Briefs on $CeCoIn_5$ papers

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1 Ikeda, Hatekeyama and Aoyama. Antiferromagnetic ordering induced by paramagnetic depairing in unconventional superconductors. Phys. Rev. B, 2010

They begin by stating the free energy in zero field and the Hamiltonian they use:

$$\mathcal{F}(H=0) = \sum_r \frac{|\Delta(r)|^2}{g} - Tln\left[Tre^{-\mathcal{H}/T}\right]$$

$$\mathcal{H} = \sum_{\alpha\beta}\left[\sum_k c^\dagger_{k\alpha} e_k \delta_{\alpha\beta} c_{k\beta} - \sum_q (m(q)S^\dagger(q) + H.C) + \frac{|m(q)|^2}{U} + \Delta(q)\Psi^\dagger(q)\right]$$

From here they calculate what they call the "normal" and "anomolous" susceptibilities which reduce to the same form as we have (we checked this)

PROS:

-They find enhancement of AFM ordering in the SC phase.

-They say the $\mathcal{O}(|\Delta|^4)$ term in GL theory changes sign which causes the enhancement

CONS:

-They use S-wave order parameter.

-They never really say what dispersion they are using, just that $e_k = -e_{k+Q} + T_c\delta$, $\delta << 1$

-The q vector of the susceptibility and magnetic order is not well defined

-They don't mention parallel susceptibility

-They find divergent perpendicular susceptibility at T=0 which we have not seen

2 Suzuki, Ichioka and Machida. Theory of an Inherent Spin-Density-Wave instability due to votices in superconductors with strong pauli effects. Phys Rev. B, 2011

They calculate the vortex lattice state by the Eilenberger equations. With strong Pauli effects they see spikes in the K-density of states near the nodal regions . Their calculation is in full 3D and they predict $Q = (0.5 \pm \delta q, 0.5 \pm \delta q, 0.5)$.

PROS:

-They do explore Q vectors which are near nodal and attempt to find some sort of maximum.

-Their K-density of states seems to be consistent with our picture (ie. spiked near nodes).

-They are fully 3D and consider various orientations of H.

-They apparently show that the transition line to the AFM/SC state is positive in T-H diagram.

CONS:

-They don't calculate anything observable or concrete.

-They rely heavily on the vortex lattice for order.

3 Kato, Batista and Vekhter. Antiferromagnetic order in pauli-limited unconventional superconductors. Phys. Rev. Lett., 2011

They use a Hamiltonian with SC and AFM (m $\perp$ H) interactions and a tight binding dispersion $\epsilon_k = 2t(\cos k_x + \cos k_y) - \mu$ $\mu/t = 0.749$:

$$\mathcal{H} = \sum_{k,s}(\epsilon_k - sh)c^\dagger_{ks}c_{ks} - \sum_k(\Delta_k c^\dagger_{k1}c^\dagger_{-k-1} + HC) - J\sum_k(m_Q c^\dagger_{k-1}c_{k+Q1} + H.C.) + |\Delta_0|^2/V + J|m_Q|^2$$

The Q vector connects nodal points excatly $Q = (\pm 0.88\pi, \pm 0.88\pi)$. Then they diagnolize $\mathcal{H}$ (presummably with a Bogolioubov type transformation) and minimize the free energy. They end up with a phase diagram very similar to that of $CeCoIn_5$.

PROS:

-They get a phase diagram which is pretty close.
-They start from a justifiable Hamiltonian.
-The Q vector connects nodal points.

CONS:

-Tight binding is periodic. How did they deal with that/justify it.
-Hamiltonian all ready assumes magnetic interactions.
-Did not explore any other Q vectors.
-Did not consider parallel susceptibility.

4 Yanase and Sigrist. Magnetic Structure of the Antiferromagnetic Fulde Ferrel Larkin Ovchinikov State. J. Phys.: Condens. Matter (2011)

They use a hoping model (2D) which includes a Pauli term, up to 3rd nearest neighbor interactions and a d-wave FFLO order parameter . Their Hamiltonian also includes attractive and AFM interactions between sites. They also use the BdG equations, but neglect the AFM contributions. Their order parameter is:

$$\Delta(\vec{i}) = \Delta_{\vec{i},\vec{i}+\vec{a}} + \Delta_{\vec{i},\vec{i}-\vec{a}} - \Delta_{\vec{i},\vec{i}+\vec{b}} - \Delta_{\vec{i},\vec{i}-\vec{b}}$$

Where $\vec{a}$ and $\vec{b}$ are lattice unit vectors. Then then calculate the bare susceptibility from the mean field Hamiltonian and assume magnetic interactions $I(i,i) = U$, $I(i, i \pm a) = I(i, i \pm b) = -J/2$, $I = 0$ otherwise to get the total susceptibility.

PROS:

-FFLO + D-wave
-They use a hoping model (not sure if this is a pro or con, but it's different from the others)
-easily get spatial magnetic structure for different orientations

CONS:

-Start by assuming magnetic interaction channel which gives divergent susceptibility
-Zero temperature
-No field dependence