

Two Research Approaches

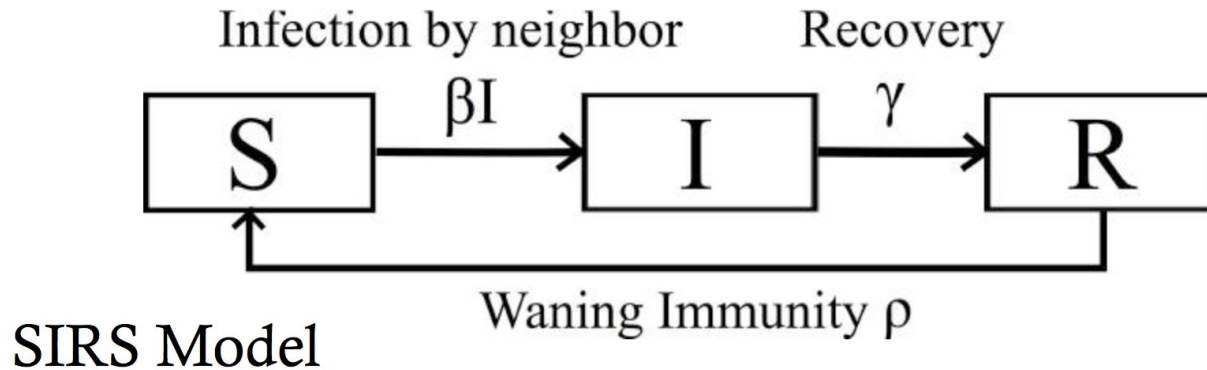
- Modeling on networks
 - Infectious disease modeling on contact networks
- Data-driven exploration of networked data sets
 - Measuring evolution of scientific sub-communities

Network Topology and Endemic Disease

Infectious disease modeling on contact networks

Infectious Disease Modeling

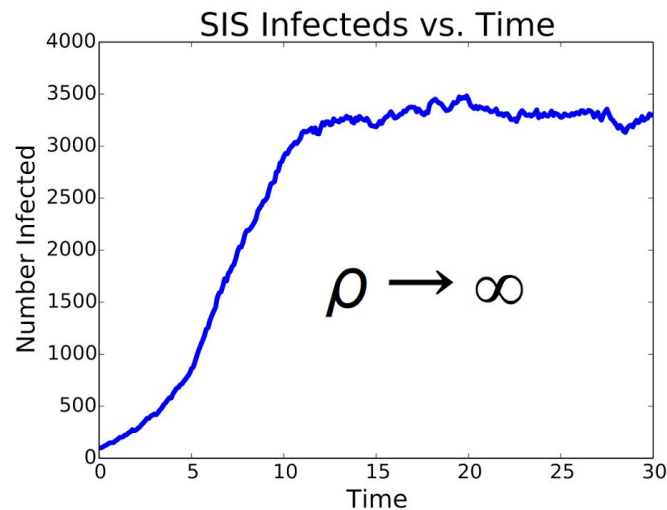
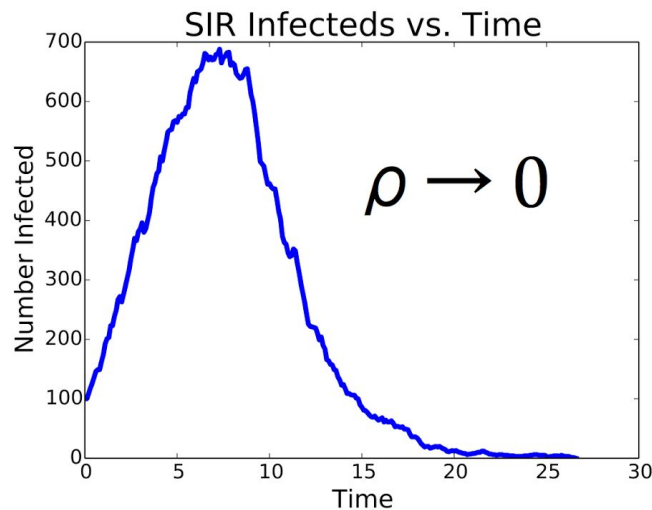
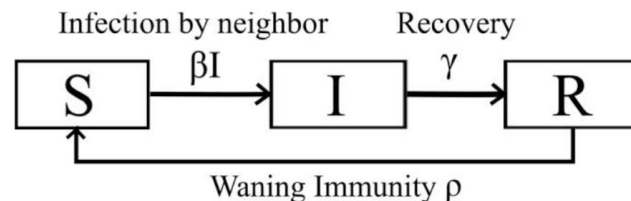
- Compartmental models describing stages of disease
- SIRS-type model: produces endemic disease



- $\beta/\gamma > 1 \Rightarrow$ Sustained endemic disease

SIRS Model

- SIRS \rightarrow SIR as $\rho \rightarrow 0$, single outbreak
- SIRS \rightarrow SIS as $\rho \rightarrow \infty$, endemic disease

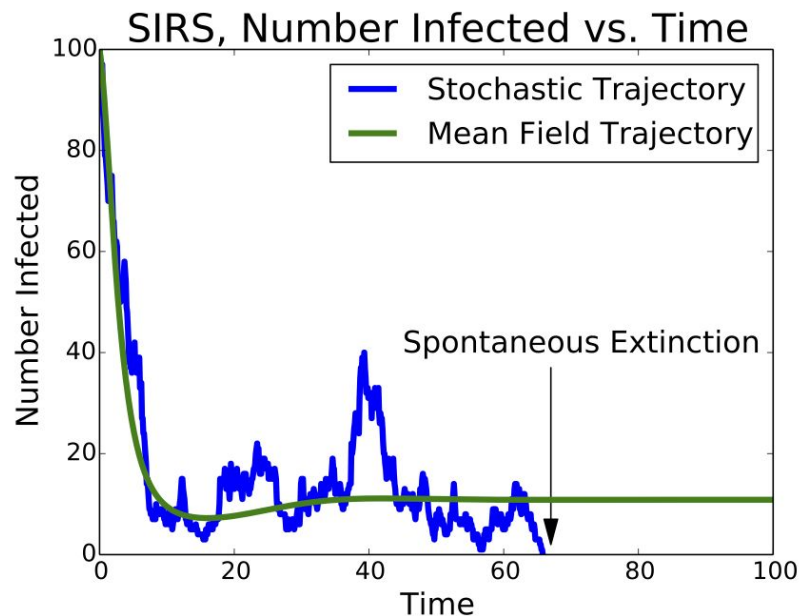


Adding Network Effects

- Networks describe contacts between population members
- Builds Heterogeneity into the model
- Each node has a degree
 - How many neighbors a node has
 - Defines exposure to others
- Degree distribution
 - How heterogeneous is the network?
 - Very heterogeneous => wide variation in interaction strengths
- Endemic threshold depends on degree distribution
 - High heterogeneity => lower threshold

Critical Community Size and Spontaneous Extinction

- Large populations can sustain endemic disease for longer times
- Spontaneous extinctions
 - Stochastic fluctuations
 - Finite size effects

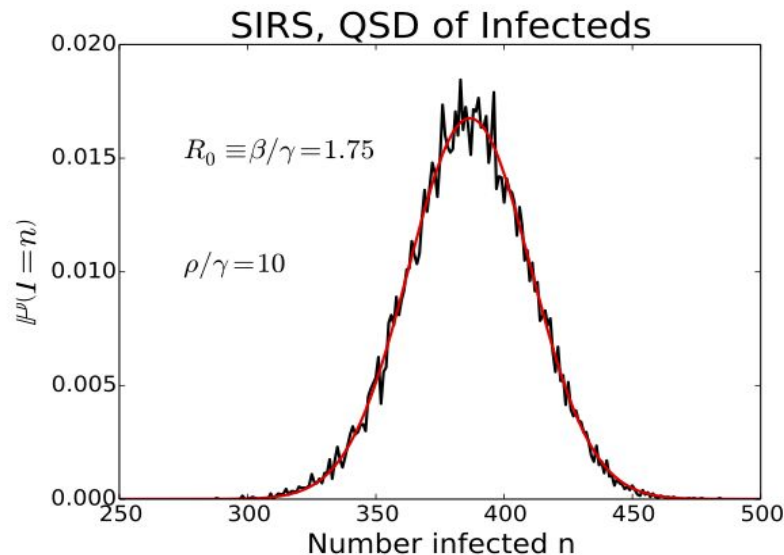
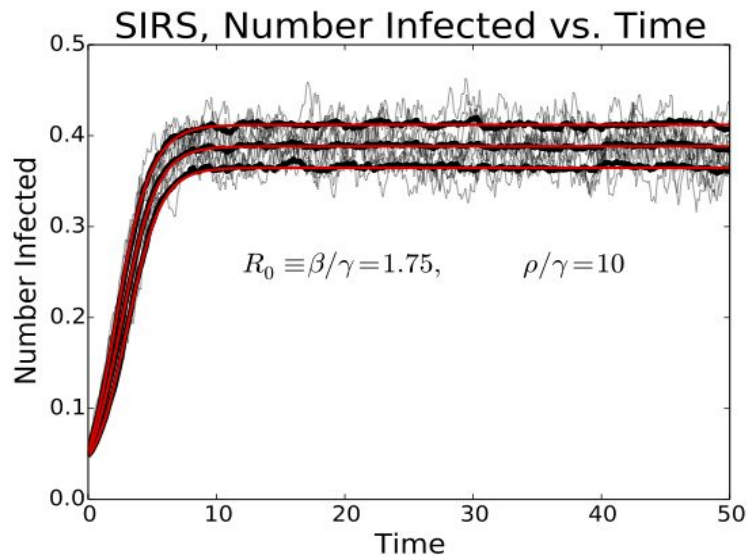


Critical Community Size and Network Effects

- Population size matters for sustained endemic disease
- What about network connectivity?
- How does introducing interaction heterogeneity into the network affect its ability to sustain endemic disease

Analytical Tools - Moment Closure

- Assume Gaussian distribution of fluctuations
- Obtain ODEs that describe means and fluctuations
- Can solve numerically for time evolution of trajectory distribution
- Good numerical agreement - including network parameters

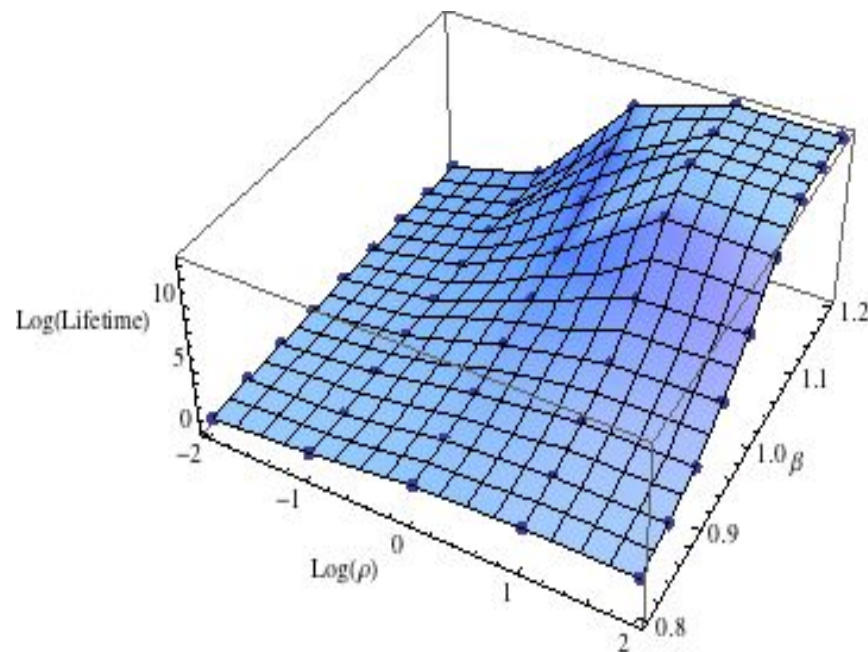


Simulations

- Developed our own code for simulations
- Continuous-time, discrete-event Markov chain model
- Gillespie's Direct Algorithm
 - Annealed networks
 - Fully quenched static networks

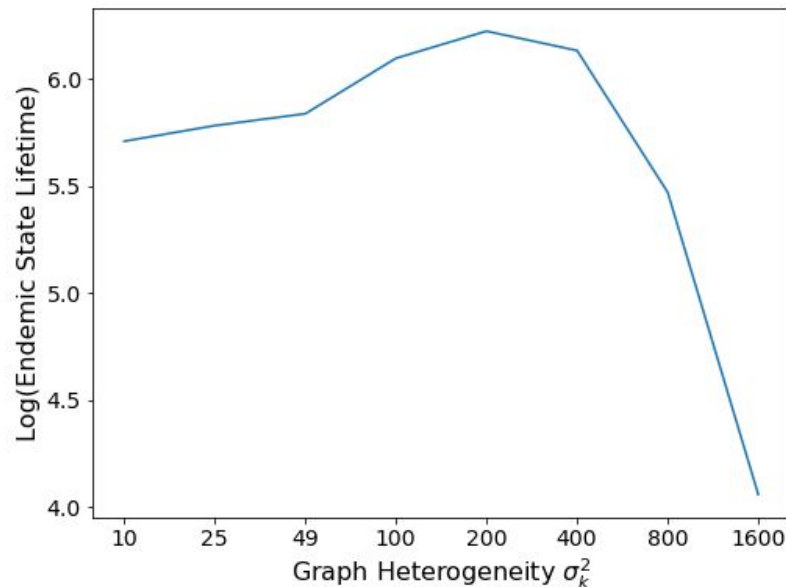
Preliminary Results

- Endemic disease sustained
 - Large ρ
 - Large β



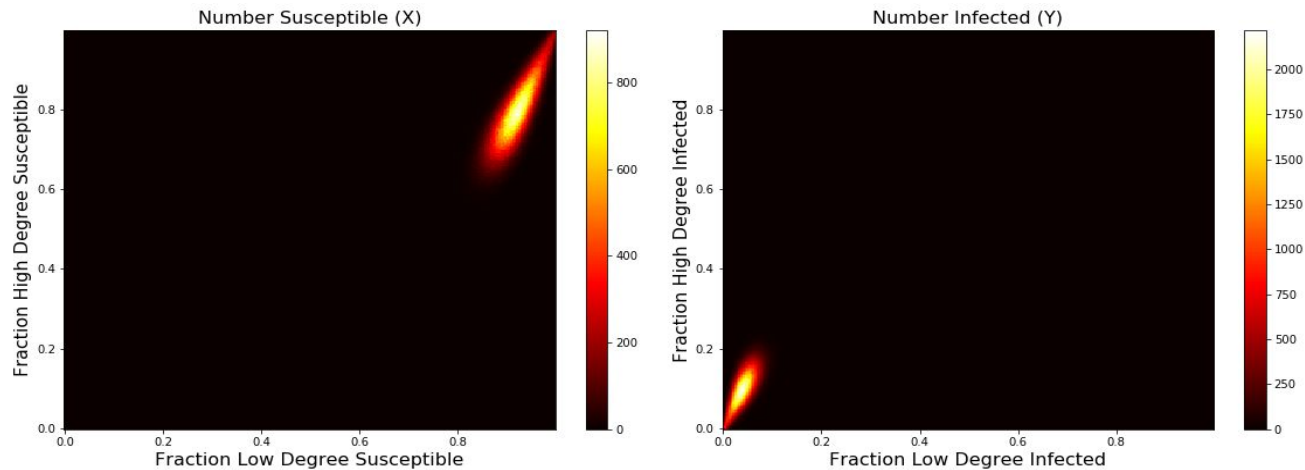
Preliminary results

- Graph heterogeneity affects time until extinction
- Different graphs take different amounts of time to reach extinction
- Suggests importance of high-degree nodes in path to extinction

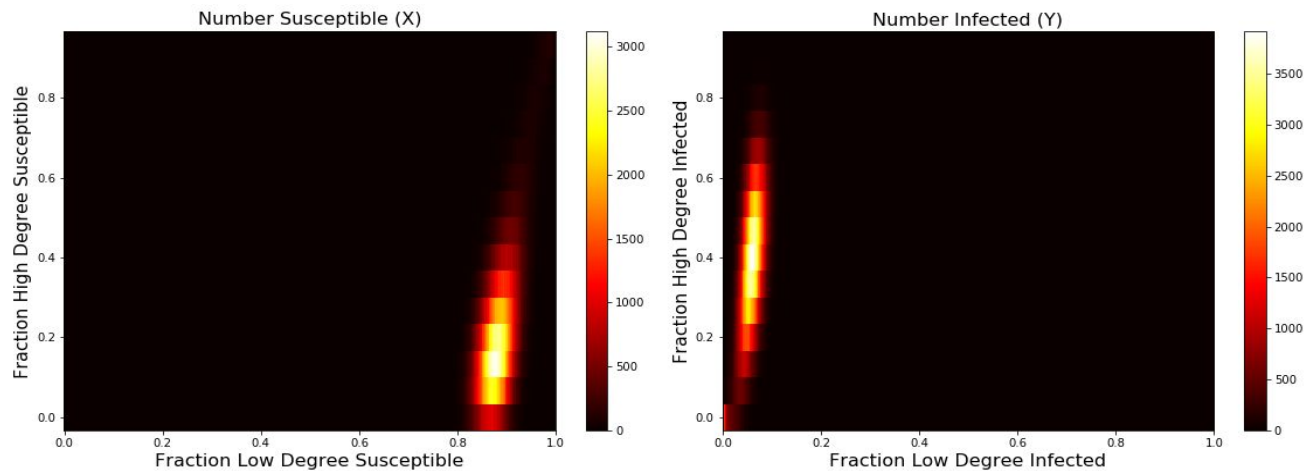


Paths to Extinction

Homogeneous:



Heterogeneous:



Data-driven Studies of Scientific Publishing

Assembly of Scientific Co-Authorship Networks

Measuring Collaboration Networks

- Conservative way to observe the development of research communities
- Nodes represent authors
- Edges represent co-authorship on one or more articles
- Over time,
 - New authors enter the field
 - New collaborations occur
 - Leads to a topological transition, forming a giant component

Our Method

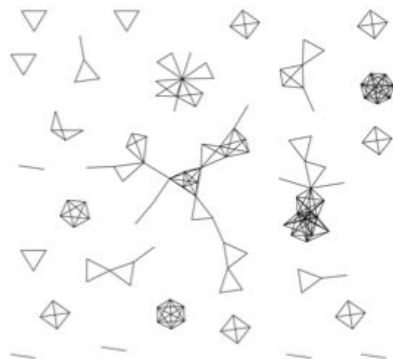
- Expand on previous studies:
 - Previously, limited by sorting papers into different categories
 - Algorithmically generate large population of scientific topics
- Topic modeling - semantic content as proxy for scientific themes
- Condensed matter physics articles from ArXiv

Topic Example

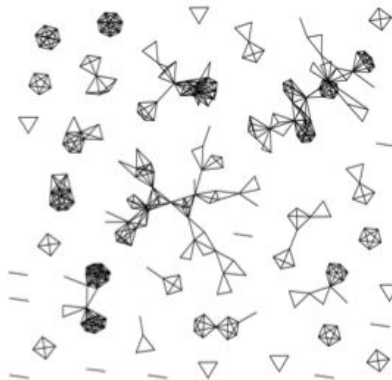
- Keywords:
 - Quantum, State, Qubit, Entanglement, Decoherence
- Articles:
 - “Demonstration of Two-Qubit Algorithms with a Superconducting Quantum Processor” (0903.2030)
 - “Controllable coupling between flux qubits” (cond-mat/0507496)
- Interpretation: Quantum Computing
- => Look at co-authorship network within quantum computing

Topic 8:
**Quantum
Computing**

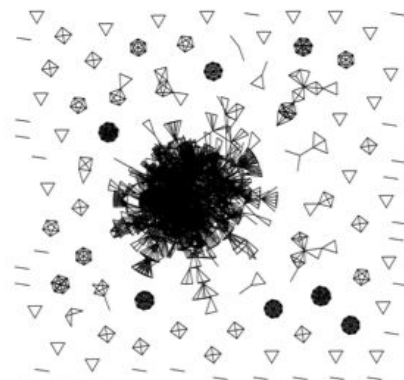
2003



2005

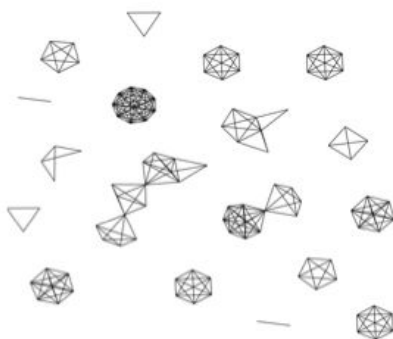


2013

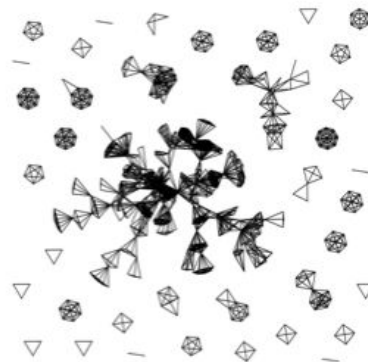


Topic 19:
**Magnetic
Materials**

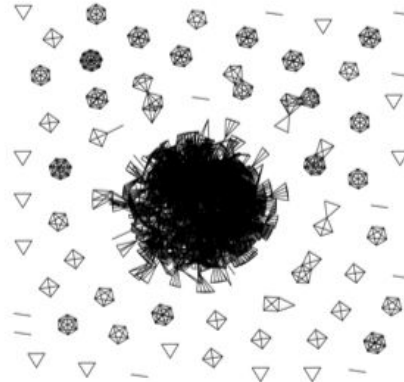
1999



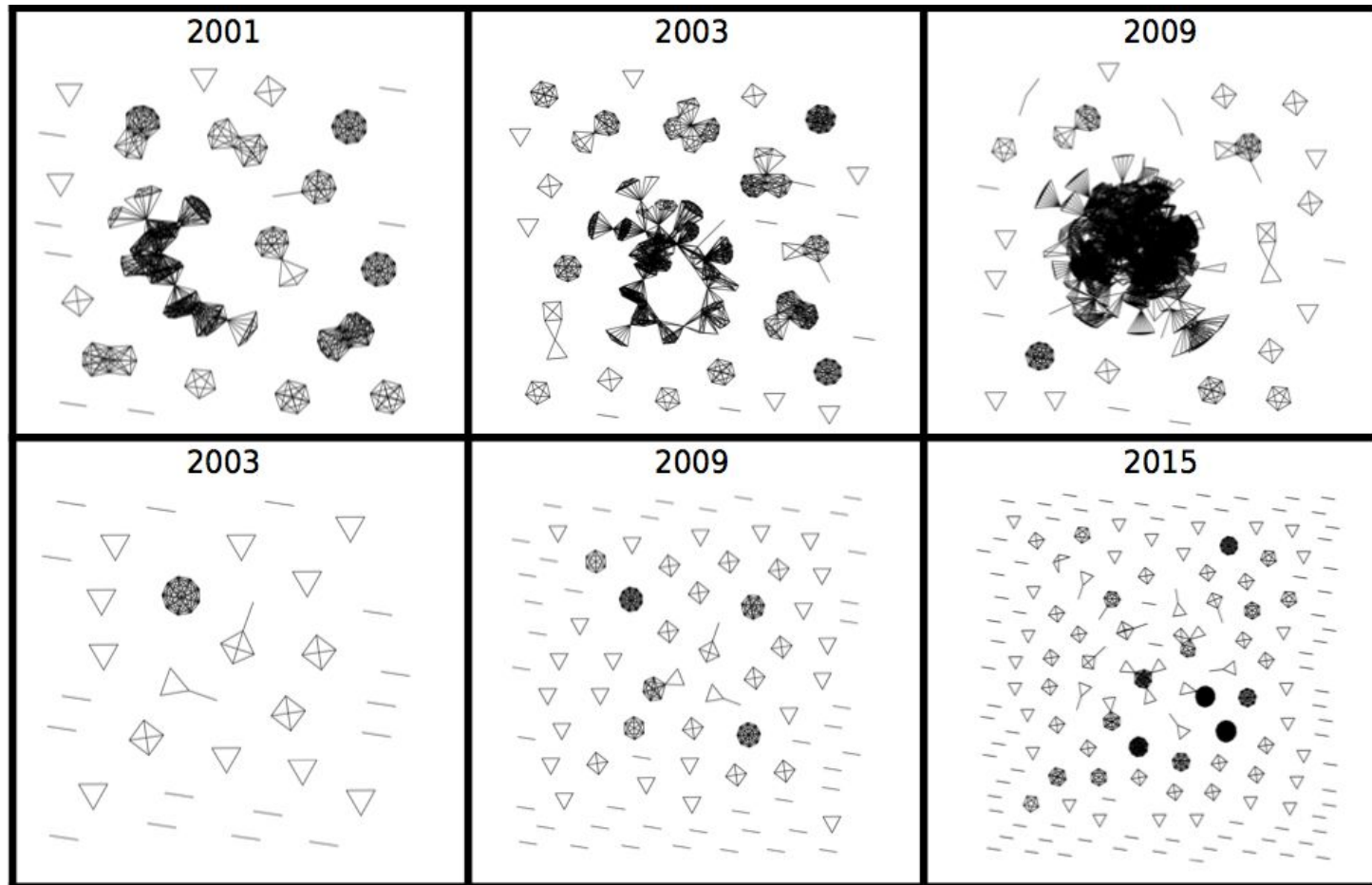
2003

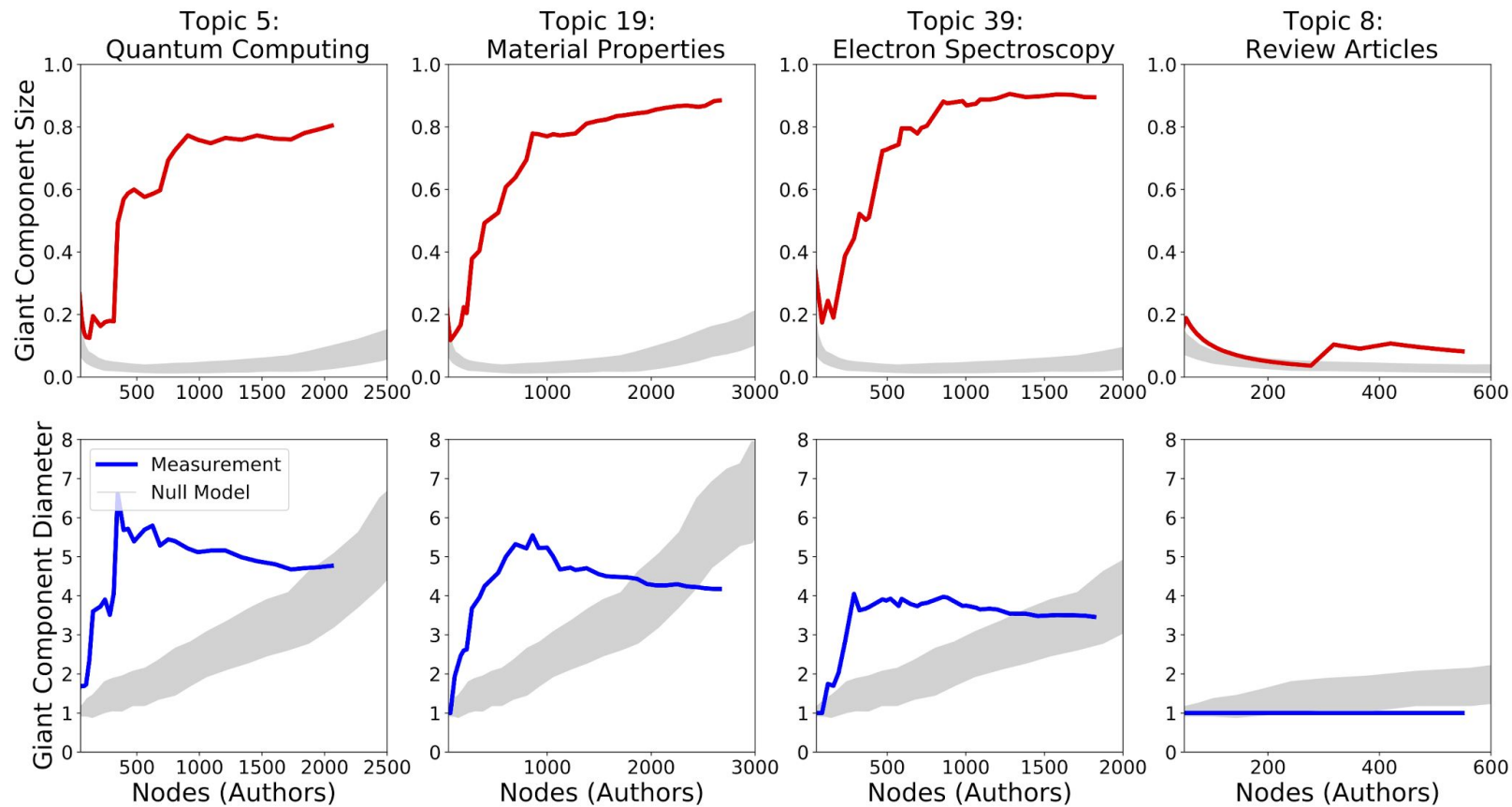


2011



Topic 39:
ARPES





Other Projects

- Multifractal Characterization of Agricultural Landscapes
- Residual networks and recurrent epidemics
- Infectious Disease Model Reduction
- Text-reuse and Plagiarism on the arXiv
- Network structure analysis of spanish power grid robustness (CSSS 2017)