$$\hat{\mathcal{H}} = \lambda \sum_1^N \sigma_z^i + J_y \sum_1^{N-1} \sigma_y^{i+1} \sigma_y^i + J_x \sum \qquad J_z \sum$$

$$\langle \psi | \hat{\mathcal{H}} | \psi \rangle = \lambda \sum_1^N \langle \psi_i | \sigma_z^i | \psi_i \rangle$$
$$+ \sum_1^3 J_j \sum_1^{N-1} \langle \psi_{i+1} | \sigma_j^{i+1} | \psi_{i+1} \rangle$$
$$\cdot \langle \psi_i | \sigma_j^i | \psi_i \rangle$$

$\lambda \sim 0 \quad J_j > 0 \quad \uparrow \downarrow \uparrow \downarrow$

$$\langle \psi_i | \sigma_j | \psi_i \rangle = - \langle \psi_{i+1} | \sigma_j | \psi_{i+1} \rangle$$

$$\langle \psi | \hat{\mathcal{H}} | \psi \rangle = \lambda \sum_1^N \underbrace{\langle \psi_i | \sigma_z | \psi_i \rangle}_{z} - \left(\sum_1^3 J_j \right) \sum_1^{N-1} \langle \psi_i | \sigma_j | \psi_i \rangle^2$$

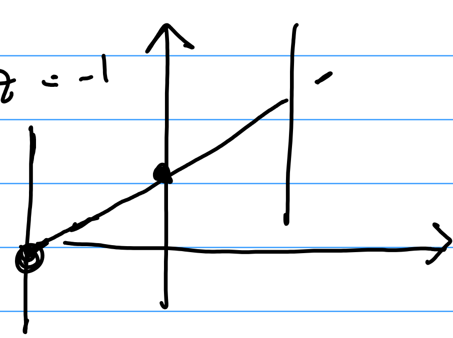
$J_j = \bar{J} \quad \forall j$

$$\lambda \sum_1^N z - \bar{J} \sum_1^{N-1} (x^2 + y^2 + z^2) \qquad x^2 + y^2 + z^2 = 1$$

$\lambda z - \bar{J} = \mathcal{E}$

$z = +1$

$z = -1$



$\mathcal{E} = \lambda z - \bar{J}$

$\mathcal{E}_0 = -\lambda - \bar{J}$

$\mathcal{E}_0 \approx - \bar{J}$

$$\mathcal{H} = \lambda \langle \psi_i | \sigma_z | \psi_i \rangle + \sum_{1}^{3} J_j \sum \langle \psi_i | \sigma_j | \psi \rangle \cdot \langle \psi_{i+1} | \sigma_j | \psi_{i+1} \rangle$$

$\lambda \to \hat{z}$ $\quad \uparrow\uparrow\uparrow \quad$ $J_j > 0$ $\quad \cancel{\downarrow\uparrow\downarrow\uparrow}\downarrow \quad \uparrow\uparrow\uparrow \; \uparrow$

$\rightarrow \leftarrow \rightarrow \leftarrow \rightarrow$

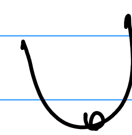
$$\psi_i^z = \psi_{i+1}^z$$

$\lambda >> 0$

$$\mathcal{E} = \lambda z - J \left(x^2 + y^2 - z^2 \right)$$

$$\lambda z - J \left(1 - z^2 - z^2 \right)$$

$$\mathcal{E} = +2J z^2 + \lambda z - J$$



$$\frac{\partial \mathcal{E}}{\partial z} = 4 J z + \lambda = 0$$

$$z = -\frac{\lambda}{4J} \qquad -1 < z < 1$$

$$\mathcal{E}_0 = 2J \frac{\lambda^2}{16 J^2} - \frac{\lambda^2}{4J} - J$$

$$\mathcal{E}_0 = +2J - \lambda - J$$

$$= J - \lambda$$