Open Questions On Itinerant FM

- Intrinsic strong correlated phenomena
- Very few itinerant electron models known have fully polarized ground state
- Non-perturbative treatment on finite temperature property is lacking

$$X_{\text{pauli}}’(T) = X_0 \left(1 - \frac{c}{\pi T}\right)$$

$$\chi_{\text{pauli}}’(T) = \frac{4}{1 - \frac{c}{\pi T}}$$ - Not Curie-Weiss Law

Curie Temperature & Effective M

$$\chi = \frac{1}{V} \int \frac{d^3 p}{(2\pi)^3} e^{-\beta \epsilon(p)}$$

Model of Orbital-Active Itinerant FM

$$H_{\text{int}} = -J \sum_{\langle i,j \rangle} \left[ P_{i \sigma} (\hat{\sigma} + \hat{\delta}_{ij}) P_{j \sigma} (\hat{\sigma} + \hat{\delta}_{ij}) + h.c. \right]$$

$$H_{\text{int}} = \frac{1}{V} \sum_{i} n_i (\hat{\sigma} + \hat{\delta}_{ij}) + \frac{1}{4} \sum_{\langle i,j \rangle} \left[ P_{i \sigma} (\hat{\sigma} + \hat{\delta}_{ij}) P_{j \sigma} (\hat{\sigma} + \hat{\delta}_{ij}) + h.c. \right]$$

Unit Filling: Heisenberg Class & Ising Class

$$\chi = A e^{-\beta T}$$

Thermal fluctuation prevents true long-range order breaking SU(2) symmetry

Unit Filling: Momentum Distribution

Highly non-trivial thermal state: Low energy excitation is not restricted to the vicinity of the Fermi surface, but extends over the entire Brillouin zone.

Experimental Realizations

- P-orbital optical lattice
  - New direction to achieve itinerant ferromagnetism in ultra cold atom systems
- Transition metal oxide (SrTiO$_3$/LaAlO$_3$ interfaces)
  - In the quasi-2D layered structure, $d_{xy}$ and $d_{yz}$ orbitals are effectively one-dimensional and behave as $p_x$ and $p_y$ orbitals considered here. They can polarize the two-dimensional $d_{xy}$ orbital as well.

Summary

- Itinerant Fermion Model with Fully Polarized Ground State
- Thermodynamic property of itinerant ferromagnet by sign-problem free Monte Carlo (SSE)
  - Coexistence of Curie-Weiss spin susceptibility & metallic compressibility
  - Highly non-trivial thermal excitation over entire Brillouin Zone
  - Crossover behavior for Heisenberg class & true long-range order for Ising class
- Experimental Realizations

Reference