TT 21: Focus Session: Topological Kagome Metals

The peculiar nature of the kagome lattice known to give rise exotic quantum states. When mixed with the itinerant character of the carriers, theoretically, it is predicted to host dispersionless electronic flat bands along with the linearly dispersing Dirac bands allowing one to bring together the topologically nontrivial states and the electronic correlations that lie at the center of condensed matter physics due to their roles in variety of novel quantum phenomena, such as unconventional superconductivity, heavy-fermion physics, Mott insulator states, etc. Recently, the experimental efforts caught with the predictions and several compounds are proposed as promising kagome metals, where one can realize the peculiar kagome physics in the real-world environment.

Organizers: Ece Uykur and Martin Dressel (Stuttgart University)

Time: Thursday 13:30–16:00 Location: H7

Invited Talk TT 21.1 Thu 13:30 H7

A new class of charge density wave superconductors in the topological kagome metals AV_3Sb_5 (A=K, Rb, Cs) — •Stephen Wilson — Materials Department, University of California Santa Barbara

Kagome metals are compelling materials platforms for hosting electronic states that feature an interplay between topologically nontrivial electronic states and correlated electron phenomena. These two features can, for instance, arise from the Dirac points, flatbands, and saddle-points endemic to the kagome lattice type in simple tight-binding models. Recently in this field, the discovery of a new class of kagome metals of the form AV_3Sb_5 with A=K, Cs, or Rb has provided a unique setting for exploring the interplay between Z_2 electronic topology and intertwined charge density wave and superconducting orders. These metals realize a kagome lattice of nonmagnetic vanadium ions with an electron-filling that populates saddle-points and their corresponding van Hove singularities in the electronic density of states near the Fermi level. Nesting effects in this setting are predicted to stabilize a variety of unusual states, ranging from charge density wave order that breaks time reversal symmetry to unconventional superconductivity. Here I will present some of our recent work exploring the phase transitions and broken symmetries in these materials. Particular attention will be given to the nature of the charge density wave instability.

TT 21.2 Thu 14:00 H7

Kagome metals — •Ronny Thomale — Theoretische Physik I, Julius-Maximilians-Universität Würzburg

The recent discovery of AV_3Sb_5 (A=K,Rb,Cs) has uncovered an intriguing arena for exotic Fermi surface instabilities in kagome metals. Aside from charge density wave order, a multi-dome superconducting phase is found, with strong indications to be of unconventional origin. We find that the sublattice interference mechanism is necessary and sufficient to uncover the nature of unconventional particle-hole and particle-particle pairing in the V net kagome metals. We predict a Peierls-type charge density wave with finite relative angular momentum and orbital current formation. With regard to the possible nature of unconventional pairing, we find a rich phase diagram depending on the range of the screened electronic interactions, the multi-orbital content, and the location of multiple van Hove singularities with respect to the Fermi level. Combined, kagome metals open a new domain of unconventional electronic order, unfolding a plethora of fascinating experimental and theoretical investigations.

TT 21.3 Thu 14:15 H7

Kagome and non-kagome physics of AV_3Sb_5 — •Alexander A. Tsirlin — EP VI, EKM, University of Augsburg, Germany

Layered compounds AV_3Sb_5 (A = K, Rb, Cs) are non-magnetic kagome metals with an intricate coexistence of and competition between superconducting and charge-density-wave (CDW) instabilities. In this talk, I will present our recent study of these compounds via x-ray diffraction, density-functional calculations, and broadband optical spectroscopy, with a focus on delineating between the roles of vanadium kagome planes and Sb atoms that encompass these planes. The following aspects will be addressed: i) band saddle points in the vicinity of the Fermi level and their positions depending on the A atom; ii) possible structures of the CDW state; iii) electronic and structural mechanisms of stabilizing the CDW; iv) evolution of crystal and electronic structures under pressure where re-entrant superconductivity has been observed. I will argue that both CDW formation in and pressure evolution of AV_3Sb_5 are strongly influenced by the Sb atoms that should be deemed an integral part of these kagome metals.

15. min. break

TT 21.4 Thu 14:45 H7

Study on the Magnetic Weyl Semimetal Phase in Kagome Lattice, $Co_3Sn_2S_2$ — •Defa Liu — Max Planck Insititute of Microstructure Physics

Materials with kagome lattice attract lots of investigations recently as they can realize many exotic phases and properties, such as the existence of flat band,superconductivity, CDW order, topological Dirac semimetal and Weyl semimetal phases, which can provide an ideal platform to study the interplay between them. Among the kagome materials, the ferromagnetic $Co_3Sn_2S_2$ has many exotic physical properties, such as the large anomalous Hall effect (AHE) and the anomalous Nernst effect (ANE). And also $Co_3Sn_2S_2$ is the first experimentally confirmed magnetic Weyl semimetal. In this talk, I will introduce how to use the angle-resolved photoemission spectroscopy (ARPES) to confirm the magnetic Weyl semimetal phase in $Co_3Sn_2S_2$, including the observation of the surface Fermi arcs and bulk Weyl point [1], the observation of the spin-orbit coupling (SOC) effect [2], and the observation of the topological phase transition in $Co_3Sn_2S_2$ [3]. These results not only can help to understand the formation mechanism of the Weyl semiemtal phase and the large anomalous Hall effect (AHE) and the anomalous Nernst effect (ANE) in $Co_3Sn_2S_2$, but also provide insights into the interplay between the magnetism and the topology.

[1] D.F. Liu et al., Science 365, 1282-1285 (2019)
[2] D.F. Liu et al., arXiv: 2103.08113
[3] D.F. Liu et al., arXiv: 2106.03229

TT 21.5 Thu 15:15 H7

Optical investigations of $\boldsymbol{Re}Mn_6Sn_6$ kagome metals — •Maxim Wenzel[1], Olga Iakutkina[1], Hechang Lei[2], Martin Dressel[1], and Ece Uykur[1] — [1]1. Physikalisches Institut, Universität Stuttgart, D-70569 Stuttgart, Germany — [2]Department of Physics, Renmin University of China, 100872 Beijing, China

Magnetic kagome metals became model compounds for exploring the interplay between strong electronic correlations and magnetism along with topologically non-trivial states. Consisting of magnetic kagome planes along with the itinerant carriers, they ought to possess Dirac Fermions, flat bands and saddle points in the vicinity of the Fermi energy, E_F. The rare earth kagome metal series, ReMn$_6$Sn$_6$ (Re = Gd, Tb, Y) opens a new way for further investigations of the influence of magnetism on the electronic properties. While the crystal structure does not differ significantly, the underlying magnetic structure strongly depends on the rare earth element separating the Mn-kagome layers. Here, we report temperature-dependent optical spectroscopy study on series of ReMn$_6$Sn$_6$ compounds in a broad frequency range of 50 - 18000 cm^{-1} down to T = 10 K. The optical signatures of the strongly correlated flat bands and the Dirac fermions are comparatively discussed.

TT 21.6 Thu 15:30 H7

Polarization dependent localization in layered kagome metal FeSn — •Ananya Biswas[1], Frederik Bolle[1], Olga Iakutkina[1], Hechang Lei[2], Yoshichika Onukio[3], Martin Dressel[1], and Ece Uykur[1] — [1]1. Physikalisches Institut, Universität Stuttgart, D-70569

Stuttgart, Germany — [2]Department of Physics, Renmin University of China, 100872 Beijing, China — [3]Faculty of Science, University of Ryukyus, Japan

The roots of coexistence of Dirac bands and flat bands (from extended Hubbard Model) in kagome metals holds immense significance to study correlated electron systems. Antiferromagnetic FeSn is an ideal 2D kagome lattice having its Néel temperature T_N=370K. Moments of Fe atoms are ferromagnetically ordered within the Fe-Sn kagome planes, which are separated by Sn layers along c direction where each layer is coupled antiferromagtically to the adjacent kagome planes. Thus, FeSn provides ideal platform of polarization dependent investigation based on isolated and spatially decoupled kagome planes of 2D kagome network in bulk crystals. We investigated polarization effect of low energy dynamics in FeSn through infrared spectroscopy down to 10K. Results show two distinct carriers along kagome plane, which can be realized by Drude like free carrier contribution and a pronounced localization peak. Furthermore, a more coherent transport across kagome plane is reflected in our polarization dependent optical studies.

TT 21.7 Thu 15:45 H7

Nature of unconventional pairing in the kagome superconductors AV_3Sb_5 — •Xianxin Wu[1], Tilman Schwemmer[2], Tobias Müller[2], Armando Consiglio[2], Giorgio Sangiovanni[2], Domenico Di Sante[3], Yasir Iqbal[4], Werner Hanke[2], Andreas P. Schnyder[1], M. Michael Denner[5], Mark H. Fischer[5], Titus Neupert[5], and Ronny Thomale[2] — [1]Max-Planck-Institut für Festkörperforschung, Stuttgart, Germany — [2]University of Würzburg, Würzburg, Germany — [3]University of Bologna, Bologna, Italy — [4]Indian Institute of Technology Madras, Chennai, India — [5]University of Zurich, Zurich, Switzerland

The recent discovery of AV_3Sb_5 (A=K,Rb,Cs) has uncovered an intriguing arena for exotic Fermi surface instabilities in a kagome metal. Among them, superconductivity is found in the vicinity of multiple van Hove singularities, exhibiting indications of unconventional pairing. We show that the sublattice interference mechanism is central to understanding the formation of superconductivity in a kagome metal. Starting from an appropriately chosen minimal tight-binding model with multiple van Hove singularities close to the Fermi level for AV_3Sb_5, we provide a random phase approximation analysis of superconducting instabilities. Non-local Coulomb repulsion, the sublattice profile of the van Hove bands, and the interaction strength turn out to be the crucial parameters to determine the preferred pairing symmetry. Implications for potentially topological surface states are discussed, along with a proposal for additional measurements to pin down the nature of superconductivity in AV_3Sb_5.