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Decomposing the Dynamics of the Lorenz 1963 model using Unstable Periodic Orbits: Averages, Transitions, and Quasi-Invariant Sets

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Unstable periodic orbits (UPOs) are a valuable tool for studying chaotic dynamical systems, as they allow one to distill their dynamical structure. We consider here the Lorenz 1963 model with the classic parameters' value. We investigate how a chaotic orbit can be approximated using a complete set of UPOs up to symbolic dynamics' period 14. At each instant, we rank the UPOs according to their proximity to the position of the orbit in the phase space. We study this process from two different perspectives. First, we find that longer period UPOs overwhelmingly provide the best local approximation to the trajectory. Second, we construct a finite-state Markov chain by studying the scattering of the orbit between the neighbourhood of the various UPOs. Each UPO and its neighbourhood are taken as a possible state of the system. Through the analysis of the subdominant eigenvectors of the corresponding stochastic matrix we provide a different interpretation of the mixing processes occurring in the system by taking advantage of the concept of quasi-invariant sets.