
Northeastern


Yanchen Liu

EDUCATION

PhD PROGRAM

Network Science Institute, Northeastern University 09/2017 – now
Advisor: Prof. Albert-László Barabási

GRADUATE STUDY

Physics Department, CUNY Graduate Center 09/2016 – 05/2017

BACHELAR DEGREE

Physics Department, Peking University 09/2012 – 07/2016

PUBLICATIONS

Shi Cheng, Yanchen Liu, and Pan Zhang. "Weighted community detection and data clustering using message passing." *Journal of Statistical Mechanics: Theory and Experiment* 2018.3 (2018): 033405.

Cantwell, George, Yanchen Liu, Benjamin F. Maier, Alice C. Schwarze, Carlos A. Serván, Jordan Snyder, and Guillaume St-Onge. "Thresholding normally distributed data creates complex networks." *arXiv preprint arXiv:1902.08278* (2019).

RESEARCH EXPERIENCE

NETWORK SCIENCE

Research on Topological Characterizaion of 3D Graph Embedding 09/2018 – now
Supervised by Prof. *Albert-László Barabási*, Network Science Institute, Northeastern University

- Creating a measure, the Graph Linking Number, for the topological tangledness for 3D graph embeddings inspired by the invariant "linking number" in knot theory.
- Designing an algorithm to measure the Graph Linking Number for any given 3D graph embeddings, and implementing the algorithm in Python.
- Finding a linear correlation between the energy and the Graph Linking Number of 3D graph embeddings, and using it to build a bridge between the topological properties and the energy landscape of 3D graph embeddings.
- Using the Graph Linking Number as a tool to analyze the 3D mouse brain network.

NETWORK SCIENCE

Research on Thresholded Normal Distribution Networks with Edge-Correlation 06/2018 – 07/2018
Project in Complex System Summer School 2018, Santa Fe Institute

- Building a network model that has edge-correlation.
- Evaluating the network model's properties, including degree distribution, triangle density.
- Comparing networks generated by the model to real-world networks.

Publication: Cantwell, George, Yanchen Liu, Benjamin F. Maier, Alice C. Schwarze, Carlos A. Serván, Jordan Snyder, and Guillaume St-Onge. "Thresholding normally distributed data creates complex networks." *arXiv preprint arXiv:1902.08278* (2019).

INTERDISCIPLINARY RESEARCH

Research on Scaling for Information Processing Capacity of Species 06/2018 – 07/2018
Project in Complex System Summer School 2018, Santa Fe Institute

- Collecting data on maximum information processing capacity for various sensory systems for different species, from single cellular species to larger animals.
- Comparing information capacity with metabolic rate, bio-mass and other features of the species and find scaling laws.

NETWORK SCIENCE

Research on Utilizing Hierarchy of Time Scales in Dynamical Processes in Networks 12/2017 – now
Supervised by Prof. *Albert-László Barabási*, Network Science Institute, Northeastern University

- Building a dynamical process with a quadratic Hamiltonian, and analyzing the relation between the time scale and eigenmode of the of the dynamical process.
- Studying the spectrum of Laplace matrix of stochastic networks with different hierarchical structures, and analyzing the correspondence between hierarchical structure and eigenmodes of Laplace matrix.
- Finding modules on different hierarchy level in the network by using K-mean clustering with eigenvectors of Laplace matrix, and doing coarse graining on the network. The nodes in different hierarchy level have different dynamical time scales.

NETWORK SCIENCE

Research on Joint Alignment Probelm 07/2017 – 10/2017

Supervised by Dr. *Pan Zhang*, Institute of Theoretical Physics, Chinese Academy of Sciences

- Deriving Bayes-optimal belief propagation and its associated spectral algorithms for random sparse systems using cavity method in statistical physics.
- Studying the stability of the message passing algorithm, and using it to determining the detectability transition beyond which no polynomial-time algorithm can tell information of the ground-true signal with success better than chance, without knowing any information of the ground-truth.
- Applying our algorithm in the non-parametric form to the real-world applications of 3-D object alignment in the *Shape-Net* datasets, and demonstrating that our algorithm significantly outperforms existing algorithms, such as the recently proposed projected powering method.

NETWORK SCIENCE and MACHINE LEARNING

Research on Using Nerve Cell Correlations in Brain to Build Brain Network 10/2016 – 03/2017

Supervised by Prof. Hernan Makse, Levich institute, Department of Physics, City College of New York

- Adapting Ising Model to use it in nerve cell systems by substituding spin $s_i=\pm 1/2$ with variable x_i that follows Gaussian distribution which represents signal of each nerve cell.
- Testing an algorithm in machine learning, Graphical Lasso, in random graphs to prove its efficiency.
- Using Graphical Lasso to infer brain network from correlations between nerve cells.

NETWORK SCIENCE

Research on Inference of Stochastic Block Model Using Touless-Anderson-Palmer Equation 09/2016 – 11/2016

Supervised by Dr. *Pan Zhang*, Institute of Theoretical Physics, Chinese Academy of Sciences

- Deriving the Touless-Anderson-Palmer (TAP) equation from Belief Propatation equation with weak-structure approximation.
- Deriving Laplacian from TAP equation by linearizing TAP equation around its paramagnetic fixed point, and doing spectral clustering using the Laplacian.
- Using TAP equation to do inference on Stochastic Block Model, and comparing its performance with Naïve Mean Field method which has the same computational complexity but much poorer performance than our TAP equation.

NETWORK SCIENCE

Research on Statistical-Physics-Based Data Clustering 07/2016 – 10/2016

Supervised by Dr. *Pan Zhang*, Institute of Theoretical Physics, Chinese Academy of Sciences

- Proposing a measure of the quality of the partition of weighted graphs.
- Mapping the data clustering problem to the Potts model at critical temperature of spin glass transition.
- Applying the cavity method in spin glass theory to solve the mariginals corresponding to the Boltzmann distribution.
- Testing our method in Stochastic Block Model and proving that our method works all the way down to the theoretical limit.
- Testing our mothod in in several problems including clustering in high-dimensional data, semi-supervised clustering, and community detection in weighted graphs, and showing that our algorithm significantly outperforms existing algorithms.

Publication: Shi, Cheng, Yanchen Liu, and Pan Zhang. "Weighted community detection and data clustering using message passing." *Journal of Statistical Mechanics: Theory and Experiment* 2018.3 (2018): 033405.

NETWORK SCIENCE

Research on Hierarchical Clustering 07/2016 – 09/2016

Supervised by Dr. *Pan Zhang*, Institute of Theoretical Physics, Chinese Academy of Sciences

- Using the method of statistical mechanics and Bayes' theorem to define entropy and energy of the network system with latent hierarchical community structure, and using them to derive the partition function of the system.

- Using Belief Propagation method to infer the latent hierarchical community structure of the network system.
- Linearizing Belief Propagation equations around its paramagnetic fixed point, and analyzing its stability by finding the basin of attraction of the paramagnetic solution.
- Found a counter-example of a widely-believed conclusion about the eigenvalues of a network system's nonbacktracking matrix.

SOFT MATTER

Research on Liquid-Liquid Phase Transition of Cerium and Abnormal Behaviors of Structural and Dynamical Coefficients in the Vicinity of Critical Point 10/2015 – 5/2016

Supervised by Prof. *Limei Xu*, International Center for Quantum Materials, Peking University

- Using molecular dynamics to compute the equations of state and the phase diagram of liquid Cerium
- Using the method of linearized Scaling Theory and by accessing the free energy of the system to calculate the liquid-liquid phase transition and critical behavior of Cerium.
- Wrote graduate thesis: Study on Liquid-Liquid Phase Transition Using Widom Method. Grade: 91/100.

QUANTUM INFORMATION

Research on Quantum Entanglement of Photons Generated by Two-Level Atomic System 11/2014 – 06/2015

Supervised by Prof. *Qiongyi He*, Institute of Modern Optics, Peking University

- Fully trained in the basic knowledge of quantum information, quantum optics, light-matter interaction and etc.
- Study of the quantum entanglement of light generated by two-level atomic system.

CONDENSED MATTER EXPERIMENT

Research on dimer-breaking induced structural phase transition of ThCr2Si2-Type Crystals 04/2013 – 09/2014

Supervised by Associate Prof. *Shuang Jia*, International Center for Quantum Materials, Peking University

- Fully trained in basic instruments including powder XRD, Solid state reaction, Glove Box, Vacuum pump and etc.
- Synthesis of alloys for the study of dimer-breaking induced crystal structural transitions in ThCr2Si2-type compounds.

CONFERENCES AND SUMMER SCHOOL

Complex Systems Summer School, Santa Fe Institute 06/2018 – 07/2018

- Project: Thresholded normal distribution networks.
- Project: Scaling for information processing capacity of species.

International Conference of Physics Students, Heidelberg 08/2014

- Poster: dimer-breaking induced crystal structural transitions in ThCr2Si2-type compounds

SELECTED COURSE PROJECTS

NETWORK SCIENCE

A new model describing the citation network 10/2017

Supervised by Prof. *Albert-Lazlo Barabasi*, Northeastern University

- Studied the properties of citation network of high energy physics theory on Arxiv from 1992 to 2003, including degree distribution, clustering coefficient, and compared it with null model – degree preserving randomized citation network.
- Created a new model describing the growth of citation networks incoorperating both aging effect and the quality of different papers. Compared networks generated by both Barabasi-Albert model and the new model with the real citation network, and proved that the new model captures crucial features that Barabasi-Albert model fails to do, such as the scaling of clustering coefficient with network size.

NONLINEAR PHYSICS

Dynamics and bifurcations of oscillating two-gene system 05/2015

Supervised by Prof. *Hongli Wang*, Peking University

- Explored and computed the different possible bifurcation diagrams under different parameter conditions, and then analyzed the dynamical behaviors of the system under each condition.
- Realized the bifurcation diagram computation by MATLAB, and the dynamic trajectories by XPPAUT.

SEMINAR FOR SOLID STATE PHYSICS

Electronic transport in mesoscopic systems 11/2014

Supervised by Prof. *Junren Shi*, Peking University

- Explored the basic knowledge of electronic transport in mesoscopic systems.
- Gave a report on the conductance of mesoscopic two dimensional electronic systems with two electrodes, especially the Landauer-Buttiker formalism.
- Gave a report on weak and strong localization effects, especially in one and two dimensional conductors.

METHODS OF MATHEMATICAL PHYSICS

Solution of the stationary state equations in time-dependent partial differential equations 05/2014

Supervised by Prof. *Chunyuan Gao*, Peking University

- Found the method to solve the stationary state equations in time-dependent equations, including homogeneous equation and nonhomogeneous equation (for example, Laplace's equation and heat conduction equation).

AWARDS AND HONORS

Honorable Mention (2nd Prize) in the Mathematical Contest in Modeling 02/2015
Honorable Mention (2nd Prize) in the Mathematical Contest in Modeling 02/2014
3rd Prize in the 30th National Physics Contest for College Students 12/2013

COURSES

Main Graduate Courses and Grades

Quantum Mechanics	A	Analytical Mechanics	A+	Mathematical Methods	A
Statistical Mechanics	A+	Electrolmagnetic Theory	A-	Quantum Mechanics (ll)	A
Network Science Data	A	Graph Theory	A	Complex Networks	B+

Main Undergraduate Courses and Grades

Quantum Theory of Many-Body Systems	95	Topics on Nonlinear Physics	90	Thermal Physics	95
Seminar for Solid State Physics	95	Quantum Mechanics (ll)	92	Seminar for Quantum Mechanics	86
Quantum Field Theory	84	Solid State Physics	87	Advanced topics in Quantum Mechanics	85

COMPUTATIONAL SKILLS

- **Programming languages:** C, C++, Python.
- **Other Softwares:** MATHEMATICA, MATLAB, GEPHI, XPPAUT, ORIGIN.