$$\begin{vmatrix} \Psi_1^{(1)} & \Psi_2^{(1)} & \Psi_3^{(1)} & \Psi_4^{(1)} \\ \vdots & & & \vdots \\ \Psi_1^{(4)} & \cdots & \cdots & \Psi_4^{(4)} \end{vmatrix}^3 = \epsilon_{\mu\nu\alpha\beta}\, \Psi_1^{(\mu)} \Psi_2^{(\nu)} \Psi_3^{(\alpha)} \Psi_4^{(\beta)}$$

$$\Downarrow \qquad (\cancel{3,0) \otimes} (3,0)$$

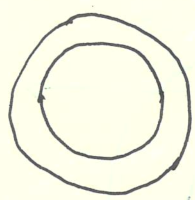
$$\cancel{\epsilon_{\alpha_1}\epsilon_{\alpha_2}\epsilon_{\alpha_3}} \quad \epsilon_{\alpha_1\alpha_2\alpha_3\alpha_4}\, \epsilon_{\alpha_5 \cdots \alpha_8}\, \epsilon_{\alpha_9 \cdots \alpha_{12}} =$$

· ^{3}He – A phase:

$$H(k) = \left(a^+_{k\uparrow} \quad a^+_{-k\uparrow} \quad a_{k\uparrow} \quad a_{-k\downarrow} \right) \begin{pmatrix} \epsilon_k - \mu & \Delta_{\sigma\sigma'}(k) \\ \Delta_{\sigma\sigma'}(k) & -(\epsilon_k - \mu) \end{pmatrix}$$

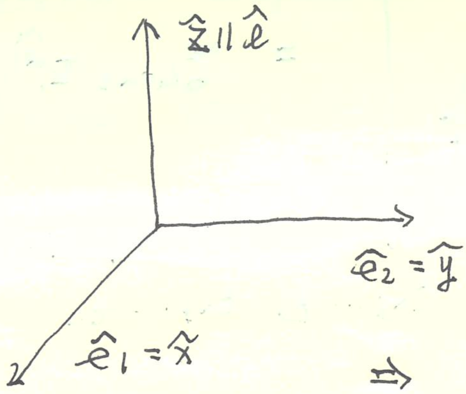
$$\Delta_{\sigma\sigma'}(k) = \Delta(k)\, d_\mu\, (\sigma_\mu i \sigma_2)_{\sigma\sigma'}$$

^{3}He – B: $\quad d(k) = \delta_{\mu a} \hat{k}_a, \qquad d(k) \,/\!/\, \hat{k}$



B · { Anderson
Lev. Landau

^{3}He – A: $\quad \Delta(k) = \Delta e^{i\theta}\, \hat{d}_\mu \left((\hat{e}_1 + i \hat{e}_2) \cdot \hat{k} \right)$



$\hat{e}_1 = \hat{x} \quad \hat{e}_2 = \hat{y}$

$$\Rightarrow \Delta_{\sigma\sigma'}(k) = \Delta e^{i\theta}(k_x + ik_y)$$

$$\left(\hat{d}_\mu \cdot (\sigma_\mu i \sigma_2)_{\sigma\sigma'}\right)$$

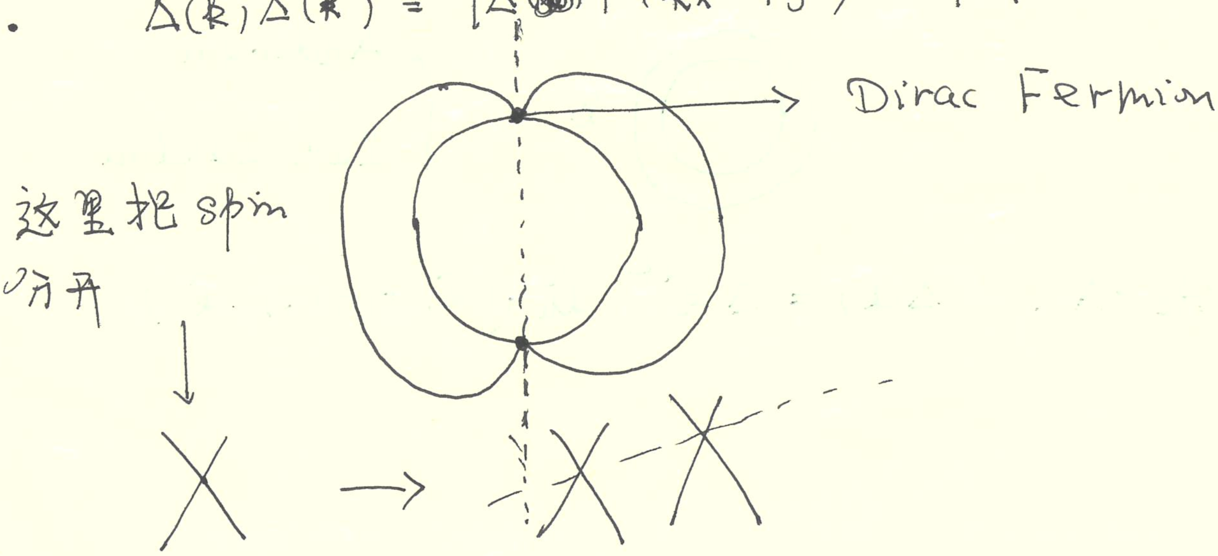
p_z 轨道没有涨落，局在 xy 平面内：

- Highest weight state：

中间的态是 most Quantum，实轨道有指向性；复轨道有指向性；

所以 d-vector 是 $\Gamma+4$？：

- $\Delta^+(k)\Delta(k) = |\Delta|^2(k_x^2+k_y^2) = |\Delta|^2 \sin^2\theta_k$



Xin Jiang Zhou:

$$\begin{pmatrix} \varepsilon_{k\uparrow}-\mu & V \\ V & \varepsilon_{k\downarrow}-\mu \end{pmatrix} \quad ☆$$

我最怕大家年纪轻轻的像得道高僧一样。

4×4 matrix

unitary parity

什么意思

non-unitary parity:

1: Bogoliubov - de - Gennes Equation

$$H = \int dx\, \Psi^{+}(x)\left(-\frac{\hbar^2}{2m}\nabla^2 + V(r)\right)\Psi(x)$$

$$- g\, \Psi_{\uparrow}^{+}(r)\, \Psi_{\downarrow}^{+}(r)\, \Psi_{\downarrow}(r)\, \Psi_{\uparrow}(r)$$

$$\Delta(r) = -g\langle \Psi_{\downarrow}(r)\Psi_{\uparrow}(r)\rangle$$

Grand state at finite T

做平均场

Important: $\Delta^T(r) = -\Delta(r)$

$$H_{MF} = \int dx\, \Psi_\sigma^\dagger(x)\, h_{\sigma\sigma'}\, \Psi_{\sigma'}(x) + \Psi_\uparrow(x)\Psi_\downarrow(x)\Delta(r)$$

$$+ \Delta^\dagger(r)\Psi_\downarrow(r)\Psi_\uparrow(r) - \frac{1}{g}\Delta^\dagger(r)\Delta(r)$$

$$= \int dr \begin{pmatrix} \Psi_\uparrow^\dagger(r) & \Psi_\downarrow(r) \end{pmatrix} \begin{pmatrix} h_\sigma(r) & \Delta \\ \Delta & -h_\sigma^T(x) \end{pmatrix} \begin{pmatrix} \Psi_\uparrow(r) \\ \Psi_\downarrow^\dagger(r) \end{pmatrix}$$

给你一个正确的题目

犯错的时候拉你的一把

$$\Psi(r) = \begin{pmatrix} \Psi_\uparrow(r) \\ \Psi_\downarrow^\dagger(r) \end{pmatrix} = \sum_n \begin{pmatrix} u_n & -v_n^* \\ v_n & u_n^* \end{pmatrix} \begin{pmatrix} a_n \\ a_{-n}^\dagger \end{pmatrix}$$

$$H_{bdg}(r) = \begin{pmatrix} h_0(\vec{r}) & \Delta(r) \\ \Delta^\dagger(r) & -h_0(r) \end{pmatrix}$$

$$\Rightarrow \begin{pmatrix} h_0(r) & \Delta(r) \\ \Delta^\dagger(r) & -h_0(r) \end{pmatrix} \begin{pmatrix} u_n \\ v_n \end{pmatrix} = E \begin{pmatrix} u_n \\ v_n \end{pmatrix}$$

symmetric solution

$\boxed{\text{Yu shiba}}$

$\boxed{\text{电荷共轭解}}$

$$\begin{pmatrix} u_n \\ v_n \end{pmatrix} \longrightarrow \begin{pmatrix} -v_n^* \\ u_n^* \end{pmatrix}$$

$$\Downarrow$$

$$\boxed{C = K(i\sigma_y)}$$

triplet: $\Delta^T(r) = -\Delta(r)$

Bdg equation to triplet:

- Spinless - p - wave

$$H = \int dx\, \Psi^\dagger(r)\left(-\frac{\hbar^2\nabla^2}{2m} - \mu\right)\Psi(r) - g\,\Psi^\dagger(r)\,\Psi^\dagger(r)\,\Psi(r)\,\Psi(r)$$

$$\lim_{a\to 0} \Psi(r)\Psi(r+a) = \lim_{a\to 0} \cancel{\Psi(r) +} \Psi(r)\frac{(\Psi(r+a) - \Psi(r))}{a}\cdot a$$

$$= \Psi(r)\,\partial_r\Psi(r)$$

$$\Downarrow$$

$$H = \int dx\, \Psi^\dagger(r)\left(-\frac{\hbar^2\nabla^2}{2m} + V(r)\right)\Psi(r) - g\,\Psi^\dagger(x)\, i\partial_x\,\Psi(x)$$

$\Psi(r)\, i\,\partial_x\Psi(r)$

$$\Delta = -g\,\Psi(r)\, i\,\partial_r\Psi(r)$$

$$= \int dr\left(\Psi^\dagger(r)\right) h(r)\,\Psi(r) + \underline{\Psi(\vec{x})\, i\,\partial_x\Psi^\dagger\,\Delta}$$

$$\Downarrow$$

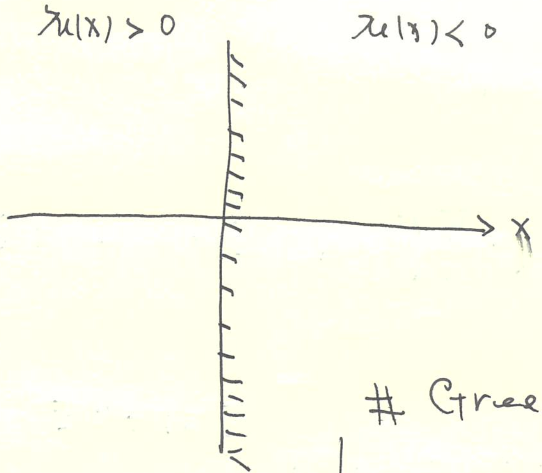
$$\Psi^\dagger(x)\, i\,\partial_x\,\Delta\,\Psi^\dagger$$

$$\Downarrow$$

$$\frac{\partial_x\Delta + \Delta\,\partial_x}{2}$$

我们并不是宇宙的中心.

Solution: for edge modes: $(p+ip)$ 2D



Green - p wave pairing

$$\begin{pmatrix} h_0(r) & \frac{\Delta}{k_F}(-i\partial_x + i k_y) \\ \frac{\Delta}{k_F}(-i\partial_x +) & -h_0(r) \end{pmatrix} \begin{pmatrix} \Psi(r) \\ \Psi^\dagger(r) \end{pmatrix}$$

y方向是空间不均匀的

$$\Downarrow$$

$$\begin{pmatrix} \Psi(x,k_y) & \Psi^\dagger(x,-k_y) \end{pmatrix} \begin{pmatrix} h_0(x,k_y) & \frac{\Delta}{k_F}(-i\partial_x) \\ \frac{\Delta}{k_F}(-i\partial_x) & -h_0(x,k_y) \end{pmatrix}$$

Let: $\begin{pmatrix} \Psi(x,y) \\ \Psi^\dagger(x,y) \end{pmatrix} = \begin{pmatrix} u_n(x) \\ v_n(x) \end{pmatrix} e^{ik_n y}$

$$\Rightarrow \begin{pmatrix} h_0(x,k_y) & \frac{\Delta}{k_F}(-i\partial_x + i k_y) \\ \frac{\Delta}{k_F}(-i\partial_x - i k_y) & -h_0(x,k_y) \end{pmatrix} \begin{pmatrix} u_n \\ v_n \end{pmatrix} = E_n \begin{pmatrix} u_n \\ v_n \end{pmatrix}$$

$$\Rightarrow \begin{pmatrix} -\mu(x) & \frac{\Delta}{k_F}(-i\partial_x + i k_y) \\ \frac{\Delta}{k_F}(-i\partial_x + i k_y) & -\mu(x) \end{pmatrix} \begin{pmatrix} u_n \\ v_n \end{pmatrix} = E_n(k_y) \begin{pmatrix} u_n \\ v_n \end{pmatrix}$$

Research 要有 belief

$$\begin{cases} -\mu(x)\, u_n + \frac{\Delta}{k_F}(-i\partial_x v_n + i k_y v_n) = E_n(k_y)\, u_n \\ \frac{\Delta}{k_F}(-i\partial_x u_n - i k_y u_n) + \mu(x)\, v_n = E_n(k_y)\, v_n \end{cases}$$

只能在西湖大学做一个中流的物理学家