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 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 mathematic 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(木) 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。


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.

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 field (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:
標題: 理論インフォーマルセミナー: Josephson Effects & Persistent 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.

標題: 新物質セミナー: Two distinct superconducting domes in n-doped SrTiO₃
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 SrTiO₃ 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 SrTiO₃, 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].

[3] X. Lin et al., to be published.