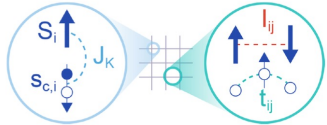


I. Motivation of the Work

f-electron heavy fermion metal:

- Atomic f-orbitals, D_f small; deep level
- Itinerant spd-orbitals, D_c large
- $D_f \ll (U_f, U_c) < D_c$

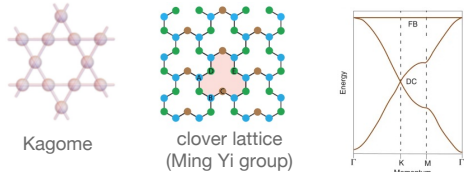


Kondo lattice:

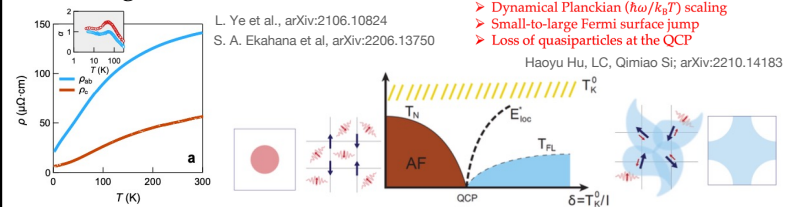
$$H = \sum_{ij} t_{ij} s_i^\dagger \cdot s_j + \sum_{ij,\sigma} t_{ij,\sigma} c_{i\sigma}^\dagger c_{j\sigma} + \sum_i J_K \mathbf{S} \cdot \mathbf{s}_{c,i}$$

Geometric frustration induced flat band:

- Flat band, W_f small
- Wide band, W_c large

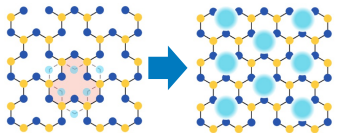


Strange metal behavior and non-Fermi liquid:



II. Model

Clover lattice:

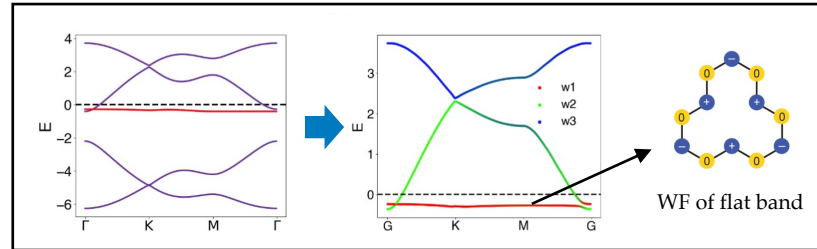


- One Wannier orbital mainly captures the flat band
- One molecular orbital much more localized than the others

L. Chen et al., arXiv:2212.08017;
H. Hu and QS, arXiv:2209.10396

Effective multiorbital Hubbard model:

$$H = H_c + H_{cf} + H_f + H_U$$

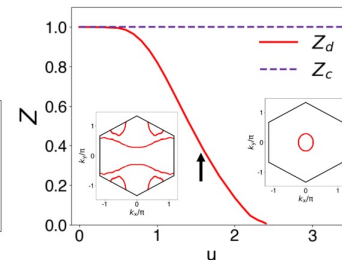
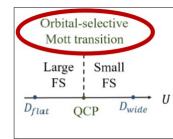


III.1 Orbital selective correlations

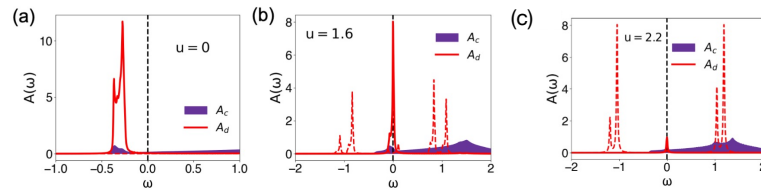
Slave spin method:

$$d_{i\sigma}^\dagger = o_{i\sigma}^\dagger f_{i\sigma}^\dagger \quad o_i^\dagger = P^+ S_i^+ P^-$$

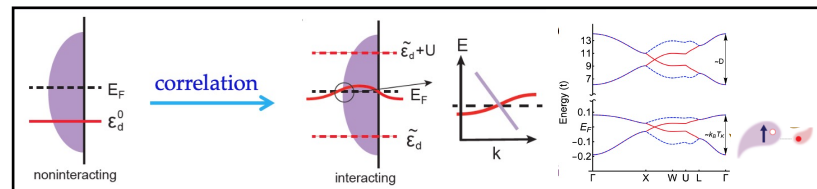
- An orbital selective Mott transition accompanied with Fermi surface reconstruction



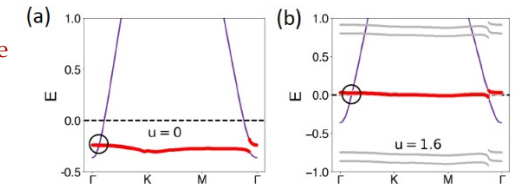
Charge transfer from coherent to incoherent spectrum:



III.2 Topological Kondo Semimetals



- Interaction drives the topological node to be close to chemical potential



III.3 Kondo destruction quantum criticality

Anderson lattice model with RKKY interactions:

(Extended DMFT: lattice \rightarrow Bose-Fermi Anderson model)

$$H = \frac{U}{2} \sum_i (n_{f,i} - n_0)^2 + V \sum_{i,\sigma} (c_{i\sigma}^\dagger f_{i\sigma} + \text{h.c.}) + \sum_{ij} t_{ij} S_{f,i} \cdot S_{f,j} + \sum_{k,\sigma} \epsilon_k c_{k,\sigma}^\dagger c_{i,k} S_{f,i}$$

$$S_{f,i} = \int_0^\beta d\tau \left[\sum_{\alpha} f_{i,\alpha}^\dagger J_{\alpha} f_{i,\alpha} + U n_{d,i} n_{d,i} - \mu n_d \right] - \int_0^\beta d\tau d\tau' \sum_{\alpha} f_{i,\alpha}^\dagger(\tau) V^2 G_{\alpha\alpha}(\tau - \tau') f_{i,\alpha}(\tau')$$

$$+ \frac{1}{2} \int_0^\beta d\tau \int_0^\beta d\tau' \sum_{\alpha \neq \beta} S^{\alpha\beta} : (\tau) | \mathbf{S} |^{-1} (\tau - \tau') : S^{\beta\alpha}(\tau') + \int_0^\beta d\tau h_{\text{loc}} S^z$$

$$E_{\text{loc}} = T_K^0 \exp\left(-\frac{4J_X(0)}{\alpha}\right)$$

L. Chen, et. al unpublished

IV. Conclusions

- One orbital Hubbard model \rightarrow effective Kondo lattice model
 - Resolving topological obstruction for combined flat and wide bands
 - Wannier orbitals are molecular orbitals; orbital differentiation
 - Mapped to Anderson/Kondo lattice description
- Implications of Kondo lattice physics for d-electron-based flat band systems
 - Loss of quasiparticles
 - Emergent flat bands & topological Kondo semimetals
 - Kondo destruction quantum criticality in the d-electron material