研究会報告

(YITP-W-04-14)

量子系およびマクロ系におけるカオスと非線形動力学

日時：2004年12月8日(水)～10日(金)
場所：京都大学基礎物理学研究所

19世紀の終りに、フランスの数学者ポアンカレは、ニュートン力学などの決定論的法則に従っていながら予測不可能な運動が出現しうることを指摘した。これは機械論的自然観の革命を示唆するものであり、現代のカオスの始まりである。コンピュータの普及した現在では、ポアンカレのいうカオス軌道を誰でも容易に視覚化できる。

本来、カオスはマクロな世界を記述する古典力学の範囲で出現した概念である。しかし、カオスはミクロな世界では出現しないとされている。量子の世界の基礎方程式であるシュレーディンガー方程式は波動関数に対する線形方程式なので、カオスという非線形の振る舞いを記述できない。このため古典的にカオスを示す系に、量子力学を適用するとさまざまな興味深い謎とテーマが発生する。これが「量子カオス」と いう新しい分野の研究テーマである。

近年、ナノテクノロジー（超微細加工技術）で作製されるナノスケール構造の電子デバイスを用いてカオスの量子論的徴候を明らかにすることが可能になっている。量子カオスを捉えることは、ナノスケールの工学や物理学の大きなテーマである。量子カオスをめぐる理論と実験の集積は目覚ましく、量子輸送や、非平衡統計力学、分子科学からナノサイエンスまで、その前線を著しく拡大しつつある。その意味で、宇宙論、超弦理論や強相関物性などのテーマと肩を並べる現代的意義と重要性を持ちはじめている。

このような学問的事情を背景として、量子カオスのテーマに先導的役割を与えながら、自然界の多岐にわたる非線形非平衡現象の理論と実験をも部分的にカバーしたテーマのもとに、「量子系およびマクロ系におけるカオスと非線形動力学」の名の下に、2004年12月8日（水）～10日（金）、京都大学基礎物理学研究所において、基研研究会を開催した。研究会では、以下のような具体的なテーマの下に、レビュー講演や招待講演の他、多くの若い研究者の講演、ポスター発表が行われた。

1. ナノサイエンスにおける量子カオスの最近の話題

2. カオス・量子カオスと平衡・非平衡統計力学

3. 散逸系がある系のカオスと非線形動力学（BECおよびパターン形成を含む）

4. 分子科学，核理論における量子カオスと半古典理論

5. 場の理論および宇宙論における量子カオス

6. 数理科学的考察・量子情報理論

本紙は、この研究会の報告である。

本研究会は、2002年9月（第1回目）と2003年11月（第2回目）に続いて行われたシリーズの第3回めである。過去2回においても、予想をこえる参加者を獲得したが（第1回目70数名；第2回目120数名）、今回も115名の参加があった。招待講演とポスター発表はそれぞれ、36件と44件であり、そのうち、招待講演では10件が、ポスター発表で2件が国外からの参加者によるものであった。基研研究会が基本的に国内研究者のための研究会であることを考えると、わが国における量子カオス研究の水準の高さを示すとともに、日本における国際研究会の開催の希望が高まっていることを示しているものとも言えよう。このような事情で、研究会では公用語を英語とすることとした。本紙も、「物性研究」編集長のお許しを得て、日本人著者については要旨のみを日本語で記載し、それ以外の全てのテキストは英語による表記とすることとした。「物性研究」が、より広く国際的に親しまれることにお役に立てれば、組織委員としても望外の喜びである。また、参加者の多くが若い研究者であったことも、特筆しておきたい。本年度の研究会も活発な質疑応答が続き、またユニークな発表も多く、分野を越えて議論することの楽しさを味わうことができる貴重な機会となった。

上記したように、多数の講演・ポスター発表が多数にのぼったため、本誌の紙数制限から、口頭講演には原則として4ページ、ポスターには2ページ分の紙幅が許されるのみとなった。執筆してくださった方々には、お許しをいただくとともに、ご尽力にお礼を申し上げたい。

組織委員：中村勝弘（大阪市大工）、高塚和夫（東大総合文化）、大場一郎（早大理工）

"Chaos and Nonlinear Dynamics in Quantum-Mechanical and Macroscopic Systems"

Dec. 8 – 10, 2004
Yukawa Institute for Theoretical Physics, Kyoto University, Japan

1) Current topics of quantum chaos in nanosciences

"The relationship between chaotic behavior and tunneling effect in quantum transport devices"
S. HARADA[1], N. KIDA[1], T. MORIMOTO[1], M. HEMMI[1], R. NAITO[1], N. AOKI[2], T. SASAKI[3], T. HARAYAMA[3], J. P. BIRD[4], and Y. OCHIAI[2] ([1]Graduate School of Science and Technology, Chiba University, [2]Department of Electronics and Mechanical Engineering, Chiba University, [3]ATR Adaptive Communications Research Laboratories, [4]Department of Electrical Engineering, University at Buffalo The State University of New York)

"Anomalous fluctuations in the annulus billiard: Magnetic-field-induced bifurcations"
Daiki HOTTA, Masanori MIYAMOTO, Syunpei MASUDA (Department of Applied Physics, Osaka City University)

"Study of the Survival Probability and the Phase Diagram of the Electronic Frenkel-Kontorova Model"
Bambi HU[1,2] and Lei YANG[1] ([1]Department of Physics, Centre for Nonlinear Studies, and The Beijing-Hong Kong-Singapore Joint Centre for Nonlinear and Complex Systems (Hong Kong), Hong Kong Baptist University, [2]Department of Physics, University of Houston)

"Resonant light induced mechanical interaction between a pair of quantum dots"
Takuya IIDA[1] and Hajime ISHIHARA[1,2] ([1]Department of Materials Engineering Science, Graduate School of Engineering Science, Osaka University, [2]CREST Japan Science and Technology Agency)

"Quantum Signature of Chaos in SQUIDs"
Takeo KATO (Institute for Solid State Physics, The University of Tokyo)

"Lasing Modes in a Spiral-Shaped Microcavity"
Tae-Yoon KWON[1,2], Soo-Young LEE[1], Chil-Min KIM[1], and Young-Jai PARK[2] ([1]National Creative Research Initiative Center for Controlling Optical Chaos, Paichai University, [2]Department of Physics, Sogang University)

"Quasiscarred Resonances in a Spiral-shaped Microcavity and Fresnel Filtering Effects"
Soo-Young LEE, Muhan CHOI, Chil-Min KIM (NCRI Center for Controlling Optical Chaos, Pai-Chai University)

"Eigenvalues of nanoscale molecular magnets"
Manabu MACHIDA (Institute of Industrial Science, The University of Tokyo)

"Fidelity recovery in the Gaussian ensembles"
R. SCHÄFER, H.-J. STÖCKMANN (Fachbereich Physik der Philipps-Universität Marburg)

"Nonequilibrium Steady States and Current Fluctuation in an AB ring with a Quantum Dot"
Junko TAKAHASHI and Shuichi TASAKI (Department of Applied Physics, School of Science and Engineering, Waseda University)

"Approach for Controlling Nano-scale Quantum Systems"
Toshiya TAKAMI[1] and Hiroshi FUJISAKI[2] ([1]Comp. & Comm. Center, Kyushu University, [2]Department of Chemistry, Boston University)

"Quantum transport of molecules and internal current"

Masaru TSUKADA (Dept. of NanoSci. and NanoEngin., Waseda University)

"Frustrated quantum three-spins coupled with vibration modes: Quantum chaos in the context of dynamical Jahn-Teller problem"
Hisatsugu YAMASAKI (Department of Applied Physics, Osaka City University)

2) Equilibrium and nonequilibrium statistical mechanics in systems showing chaos and quantum chaos

"Transition from regular to chaos from the aspect of nodal domains associated with wave functions"
Hirokazu AIBA[1] and Toru SUZUKI[2] ([1]Kyoto Koka Women's College, [2]Department of Physics, Tokyo Metropolitan University)

"Time average and canonical average of macroscopic variable in classical Hamiltonian system with long-range interaction"
Shin-itiro GOTO[1,2] and Yoshiyuki Y. YAMAGUCHI[1] ([1]Department of Applied Mathematics and Physics, Kyoto University, [2]JSPS research fellowship for Young Scientists)

"Observation on Non-linear Dynamical Fluctuation of Rare Nitrate Crystal in Low Temperature Region"
Riki KAWASHIMA and Hirosi ISODA (Muroran Institute of Technology)

"Noise-Driven Numerical Irreversibility in Time-Reversible Molecular Dynamics Simulation"
Nobuyoshi KOMATSU and Takashi ABE (The Institute of Space and Astronautical Science)

"Level statistics and energy diffusion of XXZ spin chains"
Kazue KUDO (Graduate School of Humanities and Sciences, Ochanomizu University)

"Long-Range spectral statistics of systems with infinitely many components -Investigation of classically integrable systems based on the Berry-Robnik theory-"
Hironori MAKINO[1] and Shuichi TASAKI[2] ([1]Department of Human and Information Science, Tokai University, [2]Department of Applied Physics, Waseda University)

"Nonexponential decay law of unstable multilevel quantum-systems at long times"
Manabu MIYAMOTO (Department of Physics, Waseda University)

"Quantization of Open Systems and the Quantum–Classical Transition"
Ichiro OHBA and Yukihiro OTA (Department of Physics, Waseda University)

"Thermalization and Quantum Chaos in Closed Finite Electronic systems"
Shin-ichi SAWADA (School of Science and Technology, Kwansei Gakuin University)

"Turing instability leads oscillatory systems to spatiotemporal chaos"
Dan TANAKA (Department of Physics, Graduate School of Science, Kyoto University)

"Nonequilibrium Phenomena in Junction Systems"
Shuichi TASAKI (Waseda University)

"Quantum Level Statistics of Gaussian Ensembles in One-Dimensional Conservative System"
Mitsuyoshi TOMIYA[1], Shoichi SAKAMOTO[1] and Naotaka YOSHINAGA[2] ([1]Department of Applied Physics, Seikei University, [2]Department of Physics, Saitama University)

3) Chaos and nonlinear dynamics in dissipative systems (including BEC and pattern formations)

"Nonlinear effects of the time dependent Gross-Pitaevskii equation in the potential scattering problem"
Hironobu FUJISHIMA[1], Makoto MINE[1] and Masahiko OKUMURA[2]([1]Department of Physics, Waseda University, [2]Department of Applied Physics, Waseda University)

"Morphology of Spiral Patterns in Nematic Liquid Crystals Under Rotating Magnetic Fields"
K. FUKUSHIMA, C. KOSAKA and K. NAKAMURA (Department of Applied Physics, Osaka City University)

"Quantum Tunneling in Oscillatory Driven Double-Well Potential"
Akira IGARASHI (Graduate School of Science and Technology, Niigata University)

"Bifurcation from Classical to Quantum distinguishability"
Kentaro IMAFUKU, Hideki IMAI (Institute of Industrial Science, Univ. of Tokyo)

"Formation of multiple domains and quantized vortices in two-component Bose-Eistein condensates"
Kenichi KASAMATSU (Department of Physics, Osaka City University)

"Energy spectrum of superfluid turbulence: Numerical Analysis of the Gross-Pitaevskii equation with the small scale dissipation"
Michikazu KOBAYASHI and Makoto TSUBOTA (Faculty of Science, Osaka-City-University)

"Equatorial nonequilibrium states in magnetization dynamics in ferromagnets : Generalization of Suhl's spin−wave instabilities"
C. KOSAKA[1], K .NAKAMURA[1], S. MURUGESH[2], and M.LAKSHMANAN[2] ([1]Department of Applied Physics, Osaka City University, [2]Department of Physics, Bharathidasan University)

"Thermal diode and thermal transistor: Controlling heat flow through nonlinear dynamics"
Baowen LI[1] and Giulio CASATI[2,3,1] ([1]Department of Physics, National University of Singapore, [2]International Center for Nonlinear and Complex Systems, Universita' degli studi dell'Insubria, [3]Istituto Nazionale di Fisica della Materia, Unita' di Como, and Istituto Nazionale di Fisica Nucleare)

"Formalisms of Quantum Fluctuation Theorem"
Takaaki MONNAI and Shuichi TASAKI (Department of applied physics, Waseda University)

"Transition to chaos in Bose-Einstein condensates: role of inter-component interactions on wavepacket breathing"
Katsuhiro NAKAMURA (Department of Applied Physics, Osaka City University)

"Dynamics of wave packets in two-component BEC under the oscillating external field"
H. SAKAGUCHI, H. YAMASAKI and K. NAKAMURA (Department of Applied Physics, Osaka City University)

4) Quantum chaos and semiclassical theory in molecular science and nuclear theory

"Bifurcation and merging of wavepackets: Quantum chaos induced by nonadiabatic coupling"
Yasuki ARASAKI and Kazuo TAKATSUKA (Graduate School of Arts and Sciences, The University of Tokyo)

"Quantum Non-Escape Probability in Open Chaotic System -Lyapunov Exponent versus Periodic Orbits-"

Agung BUDIYONO[1], Kazuo TAKATSUKA[1], Takeo KATO[2] ([1]Graduate School of Arts and Sciences, The University of Tokyo, [2]Institute for Solid State Physics, The University of Tokyo)

"Evaporation dynamics of clusters"
Mikiya FUJII and Kazuo TAKATSUKA (Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo)

"Chaotic Reaction Dynamics and the Phase Space Geometry of Multi-dimensional Chemical Reaction"
Chun-Biu LI[1,3], Mikito TODA[2], Tamiki KOMATSUZAKI[1] ([1]Department of Earth and Planetary Sciences, Faculty of Science, Kobe University, [2]Department of Physics, Faculty of Science, Nara Women's University, [3]Prigogine Center of Statistical Mechanics and Complex Systems, University of Texas at Austin)

"Effects of spatiotemporal fluctuation of temperature on cluster formation"
Kenta ODAGIRI and Kazuo TAKATSUKA (Graduate School of Arts and Sciences, The University of Tokyo)

"Canonically invariant formulation of the semiclassical trace formula in terms of the phase space path integral"
Ayumu SUGITA (Department of Applied Physics, Osaka City University)

"Classical scale invariance taken in semiclassical quantization of three-body Coulomb system"
Satoshi TAKAHASHI and Kazuo TAKATSUKA (Dept. of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo)

"Control of rotational motion of asymmetric top molecules"
N. TAKEMOTO, T. SAKO, K. YAMANOUCHI (Department of Chemistry, School of Science, The University of Tokyo)

"Effects of Non-Adiabatic Transitions on Proton Dynamics"
Akira TANIGUCHI, Yuji NAGAI, Yuhei NATSUME (Graduate School of Science and Technology, Chiba University)

"Rotational symmetry adapted semi-classical theory and it's application to molecules"
Hiroshi TERAMOTO and Kazuo TAKATSUKA (Graduate School of Arts and Sciences, The University of Tokyo)

"Nature of semiclassical spectrum in terms of classical trajectories"
Hiroshi USHIYAMA and Kazuo TAKATSUKA (The University of Tokyo)

"Mixing and Segregation in Binary Clusters"
Norifumi YAMAMOTO and Kazuo TAKATSUKA (Graduate School of Arts and Sciences, The University of Tokyo)

"Control of Structure and Reactions of Molecules and Clusters in Intense Laser Fields"
Kaoru YAMANOUCHI (Department of Chemistry, School of Science, The University of Tokyo)

"Efficient semiclassical quantization methods –Combination of the AFC-II theory and cellularized dynamics-
Takefumi YAMASHITA and Kazuo TAKATSUKA (Graduate School of Arts and Sciences, The University of Tokyo)

5) Quantum chaos in field theory and cosmology

"Low energy effective interaction of XXZ spin interaction on 2 dimensional quantum dot"
M. HAMATANI and Nobuhiko TANIGUCHI (Institute of Physics, University of Tsukuba)

"Chaos based on Riemannian geometric approach to SU(2) Yang-Mills classical field theory"
Tetsuji KAWABE and Shinichiro KOYANAGI (Phys. Dept., Dept. of Acoustic Design, Kyushu University)

"Dynamics of Traveling Patterns under Spatio-Temporal Forcing"
Takao OHTA, Hidekazu TOKUDA (Yukawa Institute for Theoretical Physics, Kyoto University)

6) Approaches from mathematical science and quantum information

"Reconnection of Stable/Unstable Manifolds of the Harper Map"
Shigeru AJISAKA and Shuichi TASAKI (Waseda University)

"Dynamical versus static imperfections in quantum computers"
Paolo FACCHI[1], Rosario FAZIO[2], Simone MONTANGERO[2], and Saverio PASCAZIO[1] ([1]Dipartimento di Fisica, Universit`a di Bari, and INFN, Sezione di Bari, [2]NEST-INFM & Scuola Normale Superiore)

"Asymmetric behavior in consecutive phase space point spacings and nonintegrability"
Shigeyasu FUJIWARA (Hiroshima National College of Maritime Technology)

"Quantum Information Metrics and Relative Entropies–Classification Problem"
Hiroshi HASEGAWA (Institute of Quantum Science, College of Science and Technology, Nihon University)

"Quantum-state representation based on actual measurements — Beyond the Bloch vector for *N*-level systems —"
Gen KIMURA[1,2] and Andrzej KOSSAKOWSKI[2] ([1]Department of Physics, Waseda University, [2]Institute of Physics, Nicolaus Copernicus University)

"1/f Fluctuations in a Non-Hyperbolic System"
Tomoshige MIYAGUCHI (School of Science and Engineering, Waseda University)

"Quantum Gates Based on Adiabatic Controlling Processes in a Silicon–Based Nuclear Spin Quantum Computer"
Yukihiro OTA, Shuji MIKAMI, and Ichiro OHBA (Department of Physics, Waseda University)

"Dynamical quantum localization"
Ian PERCIVAL (University of London)

"The Notion and Aspects of Quantum Integrability"
Marko ROBNIK (CAMTP - Center for Applied Mathematics and Theoretical Physics, University of Maribor)

"Stokes geometry for the quantized Hénon map"
Akira SHUDO (Department of Physics, Tokyo Metropolitan University)

"Weak values and quantum-classical correspondence"
Atsushi TANAKA (Dept. Phys., Tokyo Metropolitan Univ.)

"Quantum anomaly and effective field description of a quantum chaotic billiard"
Nobuhiko TANIGUCHI (Institute of Physics, University of Tsukuba)

"Algebras, Representations and Quantum Mechanics"
Shogo TANIMURA (Osaka City University)

"From DNA to Spatio-Temporal Order　Is DNA a Read-Only-Memory?"
Kenichi YOSHIKAWA (Department of Physics, Kyoto University)