HAIJUN ZHOU

Phone: (86) 10-6254 1816
zhouhj@itp.ac.cn
http://power.itp.ac.cn/~zhouhj/

Institute of Theoretical Physics,
Chinese Academy of Sciences
Zhong-Guan-Cun-Dong-Lu 55, Beijing 100190, China

I am a Research Professor working in the field of statistical physics and its interdisciplinary applications. My research group currently has three PhD students and two Master students. We are working on topics such as spin-glass mean-field theories, solution space structure of random constraint satisfaction problems, stochastic search dynamics on combinatorial optimization problems, structural phase transitions in single polymers, and statistical physics of networks.

EDUCATION

PhD Institute of Theoretical Physics, Chinese Academy of Sciences June 2000
Dissertation: "Elasticity and Statistical Mechanical Properties of Deoxyribonucleic Acid Polymers"
Advisor: Professor Dr. Zhong-Can Ou-Yang

BS Department of Physics, Nankai University June 1995

HONORS AND AWARDS

Special Government Allowance in 2010 （2010 年度政府特殊津贴） 2011
11th Science and Technology Award for Chinese Youth （中国青年科技奖） 2010
Hundred Talents Program（中国科学院百人计划） 2005
National Excellent Doctoral Dissertations Prize（全国优秀博士学位论文奖） 2002
Alexander von Humboldt Research Fellowship（洪堡奖学金） 2001

TEACHING EXPERIENCE

Institute of Theoretical Physics, CAS, Beijing Sep 2005 to Dec 2010

- Taught an advanced graduate course "Statistical Physics and Information Theory" during Sep 2010 to Jan 2011 (32 hours)
- Taught an advanced graduate course "Statistical Physics and Spin Glass" during Nov 2005-Jan 2006 (32 hours)

Graduate University of the Chinese Academy of Sciences, Beijing

- Taught a graduate course "Quantum Statistical Mechanics" during March 2010 to June 2010 (60 hours)

RESEARCH EXPERIENCE

My research team works on the field of statistical physics and its interdisciplinary applications. The systems we are interested in include spin glasses, single biopolymers, complex networks, constraint satisfaction problems and combinatorial satisfaction problems, message-passing algorithms, and so on. The main scientific results we obtained during the period of 1999-2010 are the following:

(1) On biopolymers, we studied the force-induced structural transitions in single double-stranded DNA and single-stranded DNA macromolecules, spider capture silk fibers, and lattice polymers (as a model of protein beta-sheets). Our theoretical calculations published in 1999 suggested that the major factor contributing to DNA's stability and high extensibility is the stacking interactions between adjacent DNA nucleotide base-pairs. This work has gained some popularity among researchers working on biopolymers. We constructed a simple "hierarchical chain" model in 2005 to understand spider capture silk's amazing combination of strength and extensibility. This model quantitatively explains the logarithmic increase of the silk chain's extension as a function of external stretching force. We demonstrated through an analytical calculation in 2006 that, the bending stiffness of a polymer can have a qualitative influence to the coil-globule (collapse) structural transition of the polymer. This work also sheds light on the structural stability of protein's beta-sheet structure.

(2) On complex networks, we investigated in 2003 the network community structure problem. By applying the random walk idea of statistical physics, we defined a node-node similarity index to quantify the extent of similarity between any two connected nodes of a network. This similarity index was then used by an hierarchical clustering algorithm to group nodes of a network into communities and super-communities. We published a paper in 2005 to study the influence of network structure to various dynamical processes on the network. It was reported that, for majority-rule-like dynamics, scale-free networks with degree scaling exponent $\gamma<2.5$ has a characteristic dynamical relaxation time that is independent of network size. This theoretical prediction sheds light on the empirical observation that, a major fraction of real-world complex networks are scale-free with exponent less than *2.5*.

(3) On spin glasses, we presented a long-range frustration theory in 2005 to study the long-range correlations among the ground-state configurations of a spin glass defined on a random finite-connectivity graph. This mean-field theory is able to predict rather accurately the ground-state energy density of a spin glass system without the need of too much numerical effort. It also gives a qualitative explanation why a combinatorial optimization problem suddenly becomes exponentially hard as certain control parameter changes slightly around a threshold value. In an invited lecture of 2010 at the 24th IUPAP International Conference of Statistical Physics, we demonstrated that the ground-state configuration space of a many-body interacting spin glass system will first experience a homogeneity-to-heterogeneity phase transition before it breaks into an exponential number of disconnected ground-state configuration subspaces. We also demonstrated that the heterogeneity of the ground-state configuration space will lead to the dynamical heterogeneity phenomenon in zero-temperature and low-temperature relaxation processes.

PUBLICATIONS (PARTIAL LIST)

Books

H. Zhou, Y. Zhang, and Z.-C. Ou-Yang, "Theoretical and computational treatment of DNA and RNA molecules", in Handbook of Theoretical and Computational Nanotechnology, edited by M. Rieth and W. Schommers (American Scientific Publishers, California, 2006), Volume 6, pages 419-487.

Journal Publications

H. Zhou and C. Wang, “Ground-state configuration space heterogeneity of random finite-connectivity spin glasses and random constraint satisfaction problems”, Journal of Statistical Mechanics: Theory and Experiment, P10010, 2010.

K. Li, H. Ma, and H. Zhou, “From one solution of a 3-satisfiability formula to a solution cluster: Frozen variables and entropy”, Physical Review E, 79, 031102, 2009.

H. Zhou, “T->0 mean-field population dynamics approach for the random 3-satisfiability problem”, Physical Review E, 77, 066102, 2008.

M. Weigt and H. Zhou, “Message passing for vertex-covers”, Physical Review E, 74, 046110, 2006.

H. Zhou, J. Zhou, Z.-C. Ou-Yang, and S. Kumar, “Collapse transition of two-dimensional flexible and semiflexible polymers”, Physical Review Letters, 97, 158302, 2006.

H. Zhou and R. Lipowsky, “Dynamic pattern evolution on scale-free networks”, Proceedings Natioanl Academy of Sciences USA, 102, 10052-10057, 2005.

H. Zhou, “Long range frustration in a spin-glass model of the vertex-cover problem”, Physical Review Letters, 94, 217203, 2005.

H. Zhou and Y. Zhang, “Hierarchical chain model of spider capture silk elasticity”, Physical Review Letters, 94, 028104, 2005.

H. Zhou and R. Lipowsky, “Network Brownian motion: A new method to measure vertex-vertex proximity and to identify communities and subcommunities”, Lecture Notes in Computer Science, 3038, 1062-1069, 2004.

H. Zhou, “Distance, dissimilarity index, and network community structure”, Physical Review E, 67, 061901, 2003.

H. Zhou, “Network landscape from a Brownian particle’s perspective”, Physical Review E, 67, 041908, 2003.

H. Zhou, “Vertex cover problem studied by cavity method: Analytics and population dynamics”, European Physical Journal B, 32, 265-270, 2003.

H. Zhou and Y. Zhang, “Pulling hairpinned polynucleotide chains: Does base-pair stacking interaction matter?”, Journal of Chemical Physics, 114, 8694-8700, 2001.

Y. Zhang, H. Zhou, and Z.-C. Ou-Yang, “Stretching single-stranded DNA: Interplay of electrostatic, base-pairing, and basepair stacking interactions”, Biophysical Journal, 81, 1133-1143, 2001.

H. Zhou, Y. Zhang, and Z.-C. Ou-Yang, "Stretch-induced hairpin-coil transitions in designed polynucleotide chains", Physical Review Letters, 86, 356-359, 2001

H. Zhou, Y. Zhang, and Z.-C. Ou-Yang, "Elastic property of single double-stranded DNA molecules: Theoretical study and comparison with experiments", Physical Review E, 62, 1045-1058, 2000.

H. Zhou, Y. Zhang, and Z.-C. Ou-Yang, "Bending and base-stacking interactions in double-stranded DNA", Physical Review Letters, 82, 4560-4563, 1999.

.

PRESENTATIONS AND INVITED LECTURES

Invited Lecture, "Heterogeneity in the low-temperature configuration space of spin glasses and random constraint satisfaction problems," XXIV IUPAP International Conference on Statistical Physics (STATPHYS-24), 19.07.2010-23.07.2010, Cairns, Australia

H. Zhou, Y. Zhang, and Z.-C. Ou-Yang, "Elastic theories of single DNA molecules", Invited lecture delivered by Prof. Z.-C. Ou-Yang at XXI IUPAS International Conference on Statistical Physics (STATPHYS-21), 15.07.2001-21.07.2001, Cancun, Mexico

PROFESSIONAL AFFILIATIONS

Institute of Theoretical Physics, the Chinese Academy of Sciences, 2005-Present
Research Professor, coordinator for the research fields "Statistical Physics, Theoretical Biophysics, and Bioinformatics"

Kavli Institute for Theoretical Physics China, 2009
Associate Director

School of Physics and Technology, Lanzhou University, 2008-2010
Adjunct Professor

Max-Planck-Institute of Colloids and Interfaces, Germany, 2000-2005
Postdoc fellow

PROFESSIONAL SERVICE

Workshop and School Co-Organizer

- Kavli Institute for Theoretical Physics Program "Growth of Hierarchical Functional Materials in Complex Fluids", Beijing, 05.07.2011-05.08.2011
- Kavli Institute for Theoretical Physics Program "Interdisciplinary Application of Statistical Physics & Complex Networks", Beijing, 28.02.2011-31.03.2011
- "StatPhysHK: Complexity, Computation and Information" (Hong Kong Satellite meeting for STATPHYS-24), Hong Kong, 13.07.2010-16.07.2010
- Workshop on Statistical Physics and Computer Science (Beijing Satellite meeting for STATPHYS-24), Beijing, 08.07.2010-11.07.2010
- Kavli Institute for Theoretical Physics Program "Nanoscale Interfacial Phenomena in Complex Fluids", Beijing, 19.05.2008-20.06.2008

- Kavli Institute for Theoretical Physics Program "Collective Dynamics in Information Systems", Beijing, 01.03.2008-15.04.2008
- 2nd Asian-Pacific School on "Statistical Physics and Interdisciplinary Applications" (ITP-ICTP joint school), Beijing, 03.03.2008-14.03.2008
- International Conference on Recent Advances in the Interdisciplinary Applications of Statistical Physics, Beijing, 20.09.2006-22.09.2006
- Asian-Pacific School on "Statistical Physics and Interdisciplinary Applications" (ITP-ICTP joint school), Beijing, 11.09.2006-19.09.2006

Referee for:

- Chinese Physics Letters
- Communications in Theoretical Physics
- European Physical Journal B
- Europhysics Letters
- Frontiers of Physics in China
- International Journal of Modern Physics B
- Journal of Physics A: Theory and General
- Journal of Physics: Condensed Matter
- Journal of Statistical Mechanics: Theory and Experiment
- Modern Physics Letters B
- Physica A
- Physical Biology
- Physical Review E
- Physical Review Letters
- Science in China G: Physics, Mechanics and Astronomy

Editor for:

- Journal of Statistical Mechanics: Theory and Experiment

REFERENCES

Prof. Dr. Zhong-Can Ou-Yang
Chair of Scientific Committee,
Institute of Theoretical Physics,
The Chinese Academy of Sciences,
Zhong-Guan-Cun-Dong-Lu 55, Beijing 100190, China
Email: oy@itp.ac.cn

Prof. Dr. Yueliang Wu
Director,
Institute of Theoretical Physics,
The Chinese Academy of Sciences,
Zhong-Guan-Cun-Dong-Lu 55, Beijing 100190, China
Email: ylwu@itp.ac.cn