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Morse-Smale spectra reveal topological phase transition in porous media flow NORBERT STOOP, Massachusetts Inst of Tech-MIT, NICOLAS WAISBORD, Tufts University, VASILY KANTSLER, University of Warwick, JEFFREY S. GUASTO, Tufts University, JOERN DUNKEL, Massachusetts Inst of Tech-MIT — We introduce spectral Morse-Smale analysis to identify topological phase transitions in disordered continuous media. Combining microfluidic experiments with large-scale, pore-resolved simulations of porous media flow, we demonstrate that invariants of Morse-Smale graphs of flow speed provide a well-defined measure of the effects of spatial disorder on fluid transport. By systematically perturbing a microfluidic lattice, the fluid flow topology undergoes a phase transition from periodic to filamentous flow structure, which corresponds to a change in the spectral density of the Morse-Smale graphs and carries important implications for advective transport and front dispersion. Due to its generic formulation, the proposed spectral Morse-Smale analysis can be extended to characterize topological transformations in physical, chemical or biological continuum systems.

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