DATE

Topo QFT (II) → RG

RG 重整化群
- BKT相变
- KPZ相变 (Kardar - Parisi - Zhang)
- spin Glass
- Gauge Potentice (规范式)
- Bosorization
- Fermi lique

CFT

书: Peskin QFT

X G Wen QFT

A. zee (徐.沼): QFT in a nutshell

Kardar (KPZ): statistical phys of field → $\boxed{RG}$

Fradkin: QFT

shanker (适合)

Kerson Huang: 统计物理 → RG

作业 50% (1次/1月)

project + preserentation 50%

1) QFT = QM + SR (量子力学 + 相对论)

= QM + ∞ 自由度 (连续)

cond' matt'

2) QFT vs many-body phys

path-integral (Green's function

主要处理发散 ↓ Feynman diag

β-function ↓ self-energy)

g(Λ) 能标 $\Lambda = k_B T$ Finite (无发散)

$\Lambda = \theta$。 $k \sim \frac{\pi}{a}$ (动量截断)

相同：多体相互作用.

Weinberg 1997 : What is QFT: and what did we think it is

QFT : QM of field

☆ field (场) $f(x)$, $\vec{v}(\vec{x})$, $\vec{E}(\vec{x})$, $\vec{B}(\vec{x})$

$\vec{x}$ 连续的函数

Faraday $\vec{F} = e\vec{E}$

早期 { 基本粒子
场 → photon 量子化
⇓
$\boxed{\text{QED}}$ 精细结构劈裂 $\Delta E \to \infty$ $\alpha = \frac{1}{137}$
↓ Lamb 移位

发散广泛存在☆

1954 Gellman-law $m_0 = m_R + \delta m$

1972 Wilson 重整化群 ⇒ RG

背景：二次量子化

$\begin{cases} \text{second quantization} \\ \text{Canonized quantization (正则量子化)} \end{cases}$

☆ 一次量子化 = 算子量子化

= = wf（波函）量子化 （不对，形式上一致）

Weinberg：should be baned.

量子化：$[x, p] = i\hbar$ ，$p = i\hbar\frac{\partial}{\partial x}$

Who need it？ 1) 粒子物理

2) cond' matt'

RG ⟹ 3) $\begin{cases} \text{P.D. Gennes (liquid crystal)} \\ \text{Parisi: spin Glass} \end{cases}$

液晶物理、复杂性系统

动力学重整化群

类比于固体物理中谐振子系统，有多体相互作用的气场

Chap I：Marriage of QM and SR = QFT

例：离散 $L = \frac{1}{2}m\sum_a \dot{q}_a^2 - \frac{1}{2}\sum_{ab} k_{ab} q_a q_b - \frac{1}{3}\sum_{abc} g_{abc} q_a q_b q_c$

连续化

$= \sum_a \frac{p_a^2}{2m} \Longleftrightarrow [q_a, p_b] = i\hbar\delta_{ab}$

（声子场）

场

来源.

标准作法： 离→连

$\int f(x)dx = \Delta x \sum_i f(x_i) = \Delta x \sum_i f_i$

$\sum_a \dot{q}_a^2(t) = \frac{1}{\Delta x}\int \dot{q}^2(x,t)dx = \int \dot{\phi}^2(x,t)dx$

坐标空间

定义：$q(x,t) = \phi(x,t)\sqrt{\Delta x}$

① 动能 $T = \frac{1}{2}m\int \dot{\phi}^2(x,t)dx$

$= \frac{1}{2}m\int \left(\frac{\partial\phi}{\partial t}\right)^2 dx$

连续化后的

物理意义：$\begin{cases} q_a(t): \end{cases}$ a点（a原子）位移　　$q_a(t) \in \mathbb{R}$ (实数)

$\dot{q}_a(t)$: a点速度

$\begin{cases} \phi(x,t) \Rightarrow \text{x点位移} \in \mathbb{R} \\ \dot{\phi}(x,t) \Rightarrow \dots \text{速度} \end{cases}$

位移（可量子化）

$$[q_a, p_b] = i\hbar\delta_{ab} \xrightarrow[\text{量子化.}]{\text{变化}} [\phi(x,t), \overset{\text{特定}}{\psi}(y,t)] = i\hbar\delta_{xy}$$

② 势能　—o—o—o—　一维系统

$$V = \frac{1}{2}k\sum_a q_a q_{a+1} = \frac{1}{2}k\Delta x\sum_a \phi(x_a,t)\,\phi(x_{a+1},t)$$

$$q_a = \sqrt{\Delta x}\,\phi(x_a,t)$$

$$= \frac{1}{2}k\Delta x \cdot \frac{1}{\Delta x}\int \phi(x,t)\phi(x+a,t)dx$$

$$= \frac{1}{2}k\int \phi(x,t)\,\phi(x+a,t)dx$$

$$\phi(x\pm\tfrac{a}{2},t) = \phi \pm \tfrac{a}{2}\left(\frac{\partial\phi}{\partial x}\right)$$

$$= \frac{1}{2}k\int \phi(x-\tfrac{a}{2},t)\,\phi(x+\tfrac{a}{2},t)dx$$

$$= \frac{1}{2}k\int\left[\phi^2(x,t) - \frac{a^2}{4}\left(\frac{\partial\phi}{\partial x}\right)^2\right]dx.$$

离→连　$\mathcal{L}^{\text{density}} = \frac{m}{2}\left(\frac{\partial\phi}{\partial t}\right)^2 - \frac{k}{2}\left[\phi^2 - \frac{a^2}{4}\left(\frac{\partial\phi}{\partial x}\right)^2\right]$

$$L = \int \mathcal{L}\,dx$$

$$S = \int L\,dt = \int \mathcal{L}\,dx\,dt \quad \text{拓扑}$$

☆：ϕ：振幅 ↔ x

$$\frac{\partial^2}{\partial t^2}\phi = A\frac{\partial^2\phi}{\partial x^2} \quad \text{弦振动波函数}.$$

$$\mathcal{L} = \frac{m}{2}\dot{x}_i^2 - \frac{1}{2}k\sum_i x_i x_{i+1}$$

x_i : x在i点的位移　　$x_i = \phi(x - x_i)$

物理量间相互共轭：热力学　$dU = -pdV + TdS$

$\begin{cases} P - V \\ T - S \end{cases}$