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Editorial: Dissertation Award in Statistical and Nonlinear Physics of APS for Dr. Adrian van Kan FREE

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What is the hardest problem in physics? While there is definitely no unique answer, pretty much anyone would agree that turbulence is a strong contender. Turbulence is ubiquitous in the universe, comprising a wide range of spatial and temporal scales. In three-dimensional (3D) homogeneous and isotropic turbulence, energy is transferred from large to small scales, the direct cascade. In two dimensions (2D), the opposite is true, the inverse cascade. Many important flows in geo- and astrophysical contexts are anisotropic due to planetary rotation, density stratification, and layer geometry. By varying the degree of anisotropy, one can study transitions between the classical cases of 2D and 3D turbulence. The physical properties of these non-equilibrium transitions, although fundamental to characterizing the nature of turbulence, remain incompletely understood. As the story goes, Werner Heisenberg had once said that, if he were allowed to ask God two questions, they would be, "Why quantum mechanics? And why turbulence?" Supposedly, he was pretty sure God would be able to answer the first question.

The 2022 Dissertation Award in Statistical and Nonlinear Physics, awarded by American Physical Society's Topical Group on Statistical and Nonlinear Physics and sponsored by Chaos, went to Adrian van Kan acknowledging his groundbreaking contributions to the understanding of turbulence. In his thesis, van Kan used direct numerical simulations (DNSs), modeling, and statistical mechanics to study different scenarios where the large scales in a turbulent flow change their properties abruptly at a parameter threshold. In particular, he performed the first systematic DNS of large-scale condensate vortices in 3D thin-layer turbulence, revealing rare transitions between the large-scale condensate and small-scale 3D turbulence states. van Kan also explored the spatiotemporal intermittency of 3D modes evolving on the condensate near the threshold for 2D turbulence. Analytical results which he obtained pertaining to the reversal of confined large-scale 2D vortices using microcanonical statistical mechanics open the door toward similar studies of even more complex systems in various applications.

In summary, Adrian van Kan's research serves as a first step toward a better understanding of the rich problem of non-equilibrium transitions between distinct turbulent flows, pointing the way for future efforts in this key direction. In doing so, he follows suit with some of the most talented and influential theoretical physicists.

AUTHOR DECLARATIONS

Conflict of Interest

The authors have no conflicts to disclose.

Author Contributions

Sebastian Deffner: Writing – original draft (equal). **Michelle Driscoll:** Writing – original draft (equal). **Juergen Kurths:** Writing – original draft (equal). **Sid Redner:** Writing – original draft (equal). **Greg Voth:** Writing – original draft (equal).