49. DMFT et transition de Mott

1. Impureté quantique
2. Ising portée ∞
3. $\Sigma(\omega)$ en $d=\infty$
4. Transition de Mott
5. Isolant de Mott dopé

VII - Symétrie brisée

50. Interactions faibles, ferromagnétisme de Stoner

$n \ll 1$

1. Arguments simples
2. Ψ variationnelle
3. Feynman variationnel
4. Équ. du gap, théorie de Landau
5. Fonction de Green

51. Instabilité de la phase normale

1. Cas sans interaction, Inv. sous rotation
2. Avec interactions
3. χ, S et paramagnons
4. Modes collectifs, Théorème de Goldstone, Mermin-Wagner, stabilité
   1. χ transversale
   2. Thermodynamique + M.W.
   3. Kanamori-Brueckner

59. AFM près du demi-remplissage

1. Pseudogap et régime classique renormalisé
2. Pseudogap, dopés aux électrons

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$$\underbrace{-\frac{t^*}{\sqrt{d}} \sum_{\langle ij \rangle} \underbrace{c^\dagger_i c_j}}\; + \; U \sum_i n_{i\uparrow} n_{i\downarrow}$$

i,j premiers voisins

$$\boxed{|\langle c^\dagger_i c_j \rangle|^2 \propto \frac{1}{d}}$$

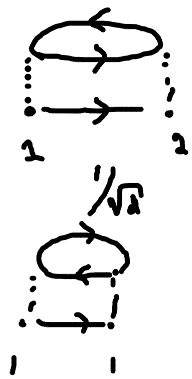
$$\langle c^\dagger_i c_j \rangle \propto \frac{1}{\sqrt{d}}$$

$$\frac{t^* \sqrt{d}}{d} \sum \frac{1}{\sqrt{d}}$$

$$- t \sum_{ij} c^\dagger_i c_j$$

$$N(\omega) \propto e^{-\left(\frac{\omega}{2t\sqrt{d}}\right)^2}$$

$\Sigma(\omega)$



$\propto \frac{1}{\sqrt{d}^{3}}$

49.3 Autocohérence

$$\mathcal{G}(k, ik_n) = \frac{1}{ik_n - (\epsilon_k - \mu) - \Sigma(\omega)}$$

$$\mathcal{G}_{ii}(ik_n) = \int \frac{d^dk}{(2\pi)^d}\, \mathcal{G}(k, ik_n)$$

$$= \int \frac{d^dk}{(2\pi)^d} \int d\epsilon\, \delta(\epsilon - (\epsilon_k - \mu)) \frac{1}{ik_n - \epsilon - \Sigma(ik_n)}$$

$$\mathcal{G}^{IAM}_{ii}(ik_n) = \int d\epsilon\, N(\epsilon) \frac{1}{ik_n - \epsilon - \Sigma(ik_n)}$$

$$\boxed{\mathcal{G}^{0\,-1}_{ff}\,\mathcal{G}_{ff} = 1 + \Sigma\,\mathcal{G}_{ff}}$$

$$\left(\mathcal{G}^{0\,-1}_{ff} - \Sigma\right)\mathcal{G}_{ff} = 1$$

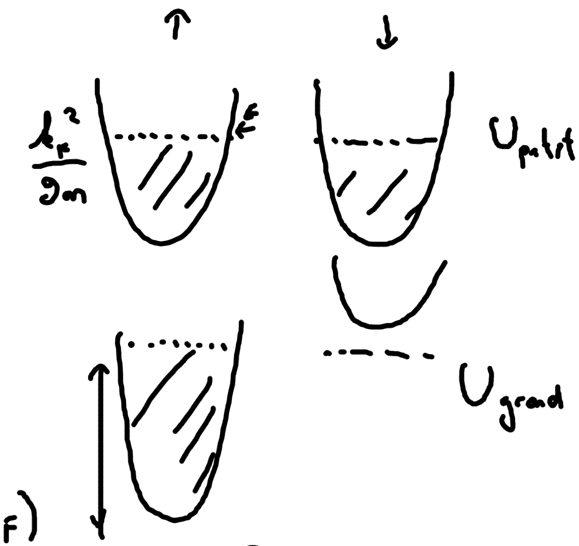
$$\mathcal{G}^{-1}_{ff} = \mathcal{G}_0^{-1} - \Sigma$$

où $\mathcal{G}^{0\,-1}_{ff} = ik_n - (\epsilon - \mu) - \underbrace{\sum_k \frac{V_{ik}^* V_{ki}}{ik_n - (\epsilon_k - \mu)}}_{\Delta(ik_n)}$

$-\Delta(ik_n)$

50.1 Stoner

$n \ll 1$ $\qquad U\, n_{i\uparrow} n_{i\downarrow}$



$$\epsilon_{k_{F\uparrow}} + U\langle n_\downarrow\rangle = \epsilon_{k_{F\downarrow}} + U\langle n_\uparrow\rangle$$

$$\underbrace{\left(\epsilon_{k_{F\uparrow}} - \epsilon_{k_{F\downarrow}}\right)} = U\left(\underbrace{\langle n_\uparrow\rangle - \langle n_\downarrow\rangle}\right)$$

$$1 = U \frac{\partial n}{\partial \epsilon_{k_F}} = U N(\epsilon_F)$$

$$n = \int_0^{\epsilon_{k_F}} N(\epsilon)\, d\epsilon$$

50.2 Ψ variationelle

$$|\Psi\rangle = \prod_{k\uparrow} \theta(|k_{F\uparrow}| - k) \prod_{k'\downarrow} \theta(k_{F\downarrow} - k') \, c^{+}_{k\uparrow} c^{+}_{k'\downarrow} |0\rangle$$

$$\langle\Psi|H|\Psi\rangle$$

50.3 Feynman

$$F \leq F_0 + \langle H - H_0 \rangle_0$$

$$\tilde{H}_0 = \sum_{k\sigma} \epsilon_{k\sigma} c^{+}_{k\sigma} c_{k\sigma} + U \sum_i \left(n_{i\uparrow} \langle n_{i\downarrow} \rangle + n_{i\downarrow} \langle n_{i\uparrow} \rangle \right)$$

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50.5 Fonctions de Green

$$\tilde{H}_0 = \sum_{k\sigma} \tilde{\epsilon}_{k\sigma} c^{+}_{k\sigma} c_{k\sigma}$$

$\tilde{\Sigma} =$  $= 0$

$$U\langle n_{-\sigma}\rangle + \epsilon_{k\sigma} - \tilde{\epsilon}_{k\sigma} = 0 \qquad \tilde{\epsilon}_{k\sigma} = \epsilon_{k\sigma} + U\langle n_{-\sigma}\rangle$$

$$\mathcal{G}_\sigma(k, ik_n) = \frac{1}{ik_n - (\epsilon_k + U\langle n_{-\sigma}\rangle - \mu)}$$

$$\langle n_\sigma \rangle = \frac{1}{N}\sum_k f(\xi_k + U\langle n_{-\sigma}\rangle)$$

50.4 Ginzburg - Landau

$m = \langle n_\uparrow \rangle - \langle n_\downarrow \rangle \qquad n = \langle n_\uparrow \rangle + \langle n_\downarrow \rangle$

$$\boxed{m = \langle n_\uparrow \rangle - \langle n_\downarrow \rangle = \frac{1}{N}\sum_k \left[f\left(\xi_k + U\frac{n}{2} - U\frac{m}{2}\right) - f\left(\xi_k + U\frac{n}{2} + U\frac{m}{2}\right)\right]}$$

$$m = \frac{1}{N}\sum_k \frac{\partial f}{\partial \xi_k}(-Um) + O(m^3)$$

$$m = \left[\int \frac{d^d k}{(2\pi)^d}\left(-\frac{\partial f}{\partial \xi_k}\right)\right] U m + b m^3 = \left[N(\epsilon_k) U\right] m + b m^3$$

$$\boxed{\left[1 - U N(\epsilon_{k_F})\right] m = b\, m^3} \qquad \boxed{b = \frac{N''}{24} - \frac{(N')^2}{8N} < 0}$$

Si $m \neq 0 \qquad \epsilon_{k\uparrow} - \epsilon_{k\downarrow} = Um = \Delta$

$$\boxed{\langle n_\uparrow \rangle + \langle n_\downarrow \rangle = \frac{1}{N}\sum_k \left[f\left(\xi_k + U\langle n_{-\sigma} \rangle\right) + f\left(\xi_k + U\langle n_{-\sigma} \rangle\right)\right]}$$

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51. Instabilité de la phase normale

1. Cas sans interaction + Inv. sous rotation

$$\frac{\delta\langle S_z\rangle}{\delta h} = \chi_0$$

$$\langle S_z S_z\rangle = \langle S_x S_x\rangle = \langle S_y S_y\rangle$$

$$S_+ = c^\dagger_\uparrow c_\downarrow = S_x + iS_y \qquad S_x = \frac{S_+ + S_-}{2} \qquad S_y = \frac{S_+ - S_-}{2i}$$

$$S_- = S_x - iS_y$$

$$\langle S_+S_-\rangle + \langle S_-S_+\rangle = \langle (S_x+iS_y)(S_x-iS_y)\rangle + \langle (S_x-iS_y)(S_x+iS_y)\rangle$$

$$= 2\langle S_xS_x\rangle + 2\langle S_yS_y\rangle = 4\langle S_zS_z\rangle$$

5.1.2 Instabilité de phase normale.

$$\chi^{zz} = \frac{\chi_0}{1 - \frac{U}{2}\chi_0} \qquad 1 = \frac{U}{2}\chi_0(0,0)$$

$$\chi_0 = -2\sum_k \frac{f(\zeta_{k+q}) - f(\zeta_k)}{\zeta_{k+q} - \zeta_k}$$

$$\chi_0(0,0) = 2N(\epsilon_F)$$

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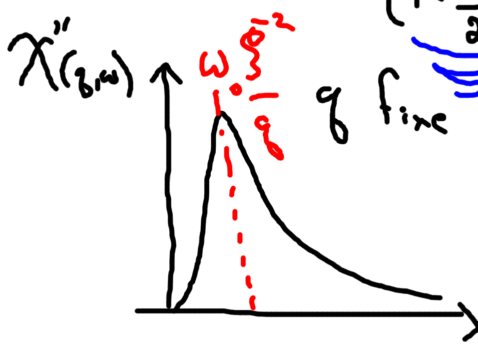
51.2 Paramagnons

$$\chi''(q,\omega) = \frac{\chi_0''(q,\omega)}{\left(1-\frac{U}{2}\chi_0'\right)^2 + \left(\chi_0''(q,\omega)\right)^2}$$



Paramagnon

$$\boxed{\frac{1}{\xi^{-2} + cq^2 - \frac{i\omega}{\omega_0}}}$$