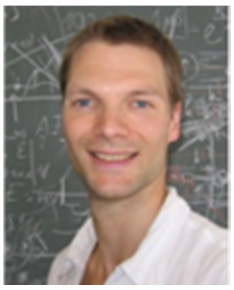
物性研究所談話会

標題：Breaking the Waves – Experiments and theories on fractional excitations from 1D to 2D

日時：2015 年 2 月 12 日(木)　午後 4 時～

場所：物性研究所本館 6 階 大講義室(A632)

講師：



Prof. Henrik M. Rønnow

所属：Laboratory for Quantum Magnetism (LQM), EPFL, Switzerland
Neutron Science Laboratory, ISSP, University of Tokyo, Japan
Centre for Emergent Matter Science, RIKEN, Japan
Niels Bohr Institute, University of Copenhagen, Denmark

要旨：

Quantum magnets have occupied the fertile ground between many-body theory and low-temperature experiments on real materials since the early days of quantum mechanics. However, our understanding of even deceptively simple systems of interacting spin-1/2 particles is far from complete. The quantum square-lattice Heisenberg antiferromagnet, for example, exhibits a striking anomaly of hitherto unknown origin in its magnetic excitation spectrum. This quantum effect manifests itself for excitations propagating with the specific wavevector (π,0). We use polarized neutron spectroscopy to fully characterize the magnetic fluctuations in the metal-organic compound $Cu(DCOO)_2 \cdot 4D_2O$, a known realization of the quantum square-lattice Heisenberg antiferromagnet model. Our experiments reveal an isotropic excitation continuum at the anomaly, which we analyse theoretically using Gutzwiller-projected trial wavefunctions. The excitation continuum is accounted for by the existence of spatially extended pairs of fractional S = 1/2 quasiparticles, 2D analogues of 1D spinons. Away from the anomalous wavevector, these fractional excitations are bound and form conventional magnons. Our results establish the existence of fractional quasiparticles in the high-energy spectrum of a quasi-two-dimensional antiferromagnet, even in the absence of frustration.

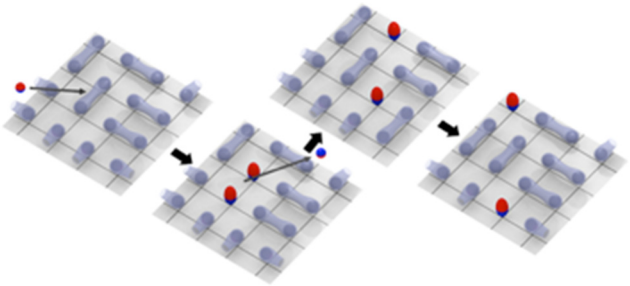


Illustration of fractionalization in the square lattice antiferromagnet: The electron's magnetic moments pair up into a non-magnetic quantum entangled state called a singlet (connected pairs of blue spheres) forming a singlet sea. An incoming particle (red and blue sphere), for instance a neutron, polarize a singlet into two fractional particles called spinons (elongated red and blue spheres). Once created, the two spinons can float free of each other onto the singlet sea.

[1] M. Mourigal *et al.*, Nature physics 9, 435 (2013) ; J. Schlappa et al., Nature 485, 82 (2012)
[2] B. Dalla Piazza *et al.*, Phys. Rev. B 85, 100508 (2012) ; M. Guarise et al., Phys. Rev. Lett. 105, 157006 (2010)
[3] N. B. Christensen *et al.*, PNAS 104, 15264 (2007); B. Dalla Piazza et al., Nature Physics 11, 62 (2014)

【講師紹介】Ronnow 先生は、スイス EPFL で研究室を主宰されており、また Paul Sherrer 研究所の中性子三軸分光器の装置責任者としても活躍されています。中性子散乱を用いた量子スピン系やフラストレーション系の研究で大きな業績をあげられています。2014 年 12 月 1 日から 2015 年 3 月 31 日まで海外客員所員として物性研に滞在される予定です。

標題：平成 26 年度物性研究所退職記念講演会
日時：2015 年 3 月 6 日(金)　午後 1 時～午後 6 時
場所：物性研究所本館 6 階 大講義室（A632）
要旨：13:00–13:10　所長挨拶

13:10	高橋敏男先生業績紹介
13:20–14:40	高橋敏男先生ご講演 講演題目「回折と表面　－放射光の歩みとともに－」
14:50	甲元眞人先生業績紹介
15:00–16:20	甲元眞人先生ご講演 講演題目「Fibonacci Quasicrystal, Hofstadter, and Quantum Hall Effect」
16:30	上田和夫先生業績紹介
16:40–18:00	上田和夫先生ご講演 講演題目「強相関電子系の磁性と超伝導」

○記念パーティを午後 6 時半より、東京大学柏キャンパス内「プラザ憩い」にて開催

標題：Bismuth and its three Dirac valleys
日時：2015 年 3 月 19 日(木)　午前 11 時～午後 0 時
場所：物性研究所本館 6 階 大講義室(A632)
講師：

Prof. Kamran Behnia

所属：Ecole Supérieure de Physique et de Chimie Industrielles, Paris, France
要旨：

Among all elements of the periodical table, elemental bismuth has the largest magnetoresistance, the highest thermoelectric figure of merit and the largest [average] diamagnetism. This intriguing solid has played an exceptional role in the history of condensed-matter physics. Numerous effects, ranging from thermoelectricity (Seebeck and Nernst effects) to quantum oscillations (Shubnikov-de Haas and de Haas-van Alphen), were first discovered in bismuth. The

ultimate reason behind this is the presence of very light and extremely mobile electrons residing in three distinct anisotropic Dirac valleys.

I will review a number of recent experimental studies, which have that both Landau spectrum[1] and orbital magnetoresistance become exceptionally complex in bismuth. While most features can be explained in the band picture of non-interacting electrons, a number of unanswered questions remain. In particular, angle-dependent magnetoresistance loses the symmetry of the underlying lattice at low temperature[2]. Recent thermodynamic measurements document a valley-dependent density of states in presence of a quantizing magnetic field[3] and very recent experiments point to a phase transition to an ordered state in which the valley-degeneracy is spontaneously lost[4]. The microscopic origin of this "valley-nematic" phase transition is yet to be understood.

[1] Z. Zhu *et al*., PNAS 109, 14813 (2012).
[2] Z. Zhu *et al*., Nature Physics 8, 89 (2012).
[3] R. Küchler *et al*., Nature Materials 13, 461 (2014).
[4] A. Collaudin, B. Fauqué, Yuki Fuseya, W. Kang and K. Behnia, ArXiv:1501.01584

標題：平成 27 年度 前期客員所員講演会
日時：2015 年 4 月 16 日(木) 午前 11 時～午後 0 時 25 分
場所：物性研究所本館 6 階 大講義室（A632）
要旨：

平成 27 年度前期客員所員講演会を開催しますので、奮ってご参加ください。
新任の客員の先生方におきましては、所内はもちろん所外を含め広くかつ活発な共同研究を展開されることを期待し、自己紹介及び物性研究所での研究目標等をご説明いただきます。

11:00-11:10　所長挨拶（瀧川　仁：物性研所長）

11:10-11:35　金崎 順一 氏（大阪大学産業科学研究所）
「時間・角度分解光電子分光法による半導体表面における超高速電子動力学の研究」

11:35-12:00　田中 良和 氏（理化学研究所）
「共鳴 X 線回折による四極子秩序観察」

12:00-12:25　Prof. Andriy Nevidomskyy (Rice University)
「Topological Surface States in the Heavy Fermion Superconductor UPt_3」