TT 5: Frustrated Magnets – Spin Liquids

Time: Monday 15:00–17:00 Location: H10

Invited Talk TT 5.1 Mon 15:00 H10

Dynamics of visons and thermal Hall effect in perturbed Kitaev models — •Aprem Joy and Achim Rosch — Institute for Theoretical Physics, University of Cologne, Cologne, Germany

A vison is an excitation of the Kitaev spin liquid which carries a $\mathbb{Z}_2$ gauge flux. While immobile in the pure Kitaev model, it becomes a dynamical degree of freedom in the presence of perturbations. We study an isolated vison in the isotropic Kitaev model perturbed by a small external magnetic field h, an offdiagonal exchange interactions Γ and a Heisenberg coupling J. In the ferromagnetic Kitaev model, the dressed vison obtains a dispersion linear in Γ and h and a fully universal low-T mobility, $\mu = 6v_m^2/T^2$, where v_m is the velocity of Majorana fermions. In contrast, in the antiferromagnetic Kitaev model interference effects preclude coherent propagation and an incoherent Majorana-assisted hopping leads to a T-independent mobility. The motion of a single vison due to Heisenberg interactions is strongly suppressed for both signs of the Kitaev coupling. Vison bands induced by h in the AFM Kitaev model are topological and contribute to the thermal Hall effect.

TT 5.2 Mon 15:30 H10

Microscopic modeling of the Kitaev spin liquid candidates $Li_3Co_2SbO_6$ and $Na_3Co_2SbO_6$ under uniaxial strain — •Willi Roscher, Huimei Liu, Jeroen van den Brink, and Oleg Janson — Leibniz Institute for Solid State and Materials Research IFW Dresden, 01069 Dresden, Germany

We have studied the magnetic properties of two Kitaev spin liquid candidates $Li_3Co_2SbO_6$ [1] and $Na_3Co_2SbO_6$ [2] under strain effect by using a microscopic density functional theory (DFT)-based analysis. Previous theoretical work [3] suggested that honeycomb cobaltates are promising candidates to realize the Kitaev spin liquid phase and can be driven there by lattice engineering. Following this conjecture, we simulate the effect of uniaxial strain along the c-axis. Low-energy tight-binding Hamiltonians were first obtained using DFT calculations and Wannier projections. Using the DFT-estimated parameters, we calculate the exchange parameters of the extended Kitaev-Heisenberg model. In this way, we get insights into the magnetic behavior of these materials under uniaxial strain. A small reduction of the trigonal splitting is found for tensile strain. Even though the strain is insufficient to drive the compounds into the spin liquid phase, the non-Kitaev terms are greatly suppressed in the investigated strain range. Our quantitative calculations shed light for the materialization of the Kitaev model.

[1] M. Stratan *et al.*, New J. Chem. **43**, 13545 (2019)
[2] L. Viciu *et al.*, J. Solid State Chem. **180**, 1060 (2007)
[3] H. Liu *et al.*, Phys. Rev. Lett. **125**, 047201 (2020)

TT 5.3 Mon 15:45 H10

Thermal conductivity of a new quantum Kagome antiferromagnet $YCu_3(OH)_{6.5}Br_{2.5}$ — •Xiaochen Hong[1,2], Mahdi Behnami[2], Long Yuan[3], Boqiang Li[3], Wolfram Brenig[4], Bernd Büchner[2], Yuesheng Li[3], and Christian Hess[1,2] — [1]Bergische Universität Wuppertal — [2]IFW-Dresden — [3]Huazhong University of Sci. and Tech., Wuhan, China — [4]TU Braunschweig

Herbertsmithite $ZnCu_3(OH)_6Cl_2$ has long been studied as the archetypal quantum Kagome antiferromagnet whose ground state is anticipated to be a spin liquid. However, there is no consensus on the ground state properties of Herbertsmithite, in particular whether a spin gap exist or not, due to its Cu/Zn site mixing effect that distorts the Kagome plane.

Here we report low temperature thermal conductivity measurements of a newly synthesized quantum Kagome antiferromagnet $YCu_3(OH)_{6.5}Br_{2.5}$. We observe a downwards deviation of its thermal conductivity κ from a standard phononical power-law temperature dependence beyond a characteristic temperature T^* and a systematic enhancement of this deviation upon application of a magnetic field. Furthermore, up to 16 T no residual κ/T occurs. Our findings imply that the thermal conductivity is dominated by phonons in the mK range, excluding itinerant gapless excitations contributing to it. We interpret the suppression of κ in magnetic field as a consequence of enhanced scattering of the phonons off magnetic fluctuations beyond T^*. Our analysis favors a small gap in the magnetic excitations, which is be suppressed by the magnetic field.

TT 5.4 Mon 16:00 H10

Spinless fermions in a $\mathbb{Z}_2$ gauge theory on a triangular ladder — •Wolfram Brenig — Institute for Theoretical Physics, Technical University Braunschweig, D-38106 Braunschweig, Germany

A study of spinless matter fermions coupled to a constrained $\mathbb{Z}_2$ lattice gauge theory on a triangular ladder is presented. The triangular unit cell and the ladder geometry lead to a physics different from that on the square lattice. In the static case, even and odd gauge theories are identical. The gauge field dynamics is strongly influenced by the absence of periodic boundary conditions, rendering the deconfinement-confinement process a crossover in general and a quantum phase transition only for decorated electric coupling. At finite doping and in the static case, distinct flux phases can be identified versus magnetic energy. As for the square lattice, a single transition into a confined fermionic phase is found versus electric coupling, however dimer resonances in the confined phase are second order processes only. Global scans of the quantum phases in the intermediate coupling regime are provided.

TT 5.5 Mon 16:15 H10

Nesting instability of gapless U(1) spin liquids with spinon Fermi pockets in two dimensions — •Wilhelm Krüger and Lukas Janssen — Institut für Theoretische Physik and Würzburg-Dresden Cluster of Excellence ct.qmat, Technische Universität Dresden, 01062 Dresden, Germany

Quantum spin liquids are exotic states of matter that may be realized in frustrated quantum magnets and feature fractionalized excitations and emergent gauge fields. Here, we consider a gapless U(1) spin liquid with spinon Fermi pockets in two spatial dimensions. Such a state appears to be the most promising candidate to describe the exotic field-induced behavior observed in numerical simulations of the antiferromagnetic Kitaev honeycomb model. We consider the regime close to a Lifshitz transition, at which the spinon Fermi pockets shrink to small circles around high-symmetry points in the Brillouin zone. By employing renormalization group and mean-field arguments, we demonstrate that interactions lead to a gap opening in the spinon spectrum at low temperatures, which can be understood as a nesting instability of the spinon Fermi surface. This leads to proliferation of monopole operators of the emergent U(1) gauge field and confinement of spinons. While signatures of fractionalization may be observable at finite temperatures, the gapless U(1) spin liquid state with nested spinon Fermi pockets is ultimately unstable at low temperatures towards a conventional long-range-ordered ground state, such as a valence bond solid.

TT 5.6 Mon 16:30 H10

Frustrated magnetism in pyrochlore rare earth materials: a pseudofermion-FRG study — •Bernhard Wortmann — Univeristät zu Köln — Köln — Deutschland

The family of rare earth pyrochlore materials is intensely scrutinized in the search for quantum spin-ice and quantum spin liquid phases. On the theoretical side, an initial focus has been to explore frustration phenomena in Heisenberg models in order to model the low temperature physics of these materials. It has, however, become increasingly clear that one has to also consider the sometime dominating effect of anisotropic exchange interactions, such as bond-directional Kitaev or Gamma couplings. In this talk, I will discuss the phase diagram of the Heisenberg-Kitaev-Gamma model on the pyrochlore lattice, calculated for S=1/2 quantum spins using the pseudofermion functional renormalization group. The rich phase diagram obtained when considering the competition of antiferromagnetic and ferromagnetic exchanges allows us to identify coupling regimes where we find agreement with recent neutron scattering experiments.

TT 5.7 Mon 16:45 H10

Competition between X-Cube and Toric Code in three dimensions — •Matthias Mühlhauser[1], Kai Phillip Schmidt[1], Julien Vidal[2], and Matthias Reimund Walther[1] — [1]Institute for Theoretical Physics I, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany — [2]Sorbonne Université, CNRS, Laboratoire de Physique Théorique de la Matière Condensée, LPTMC, F-75005 Paris, France

We investigate the competition of the X-Cube model with the 3D Toric

Code using high-order series expansions. We determine the complete phase diagram, which interestingly consists of four regions, i.e. apart from the topologically ordered Toric-Code phase and the X-Cube fracton phase we find two regions which are adiabatically connected to classical spin-liquid phases.

[1] M. Mühlhauser, K. P. Schmidt, J. Vidal, M. R. Walther. SciPost Phys. 12, 069 (2022)