TT 57: Correlated Magnetism – Kagome Systems

Time: Wednesday 15:00–18:15 Location: CHE/0091

TT 57.1 Wed 15:00 CHE/0091

Probing Spin Dynamics and Hyperfine Coupling in the Frustrated Quantum Magnet Clinoatacamite: An NMR Study — •Roni Bose[1], Hans-Joachim Grafe[1], Bernd Büchner[1], Anja U. B. Wolter[1], Leonie Stödter[3], Caroline Kastner[2], and Stefan Süllow[2] — [1]IFW Dresden, Helmholtzstraße 20, 01069, Germany — [2]IPKM, TU Braunschweig, Braunschweig, Germany — [3]FZ Jülich, JCNS at MLZ, Garching, Germany

Recent work on Atacamite reveals a quantum critical point above 21.9 T with a dimensional reduction from 3 D AFM ordering to 1 D quantum spin liquid behavior. Clinoatacamite has same chemical formula as Atacamite, but displays distinct magnetic behaviour due to different crystal structure. Previous μSR studies on polycrystals reveal coexistence of long range magnetic ordering and fluctuations below 18 K, which transforms into a metastable state below 6.5 K, while neutron-diffraction observes magnetic reflections only below 6.5 K, but not below 18 K.

To address the discrepancy in reported ordering temperatures and to investigate the magnetic behaviour below 18 K, we performed ^{1}H-NMR measurements with magnetic field orientations $B \parallel [201]$ (perpendicular to the Kagome plane) and $B \parallel [010]$. For both field directions, the NMR spectra show splittings near 18 K and again near 6 K, indicating magnetic transitions. Furthermore, the temperature dependence of the spin-lattice relaxation rate at different proton sites reveals a coexistence of partial spin freezing and strong fluctuations below 18 K, followed by a fully ordered state below 6 K.

TT 57.2 Wed 15:15 CHE/0091

Competing ordering modes in the distorted quantum Kagome material clinoatacamite $Cu_2Cl(OH)_3$ — •Leonie Stödter[1,2], Carolin Kastner[1], Harald O. Jeschke[3], Manfred Reehuis[4], Ketty Beauvois[5], Bachir Ouladdiaf[5], Edmond Chan[5], Fabiano Yokaichiya[4], Fabrice Bert[6], Thomas J. Hicken[7], Jonas A. Krieger[7], Hubertus Luetkens[7], Jackson L. Allen[8], Ralf Feyerherm[4], Michael Tovar[4], Dirk Menzel[1], Anja U. B. Wolter[9], Kirrily C. Rule[10], F. Jochen Litterst[1], Ulrich K. Rössler[9], and Stefan Süllow[1] — [1]IPKM, TU Braunschweig, Braunschweig, Germany — [2]FZ Jülich, JCNS at MLZ, Garching, Germany — [3]RIIS, Okayama University, Okayama, Japan — [4]HZB, Berlin, Germany — [5]ILL, Grenoble, France — [6]SQM, Université Paris-Saclay, Orsay, France — [7]PSI, Villigen, Switzerland — [8]ISEM, University of Wollongong, Australia — [9]Leibniz IFW Dresden, Dresden, Germany — [10]ANSTO, Lucas Heights, Australia

Structurally, the mineral clinoatacamite $Cu_2Cl(OH)_3$ is closely related to the Kagome material herbertsmithite $ZnCu_3Cl_2(OH)_6$, however, its Kagome motif of Cu sites is embedded into a low-symmetry crystal structure. The magnetic ground states of clinoatacamite below an ordering temperature of 18.1 K have remained inconclusive to date. Here, we revisit the magnetic properties using single-crystalline material. We have characterized clinoatacamite by means of thermodynamic measurement techniques, μSR as well as neutron diffraction. We reveal a complex zero-field sequence of phases and discuss our data within a scenario of competing antiferromagnetic ordering modes.

TT 57.3 Wed 15:30 CHE/0091

High-field μSR on the frustrated quantum magnet clinoatacamite $Cu_2Cl(OH)_3$ — •Carolin Kastner[1], Fabrice Bert[2], Andrin Doll[3], Thomas J. Hicken[3], Jonas A. Krieger[3], Hubertus Luetkens[3], Dirk Menzel[1], F. Jochen Litterst[1], Leonie Stödter[4], Kirrily C. Rule[5], Anja U. B. Wolter[6], and Stefan Süllow[1] — [1]IPKM, TU Braunschweig, Braunschweig, Germany — [2]SQM, Université Paris-Saclay, Orsay, France — [3]PSI, Villigen, Switzerland — [4]FZ Jülich, JCNS at MLZ, Garching, Germany — [5]ANSTO, Lucas Heights, Australia — [6]Leibniz IFW Dresden, Dresden, Germany

The natural mineral clinoatacamite $Cu_2Cl(OH)_3$ is a distorted Kagome system with antiferromagnetic in-plane couplings of the order of a few hundred K and ferromagnetic interplane couplings of the order of a few tens of K. This dominance of the antiferromagnetic couplings within the Kagome planes establishes clinoatacamite as a frustrated quantum magnet in its own right. In recent years, we have extensively characterized the complex magnetic phase diagram of clinoatacamite which contains a sequence of magnetic transitions of unknown symmetry. In particular, we have performed a detailed μSR study in zero magnetic field, thus characterizing the different magnetic regions below $T_N = 18.1$ K using this experimental technique.

To provide further insight into the microscopic details of the different magnetic regions we now have performed a μSR study on single-crystalline clinoatacamite in high magnetic fields up to 6.5 T and will discuss the results in this presentation.

TT 57.4 Wed 15:45 CHE/0091

Pathway to the ground state in Kagome spin ice HoAgGe — •Philipp Gegenwart — Lehrstuhl für Experimentalphysik VI, Universität Augsburg

HoAgGe represents the first crystalline realization of Kagome spin ice and displays striking fractionalized plateau states in magnetic and transport experiments [1,2]. We report single crystal neutron diffuse scattering to map the pathway from paramagnetism via partial order to the Kagome spin ice ground state [3]. The symmetry-broken nature of the latter is evidenced by the nonlinear magnetic susceptibility.

[1] K. Zhao, H. Deng, H. Chen, K.A. Ross, V. Petricek, G. Günther, M. Russina, V. Hutanu, P. Gegenwart, Science 367, 1218 (2020)
[2] K.Zhao, Y.Tokiwa, H.Chen, P.Gegenwart, Nat.Phys. 20,442 (2024)
[3] K.Zhao, H.Deng, H.Chen, N.Ma, N.Oefele, J.Guo, X.Cui, Ch.Tang, M. J. Gutmann, T. Mueller, Y. Su, V. Hutanu, Ch. Jin, P. Gegenwart, arXiv:2505.22544

TT 57.5 Wed 16:00 CHE/0091

Pressure-tuned Kagome spin liquid in Herbertsmithite $ZnCu_3(OH)_6Cl_2$ — •Victoria Ginga[1], Rodolfo A. Rangel Hernandez[1], Bin Shen[2], Louis Stein[3], Ece Uykur[3], Philipp Gegenwart[2], and Alexander A. Tsirlin[1] — [1]Felix Bloch Institute, University of Leipzig, Germany — [2]EP VI, EKM, University of Augsburg, Germany — [3]Helmholtz-Zentrum Dresden-Rossendorf, Germany

Herbertsmithite is a benchmark $S = 1/2$ Kagome quantum spin-liquid candidate. At ambient pressure, our magnetization data confirm the absence of long-range order down to 2 K while revealing a low-field spin-freezing that is suppressed by moderate fields. High-pressure single-crystal diffraction shows that the trigonal structure remains stable up to 22 GPa, beyond which the material becomes amorphous. Whereas an earlier study [1] reported non-monotonic changes in Cu-O distances and Cu-O-Cu angles near 2.5 GPa concomitant with pressure-induced T_N around 6 K, our high-pressure structural data show no such behavior. Our pressure-dependent magnetization up to 4.2 GPa shows no transition, while spin freezing persists with an almost constant freezing temperature of 7 K. Using experimentally determined high-pressure structures, we quantify exchange couplings via DFT and map how the dominant interactions evolve with bond geometry. Our findings show that, to at least 4.2 GPa, Herbertsmithite preserves its quantum-disordered ground state and provides a reference framework for pressure tuning in Kagome spin-liquid candidates.

[1] Phys. Rev. Lett. 108, 187207

TT 57.6 Wed 16:15 CHE/0091

Anisotropic Transient Reflectivity Observed in Fe-Sn Kagome Binary Compounds — •Marcos Vinicius Goncalves Faria[1,2], Alexej Pashkin[1], Stephan Winnerl[1], Manfred Helm[1,2], Hechang Lei[3], Qi Wang[3], Jure Demsar[4], Chandra Kotyada[4], Lilian Prodan[5], István Kézsmárki[5], and Ece Uykur[1] — [1]Helmholtz-Zentrum Dresden-Rossendorf — [2]Technische Universität Dresden — [3]Renmin University of China — [4]Johanes Gutenberg University Mainz — [5]Universität Augsburg

In this work, we investigate the interlayer coupling in Fe-Sn Kagome binaries using ultrafast transient reflectivity. Previous pump-probe studies have revealed that many Kagome metals exhibit similar relaxation features when probing the Kagome plane. However, the ultrafast response changes significantly by moving the probe direction from in-plane to out-of-plane, which we ascribe to the confinement of localized carriers in the Kagome layers. Such anisotropic behavior is consistent with what has also been observed with resistivity and broadband optics. The strong coupling between the Kagome layers shows that the single-Kagome layer approximation is not sufficient to describe the physics in this material family.

Beyond electronic anisotropy, the presence of magnetism, CDW and other lattice instabilities can strongly influence the nonequilibrium response of Kagome metals. Fe_3Sn and Fe_3Sn_2 are systems where there is an in-plane breathing mode and a coherent optical phonon can be excited. However, for FeSn, which has a pristine Kagome lattice, no coherent phonon could be observed.

15 min. break

TT 57.7 Wed 16:45 CHE/0091

Many-body interference in Kagome crystals — •Chunyu Guo[1], Kaize Wang[1], Ling Zhang[1], Carsten Putzke[1], Dong Chen[2], Takashi Oka[3], Roderich Moessner[4], Mark Fischer[5], Titus Neupert[5], Claudia Felser[2], and Philip Moll[1] — [1]Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany — [2]Max Planck Institute for Chemical Physics of Solids, Dresden, Germany — [3]The Institute for Solid State Physics, The University of Tokyo, Kashiwa, Japan — [4]Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — [5]Department of Physics, University of Zurich, Zurich, Switzerland

When electrons in metals act collectively, they create emergent phenomena that exceed the behavior of individual particles. We present experimental evidence of coherent charge transport in the normal state of the Kagome metal CsV_3Sb_5. This is evidenced by magnetoresistance oscillations in mesoscopic crystalline pillars under in-plane magnetic fields, with periodicity determined by magnetic flux quanta, h/e, between adjacent Kagome layers, resembling an interlayer Aharonov-Bohm interferometer. The oscillation amplitude also correlates directly with other unusual electronic responses in CsV_3Sb_5, suggesting an intrinsic coherence mechanism. These findings shed light on the debated nature of correlated order in Kagome metals, positioning CsV_3Sb_5 as a unique platform for long-range coherent charge transport outside of superconductivity, and opening new avenues for understanding coherence in correlated electron systems.

TT 57.8 Wed 17:00 CHE/0091

Correlation effects in extended Kagome Hubbard models — •Alon Strugatsky and Roser Valenti — Goethe-Universität Frankfurt, Frankfurt am Main, Germany

Kagome materials display a rich interplay of topology, strong electronic correlations, and lattice dynamics. Recently, attention has focused on a class of Kagome metals whose nearly flat bands sit close to the Fermi level. Examples include FeGe, CsV_3Sb_5, $YbCr_6Ge_6$. Such systems are natural hosts for flat-band phenomena (for instance, flat-band ferromagnetism and unconventional superconsuctivity), but their large density of states makes perturbative diagrammatic approaches challenging. Here, we present a systematic study using dynamical mean-field theory (DMFT) and cluster DMFT on an extended Kagome Hubbard model, and map the phase diagram at various fillings.

TT 57.9 Wed 17:15 CHE/0091

Emergent Network of Josephson Junctions in a Kagome Superconductor — •Tycho Blom[1], Matthijs Rog[1], Marieke Altena[2], Andrea Capa Salinas[3], Stephen Wilson[3], Milan Allan[1,4], Chuan Li[2], and Kaveh Lahabi[1] — [1]Huygens-Kamerlingh Onnes Laboratory, Leiden University, 2300 RA Leiden, The Netherlands — [2]MESA+ Institute for Nanotechnology, University of Twente, 7500 AE, Enschede, The Netherlands — [3]Materials Department, University of California Santa Barbara, Santa Barbara, California 93106, USA — [4]Munich Center for Quantum Science and Technology (MCQST), Ludwig-Maximilians- University Munich, Munich 80799, Germany

Materials with a Kagome lattice are intensely studied because they host exotic states that combine strong correlations and topology. In this talk, I will describe several unique phenomena that are observed in the Kagome superconductor $CsV_3Sb_{5-x}Sn_x$ (x = 0.03-0.04), and show that a network of Josephson junctions spontaneously emerges below the transition temperature in thin, homogeneous flakes. Using magnetotransport experiments under both DC and radio frequency current bias, I will demonstrate that the junctions are localized and stable, and that supercurrent must flow in filaments. These results pave the way for determining the exact nature of superconductivity in the AV_3Sb_5 family.

TT 57.10 Wed 17:30 CHE/0091

Unconventional gap structure in Kagome superconductor coupled to hybrid microwave resonators — •Yejin Lee, Haolin Jin, Berit Goodge, Edouard Lesne, Sushmita Chandra, and Uri Vool — Max Planck Institute for Chemical Physics of Solids, Dresden, Germany

Kagome superconductors have been recently discovered, offering a rich platform to study strongly correlated systems, including superconductivity, charge density wave, and time reversal symmetry broken states, and their electronic properties, featuring flat bands and van Hove singularities. Finding a pairing symmetry is crucial to understand the quantum phases interplay. Despite numerous experimental efforts focused on bulk crystals, there is no consensus for microscopic origin so far. Additionally, van der Waals flakes show distinct phases that are hard to probe with conventional methods. Superconducting microwave resonator is highly sensitive to detect the kinetic inductance and allows for studying the microwave response when hybridized with vdW layered flakes. Using this technique we investigate the pairing symmetry of the Kagome superconductor. We fabricate the CVS flake-coupled circuits with cryogenic transfer method, which preserves the pristine property and atomically sharp interface. We find any disorder in the flake disrupts coupling in the circuits that hinders the investigation of the low temperature properties. The temperature dependent resonance frequency shows a linear behavior, which deviate from a conventional fully gapped structure. The linear dependence is a signature for a nodal structure, as a hallmark of unconventional superconductivity.

TT 57.11 Wed 17:45 CHE/0091

Superconductivity in Kagome metals due to soft loop-current fluctuations — •Daniel Schultz[1], Grgur Palle[2], Asimpunya Mitra[3], Yong-Baek Kim[3], Rafael Fernandes[2], and Jörg Schmalian[1] — [1]Institute for Theoretical Condensed Matter Physics, Karlsruhe Institute of Technology, 76131 Karlsruhe, Germany — [2]Department of Physics, The Grainger College of Engineering, University of Illinois Urbana-Champaign, Urbana, Illinois 61801, USA — [3]Department of Physics, University of Toronto, Toronto, Ontario M5S 1A7, Canada

We demonstrate that soft fluctuations of translation symmetry-breaking loop currents provide a mechanism for unconventional superconductivity in Kagome metals that naturally addresses the multiple superconducting phases observed under pressure. Focusing on the rich multi-orbital character of these systems, we show that loop currents involving both vanadium and antimony orbitals generate low-energy collective modes that couple efficiently to electrons near the Fermi surface and mediate attractive interactions in two distinct unconventional pairing channels. While loop-current fluctuations confined to vanadium orbitals favor chiral d+id superconductivity, which spontaneously breaks time-reversal symmetry, the inclusion of antimony orbitals stabilizes an $s^{\pm}$ state that is robust against disorder. We argue that these two states are realized experimentally as pressure increases and the antimony-dominated Fermi surface sheet undergoes a Lifshitz transition.

TT 57.12 Wed 18:00 CHE/0091

Strain Tuning of the Kagome Metal GdV_6Sn_6 — •Francisco Lieberich[1,2], Ganesh Pokharel[3], Stephen Wilson[4], and Elena Gati[1,2,5] — [1]MPI–CPfS, Dresden, Germany — [2]TUD, Dresden, Germany — [3]UWG, Georgia, USA — [4]UCSB, Santa Barbara, USA — [5]Goethe Universität, Frankfurt, Germany

Kagome metals are a fertile ground for exotic states of matter, driven by the interplay of nontrivial band topology and strong correlation effects [1]. In the RV_6Sn_6 series, alternating rare-earth (R) triangular-lattice and V Kagome layers generate a unique environment for exploring the interaction of correlated topological behavior with magnetic frustration. GdV_6Sn_6, in particular, exhibits strong coupling between Gd local magnetic moments and Kagome-plane itinerant electrons [2], giving rise to a fascinating interplay of commensurate and incommensurate spin modulations under applied magnetic field [3]. In this talk, we discuss the effects of uniaxial pressure, which lifts the inherent lattice frustration, on the thermodynamic properties of GdV_6Sn_6. Using high-resolution elastocaloric effect [4] measurements we establish a rich phase diagram and show that the balance of commensurate and incommensurate spin modulations is highly tunable by uniaxial pressure. These findings highlight the exceptional sensitivity of magnetic Kagome metals to lattice tuning by uniaxial pressure.

[1] Sante *et al*, arXiv:2511.12731 (2025)
[2] Ishikawa *et al*, JPSC 90, 124704 (2021)
[3] Porter *et al*, PRB 108, 035134 (2023)
[4] Ikeda *et al*, RSI 90, 083902 (2019)