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Using Persistent Homology to Describe Rayleigh-Bénard Convection[1] JEFFREY TITHOF, BALACHANDRA SURI, Georgia Institute of Technology, MU XU, Virginia Tech, MIROSLAV KRAMAR, RACHEL LEVANGER, KONSTANTIN MISCHAIKOW, Rutgers University, MARK PAUL, Virginia Tech, MICHAEL SCHATZ, Georgia Institute of Technology — Complex spatial patterns that exhibit aperiodic dynamics commonly arise in a wide variety of systems in nature and technology. Describing, understanding, and predicting the behavior of such patterns is an open problem. We explore the use of persistent homology (a branch of algebraic topology) to characterize spatiotemporal dynamics in a canonical fluid mechanics problem, Rayleigh Bénard convection. Persistent homology provides a powerful mathematical formalism in which the topological characteristics of a pattern (e.g. the midplane temperature field) are encoded in a so-called persistence diagram. By applying a metric to measure the pairwise distances across multiple persistence diagrams, we can quantify the similarities between different states in a time series. Our results show that persistent homology yields new physical insights into the complex dynamics of large spatially extended systems that are driven far-from-equilibrium.

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