物性研究所セミナー

標題：理論インフォーマルセミナー：Problem specific solutions for linear systems and eigenproblems in condensed matter physics

日時：2014 年 7 月 1 日(火)　　午後 3 時～午後 4 時

場所：物性研究所本館 6 階 第 2 セミナー室（A612）

講師：SHINOHARA Yasushi

所属：Max-Planck-Institut fur Mikrostrukturphysik

要旨：

Most of recent numerical algorithms in applied mathematics for linear system and eigenproblem are not so popular in physical society. We have applied two algorithms of them to problems appeared in condensed matter physics, linear response TDDFT calculation and Bogoliubov-de Gennes equation, to obtain the results efficiently.

We have employed a shifted-Krylov subspace solver to obtain photo absorption cross section in isolated systems, molecules and clusters, within modified Sternheimer scheme. We assume relatively large system and spatial grid representation for Kohn-Sham orbital with a pseudopotential in the time-dependent Kohn-Sham equation. In order to obtain the cross section for relatively high frequency, the modified Sternheimer scheme is a moderate approach. Regarding the modified Sternheimer equation as shifted linear system, we could just apply shifted-BiCG solver which is one of shifted-Krylov solvers to it. Just application of the shifted-BiCG solver makes it to extensively reduce calculation cost. We generalize the shifted-BiCG solver to reduce calculation cost as well as memory usage, using a specific property from physical point of view. We will show results of cross section calculation of nitrogen molecule as a benchmark.

We have applied an eigenvalue filtering solver, Sakurai-Sugiura (SS) method, to Bogoliubov-de Gennes equation to solve interior and large eigenproblems. To obtain eigenpairs around lowest or highest eigenvalue with large symmetric sparse matrix, iterative solvers, like conjugate gradient method, work quite well. However, there is controversial choice to obtain interior eigenpairs, which is just our objective: the eigenvalues at the center of an energy distribution of the Bogoliubov-de Gennes Hamiltonian. The SS method gives us to a numerical procedure to construct a reduced eigenproblem from original large matrix in terms of eigenvalue what we are interested in. In addition, this method has quite good compatibility with parallel computational environment. We have shown good performance in the numerical calculation with parallel computational environment: almost linear scaling of calculation time up to 2^17 dimension matrix and 4096 CPUs.

We would like to present our results and also give seeds for further application using recent applied mathematical to achieve more efficient calculation.

標題：理論インフォーマルセミナー：Self-propelled motion of a fluid droplet under chemical reaction
日時：2014 年 7 月 2 日(水)　　午後 1 時 30 分～
場所：物性研究所本館 6 階 第 3 セミナー室（A613）
講師：藪中 俊介
所属：京都大学基礎物理学研究所
要旨：

By means of interface approach, we study self-propelled dynamics of a droplet due to a Marangoni effect and chemical reactions. The equation for the migration velocity of the center of mass of a droplet is derived in the limit of an infinitesimally thin interface. We found that there is a bifurcation from a motionless state to a propagating state of droplet by changing the strength of the Marangoni effect. I will also present results of direct numerical simulation of our theoretical model.

標題：理論インフォーマルセミナー：量子ドット系における非平衡量子断熱ポンプの量子マスター方程式による解析
日時：2014 年 7 月 9 日(水)　　午前 11 時～午後 0 時
場所：物性研究所本館 6 階 第 5 セミナー室（A615）
講師：吉井 涼輔
所属：大阪大学大学院理学研究科
要旨：

近年、非平衡断熱量子ポンプの量子マスター方程式を用いた解析が提案されている。量子マスター方程式において、Liouvillian のパラメータを変化させると、固有状態が Berry 位相に類似した位相を得る。この幾何学的位相は Berry-Sinitsyn-Nemenman(BSN) 位相と呼ばれ、BSN 位相がパラメータ空間において有限の曲率を持つ場合、サイクリックなパラメータ変調でポンプカレントが生じる場合がある。Ref. [1]において、二重量子ドット系での Spinless Fermion の断熱ポンプが調べられている。この場合、量子ドット間相互作用が有限の場合、熱浴の化学ポテンシャルと温度(外部パラメータ)だけを操作して、断熱ポンプが得られることが結論付けられている。ただし、彼らのモデルではスピン自由度、量子ドット内の電子間相互作用が無視されている。

我々は、左右のリードに二重量子ドットが結合した系において、外部パラメータの操作による断熱ポンプの可能性について調べた。具体的には、不純物アンダーソンモデルを用い、計数場を入れた量子マスター方程式を摂動の 2 次まで求め、BSN 曲率およびポンプカレントの解析的表式を求めた。結果として、量子ドットの有効的なエネルギー準位付近においてパラメータ変調を行った場合、ポンピングが生じ得ることを示した。

[1] T. Yuge, T. Sagawa, A. Sugita,and H. Hayakawa, Phys. Rev. B **86**, 235308 (2012).
[2] R. Yoshii and H. Hayakawa, arXiv: 1312.3772.

標題：理論セミナー：Interactions and charge fractionalization in an electronic Hong-Ou-Mandel interferometer
日時：2014 年 7 月 11 日(金)　　午後 4 時～午後 5 時
場所：物性研究所本館 6 階 第 5 セミナー室（A615）
講師：Thibaut Jonckheere
所属：Centre de Physique Théorique (Marseille, France) and ISSP
要旨：

Electron quantum optics aims at translating the concepts of quantum optics to electronic systems. Recent experimental advances make it possible to emit electrons one by one, and to control their propagation. I will present a study of the electronic analog of the Hong-Ou-Mandel (HOM) interferometer, where two single electrons travel along opposite chiral edge states and collide at a Quantum Point Contact. In addition to the difference of statistics (fermionic vs. bosonic), a crucial difference with the photonic system is the presence of Coulomb interaction for electrons. Because of interactions between co-propagating edge states, the degree of indistinguishability between the two electron wavepackets is dramatically reduced, leading to reduced contrast for the HOM signal.

This decoherence phenomenon strongly depends on the energy resolution of the packets. These calculations explain recent experimental results (E. Bocquillon, et al., Science 339, 1054 (2013)]) where an electronic HOM signal with reduced contrast was observed.

標題：理論インフォーマルセミナー：Quantum Metamaterials
日時：2014 年 7 月 18 日(金)　午後 1 時 30 分～午後 2 時 30 分
場所：物性研究所本館 6 階 第 5 セミナー室（A615）
講師：Dr. James Quach
所属：ISSP, the University of Tokyo
要旨：

Quantum metamaterials offer the possibility of harnessing novel quantum mechanical properties to build devices far beyond that which is possible by classical means. With recent advances in quantum technologies, we are on the cusp of realising such quantum metamaterials. In this seminar I will provide a general introduction to quantum metamaterials. As a frontier technology, there are numerous competing designs; I will concentrate on coupled-cavity based designs, known as cavity array metamaterials (CAMs).

CAMs are a class of quantum metamaterials that my colleagues and I proposed in 2011. The system is composed of either coupled cavities or coupled atomic cavities. Coupling atomic systems to optical cavities introduces non-linear dynamics and extra controllable parameters in the form of atom-cavity detuning. I will discuss how this parameter space can be used to control quantum metamaterial properties such as diffusion. Using this highly controllable parameter space, I will also show how CAMs can be used to construct such devices as reconfigurable quantum superlenses and cloaking instruments.

[1] J. Q. Quach, C. H. Su, A. M. Martin, A. D. Greentree, and L. C. L. Hollenberg, "Reconfigurable quantum metamaterials", Opt Express 19, 11018 (2011).

[2] J. Q. Quach, C. H. Su, and A. D. Greentree, "Transformation optics for cavity array metamaterials", Opt Express 21, 5575 (2013).

[3] J. Q. Quach, "Disorder-correlation-frequency-controlled diffusion in the Jaynes-Cummings-Hubbard model", Phys Rev A 88, 053843 (2013).

標題：シリーズセミナー　極限コヒーレント光科学 25 回目 「1.5 サイクル赤外パルスによる超高速限界電子駆動」
日時：2014 年 7 月 24 日(木)　　午後 1 時 30 分～
場所：東京大学 柏図書館メディアホール
講師：岩井伸一郎
所属：東北大学大学院理学研究科
要旨：

Optical responses of organic charge ordered (CO) and dimer Mott insulators has attracted much attention, because they exhibit ultrafast changes in the conducting and/or dielectric properties upon photo-excitations[1-8]. Recent progress of several fs optical and ps THz pulses enables us to detect and manipulate various new aspects of the strongly correlated system.

In this study, photoinduced metal to insulator (M-I) transition was demonstrated by strong electric filed (10 MV/cm) of 1.5-cycle, 7 fs near infrared pulse in a layered organic conductor - α (ET)2I3. A large reflectivity change of > 25% and a coherent charge oscillation in time axis reflecting the CO gap have shown that the generation of CO insulator state which survives ~50 fs in the metallic phase.

Such photoinduced metal to CO insulator change is attributable to the dynamical localization, i.e., reduction of the inter-molecular transfer integral realized by high frequency strong electric field[8-10].

References:

[1] Iwai, Yamamoto *et al.*, PRL98, 097402(2007)., PRB 77, 125131(2008).
[2] Yamamoto, Iwai *et al.*, JPSJ77, 074709(2008).
[3] Kawakami, Iwai *et al.*, PRL103, 066403 (2009).
[4] Kawakami, Iwai *et al.*, PRL105, 246402(2010).
[5] Nakaya, Iwai *et al.*, PRB81,15511(2010).
[6] K. Itoh, Iwai *et al.*, PRL110, 10640(2013).
[7] K. Itoh, Iwai *et al.*, PRB88, 125101(2013).
[8] H. Itoh, Iwai *et a*l., APL104, 173302(2014).
[9] N. Tsuji, T. Oka, P. Werner, and H. Aoki, Phys. Rev. Lett. 106, 236401(2011).
[10] D. H. Dunlap and V. M. Kenkre, Phys. Rev. B34, 3625(1986).
[11] K. Nishioka and K. Yonemitsu, J. Phys. Soc. Jpn. 83, 024706 (2014).

標題：第三回光量子融合連携研究開発プログラム研究会
日時：2014 年 7 月 29 日(火)　　午前 10 時～
場所：物性研究所本館 6 階 第 1 会議室（A636）
要旨： 10：00～　瀧川 仁所長挨拶
10：10～　辛 埴：概要説明
10：45～　休憩
11：00～　板谷 治郎：極短パルス高調波レーザー開発
11：30～　小林 洋平：超高分解能真空紫外レーザー開発
12：00～　昼休み
13：30～　岡崎 浩三：時間分解光電子分光
14：00～　原田 慈久：SPring-8 を用いた差動排気型軟 X 線発光分光システムの開発
14：30～　休憩

15：00～　木下 豊彦（JASRI）：SPring-8 を用いた時間分解顕微光電子分光

15：30～　室 隆桂之（JASRI）：SPring-8 を用いたマイクロ光電子分光

16：00～　小森 文夫副所長まとめ

詳細ページ： http://shin.issp.u-tokyo.ac.jp/hikariryoushi/index.html

標題：理論インフォーマルセミナー：Josephson Effects & Persisitent Spin Current in Magnon-BEC due to Berry Phase

日時：2014 年 9 月 2 日(火)　　午前 10 時 30 分～午前 11 時 30 分

場所：物性研究所本館 6 階 第 5 セミナー室（A615）

講師：仲田 光樹

所属：University of Basel

要旨：

Motivated by the experimental progresses achieved by Kajiwara et al. [1] and Demokritov et al. [2], we [3] present a microscopic theory of the Josephson effects in quasi-equilibrium Bose-Einstein condensates (BECs) of magnons in ferromagnetic insulators. Our theory provides a handle to electromagnetically control Josephson magnon-BEC currents through the Berry phase called Aharonov-Casher phase, and enables to experimentally generate and directly measure the persistent magnon-BEC currents. Due to the macroscopic coherence of magnon-BECs, the persistent magnon-BEC current becomes much larger, about by a factor of ten thousand, than the one which has been predicted in non-condensed magnonic systems.

We sincerely would like to discuss with experimentalists as well as theorists of ISSP and ask for your guidance.

[1] Y. Kajiwara et al., Nature 464, 262 (2010).

[2] S. O. Demokritov et al., Nature 443, 430 (2006).

[3] K. N., Kevin A. van Hoogdalem, Pascal Simon and Daniel Loss, arXiv:1406.7004

標題：新物質セミナー：Two distinct superconducting domes in n-doped $SrTiO_3$

日時：2014 年 9 月 5 日(金)　　午前 11 時～午後 1 時

場所：物性研究所本館 6 階 第 5 セミナー室（A615）

講師：Prof. Kamran Behnia

所属：LPEM CNRS-UPMC, Paris

要旨：

Discovered as early as 1964, the superconducting state of n-doped $SrTiO_3$ occupies a singular place in the history of superconductivity. Besides being the first oxide superconductor, it was one of the earliest "semiconducting superconductors", the first experimentally-detected multi-gap superconductor and the first case of a superconducting dome. Half a century after its discovery, it remains the most dilute superconductor [1]. Superconductivity emerges when the carrier concentration is 10-5 per atom and vanishes when It exceeds 2 10-2 per atom.

We present a systematic study of quantum oscillations and superconducting transition in doped $SrTiO_3$, over a wide range of carrier concentration from 1017 to 1020 cm-3 [2]. Mobile carriers were introduced either by removing oxygen or by substituting Ti by Nb. Superconductivity was found to persists down to an exceptionally low concentration of mobile electrons (n=3 1017 cm-3 and Tc=34 mK). At this concentration range, the Fermi temperature is below 10 K, restricting the relevant energy window and possible pairing scenarios. We identify two critical doping levels, which are the filling thresholds of the upper conduction bands. This clarifies the limits of single-band, two-band and three band superconducting regimes. We find that the exceptionally-wide superconducting dome of SrTiO3 has a structure. There are two distinct domes, each peaking near a critical doping level. Moreover, in the dilute limit, the two doping routes (oxygen deficiency and Nb substitution) are not identical. They generate metals identical in Fermi surface but different in superconducting critical temperature as well as in inelastic scattering [3].

[1] X. Lin *et al.*, Phys. Rev. X 3, 021002 (2013).
[2] X. Lin *et al.*, Phys. Rev. Lett. 112, 207002 (2014).
[3] X. Lin *et al.*, to be published.

標題：理論セミナー：Topological Current in Fractional Chern Insulators
日時：2014年9月5日(金)　　午後4時～
場所：物性研究所本館6階 第5セミナー室（A615）
講師：高麗 徹
所属：学習院大学　理学部
要旨：

We consider interacting fermions in a magnetic field on a two-dimensional lattice with the periodic boundary conditions.

In order to measure the Hall current, we apply an electric potential with a compact support.

Then, due to the Lorentz force, the Hall current appears along the equipotential line. Introducing a local current operator at the edge of the potential, we derive the Hall conductance as a linear response coefficient. For a wide class of the models, we prove that if there exists a spectral gap above the degenerate ground state, then the Hall conductance of the ground state is fractionally quantized without averaging over the fluxes. This is an extension of the topological argument for the integrally quantized Hall conductance in noninteracting fermion systems on lattices.

標題：新量子相 Lecture Series 第5回：「量子スピン液体：対称性、トポロジカル秩序、スピノンの量子電磁気学」
日時：2014年9月29日(月)　　午前10時～午後0時
場所：物性研究所本館6階 第5セミナー室（A615）
講師：小野田 繁樹
所属：理化学研究所
要旨：

対称性は状態を分類するために有用な基本概念のひとつである。しかし、量子ホール系のように、対称性が同じでも断熱的に接続しない量子状態が存在する。このような量子状態を分類して理解するためには、トポロジー、エンタングルメント、といった概念が必要となる。さらに非自明な場合には、基底状態からの励起が、電子やスピンから自発的に分化し、閉じ込めから解放された新しい準粒子によって記述されることがある。これらの新奇な量子状態の具体例は、スピン交換相互作用がフラストレートした磁性体の研究から、広範に見出されてきた。本講演では、対称性、トポロジー、エンタングルメントといった概念を非専門家向けに平易に解説しながら、次元、スピンから分化した準粒子スピノンの統計性を基本概念に加えて、量子スピン液体を系統的に分類し、磁性体における実験を例に量子スピン液体の探求の道について解説する。最後に、量子スピンアイス系を例に、スピノンが量子電磁気学の範囲で示す、金属、絶縁体、マイスナー状態について紹介する。