Abstract Submitted
for the DFD14 Meeting of
The American Physical Society

A Jacobian-free Newton-Krylov solver for determination of scaling laws in coherent Rayleigh-Bénard convection[1] DAVID SONDAK, LESLIE SMITH, FABIAN WALEFFE, ANAKEWIT BOONKASAME, University of Wisconsin, Madison — Computational studies of *coherent* Rayleigh-Bénard convection in a two-dimensional channel with no-slip top and bottom walls are performed in order to determine scaling laws for a range of Rayleigh (Ra) and Prandtl (Pr) numbers. Since these coherent states are unstable, a Jacobian-free Newton-GMRES algorithm is developed. This approach allows us to determine scaling of the Nusselt number (Nu) with Ra by tracking unstable solutions to the Boussinesq equations. Scaling laws are presented for the primary solution that bifurcates from the conducting state at $Ra \sim 1708$, becomes unstable in a Hopf bifurcation at $Ra \sim 5.4 \times 10^4$ but have been computed up to $Ra \sim 5 \times 10^6$. We also determine scaling laws for the optimal heat transport up to $Ra \sim 10^8$. Mechanisms for the observed behavior are discussed including the relationship between the optimal solution and the primary solution as well as the effect of Pr. We explore properties of the algorithm and review its potential as a tool in determining scaling laws for thermal convection as well as some areas for improvement. Extensions of this work to three-dimensional Rayleigh-Bénard convection will be discussed.

[1]Partial support from NSF-DMS grant 1147523 is gratefully acknowledged.

David Sondak
University of Wisconsin, Madison

Date submitted: 01 Aug 2014 Electronic form version 1.4