PHYSICS 621 : Advanced Many Body Theory

- Classes in 287, 12.10 Weds & 2pm Friday.
- Additional Make-up Classes on Mondays, as required. 3.30 Monday?
- Office hour, to be determined. Opportunity to discuss details
- Four assignments.

Introductions
- Background + interests
- Your favorite Equation!
- Areas of Q.C.M you'd like to learn about

Texts
- P.C. Intro to Many Body Physics
- Eduardo Fradkin Quantum Field Theory, an Integrated Approach Ch. 18.
- Subir Sachdev Quantum Phases of Matter. Fractionalization + Emergent Gauge Fields

Traditional Frontiers of Physics: Reductionism.

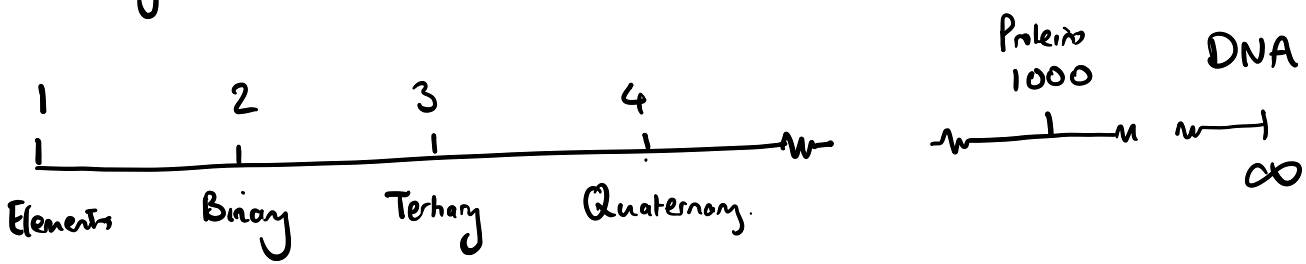
Tremendous appeal of reducing all of nature to its most fundamental elements.

Discovery of antimatter, eight-fold way, quarks ....

But this does not mean that once we have a complete reductionist view we will know everything.

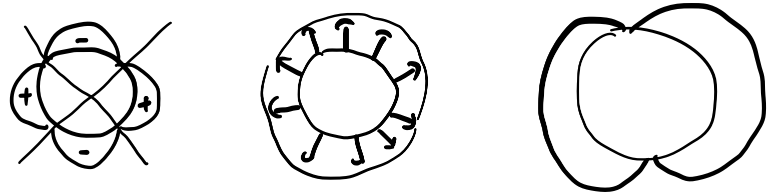
Emergence. Anderson 1967 "More is Different"

Complex systems, matter, develop new emergent properties of a fundamental nature.



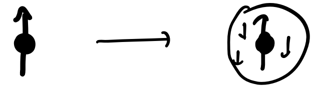
- Pressure
- Heat: Random Energy
- Broken symmetry, gauge symmetry.
- Fractionalization + Emergent Gauge Fields.

Topics In Course



- Anisotropic Pairing + Hi Tc

$$\langle c_{\vec{k}\alpha}\, c_{-\vec{k}\beta} \rangle = \underbrace{\Delta_s(k)}_{\substack{\text{even} \\ l=0,2,4\ldots}} (i\sigma_2)_{\alpha\beta} + \left[\left(\underbrace{\vec{d}(\vec{k})}_{\substack{\text{odd} \\ l=1,3,5\ldots}} \cdot \vec{\sigma} \right) i\sigma_2 \right]_{\alpha\beta}$$

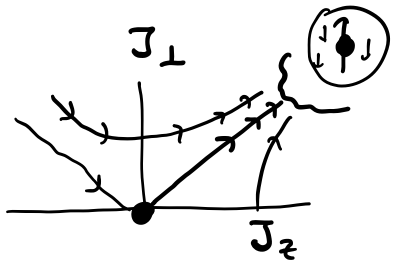


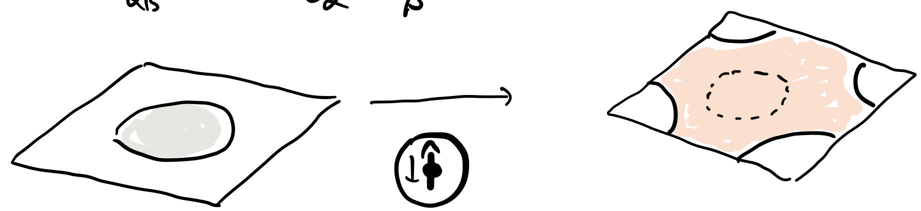
"Kondo effect"

$S_{\alpha\beta} \longrightarrow f^{+}_{\alpha} f_{\beta}$ "Fractionalization"

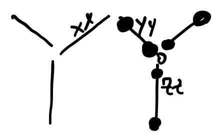
- Heavy Fermions + Kondo Lattice

$J(c^{+}\sigma c)\cdot \vec{S}$



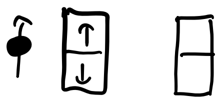


- Z_2 gauge theories + Kitaev Spin Liquids



$$\mathcal{H} = \sum_{x \text{ bonds}} \sigma_i^x \sigma_j^x + \sum_{y \text{ bonds}} \sigma_i^y \sigma_j^y + \sum_{z \text{ bonds}} \sigma_i^z \sigma_j^z$$

$\vec{S}_j \to i a_j \vec{b}_j$



ancillar

$\vec{\chi} = b\vec{\sigma}$

$\vec{\sigma} = -i\vec{\chi}\times\vec{\chi}$

$b = -i2\chi_1\chi_2\chi_3$

$$\boxed{\mathcal{H} = k \sum 2i\, a_i\, u_{ij}\, a_j}$$

$u_{ij} = \pm 1$

$\{a,b\}=0$ $\quad \dfrac{a+ib}{\sqrt{2}} = c$ $\quad a^2 = \tfrac{1}{2}$

$1 = \{a,a\} = \{b,b\}$ $\quad a = a^{+},\ b = b^{+}$ $\quad a, a$

$c^{+}c = \dfrac{(a-ib)(a+ib)}{2}$

$= \tfrac{1}{2} + iab$

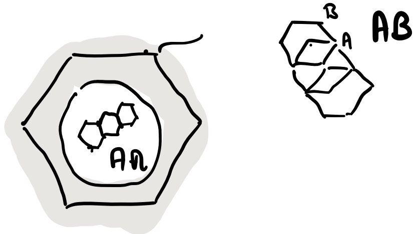
$c^{+}c = 1 \quad 2iab = 1 \quad 4a\chi_1\chi_2\chi_3 = 1 \Rightarrow 2ia\vec{\chi} = \vec{\sigma} \Rightarrow$

$\sigma_i^\alpha \sigma_j^\alpha$

$= (2ia_i a_j)$

$\times (2i\chi_i^\alpha \chi_j^\alpha)$

- Twisted Bilayer Graphene



Moiré Unit Cell.