

## **Data-driven model discovery and coordinate embeddings for physical systems**

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A major challenge in the study of dynamical systems is that of model discovery: turning data into models that are not just predictive, but provide insight into the nature of the underlying dynamical system that generated the data and a good coordinate embedding to accompany the model. We introduce a number of data-driven strategies for discovering dynamical systems and their embeddings from data. We consider two canonical cases: (i) systems for which we have full measurements of the governing variables, and (ii) systems for which we have incomplete measurements. For systems with full state measurements, we show that the recent sparse identification of nonlinear dynamical systems (SINDy) method can discover governing equations with relatively little data. For systems with incomplete observations, we show that the Hankel alternative view of Koopman (HAVOK) method, based on time-delay embedding coordinates, can be used to obtain a linear model and Koopman invariant measurement system that nearly perfectly captures the dynamics of nonlinear quasiperiodic systems. We introduce two strategies for using HAVOK on systems with multiple time scales. Together, our approaches provide a suite of mathematical strategies for reducing the data required to discover and model nonlinear systems.