
A trajectory-free framework for analysing multiscale systems

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Abstract

This paper introduces coordinate-independent methods for analyzing multiscale dynamical systems using numerical techniques based on the transfer operator and its adjoint. In particular, we present a method for testing whether an arbitrary dynamical system exhibits multiscale behavior and for estimating the time-scale separation. For systems with such behavior, we establish techniques for analyzing the fast dynamics in isolation, extracting slow variables for the system, and accurately simulating these slow variables at a large time step. By avoiding trajectory integration, the developed techniques are highly computationally efficient. We illustrate our method with numerical examples and show how the reduced slow dynamics faithfully represents statistical features of the full dynamics.

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