Abstract Submitted
for the DFD16 Meeting of
The American Physical Society

New variational bounds on convective transport. I. Formulation and analysis[1] IAN TOBASCO, ANDRE N. SOUZA, CHARLES R. DOERING, University of Michigan — We study the maximal rate of scalar transport between parallel walls separated by distance h, by an incompressible fluid with scalar diffusion coefficient κ. Given velocity vector field $\mathbf{u}$ with intensity measured by the Péclet number $Pe = h^2\langle|\nabla\mathbf{u}|^2\rangle^{1/2}/\kappa$ (where $\langle\cdot\rangle$ is space-time average) the challenge is to determine the largest enhancement of wall-to-wall scalar flux over purely diffusive transport, i.e., the Nusselt number Nu. Variational formulations of the problem are presented and it is determined that $Nu \leq cPe^{2/3}$, where c is an absolute constant, as $Pe \to \infty$. Moreover, this scaling for optimal transport—possibly modulo logarithmic corrections—is asymptotically sharp: admissible steady flows with $Nu \geq c'Pe^{2/3}/[\log Pe]^2$ are constructed. The structure of (nearly) maximally transporting flow fields is discussed.

[1]Supported in part by National Science Foundation Graduate Research Fellowship DGE-0813964, awards OISE-0967140, PHY-1205219, DMS-1311833, and DMS-1515161, and the John Simon Guggenheim Memorial Foundation.

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Date submitted: 29 Jul 2016 Electronic form version 1.4