will be useful for developing climate and other forecast models that do not explicitly resolve all possible wave dynamics.

ABOUT THE SPEAKER

Dr. Dipti Ranjan Parida is a postdoctoral fellow at the TIFR Centre for Applicable Mathematics, Bangalore. He received his B.Tech in Mechanical Engineering from BPUT, Odisha, and his M.Tech in Materials Science and Engineering from IIT Bhubaneswar. He completed his Ph.D. in 2023 in the Department of Mechanical Engineering at IISc Bangalore, where he studied stratified thermal energy storage for concentrated solar power applications. In his postdoctoral research at TIFR CAM, he explores wave turbulence using mathematical modeling and numerical simulations. His work also has potential applications in wave energy harvesting, contributing to the development of sustainable energy technologies.

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