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**Using Persistent Homology to Describe Kolmogorov Flow and Rayleigh-Bénard Convection**[1] JEFFREY TITHOF, BALACHANDRA SURI, SAMUEL RABEN, Georgia Institute of Technology, MIROSLAV KRAMAR, RACHEL LEVANGER, Rutgers University, MU XU, MARK PAUL, Virginia Tech, KONSTANTIN MISCHAIKOW, Rutgers University, MICHAEL SCHATZ, Georgia Institute of Technology — We employ a new technique for describing the dynamics of spatially extended systems evolving in time. In particular, we study two canonical fluid flows: Kolmogorov flow and Rayleigh-Bénard convection. The technique used, known as persistent homology, provides a powerful mathematical tool in which the instantaneous topological characteristics of the system are encoded in a so-called persistence diagram, which is independent of the global symmetries of the system. By applying a metric to measure the distances across multiple persistence diagrams, we can quantify the symmetry-independent similarities between states, providing an opportunity for unique physical insights into the time evolution of a dynamical system. The two systems studied are particularly interesting, as each display a wide range of dynamical behavior and possess their own symmetries. We perform our analysis using flow field patterns from numerical simulations of these systems; however, we emphasize that our analysis can be conducted with patterns measured in experiment. Our results show that persistent homology is a powerful way to gain new physical insights into the complex dynamics of large spatially extended systems that are driven far-from-equilibrium.

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