

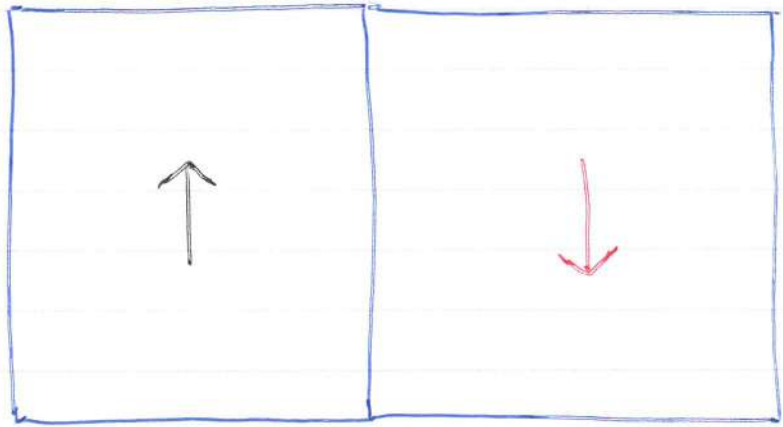
LECTURE 2

← Weak interactions, near Pd
State → System → nucleus

- Strong interactions
 - Possibility for ferromagnetic metals
- New field Stone transition calculations
 - Cold stars language
 - Second order
 - Behaviour with temperature
- Observations:
 - Solid slab
 - Cold stars
- Going beyond non field theory
 - Order by disorder
 - Spin, p-wave
- Polar limit.

Lecture 2

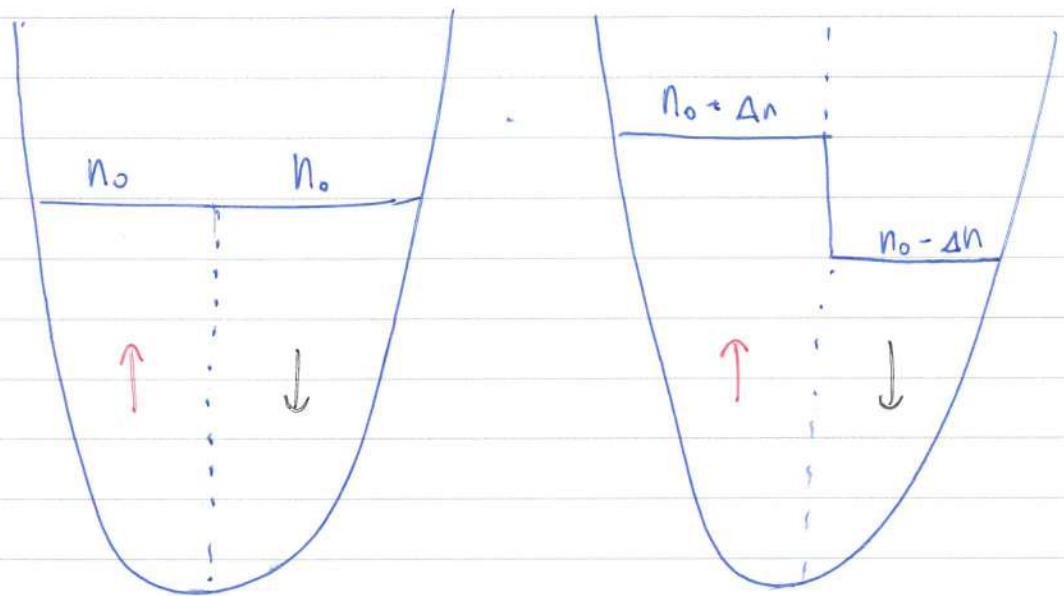
Repulsive interactions : split into domains



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

$$KE \sim n^{2/3} \quad \text{so} \quad \times 2^{2/3}$$

To search for Perovskite transition



$$KE = \int_0^{E_F} E \cdot v_{F0} \sqrt{\frac{E}{E_{F0}}} dE$$

$$= \frac{v_{F0}}{\sqrt{E_{F0}}} \frac{2}{5} E_F^{5/2}$$

$$= \frac{v_{F0}}{\sqrt{E_{F0}}} \frac{2}{5} \left(\frac{3}{2} n \frac{\sqrt{E_{F0}}}{v_{F0}} \right)^{5/2}$$

$$= \left(\frac{\sqrt{E_{F0}}}{v_{F0}} \right)^{3/2} \frac{2}{5} \left(\frac{3}{2} \right)^{5/2} n^{5/2}$$

$$n = \int_0^{E_F} v_{F0} \sqrt{\frac{E}{E_{F0}}} dE$$

$$= \frac{v_{F0}}{\sqrt{E_{F0}}} \frac{2}{3} E_F^{3/2}$$

$$E_F^{3/2} = \left(\frac{3}{2} n \frac{\sqrt{E_{F0}}}{v_{F0}} \right)^{3/2}$$

$$E = \left(\frac{\sqrt{E_{F0}}}{v_{F0}} \right)^{3/2} \frac{2}{5} \left(\frac{3}{2} \right)^{5/2} n^{5/2} \left(|1 + \Delta n|^{3/2} + |1 - \Delta n|^{3/2} \right) + g(n + \Delta n)(n - \Delta n)$$

$$= \left(\frac{\sqrt{E_{F0}}}{v_{F0}} \right)^{3/2} \frac{2}{5} \left(\frac{3}{2} \right)^{5/2} n^{5/2} \left(1 + \frac{1}{2} \frac{5}{3} \frac{2}{3} \Delta n^2 \right) + g n^2 (1 - \Delta n^2)$$

$$= \left(\frac{\sqrt{E_{F0}}}{v_{F0}} \right)^{3/2} \frac{2}{5} \left(\frac{3}{2} \right)^{5/2} n^{5/2} \left(1 + \frac{5}{9} \Delta n^2 \right) + g n^2 (1 - \Delta n^2)$$

look at coefficient of Δn^2 :

$$\left| \frac{\sqrt{E_{F0}}}{V_{F0}} \right|^{2/3} \cdot \frac{4}{8} \cdot \left| \frac{3}{2} \right|^{2/3} \cdot \cancel{n^{2/3}} \cdot \frac{8}{9} = g \cdot \cancel{n^2} \cdot n^{1/3}$$

$$\left| \frac{\sqrt{E_{F0}}}{V_{F0}} \right|^{2/3} \cdot \frac{4}{9} \cdot \left| \frac{3}{2} \right|^{2/3} = g \cdot \left| \frac{V_{F0}}{E_{F0}} \right|^{1/3} \cdot \left| \frac{2}{3} \right|^{1/3} \cdot E_{F0}^{1/2}$$

$$\frac{4}{9} \cdot \left| \frac{3}{2} \right|^2 = g V_{F0}$$

$$1 = g V_{F0}$$

So second order Fermi liquid transition at $g V_F = 1$

Swittele wavefunction

- Perturbation theory o. Slater Determinants
- $\Psi = D_{\uparrow} D_{\downarrow}$ with different #'s of \uparrow and \downarrow
- Problem with spin uncertainty
 - $\langle \Delta S_x \times \Delta S_y \rangle \geq \frac{\hbar}{2} |S_z|$ • Only ok for unpolarized and fully polarized.
- Jordan Form $e^J D_{\uparrow} D_{\downarrow}$ allows further correlations to be captured
- Strategy: plot E(M)

Beyond mean field: fluctuations increase
 partition function \rightarrow lower the energy

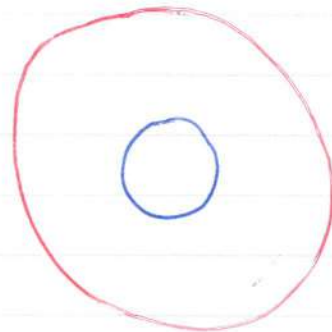
$$F = -kT \ln Z, \quad Z = \sum_i e^{-\beta E_i}$$

Soft fluctuations M_s are favorable
 Consider few surface

Paramagnet

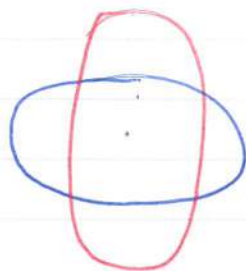


Ferrimagnet



FIRST
ORDER

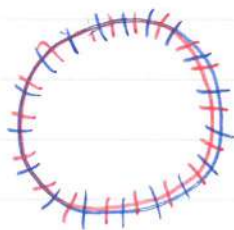
Nematic



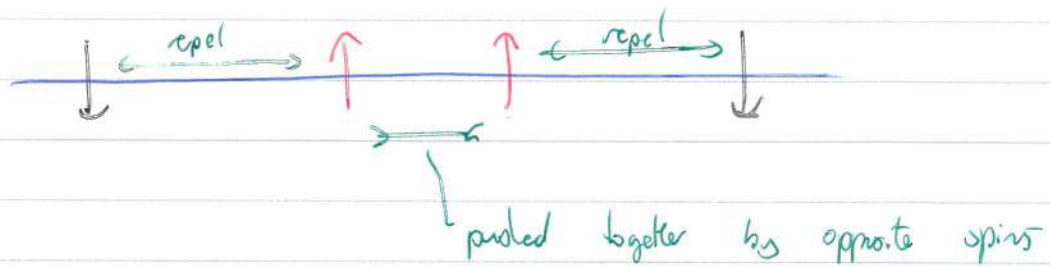
Spin spiral



Superconductors -

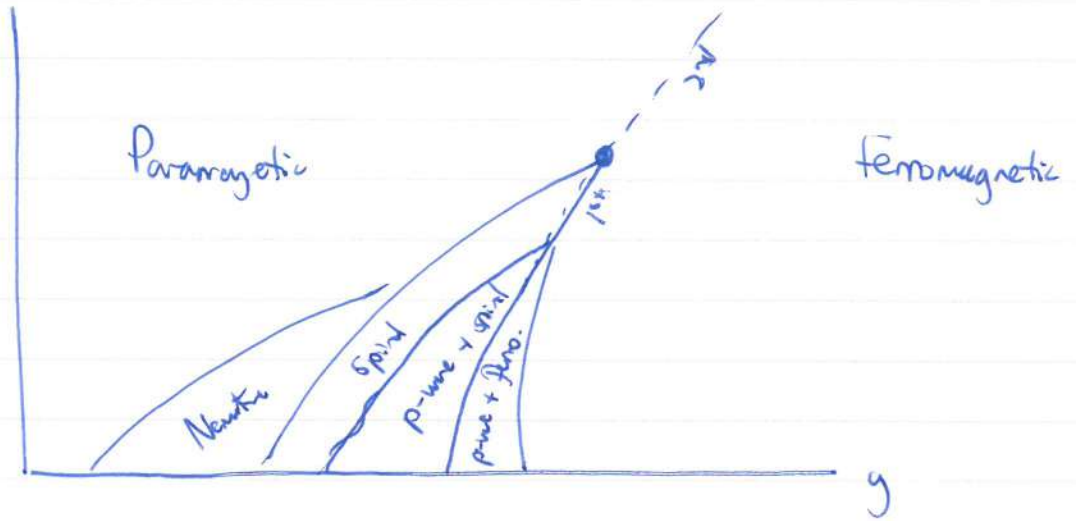


Superconductor pairing between equal spins



$$\Delta_k = \langle C_k C_{-k} \rangle \quad \text{so } \Delta_k = -\Delta_{-k}, \quad \text{so p-wave}$$

Phase diagram



Observation

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

Solid state : CeFePO ——— SC
 UGe_2 ——— SC
 $\text{Sr}_3\text{Ru}_2\text{O}_7$ ——— Spinl
 NbFe_2 ——— Spinl

Cold atoms : Felted
Problems with losses
Two body losses with energy going
into few surface
Zenoit collapse clouds

Summary

Seen low juxtaposition of quantum
mechanics and interactions, drive new phenomena

Scattering theory

Fermionization, consequences of interactions