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Reduced order representations of turbulent Kolmogorov flow using machine learning JACOB PAGE, University of Edinburgh, MICHAEL BRENNER, Harvard University and Google Research, RICH KERSWELL, University of Cambridge — A long-standing challenge in low-order modelling is to design reduced representations of turbulent flows which are connected to the underlying dynamical system. In this work, we train a family of deep convolutional autoencoders to identify highly efficient low-dimensional representations of monochromatically forced, two-dimensional turbulence which are connected to the simple invariant solutions embedded in the turbulent attractor. We establish this connection by developing a technique we term "latent Fourier analysis" a decomposition of the low-dimensional latent representation of vorticity into a set of orthogonal modes parameterised by latent wavenumbers. Individual latent Fourier modes decode into physically meaningful recurrent patterns. We show how projections onto latent Fourier modes can identify different dynamical regimes visited by the turbulence. Moreover, using latent Fourier modes to measure near recurrences along long turbulent orbits results in the identification of an order of magnitude more periodic orbits than are flagged using a Euclidean norm in physical space.

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