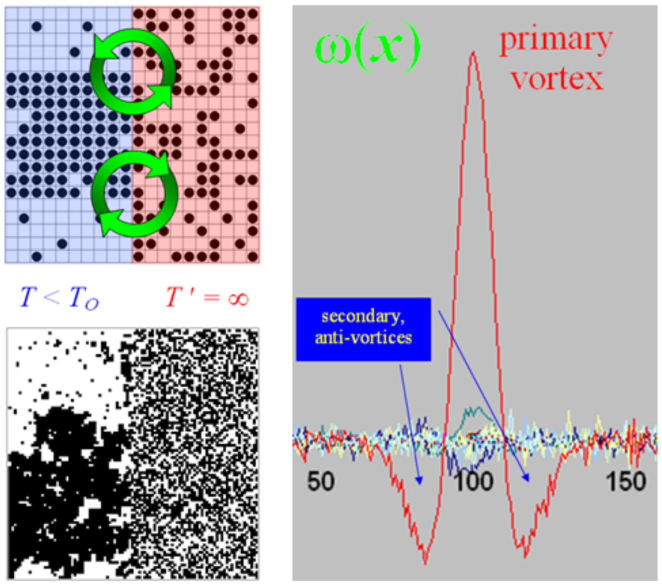
Statistical Mechanics of Systems far from Equilibrium

Beate Schmittmann and Royce K.P. Zia
Virginia Tech DMR-0705152

Ubiquitous and common, convection cells are clear signatures of non-equilibrium phenomena. Well understood in terms of macroscopic descriptions in hydrodynamics, their existence depend on the velocity field and/or density gradients, driven by a variety of forces, such as temperature gradients, gravity, shear, etc. We ask: Are there ***minimal conditions*** for convection cells to exist? Can they be produced in, say, the simplest of models in statistical mechanics: the Ising lattice gas? The answers seem to be affirmative. With no gravity, no shear, and no velocity fields, this iconic system is coupled via standard particle-hole exchange dynamics with Metropolis rates, to two thermal baths at *different* temperatures (shown in figure as blue and red sectors). The temperature gradient is one minimal condition – for inducing non-equilibrium behavior. The other condition – for inducing convection cells – is a density gradient, achieved here by setting the colder thermostat to be below the Onsager temperature (T_O). Phase separation is eventually established in the cold sector and density gradients induce steady current-loops (green in the sketch). The *curl* of these currents define $\omega(\boldsymbol{x})$, the vorticity field. In the figure is the result of simulations of a 50×200 lattice at half filling, showing $\omega(\boldsymbol{x})$ as *localized* to the boundary between the sectors, with interesting substructures.



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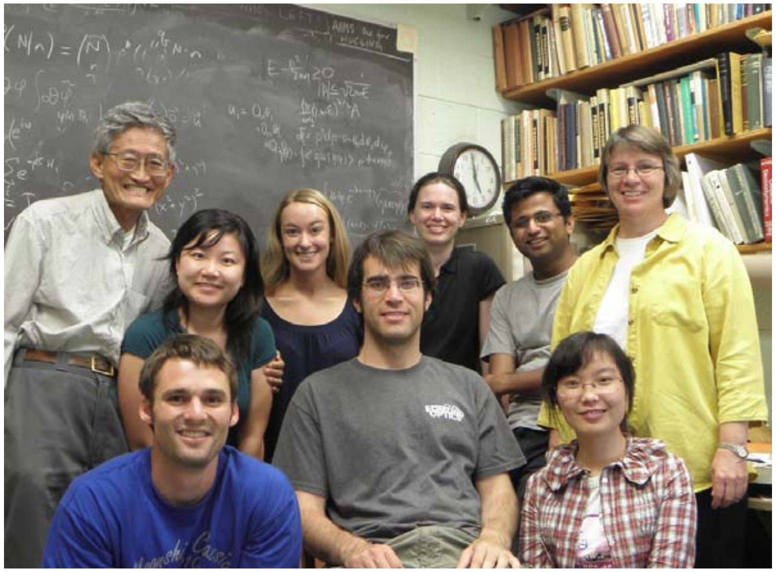
Education and outreach:
Undergraduate and graduate research is an important component of our project. While undergraduates often conduct explorations and discover novel nonequilibrium phenomena, graduates and postdocs carry out more in-depth analysis to understand these findings. We also continue to collaborate with our alumni; two of them visited recently (both Assistant Professors, in photo). The PI's present their work at conferences, workshops and colloquia regularly. In May, a series of research workshops was initiated. Designed for students to present their investigations, these meetings are held in conjunction with Washington & Lee University in Virginia.



Back row: *Royce Zia, Jiajia Dong (alumnae), Sara Case (now Junior), Leah Shaw (alumnae), Shivakumar Jolad (postdoc) and Beate Schmittmann.*
Front row: *Clinton Durney (Senior), Daniel Linford (PhD), Wenjia Liu (PhD).*
Not in photo: *L. Jonathan Cook (PhD), Maxim Lavrentovich (summer intern), Abhishek Mukhopadhyay (PhD), Thierry Platini (postdoc)*