iTHEMS Colloquium

How is turbulence born: Statistical mechanics and ecological collapse in transitional fluids

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via Zoom
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The onset of turbulence is ubiquitous in daily life and is important in various industrial applications, yet how fluids become turbulent has remained unsolved for more than a century. Recent experiments in pipe flow finally quantified this transition, showing that non-trivial statistics and spatiotemporal complexity develop as the flow velocity is increased. Combining numerical simulations of the hydrodynamics equations and an effective theory from statistical mechanics, we discovered the surprising fact that fluid behavior at the transition is governed by the emergent predator-prey dynamics, leading to the mathematical prediction that the laminar-turbulent transition is analogous to an ecosystem on the edge of extinction. This prediction demonstrates that the laminar-turbulent transition is a non-equilibrium phase transition in the directed percolation universality class, and provides a unified picture of transition to turbulence in various systems. I will also show our recent progresses on transitional turbulence, including how an extended ecological model with energy balance successfully recapitulates the spatiotemporal patterns beyond the critical point, and the determination of the critical behavior and an emergent novel phase under interactions in the experimental collaboration.