Lecture 2

- Weak interactions: new field
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- Story: interesting possibility for ferromagnetic trails
  - Novel field: strontium calcium
    - Cold states language
    - Send order
    - Behavior will improve

- Observation:
  - Cold state
  - Cold states

- cold, hot
  - Order by: disorder
  - Special, unique

- Plan, limit
Lecture 2

Repulsive interactions: split into domains

No repulsion, but kinetic energy cost & squeezing spins into smaller box

\[ kE \sim n^{2/3} \quad \text{so} \quad 2^{2/3} \]
To search for ferromagnetic transition

\[ \Delta G = \int E \, dE \]

\[ E = \left( \frac{3}{2} n \cdot \frac{\sqrt{EF_0}}{V_F^0} \right)^{\frac{3}{2}} \cdot n^{\frac{3}{2}} \left( 1 + \frac{1}{2} \frac{S}{3} \Delta n^2 \right) + g \Delta n \cdot n^{\frac{3}{2}} \]

\[ n = \int V_F^0 \, \frac{\sqrt{E_F}}{E_F^0} \, dE \]

\[ E_F = \left( \frac{3}{2} n \cdot \frac{\sqrt{EF_0}}{V_F^0} \right)^{\frac{3}{2}} \]

\[ \Delta E = \left( \frac{3}{2} \Delta n \cdot \frac{\sqrt{EF_0}}{V_F^0} \right)^{\frac{3}{2}} \cdot n^{\frac{3}{2}} \left( 1 + \frac{1}{2} \frac{S}{3} \Delta n^2 \right) + g \Delta n \cdot n^{\frac{3}{2}} \]
look at coefficient of \( \alpha n^2 \):

\[
\sqrt{E_F_0} \left| \frac{3}{2} \right| \frac{4}{9} \left| \frac{3}{2} \right| \frac{8}{3} \frac{\hbar}{\xi} = g \frac{\xi}{\hbar^n} \frac{\alpha n^2}{\eta^2}
\]

\[
\sqrt{E_F_0} \left| \frac{3}{2} \right| \frac{4}{9} \frac{8}{3} = g \left( \frac{2 \hbar}{\xi} \right) \left| \frac{3}{2} \right| \frac{3}{2} \frac{E_F_0}{\hbar^2}
\]

\[
\frac{4}{9} \left| \frac{3}{2} \right|^2 = g V_F
\]

\[
1 = g V_F
\]

So second order Fermi-Dirac statistics at \( g V_F = 1 \)
Suitable wavefunction

- Perturbation theory of Slater Determinant
- \( | \psi = 0 \rangle \) with different \( \#s \) of \( \uparrow \) and \( \downarrow \)
- Problem with spin uncertainty
  \[ \langle s_x s_x \rangle > \frac{1}{2} | s_z | \]
  Only ok for unpolarized and fully polarized.
- Jacobi form of \( e^{i \theta} \) allows further correlations to be captured
- Strategy: plot \( E(M) \)
Beyond mean field: Fluctuations increase partition function and lower the energy.

\[ F = -kT \ln Z, \quad Z = \sum_i e^{-\beta E_i} \]

Soft fluctuations Ms are favorable.

Consider the surface

Paramagnet \hspace{1cm} Ferrimagnet

Nematic \hspace{1cm} Spin spiral

Superconductor

First Order
Superconductor pairing between equal spins

\[ \Delta_n = \langle c_n c_{-n} \rangle \quad \text{so} \quad \Delta_n = -\Delta_{-n}, \quad \text{so p-wave} \]
Phase diagram

Paramagnetic

Ferromagnetic

Neutro

Spind
pro + quin
pro + pro
Observation

f-like conduction electrons
screened by s,p to give conduction

Solid state:

CeFePO ——— Sc
U6e2 ——— Sc
Sr3RuO7 ——— Spiral
NbFe2 ——— Spiral

Cold atoms:

Felt-like
Problems with losses
Two body losses with energy going
into few states.
Zaorki, all size clouds

Summary

Seen how juxtaposition of quantum
mechanics and interactions drive new phenomena

Scattering theory

Fermi migration, consequences of interactions