低温物質科学研究センターセミナー報告

日時：2004 年 4 月 8 日（木）　午後 4 時～5 時 30 分
場所：理学研究科 5 号館　物理学教室 439 号室
講師：Dr. F. Caupin
所属：Laboratoire de Physique Statistique de l'Ecole Normale Superieure, Paris, France
題目：Search for homogeneous crystallization of superfluid helium 4
要旨：

When one tries to quench a bulk sample of superfluid helium above its freezing pressure Pf, he can only reach overpressures of a few millibars, because of heterogeneous nucleation on the container walls. Recently, we have successfully reached 4.3 bar above Pf by focusing an acoustic wave on a small spot (150 microns) on a clean glass plate, but heterogeneous nucleation prevented the observation of larger overpressures. After removing the glass plate, we were able to reach 160 bar without detecting any crystal, which is inconsistent with classical nucleation theory. We propose alternative theoretical pictures to explain this discrepancy.

日時：2004 年 4 月 28 日（水）　午後 4 時 30 分～6 時
場所：理学研究科 5 号館　物理学教室 439 号室
講師：Pr. Martti　M.　Salomaa
所属：Materials Physics Laboratory, POB 2200　（Technical Physics）
Helsinki University of Technology, FIN-02015 HUT, Finland
題目：Imaging the Quantum Interference of Cuprate Qnasiqarticles
要旨：

Quantum-circuit optimization is essential for any practical realization of quantum computation, in order to beat decoherence. We discuss a scheme for implementing the final stage in the compilation of quantum circuits, i.e., for finding the actual physical realizations of the individual modules in the quantum-gate library, without invoking elementary gates. We find that numerical optimization can be efficiently utilized to generate the appropriate control-parameter sequences. The scenario is readily extended to other physical realizations, such as holonomic quantum computing [1], but here we concentrate on the Josephson charge-qubit model and discuss how to produce the desired three-qubit modules [2]. Our work suggests ways in which one can in fact considerably reduce the number of gates required to implement a given quantum circuit [3], hence diminishing idle time and significantly accelerating the execution of quantum algorithms.

[1] A. O. Niskanen, M. Nakahara, and M. M. Salomaa,　"Realization of arbitrary gates in holonomic quantum computation", Physical Review A67, 012319 (2003).
[2] A.O.Niskanen, J.J.　Vartiainen, and M. M. Salomaa,} "Optimal multiqubit operations for Josephson charge

qubits", Physical Review Letters 90, 197901 (2003).
[3] J. J. Vartiainen, A. O. Niskanen, M. Nakahara, and M. M. Salomaa, "Implementing Shor's algorithm on Josephson charge qubits", Physical Review A (in print), LANL preprint: quant-ph/0308171v3 (2 March 2004);

日時：2004 年 6 月 3 日（木） 午後 4 時～5 時 30 分
場所：理学研究科 5 号館 物理学教室 439 号室
講師：福山 寛 氏
所属：東京大学 大学院理学系研究科
題目：グラファイトの磁場中電子物性とエッジ状態
要旨：

ゼロギャップ半導体として知られるグラファイトはフラレンやカーボンナノチューブの基礎となる物質である．しかし，低温強磁場下での金属－絶縁体転移や，人工グラファイト（HOPG）試料に対して最近報告された整数量子ホール効果に似た振る舞いなど，その磁場中電子物性には未解明な点も残っている．最近我々は，グラファイトのランダウ量子化を 50 mK， 6 T の超低温高磁場下で走査トンネル分光測定することに成功した．磁場中では状態密度に特徴的なピーク構造が現れ，単結晶試料と HOPG 試料ではピーク構造に明瞭な差異が見られる．第一原理計算との定量的な比較は，前者が無限厚みをもつバルク試料の，後者が実効的に 40 原子層程度の有限厚みをもつグラファイトの，それぞれ最表面の局所状態密度を観測したものであることを示している．また，グラファイト結晶構造に特有の磁場にほとんど依存しないランダウ準位も直接観測できた．この HOPG 試料のホール抵抗を測定（0.5 K、9 T）したところ，我々も整数量子ホール効果を示唆する複数のプラトー構造を観測した．こうした試料依存性は，系の 2 次元性の相違に起因すると考えられる．時間が許せば，2 次元グラファイトシートがもつ 2 種類のトポロジカルに異なる端（ジグザグ端とアームチェア端）のうち，ジグザグ端にのみ存在するパイ電子の局在状態（端状態）を観測した走査トンネル分光測定の結果についても紹介したい．

日時：2004 年 6 月 7 日（月） 午後 4 時～5 時 30 分
場所：理学研究科 5 号館 第 4 講義室
講師：田仲 幸雄 氏
所属：名古屋大学
題目：Recent theoretical development of unconventional superconductor junctions
要旨：

In unconventional superconductor junctions, reflecting the internal phase of the pair potential, charge transport becomes essentially phase sensitive. The most dramatic effect is the manifestation of the zero bias conductance peak (ZBCP) [1,2] in tunneling spectroscopy due to the formation of the mid gap Andreev resonant state (MARS). The ZBCP due to MARS is a very universal phenomenon which is expected for any unconventional superconductor which has sign change on the Fermi surface. Although it was revealed that the MARS influences significantly on various charge transport phenomena, preexisting theories are limited in the ballistic transport

regime. Recently, we have developed a new theory which is available for diffusive normal metal (DN) / unconventional superconductor junctions[3]. Applying this theory for triplet superconductor junctions, we have revealed very unusual charge transport properties[4]. Contrary to the unconventional singlet superconductor junction case, the MARS is shown to enhance the proximity effect in the DN. The total resistance of the junction is drastically reduced and is completely independent of the resistance of the DN in the extreme case. Such anomalous transport accompanies a giant zero-bias peak in the conductance spectra and a zero-energy peak of the local density of states in the DN region. These striking features manifest the presence of novel proximity effect peculiar to triplet superconductor junctions.

[1] Y. Tanaka and S. Kashiwaya, Phys. Rev. Lett. **74**, 3451 (1995).

[2] S. Kashiwaya and Y. Tanaka, Rep. Prog. Phys. **63**, 1641 (2000).

[3] Y. Tanaka *et al.*, Phys. Rev. Lett. **90**, 167003 (2003); Phys. Rev. B **69** (2004).

[4] Y. Tanaka and S. Kashiwaya, cond-mat 0308123; Phys. Rev. B 70 (2004).

Collaborators : S. Kashiwaya (NAIST) Y.V. Nazarov (Delft), A. Golubov (Twente).

日時：2004 年 7 月 16 日（金）　午後 3 時～4 時 30 分

場所：理学研究科 5 号館　物理学教室 439 号室

講師：Prof. Makariy TANATAR

所属：Visiting Professor, ISSP, Tokyo University, Post Doctoral Research Associate, University of Toronto, Canada

題目：Thermal and electrical conductivity of $CeCoIn_5$: quantum critical phenomena and unconventional superconductivity

要旨：

CeCoIn5 is the highest Tc heavy fermion superconductor, in which superconductivity is believed to be mediated by antiferromagnetic fluctuations in a proximity to a quantum critical point. In this talk I will report recent studies of quantum critical phenomena and superconductivity with measurements of electrical and heat transport as a function of direction of heat/charge flow, magnetic field and doping. The observed divergence of the T2 coefficient of the resistivity with magnetic field reveals a new quantum critical point (QCP) [1]. Comparison of heat and charge transport in the vicinity of the QCP allows us to shed light on the momentum dependence of the critical inelastic scattering at finite temperatures and reveal novel features of the superconducting state.

[1]　J. Paglione et al. Phys. Rev. Lett. 91, 246405 (2003).