Curriculum Vitae

Jinshan Wu

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Post-Secondary Education

Dates	Degree	University or Institution/ Mentions
2006-2011	Ph.D.	Department of Physics and Astronomy University of British Columbia (UBC) Vancouver, Canada
		Supervisor: Mona Berciu **Area**: Condensed Matter Physics **Thesis Title**: *Quantum Transport Through Open Systems* **Date:** May 2011
2004-2006	M.Sc.	Department of Physics and Astronomy University of British Columbia Vancouver, Canada
		Supervisor: Mona Berciu **Area**: Condensed Matter Physics
2003-2004	Ph.D.	Department of Physics and Astronomy Simon Fraser University Vancouver, Canada
		One year before transferring to UBC
1999-2002	M.Sc.	Department of Physics Beijing Normal University Beijing, China
		Supervisor: Zhanru Yang **Area**: Statistical Physics
1995-1999	B.Sc.	Department of Physics Beijing Normal University Beijing, China

Employment Record

Dates	University	Description
2011-	Beijing Normal University	Associate Prof., lead a team on statistical physics and systems science, teach Quantum Mechanics, Invitation to Systems Science, Math and Physics in Studies of Complexity, Mathematical Modeling
2004 - 2011	Department of Physics and Astronomy, UBC	Research Assistant for Mona Berciu
2004 - 2011	Department of Physics and Astronomy, UBC	Teaching Assistant
2003-2004	Department of Physics, SFU	Teaching Assistant
2003, Spring	Department of System Science, BNU	Lecturer for an undergraduate course in math modeling
2002-2003	Department of Physics, BNU	Research Associate for Zengru Di. I lead a team working on empirical studies and modeling of weighted complex networks.
2002, Fall	Department of System Science, BNU	Lecturer for "Econophysics", a course for graduate students. I designed and established this course from scratch.
1999-2002	Department of Physics, BNU	Research Assistant for Zhanru Yang. During the later years (2001-2003), I lead a team working on physical models on complex networks

Awards, Scholarships, and Fellowships

Dates	Distinction	Awarded by
2006-2009	University Graduate Fellowship	University of British Columbia
Spring 2004	Graduate Fellowship	Simon Fraser University
Spring 2004	Sidney Hong Memorial Grad Scholarship	Canron Limited, via SFU
Spring 2004	Graduate Scholarship in Expert Systems	Westak International Sales Inc., via SFU
2000	Scholarship for Excellent Graduate Students	Beijing Normal University
1998	Award for Excellent Undergraduate Students	Beijing Normal University

Publications

Refereed Journals:

1. Wenjie Dai, Xin Wang, **Jinshan Wu**, Logical gaps in the approximate solutions of the social learning game and an exact solution, PLoS ONE, in press
2. Zehui Deng, **Jinshan Wu**, and Wenan Guo, Renyi information flow in the Ising model with single-spin dynamics, Physical Review E, in press
3. Qiang Zhang, Tianxiao Qi, Keqiang Li, Zengru Di and **Jinshan Wu**, Games on graphs: A minor modification of payoff scheme makes a big difference 2014 EPL 107 10002 doi:10.1209/0295-5075/107/10002
4. Qian Zhuang, Zengru Di, **Jinshan Wu**, Stability of Mixed-Strategy-Based Iterative Logit Quantal Response Dynamics in Game Theory, PLoS ONE 9(8): e105391. doi:10.1371/journal.pone.0105391
5. Xiaoyong yan, Ying Fan, Zengru Di, Shlomo Havlin, **Jinshan Wu**, *Efficient learning strategy of chinese characters based on network approach*, PloS ONE, 8, e69745 DOI: 10.1371/journal.pone.0069745.
6. Tian Wei, Menghui Li, Chensheng Wu, Xiao-Yong Yan, Ying Fan, Zengru Di and **Jinshan Wu**, *Do scientists trace hot topics?* Scientific Reports 3: 2207, doi:10.1038/srep02207 . (This work is highlighted in the Career Brief column in Nature "Fashion rules in Physics")
7. Jinshan Wu and Mona Berciu, *Heat transport in quantum spin chains: the relevance of integrability*, Phys. Rev. B 83(2011), 214416.
8. Jinshan Wu and Mona Berciu, *Kubo formula for open finite-size systems*, Europhysics Letters, 92(2010), 30003.
9. Jinshan Wu, *Non-equilibrium stationary states from the equation of motion of open systems*, New Journal of Physics, 12(2010), 083042.
10. Menghui Li, Liang Gao, Ying Fan, **Jinshan Wu** and Zengru Di, *Emergence of global preferential attachment from local interaction*, New Journal of Physics, 12(2010), 043029.
11. Yanqing Hu, Jinshan Wu and Zengru Di, *Enhance the efficiency of heuristic algorithms for maximizing the modularity Q*, Europhysics Letters, 85(2009), 18009.
12. Ying Fan, Menghui Li, Peng Zhang, **Jinshan Wu** and Zengru Di, *The effect of weight on community structure of networks*, Physica A, 378(2007), 583-590.
13. Ying Fan, Menghui Li, Peng Zhang, Jinshan Wu and Zengru Di, *Accuracy and precision of methods for community identification in weighted networks*, Physica A, 377(2007), 363-372.
14. Menghui Li, Jinshan Wu, Dahui Wang, Tao Zhou, Zengru Di and Ying Fan, *Evolving model of weighted networks inspired by scientific collaboration networks*, Physica A, 375(2007), 355-364.
15. Menghui Li, Ying Fan, Dahui Wang, Daqing Li, Jinshan Wu and Zengru Di, *Small-world effect induced by weight randomization on regular networks*, Physics Letters A, 364(2007), 488-493.

16. Menghui Li, Dahui Wang, Ying Fan, Zengru Di and **Jinshan Wu**, *Modelling weighted networks using connection count*, New Journal of Physics, 8(2006), 72.
17. Peng Zhang, Menghui Li, Jinshan Wu, Zengru Di and Ying Fan, *The analysis and dissimilarity comparison of community structure*,Physica A, 367(2006), 577-585.
18. Menghui Li, Ying Fan, Jiawei Chen, Liang Gao, Zengru Di and Jinshan Wu, *Weighted networks of scientific communication: the measurement and topological role of weight*, Physica A, 350(2005), 643-656.
19. Ying Fan, Menghui Li, Zengru Di, Jiawei Cheng, Liang Gao, and **Jinshan Wu**, *Networks of Econophysicists*, International Journal of Modern Physics B, Vol. 18, Nos. 17-19 (2004) 2505-2511.
20. 13. Jingzhou Liu, Jinshan Wu and Z. R. Yang, *The spread of infectious disease on complex networks with household-structure*, Physica A, 341(2004), 273-280.
21. Jinshan Wu and Zengru Di, *Complex networks in statistical physics*, Progress in Physics (Chinese), 24-1(2004), 18-46.
22. Jinshan Wu, Zengru Di and Zhanru Yang, *Division of labor as the result of phase transition*, Physica A, 323(2003), 663-676.
23. Jinshan Wu, Jingdong Bao and Zhanru Yang, *Improved Metropolis method for systems with discrete states*, Chinese Journal of Computational Physics, 19-2(2002), 103-107.

Preprints on arXiv:

1. Jinshan Wu and Shouyong Pei, *Could a Classical Probability Theory Describe Quantum Systems?*, arXiv:quant-ph/0503093.
2. Yougui Wang, Jinshan Wu and Zengru Di, *Physics of Econophysics*, arXiv:cond-mat/0401025.
3. Jinshan Wu, A series of papers on Game Theory: A new mathematical representation of Game Theory I, II arXiv:quant-ph/0404159,arXiv:quant-ph/0405183.

Talks and Conference Presentations

1. Talk at APS March meeting 2009, "*Heat transport in quantum spin chains: the relevance of integrability*", March, 2009
2. A talk on Quantum Games for "Complex systems forum in Shanghai" , June, 2011
3. A presentation on Quantum Games in the "Internaltional conference on Econophysics in Shanghai", June, 2011
4. A lecture on "Games on quantum objects" for "BNU summer school on Complex Systems"

Computational Skills

- High-performance computational software: Lapack, Petsc, gsl, xmds
- Programming language: C, Java, Linux shell script

Courses taught

- Undergraduate: Quantum Mechanics, Invitation to Systems Science
- Graduate: Math and Physics in Studies of Complexity, Advanced Statistical Mechanics
- Others: Monthly seminar on Concept Mapping and Teaching, Lectures on Concept Mapping

Research Summary

Physics is all about interactions. It is also interaction that makes the world diverse (instead of homogeneous), beautiful and worth studying. Statistical physics starts from theories and their related computational techniques for collections of non-interacting units (thus non-interacting systems) and then moves to dealing with interacting systems, where one unit of the system is connected to others. Dealing with such interactions at microscopic level is called mechanics (we have classical and quantum mechanics), while dealing with such interactions at macroscopic level, sometimes phenomenologically, is called thermodynamics, and here comes the statistical mechanics or statistical physics when asking for the bridge between the micro and the macro level.

First major theme that I am working on is theoretical and computational foundations of statistical physics: why the Boltzmann distribution is valid for equilibrium statistical systems and what is the correspondence for non-equilibrium but still stationary systems, especially when the system has quantum nature and is interacting?

Second, beyond physics objects, there are other interacting systems, can the theories and computational techniques from statistical physics be applied to them, such as interactions among rational (full or partial) and intellectual agencies. This is where I started to look into game theory, a theory about agencies, which are quite often human being, with conflicting interests.

There are other more general interacting systems too, such as a collection of Chinese characters (they are different from a collection of light bulbs), a set of research papers, a set of all kinds of industrial products, a set of science concepts. This drives me into the third topic that I am actively working on now and hopefully for the future: network science and its application to (also back action from) scientometrics, knowledge management, meaningful learning and input-output analysis.

Sometimes, my thoughts get stuck in foundations of quantum mechanics too. It is such a fascinating field and it drives me into excited states all the time.

Quantum transport

In my Ph. D. work at UBC I aimed to establish a theoretical framework for finding the non-equilibrium stationary states of quantum systems starting mostly from first principles. Approaches exist for this problem such as the Landauer-Buttiker formula and the non-equilibrium Green's function method. We decided to use the open-system scenario, which is not widely used because of the difficulty in solving the resulting open-system master equation. Using direct methods, one needs to solve an eigenvalue problem of size 4^N where N is the size of the system measured in qubits. We first searched for efficient methods to solve this problem and then applications of this framework on physical models. The following lists several projects I have worked on.

- Using a **BBGKY-like method for solving the open-system master equation** [4] the task of solving an eigenvalue problem of size 4^N becomes a problem of solving a linear system of size $\mathbf{N^2}$ by converting the open-system master equation into linear equations of Green's functions. The equations of different Green's functions (single-particle ones, tow-particle ones and so on) are coupled. The cluster expansion, originally used for the equilibrium BBGKY method, is used to truncate the coupled equation. The accuracy of this method is around 2%.

- The **second order form of the BBGKY-like method** requires solving a linear system of size $\mathbf{N^4}$ but improves accuracy even further. Such a form also gives the two-particle correlated Green's functions beyond the Hartree-Fock approximation. Manuscript in preparation.

- A **coherent-state representation approach** was also explored to solve the above problem of size 4^N by simulating a stochastic differential equation with **2N** complex variables by converting the open-system master equation into a generalized Fokker-Planck equation. Analytical expression of the non-equilibrium stationary states are derived for some systems. The accuracy of this method is around 6%. Manuscript in preparation.

Network Science and its application

Network Science is all about interaction, such interaction that is beyond physical interaction and is not usually studied by physicists, such as how others' action and opinion act on your decision, how learning one concept can help you to learn other related concepts. Works in this direction concerns both the tools, concepts and methodologies about network, and the applications, how network concepts and methodologies can solve problems in other fields.

- Network Science helps to improve learning Chinese[2] and science. Chinese characters are connected to each other meaningfully: One character quite often becomes a component of another character and it indicates meaning or pronunciation of the composed character. How often is such relation, how to present the relation, and how to make use of the relation in learning characters? Those are the questions we investigated in this work.
- Network Science is applied to Scientometrics[1]. How one field of science affect another, how science lead to innovations in technology, can such questions be answered based on publication data, such as publication records from ISI and Patent database? Those are the questions we are trying to answer in this project.
- **Evolutionary model for weighted networks** [5,9,11]: Inspired by social networks and the above weighted networks of econophysicists, a new model of weighted networks was proposed. It is based on local rules, which means that nodes in the network only need to know limited information about their neighbors and at most their next neighbors. That is in this model a data centers providing global information is not required. We went one step further and conjectured that the well-known mechanism of global preferential attachment (that the richest gets richer while the poorest gets poorer) can be an emergent phenomenon rooted from local rules. We tested and confirmed this conjecture on our own model and several others.

Quantum Game Theory [working paper 3]

In physicists' terminologies, classical games can be regarded as games based on classical objects. The state of the object changes according to players' choice of strategies. These strategies are described by operators acting on the object to modify its state. The final state of the object determines the payoff for every player. The coin flipping games is a perfect example of this picture. The coin is a classical two-state system, which is denoted by physicists as a mixture state of "heads" and "tails". Flipping and non-flipping correspond respectively to the Pauli matrix σ_x and identity matrix. A natural question then arises of what happens if the classical coin is replaced by a quantum spin.

I found that the answer is very non-trivial: a probability distribution over the strategy space, which is the description of a general strategy in classical game theory, is no longer capable of describing games with quantum objects. A density matrix over a basis of the strategy space has to be used. The same transition happens from Classical Mechanics to Quantum Mechanics. A probability distribution is replaced by a density matrix, which allows superpositions while the former allows only probability summations.

Quantum Foundations [working paper 1]

Partially inspired by the above work on quantum game theory, I was motivated to study the difference between a probability distribution and a density matrix. Can the former be converted to the later equivalently or vice versa? Luckily I found that the same question has been asked and investigated by physicists on the question of validity of hidden variable theory. In a hidden variable theory, there is no superposition principle, but classical probability summations are allowed. In a sense, the hidden variable theory is searching for a map from a density matrix to a classical probability distribution.

On one hand there is a theorem stating that all convex theories, which includes quantum mechanics, can be embedded into a classical probability theory with constraints (see for example, A. S. Holevo, Probabilistic and Statistical Aspects of Quantum Theory). On the other hand, Bell's inequality rules out all local hidden variable theories. The constrained classical theory has to be non-local. Of course many believe that physical theory should be local, but some are still willing to sacrifice locality. I investigated the question of what beyond locality one has to give up in order to have such a classical theory for quantum systems. I found there are many other unacceptable features of the classical theory by explicitly constructing such a theory for systems of one spin half and two spin halves. Those unwanted features make the theory even harder to understand than the usual quantum mechanics.