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Complex Transient Patterns and their Topology

Many partial differential equation models arising in applications generate complex time-evolving patterns which are hard to quantify due to the lack of any underlying regular structure. Such models may include some element of stochasticity which leads to variations in the detail structure of the patterns and forces one to concentrate on rougher common geometric features. In many of these instances, one is interested in the geometry of sublevel sets of a function in terms of their topology, in particular, their homology. In practice, however, these sublevel sets are approximated using an underlying discretization of the considered partial differential equation—which immediately raises the question of the accuracy of the resulting homology computation. In this talk, I will present a probabilistic approach which gives insight into the suitability of this method in the context of random fields. We will obtain explicit probability estimates for the correctness of the homology computations, which in turn yield *a priori* bounds for the suitability of certain grid sizes. In addition, we present a computational approach to homology validation in the above setting, and apply our results to certain stochastic partial differential equations arising in materials science.