TT 72: Correlated Magnetism – Spin Liquids I

Time: Thursday 9:30–12:00 Location: HSZ/0105

TT 72.1 Thu 9:30 HSZ/0105

Anisotropic Spin Ice on a Breathing Pyrochlore Lattice — •Gloria Isbrandt[1,2], Frank Pollmann[1,2], and Michael Knap[1,2] — [1]Technical University of Munich, TUM School of Natural Sciences, Physics Department, 85748 Garching, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany

Spin ice systems represent a prime example of constrained spin systems and exhibit rich low-energy physics. We investigate how a tunable anisotropic spin coupling modifies the classical Ising spin-ice Hamiltonian on the breathing pyrochlore lattice. Introducing sublattice-dependent anisotropy reshapes the ground-state manifold, reduces the residual entropy, and induces qualitative changes in the spin-structure factor. We theoretically uncover a rich phase diagram by varying the anisotropy and demonstrate how this modification reduces the ground state degeneracy across different phases. Using Monte Carlo simulations, we find that at low temperatures the system either crosses over into a constrained spin-ice manifold, whose entropy density falls below the Pauling value, or undergoes a transition into an ordered, symmetry-broken state. We further compute spin-structure factors for the anisotropic model and show that they are well captured by a self-consistent Gaussian approximation. Our results develop the understanding of spin ice in anisotropic limits, which may be experimentally realized by strain, providing, among others, key signatures in entropy and specific heat.

TT 72.2 Thu 9:45 HSZ/0105

The monopole plasma resonance: an opto-electronic smoking gun of 3D U(1) spin liquids — •Anish Koley, Saranyo Moitra, and Inti Sodemann Villadiego — Institut für Theoretische Physik, Universität Leipzig,04103 Leipzig, Germany

Certain 3D U(1) spin liquids, such as those arising in quantum spin ice models, have a low-energy "monopole-like" emergent particle which acts as the source of an emergent magnetic field that has the same transformations under symmetries as an electric polarization. As a consequence, these monopoles carry a polarization physical electric charge. Curiously, at finite temperatures these monopoles form a finite density plasma, but due to their coupling to emergent gauge fields, the full physical system behaves as an electrical insulator from the point of view of DC transport. Remarkably, however, we have found that when the system is probed at finite frequencies, the monopoles can display a sharp and low frequency plasma resonance analogous to a metal. This offers a new blueprint to experimentally detect these elusive but fascinating states in real materials.

TT 72.3 Thu 10:00 HSZ/0105

Spin-liquid-like ground states in the double hydroxyperovskites $CuSn(OD)_6$ and $MnSn(OD)_6$ evidenced by μSR spectroscopy — •moumita naskar[1], anton a. kulbakov[1], kaushick k. parui[1], jonas a. krieger[2], ellen häussler[3], thomas doert[3], darren c. peets[1], hans henning klauss[1], dmytro s. inosov[1,4], and rajib sarkar[1] — [1]Institut für Festkörper und Materialphysik, Technische Universität Dresden, 01062 Dresden, Germany — [2]Laboratory for Muon Spin Spectroscopy, Paul Scherrer Institut, CH-5232 Villigen PSI, Switzerland — [3]Fakultät für Chemie und Lebensmittelchemie, Technische Universität Dresden, 01062 Dresden, Germany — [4]Würzburg-Dresden Cluster of Excellence on Complexity and Topology in Quantum Matter - ct.qmat, Technische Universität Dresden, 01062 Dresden, Germany

Muon spin rotation measurements were carried out on the hydroxy perovskites $CuSn(OD)_6$ and $MnSn(OD)_6$ over the temperature range 0.053-50 K. The absence of long range magnetic order is confirmed down to 0.053 K. The temperature dependence of the muon relaxation rates show an increase with decreasing temperature, indicating that spin fluctuations remain present down to 0.053 K in both the compounds. Spin correlations results from both samples indicate homogeneous spin dynamics. These observations suggest that both compounds possess a fluctuating ground state consistent with a spin-liquid phase.

TT 72.4 Thu 10:15 HSZ/0105

Emergent magnetic order and spin dynamics in a Yb-based triangular lattice delafossite — •Arjun Unnikrishnan[1,2,3], Bishnu Prasad Belbase[1], Piyush Chhallare[1], Mohan Bikram Neupane[1], Eun Sang Choi[4], Philipp Gegenwart[2], and Arnab Banerjee[1] — [1]Department of Physics and Astronomy, Purdue University, West Lafayette, Indiana 47906, USA — [2]Experimental Physics VI, Center for Electronic Correlations and Magnetism, Institute of Physics, University of Augsburg, Augsburg 86159, Germany — [3]Solid State and Structural Chemistry Unit (SSCU), Indian Institute of Science, Bengaluru - 560012, India — [4]National High Magnetic Field Laboratory, Tallahassee, Florida - 32310, USA

We have synthesized a new member of the $AYbX_2$ (A = monovalent cation; X = O, S, Se, Te) delafossite family and investigated its magnetic properties using magnetization and heat-capacity measurements. At zero magnetic field, the system shows no evidence of long-range magnetic order down to 20 mK. When a magnetic field is applied along the ab-plane, multiple field-induced magnetic phases emerge above $\sim$ 2.5 T, followed by full spin polarization near 17 T. The material exhibits stronger exchange interactions compared to other known Yb-based delafossites. We will discuss the magnetic phase transitions and the evolution of the spin dynamics under applied fields. The heat-capacity results suggest the presence of a possible quantum spin liquid (QSL) phase at low temperatures and low magnetic fields, highlighting this system as a promising platform for exploring QSL physics.

TT 72.5 Thu 10:30 HSZ/0105

Microscopic modelling of the honeycomb system $Na_3Ni_2BiO_6$ and its field-induced phases — •Amanda Anna Konieczna, Panagiotis Stavropoulos, and Roser Valentí — Goethe Universität, Frankfurt am Main, Germany

Frustration in magnetic systems has for decades provided a central testbed for the investigation of unconventional properties. Among others, frustrated systems may show magnetic-field-induced phases with characteristic magnetization plateaus, as is the case in triangular lattice and Kagome lattice spin-1/2 systems, where magnetic frustration arises due to the geometry of the lattice. Although the honeycomb lattice geometry is not geometrically frustrated, frustration may still appear due to bond-dependent magnetic exchanges, as proven by the Kitaev honeycomb model with its quantum spin liquid ground state.

Experimental evidence for a one-third magnetization plateau at intermediate magnetic fields has been reported for the spin-1 honeycomb compound $Na_3Ni_2BiO_6$. The aim of this talk is to present our approach based on an ab initio scheme in order to understand the origin of the plateau phase. The approach involves the modeling of an ab-initio-derived multiorbital relativistic Hubbard Hamiltonian and utilize projective diagonalization techniques to construct an effective spin model. The data extracted from the model is compared to and discussed in the context of experimental findings.

TT 72.6 Thu 10:45 HSZ/0105

Evolution of $Na_3Co_2SbO_6$ under pressure — •Thore Martens[1], Prashanta Mukharjee[2], Philipp Gegenwart[2], and Alexander A. Tsirlin[1] — [1]Leipzig University — [2]University of Augsburg

$Na_3Co_2SbO_6$ is a potential candidate for the Kitaev spin liquid where the high-spin S=3/2-state is turned into the J_{eff}=1/2-state under spin-orbit coupling. Recently, the impact of the trigonal field in $Na_3Co_2SbO_6$ on the formation of the spin liquid phase has been discussed and theorized that finetuning of the trigonal field by applying pressure may lead to the desired Kitaev state. Therefore, neutron diffraction experiments are performed to obtain the lattice parameters and probe the evolution of the magnetically ordered state of $Na_3Co_2SbO_6$ under pressure. Using density functional theory, new relaxed unit cells are calculated as well as the subsequent exchange couplings and trigonal field as a function of pressure.

15 min. break

TT 72.7 Thu 11:15 HSZ/0105

Low temperature thermodynamic studies on the Kitaev candidates $Na_2Co_2TeO_6$ and $Na_3Co_2SbO_6$ — •Sebastian Erdmann[1], Prashanta Mukharjee[1], Chanhyeon Lee[2], Kwang-Yong Choi[3], and Philipp Gegenwart[1] — [1]Experimental Physics

VI, University of Augsburg, Germany — [2]Department of Physics, Chung-Ang University, Republic of Korea — [3]Department of Physics, Sungkyunkwan University, Republic of Korea

Cobalt-based honeycomb magnets have recently attracted considerable attention as a new class of materials that may host bond-directional Kitaev interactions [1]. Among these, $Na_2Co_2TeO_6$ and $Na_3Co_2SbO_6$ undergo antiferromagnetic ordering below 27 K and 5 K, respectively [2, 3]. We employed heat-capacity and magnetic Grüneisen parameter measurements to study the nature of the various low-temperature field-induced phase transitions, building on our previous work with the sister compound $BaCo_2(AsO_4)_2$ [4]. The phase diagrams are extended to below 2 K and the entropy $S(T, B)$ of the different field-induced phases is determined. Our results provide new insights on proposed field-induced spin liquid states and reveal commonalities and distinctions of different prototype Kitaev candidate materials.

[1] H. Liu, G. Khaliullin, Phys. Rev. B 97, 014407 (2018).
[2] E. Lefrançois et al., Phys. Rev. B 94, 214416 (2016).
[3] J.-Q. Yan et al., Phys. Rev. Materials 3, 074405 (2019)
[4] Prashanta K. Mukharjee et al., Phys. Rev. B 110, L140407 (2024).

TT 72.8 Thu 11:30 HSZ/0105

High pressure phase transition of quantum spin liquid candidate $Na_2Co_2TeO_6$ observed using Raman spectroscopy — •Ihsan Ahmed Kolasseri[1], Subhadip Das[1,2], and Yong P. Chen[1] — [1]Aarhus University, Aarhus, Denmark — [2]University of Copenhagen, Copenhagen, Denmark

Quantum spin liquids (QSL) are materials that have possible data storage applications in quantum computing. Conflicting neighbor electron spin interactions of antiferromagnetically coupled magnetic atoms on triangle-based geometries can lead to QSL phase. Two structural phases of NCTO have been reported: the hexagonal $P6_322$ phase and the monoclinic C2/m phase. The hexagonal phase of NCTO has an antiferromagnetic ordering at 27 K. An in-plane magnetic field of 7T can suppress the QSL state because of the material's structure. Understanding and discovering different structural phases of these classes of materials is crucial to learn about QSL states. In this study we applied pressures upto 20 GPa on hexagonal NCTO single crystal and observed significant changes in the Raman peak profile. We have classified the pressure evolution into four pressure regions were the Raman peak profiles change drastically. High pressure single crystal X-ray diffraction and high pressure polarization dependent Raman study could be conducted to confirm this conclusion. Those data are currently under analysis, but will be briefly mentioned.

TT 72.9 Thu 11:45 HSZ/0105

Pressure dependent ab-initio studies of the Kitaev candidate $Ag_3LiRh_2O_6$ — •Bolivar Efrain Insuasti Pazmino[1], Ramesh Dhakal[2], Shi Feng[3], Steve M. Winter[2], Johannes Knolle[3], and Alexander A. Tsirlin[1] — [1]Leipzig University, Germany. — [2]Wake Forest University, USA — [3]Technical Universty of Munich, Germany

$Ag_3LiRh_2O_6$ is created by substituting Li with larger Ag atoms in Li_2RhO_3 [1]. This "negative pressure" expands the lattice and distorts the RhO_6 octahedra, altering the Rh-O-Rh angle that governs proximity to the quantum spin liquid state. Under hydrostatic pressure, the compound shows a sharp reduction in Néel temperature up to 4 GPa, with a transition to a non-magnetic state only at 6.6 GPa [2].

We perform ab initio calculations on the ideal crystal. Geometry optimization and Wannier functions are obtained using DFT. Magnetic couplings are derived from second-order perturbation theory and exact cluster diagonalization. Both methods agree well on the general trends of the couplings, but also reveal differences. While a large negative off-diagonal Γ' along with the sizable trigonal crystal field may indicate deviations from the $j_{\mathrm{eff}}=1/2$ state, the strong Kitaev coupling suggests the material remains close to that limit. The talk will address these questions by discussing the material's microscopic behavior. This work was supported by DFG via TRR360 (492547816).

[1] F. Bahrami et al., Sci. Adv. 8, eabl5671 (2022)
[2] P. Sakrikar, B. Shen, E. Poldi et al., Nat Com. 16:4712 (2025)