Abstract Submitted
for the DFD11 Meeting of
The American Physical Society

Beyond mean-field theory: An asymptotically-inspired single-mode model of Langmuir circulation ZHEXUAN ZHANG, GREG CHINI, University of New Hampshire, KEITH JULIEN, University of Colorado, Boulder — Mean-field theory for convecting flows dates back to the pioneering work of Spiegel (1962), Herring (1963, 1964, 1966), and others. In the classical approach, all fields are decomposed into horizontally-averaged and fluctuating components. The approximation involves retaining only those fluctuating-fluctuating nonlinearities in the governing equations that modify the mean fields. In laterally periodic geometries, the resulting mean-field PDEs admit single horizontal (Fourier) mode solutions, reducing the problem to a set of PDEs in the vertical (boundary-normal) coordinate and time. In this investigation, we develop a single horizontal-mode reduction of the Craik–Leibovich (CL) equations governing Langmuir circulation (LC). Unlike classical mean-field theory, however, we retain important but spatially localized fluctuating-fluctuating nonlinearities in our reduced model. The spatial structure of the basis functions and the choice of modes on which to project the dynamics are guided by the matched asymptotic analysis of fully nonlinear LC by Chini (2008). As in mean-field theory, our single-mode reduction yields a set of 1D PDEs, which are readily solved numerically. We demonstrate the efficacy of our reduced model via quantitative comparisons with full pseudospectral numerical simulations of the downwind-invariant CL equations.

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Date submitted: 05 Aug 2011 Electronic form version 1.4