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14. ABSTRACT

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a. REPORT	b. ABSTRACT	c. THIS PAGE			Chjan Lim
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RPPR Final Report
as of 31-Jul-2018

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Final Report for Period Beginning 12-May-2009 and Ending 31-Aug-2015
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Report Term: 0-Other

Submitted By: Chjan Lim   Email: limc@rpi.edu
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STEM Degrees: 2   **STEM Participants:** 2

Major Goals: The major aims of this project are to first solve a simple equilibrium statistical mechanics model exactly for symmetry breaking phase transitions to super and sub rotating flows on rotating planets, and applications to solar system planetary atmospheres such as the enigmatic Venusian atmosphere, and second, to solve problems arising from social opinion dynamics on networks.

Accomplishments: Both major goals have been accomplished.

The first was done with a simple but physically realistic model of barotropic flows on a rotating sphere which is essentially a long range Kac's spherical model, and unlike previous expectations, was solvable exactly and found to support a phase transition to super rotation when the solid planet rotates slowly enough and the initial kinetic energy of the mixed barotropic flow is high enough (at negative temperatures).

The second was solved through the development of new mathematical methods for the exact solutions of social network models such as the nonequilibrium voter and naming game models. Such exact solutions are available only for the complete network but can be approximately extended to realistic social networks including small worlds and other clustered inhomogeneous networks. Our main results support a tipping point of around 9 percent of diehards for the minority opinion to dominate relatively quickly the majority opinion.

Training Opportunities: Nothing to Report

Results Dissemination: [79] W. Zhang, Chjan Lim, G. Korniss, B. Szymanski, "Opinion Dynamics and Social Influencing in Random Geometric Graphs", Scientific Reports 4, 5568 (2014) and doi: 10.1038/srep05568
[80] A. M. Thompson, B. Szymanski, C. Lim "Propensity and Stubbornness in the Naming Games - Tipping Fractions of Mavens", Phys Rev E 90, 042809, oct 15 2014

[81] W. Zhang and Chjan Lim, "Social Networks – a new preferential attachment procedure based on relevance and importance, submitted 2014.

[82] W. Pickering and C. Lim, "Solution of the Voter Models by Spectral Analysis", Physical Review E (Vol.91, No. 1):
DOI: 10.1103/PhysRevE.91.012812
http://link.aps.org/doi/10.1103/PhysRevE.91.012812

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: Nothing to Report

PARTICIPANTS:

Participant Type: PD/PI
Participant: Chjan Lim
Person Months Worked: 15.00 **Funding Support:**
Project Contribution:
International Collaboration:
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National Academy Member: N
Other Collaborators:

Participant Type: Graduate Student (research assistant)
Participant: Weituo Zhang
Person Months Worked: 15.00 **Funding Support:**
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ARTICLES:

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Volume: 84 Issue: 0 First Page #: 0
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Article Title: Social consensus through the influence of committed minorities
Authors:
Keywords: tipping point, committed minority, naming games, consensus times
Abstract: The drive towards consensus in opinion or behavior in a social system is dramatically affected by the commitment and influenceability of individuals in the population, and the networks that bind them together. In this Letter, we show how the prevailing majority opinion in a population can be rapidly reversed by a small fraction p of randomly distributed agents who consistently proselytize the opposing opinion and are immune to influence. We call such agents committed agents. Specifically, we show that when the committed minority fraction grows beyond a critical value $p_c \approx 0.0979$, there is a super-exponential decrease in the time taken for the entire population to adopt the opinion of the committed set. We prove this by analyzing mean field equations for the particular model of influence dynamics considered here, and support our arguments using extensive simulations of the dynamics on complete graphs. Furthermore, using a quasi-stationary approximation, we show that for $p<p
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Article Title: Social influencing and associated random walk models: Asymptotic consensus times on the complete graph
Authors:
Keywords: Social Influencing, Tipping Points, Random walk models, Naming Games
Abstract: We investigate consensus formation and the asymptotic consensus times in stylized individual- or agent-based models, in which global agreement is achieved through pairwise negotiations with or without a bias. Considering a class of individual-based models on the complete graph, we introduce a coarse-graining approach (lumping microscopic variables into macrostates) to analyze the ordering dynamics in an associated random-walk framework. Within this framework yielding a linear system, we derive general equations for the expected consensus time and the expected time spent in each macro-state. Further, we present the asymptotic solutions of the two-word naming game, and separately discuss its behavior under the influence of an external field and with the introduction of committed agents.
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Volume: 86 Issue: 6 First Page #: 66304
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Article Title: Phase Transition to Super-rotating Atmospheres in a Simple PlanetaryModel for a Non-Rotating Massive Planet - Exact Solution
Authors:
Keywords: Kac's spherical model, Kraichnan energy-enstrophy theory, super-rotation of Venus
Abstract: A new energy-enstrophy model for the equilibrium statistical mechanics of Barotropic flow on a massive non-rotating sphere is introduced and solved exactly for phase transitions to rotating solid-body atmospheres when the kinetic energy level is high. Unlike the Kraichnan theory which is a Gaussian model, we substitute a micro-canonical enstrophy constraint for the usual canonical one, a step which is based on sound physical principles. This yields a Spherical model with zero total circulation, microcanonical enstrophy constraint and canonical constraint on energy, leaving angular momentum free as is required for any model whose objective is to predict super-rotation in planetary atmospheres. Closed form solution of this Spherical model, obtained by the Kac-Berlin method of steepest descent, provides critical temperatures and amplitudes of the symmetry-breaking rotating solid-body flows. This model and its results differ from previous solvable models for related phenomena in the sense
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Article Title: The Concentration and Stability of the Community Detecting Functions on Random Networks
Authors:
Keywords: Community Detection, Robustness of Algorithms, Large Deviation Principles, Spin-Glass
Abstract: We propose a general form of community detecting functions for finding the communities or the optimal partition of a random network, and examine the concentration and stability of the function values using the bounded difference martingale method. We derive LDP inequalities for both the general case and several specific community detecting functions: modularity, graph bipartitioning and q-Potts community structure. We also discuss the concentration and stability of community detecting functions on different types of random networks: the sparse and non-sparse networks and some examples such as ER and CL networks.
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Volume: 86 Issue: 6 First Page #: 61134
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Article Title: Analytic Treatment of Tipping Points for Social Consensus in LargeRandom Networks
Authors:
Keywords: Tipping points, committed minority, Naming games, large random networks
Abstract: We introduce a homogeneous pair approximation to the Naming Game (NG) model by deriving a six-dimensional ODE for the two-word Naming Game. Our ODE reveals the change in dynamical behavior of the Naming Game as a function of the average degree $<k>$ of an uncorrelated network. This result is in good agreement with the numerical results. We also analyze the extended NG model that allows for presence of committed nodes and show that there is a shift of the tipping point for social consensus in sparse networks.
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Volume: 4 Issue: 0 First Page #: 0
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Article Title: Opinion Dynamics and Influencing on Random Geometric Graphs
Authors:
Keywords: Opinion Dynamics on Random Geographic Networks
Abstract: Naming game, the prototypical case of opinion dynamics, on 2-dimensional random geometric graph is investigated. Study of this model helps to understand the spatial distribution and propagation of social opinions. A main feature of this model is the automatic emergence of spatial structure called opinion domains which are geographic regimes sharing the same opinion with clear boundaries. We provide the mean field equation for this dynamics and discuss several properties of the equation such as the stationary solutions and two-time-scale separation. We find the governing rule of the opinion domain evolution that the opinion domain boundary propagates at the speed proportional to its inverse curvature. Finally we investigate the impact of committed agents on opinion domains and find the scaling of consensus time.
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Article Title: Propensity and Stickiness in the Naming Games - Tipping Fractions of Minorities
Authors:
Keywords: generalized Naming Games and Tipping fractions
Abstract: Agent-based models of the binary Naming Games are generalized here to represent a family of models parameterized by the introduction of two continuous parameters. These parameters define varying listener-speaker interactions on the individual level with one parameter controlling the speaker and the other controlling the listener of each interaction. The major finding presented here is that the generalized Naming Game preserves the existence of critical thresholds for the size of committed minorities. Above such threshold, a committed minority causes a fast (in time logarithmic in size of the network) convergence to consensus even when there are other parameters influencing the system. Below such threshold, reaching consensus requires time exponential in the size of the network. Moreover, the two introduced parameters cause bifurcations in the stabilities of the system's fixed points and may lead to changes in the systems consensus.
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Nothing to report