MA 16: Frustrated Magnets

Time: Tuesday 15:00–17:45 Location: H37

MA 16.1 Tue 15:00 H37

Another Exact Ground State of a 2D Quantum Antiferromagnet — •Pratyay Ghosh, Tobias Müller, and Ronny Thomale — Institut für Theoretische Physik und Astrophysik and Würzburg-Dresden Cluster of Excellence ct.qmat, Universität Würzburg, Am Hubland Campus Süd, Würzburg 97074, Germany

We present the exact dimer ground state of a quantum antiferromagnet on the maple-leaf lattice. A coupling anisotropy for one of the three inequivalent nearest-neighbor bonds is sufficient to stabilize the dimer state. Together with the Shastry-Sutherland Hamiltonian, we show that this is the only other model with an exact dimer ground state for all two-dimensional lattices with uniform tilings.

MA 16.2 Tue 15:15 H37

Pseudo-Majorana approach to Spin-Systems: Advanced Diagrammatics and Applications — •Björn Sbierski — LMU München, Germany

Frustrated three-dimensional quantum magnets bear a rich phenomenology but are notoriously hard to treat theoretically. We show how a SO(3) Majorana representation of spin operators, in combination with advanced diagrammatic techniques like the functional renormalization group or the parquet approximation allows for quantitative simulations at finite temperatures. We apply our method on various frustrated Heisenberg magnets. On the cubic lattice, we study magnetic phase transitions via finite-size scaling and we also present results for the Pyrochlore lattice. We also show how the method can be applied to meet some challenges of long-range interacting spin Hamiltonians arising in the context of Rydberg atom array quantum simulators.

Based on: [1] PRB 103.104431 (2021) [2] SciPost Phys. 12, 156 (2022)

MA 16.3 Tue 15:30 H37

Dynamical Spin Structure Factor of the spin-$\frac{1}{2}$ $J_1 - J_2$ Heisenberg Model on the Triangular Lattice — •Markus Drescher[1], Laurens Vanderstraeten[2], Roderich Moessner[3], and Frank Pollmann[1,4] — [1]TU München, 85748 Garching, Germany — [2]University of Ghent, 9000 Gent, Belgium — [3]Max-Planck-Institut für Physik komplexer Systeme, 01187 Dresden, Germany — [4]Munich Center for Quantum Science and Technology, 80799 Munich, Germany

The spin-$\frac{1}{2}$ Heisenberg model with antiferromagnetic nearest and next-to-nearest neighbour interactions on a triangular lattice exhibits—driven by the highly frustrated spins—a rich phase diagram and is relevant for various two-dimensional quantum materials. Using large-scale density matrix renormalization group simulations and time evolution algorithms for matrix product states, we obtain the dynamical spin structure factor of the triangular $J_1 - J_2$ Heisenberg model depicting the low-energy excitations both in the 120°-ordered phase at $J_2 = 0$ and the spin liquid phase at $J_2/J_1 = 0.125$. This method allows us to compare the low-energy properties of the isotropic Heisenberg model with previous analytical and numerical approaches.

In the ordered phase, we observe avoided decay of the lowest magnon branch. Our findings in the spin-liquid phase support the field-theoretical predictions by Song *et al.* [1,2], in particular the emergence of low-lying monopole excitations at the corners of the Brillouin zone.

[1] X.-Y. Song *et al.*, Nat. Comm. **10**, 4254 (2019).
[2] X.-Y. Song *et al.*, Phys. Rev. X **10**, 011033 (2020).

MA 16.4 Tue 15:45 H37

An Exact Chiral Amorphous Spin Liquid — •Peru d'Ornellas[1], Tom Hodson[1], Gino Cassella[1], Johannes Knolle[1,2,3], and Willian Natori[4] — [1]Blackett Laboratory, Imperial College London, London SW7 2AZ, United Kingdom — [2]Department of Physics TQM, Technische Universität München, James-Franck-Straße 1, D-85748 Garching, Germany — [3]Munich Center for Quantum Science and Technology (MCQST), 80799 Munich, Germany — [4]Institut Laue-Langevin, BP 156, 41 Avenue des Martyrs, 38042 Grenoble Cedex 9, France

The conventional wisdom has been that amorphous lattice structure would provide an obstacle to the formation of a long-range entangled ground states because of the inherent geometric disorder. Recently, symmetry protected topological phases have been proposed in non-interacting amorphous systems, raising the question of whether it is possible to construct a topologically ordered quantum many-body phase on an amorphous lattice. Here we provide such an example. We extend the Kitaev honeycomb Hamiltonian to amorphous lattices, constructed using the Voronoi method on a set of random points. The resulting model retains its exact solubility, displaying Abelian as well as a non-Abelian quantum spin liquid phases. However, the presence of plaquettes with an odd number of sides leads to a spontaneous breaking of time reversal symmetry, opening a gap in the non-Abelian phase. Furthermore, we show that the system undergoes a finite-temperature phase transition to a conducting thermal metal state. Possible experimental realisations in metal-organic frameworks are discussed.

MA 16.5 Tue 16:00 H37

Hole Spectral Function of a Chiral Spin Liquid in the Triangular Lattice Hubbard Model — •Wilhelm Kadow[1,2], Laurens Vanderstraeten[3], and Michael Knap[1,2] — [1]Department of Physics, Technical University of Munich, 85748 Garching, Germany — [2]Munich Center for Quantum Science and Technology (MCQST), Schellingstr. 4, 80799 München, Germany — [3]Department of Physics and Astronomy, Ghent University, B-9000 Ghent, Belgium

Quantum spin liquids are fascinating phases of matter, hosting fractionalized spin excitations and unconventional long-range quantum entanglement. These exotic properties, however, also render their experimental characterization challenging and finding ways to diagnose quantum spin liquids is therefore a pertinent challenge. Here, we numerically compute the spectral function of a single hole doped into the half- filled Hubbard model on the triangular lattice using techniques based on matrix product states. At half filling the system has been proposed to realize a chiral spin liquid at intermediate interaction strength, surrounded by a magnetically ordered phase at strong interactions and a superconducting/metallic phase at weak interactions. We find that the spectra of these phases exhibit distinct signatures. By developing appropriate parton mean-field descriptions, we gain insight into the relevant low energy features. Our results suggest that the hole spectral function, as measured by Angle-Resolved Photoemission Spectroscopy (ARPES), provides a useful tool to characterize quantum spin liquids.

MA 16.6 Tue 16:15 H37

The nature of visons in the perturbed ferromagnetic and anti-ferromagnetic Kitaev honeycomb models — Chuan Chen[1] and •Inti Sodemann Villadiego[2,3] — [1]Institute for Advanced Study, Tsinghua University, 100084 Beijing, China — [2]Institut für Theoretische Physik, Universität Leipzig, 04103 Leipzig, Germany — [3]Max-Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany

The Kitaev honeycomb model hosts a fascinating fractionalized state of matter that features emergent Majorana fermions and a vison particle that carries the flux of an emergent gauge field. In the exactly solvable limit, these visons are static, but perturbations can induce their motion.

We show that the nature of the vison motion is sharply distinct in the ferromagnetic vs the anti-ferromagnetic Kitaev models. Namely, in the ferromagnetic model the vison has a trivial non-projective translational symmetry, whereas in the anti-ferromagnetic Kitaev model it has a projective translational symmetry with pi-flux per unit cell. The visons of the FM case have zero Berry curvature, and no associated intrinsic contribution to the Thermal Hall effect. In contrast, in the AFM case and under a Zeeman perturbing field, there are two gapped vison bands with opposite Chern numbers and an associated intrinsic vison contribution to the Thermal Hall effect. We will comment on other results in the literature that are in disagreement with ours (arXiv:2109.00250, 2021) and discuss the potential connections of our findings to the physics of the spin liquid candidate alpha-RuCl_3.

MA 16.7 Tue 16:30 H37

Magnetism in a distorted kagome lattice: the case of Y-kapellasite — •Aleksandar Razpopov[1], Max Herring[2], Francesco Ferarri[1], Igor Mazin[3], Roser Valenti[1], Harald Jeschke[4], and Johannes Reuther[2] — [1]Goethe University, Frankfurt, Germany — [2]Free University of Berlin, Berlin, Germany — [3]George Mason University, Washington DC, United States —

[4]Okayama University, Okayama, Japan

Compounds like the well-known Herbertsmithite are examples of the ideal spin-1/2 antiferromagnetic (AFM) kagome lattice which has one of the most interesting magnetic phase diagrams. However, while the perfect AFM kagome lattice has been extensively investigated, less is known about distorted kagome lattices.

Here we focus on an unexplored distorted spin-1/2 kagome lattice with three symmetry-inequivalent nearest-neighbor AFM Heisenberg couplings. The recently synthesized Y-kapellasite $Y_3Cu_9(OH)_{19}Cl_8$ is a realization of such a distorted lattice. First, we analyse the classical magnetic phase diagram using analytical arguments and numerical methods, and find a rich classical phase diagram with a Q=0 magnetic phase, Q=(1/3,1/3) non-collinear coplanar magnetic phases and a classical spin liquid regime. In a second step we estimate the effective magnetic Heisenberg Hamiltonian by total-energy mapping analysis within the FPLO framework. Using the extracted Heisenberg Hamiltonian we predict Y-kapellasite to be localized in the Q=(1/3,1/3) phase which is stable after inclusion of quantum effects.

MA 16.8 Tue 16:45 H37

Thermodynamic and magnetic properties of the rare-earth delafossite $NaGdS_2$ — •Justus Grumbach[1], Mathias Doerr[1], Ellen Haeussler[2], and Sergey Granovsky[1] — [1]Institut für Festkörper- und Materialphysik, Technische Universität Dresden, 01062 Dresden, Germany. — [2]Fakultät für Chemie und Lebensmittelchemie, Technische Universität Dresden, 01062 Dresden, Germany

Rare-earth delafossites are materials containing ideal triangular magnetic planes which are frustrated. Due to their properties, rare-earth delafossites are promising candidates for a QSL ground state. In recent years, research has focused on $S = \frac{1}{2}$ delafossites where either QSL or AFM ground states occur, with transitions in the mK range (e.g. [1] vs. [2]).

Now a number of new measurements have been made on $NaGdS_2$ single crystals with the pure spin moment $J = S = \frac{7}{2}$ of the Gd^{3+} magnetic ion. Measurements of several thermodynamic and magnetic properties were performed on very small samples (size $\sim \mu$m) down to 40 mK. Essential physical data could be extracted which consistently show a magnetic ordered AFM ground state below ∼200 mK.

[1] G. Bastien et al., SciPost Phys. 9, 041 (2020)
[2] M. Baenitz et al., Phys Rev B 98, 220409(R) (2018)

MA 16.9 Tue 17:00 H37

Single crystal study of the magnetic phase diagrams in $BaCo_2(PO_4)_2$ — •Xiao Wang[1], Rohit Sharma[1], Petra Becker-Bohatý[2], Ladislav Bohatý[2], and Thomas Lorenz[1] — [1]II. Physikalisches Institut, Universität zu Köln, Zülpicher Straße 77, D-50937 Köln, Germany — [2]Abteilung Kristallographie, Institut für Geologie und Mineralogie, Universität zu Köln, Zülpicher Straße 49b, 50674 Köln, Germany

The study of the Kitaev materials has been an active area in the past decades, mainly motivated by their novel physical properties such as topological order, exotic excitations and potential application for quantum computing . Motived by recent theoretical proposals that Kitaev model might be realized in $3d$ transition-metal compounds , we have successfully synthesized single crystal samples of $BaCo_2(PO_4)_2$. Our work on the high-quality $BaCo_2(PO_4)_2$ sample unveils a sharp phase transition at ∼3.5K which signals the evolution of antiferromagnetic long-range order in zero magnetic field. Such a transition is not observed in previous studies on polycrystalline $BaCo_2(PO_4)_2$ [3], while for a $T_N = 5.4$ K is reported for $BaCo_2(AsO_4)_2$ [4]. Here we present a comprehensive study of the magnetic phase transitions by magnetization, specific heat and thermal expansion measurements and construct the magnetic phase diagram of $BaCo_2(PO_4)_2$. This work is funded by the DFG via CRC 1238 Projects A02 and B01.

[1] A. Kitaev, Ann. Phys. (N. Y). 321, 2 (2006) [2] H. Liu, et al. Phys. Rev. Lett. 125, 3 (2020) [3] H. S. Nair, et al. Phys. Rev. B 97, 1 (2018) [4] R. Zhong, et al. Sci. Adv. 6, 1 (2020)

MA 16.10 Tue 17:15 H37

Resonant X-ray and neutron investigation of the double perovskite Nd_2ZnIrO_6 — •Fabian Stier, Marein Rahn, and Jochen Geck — Institut für Material- und Festkörperphysik, TU Dresden, Deutschland

We present a study of the magnetic order in the double perovskite Nd_2ZnIrO6 as a function of temperature and magnetic field. This material contains Ir with a formal valence of 4+, which is is very often described in terms of localized j=1/2 states. The magnetism of such j=1/2 states has attracted much attention, especially in relation to the possible formation of quantum spin liquids in actual materials. In order to elucidate the magnetism of the Nd 4f- and the Ir 5d-electrons in Nd2ZnIrO6, we performed resonant magnetic x-ray scattering and neutron powder diffraction. Below T_N=15 K we observe magnetic order with propagation vector (0.5 0.5 0) and moments in the ab plane. The temperature dependence reveals the Ir moment as the driving force of the magnetic ordering below T_N. Applying a magnetic field along the crystallographic a-direction at T=5K causes a metamagnetic transition to a phase with a propagation vector (0 0 0). Interestingly, applying the magnetic field along the crystallographic c-direction shows a linear field dependence.

MA 16.11 Tue 17:30 H37

Pressure induced multicritical behaviour in a kagome ferromagnet — •Arvind Maurya — Max Planck Institute for Solid State Research, Heisenbergstrasse 1, 70569 Stuttgart, Germany

We report high quality single crystal growth of ferromagnetURhSn, crystallizing in ZrNiAl- type hexagonal structure in which the magnetic U-atoms form potentially frustrated quasi-kagome two-dimensional net. Our measurements of electrical transport under hydrostatic pressures up to 11 GPa reveals two bicritical points concurrent at P_C = 6.25 GPa corresponding to its successive double phase transitions (T_O = 54 K, T_C = 18 K at ambient). Rermakably, the intermediate phase remains hidden as local probes like neutron scattering and Mössbauer spectra do not capture any new feature across the T_O. Our low temperature resistivity data under pressure points out a Fermi surface reconstruction across the P_C, corresponding to an unconventional class of quantum phase transition involving multicritical points. This picture is further ascertained by gradual development of -ln$T$ behavior in 5f-derived electrical resistivity and appearance of $T^{5/3}$ dependence in the pressure induced phase.