

Title: Lecture - QFT I, PHYS 601

Speakers: Gang Xu

Collection/Series: Quantum Field Theory I (Core), PHYS 601, October 7 - November 6, 2024

Subject: Condensed Matter, Particle Physics, Quantum Fields and Strings

Date: October 24, 2024 - 9:00 AM

URL: <https://pirsa.org/24100033>

Canonical Quantization

① Weyl Lagrangian

The interaction trilogy

- 1) what kind of interaction
- 2) LSZ - Dyson - Wick
- 3) Rules

1) Quantization

Dan's recipe

$$1) \mathcal{L} = \bar{\psi} (i \not{\partial} - m) \psi$$

$$2) \pi = \frac{\partial \mathcal{L}}{\partial \dot{\psi}} = i \psi^\dagger$$

$$④ \underline{\psi: \text{complex} \times 4}$$

1 d classical particle

phase space

$$\text{dof} = \frac{1 + 1}{2} = 1$$

$$\frac{8+0}{2} = 4$$

$$H = \psi^\dagger \left(-i\gamma^0 \gamma^i \partial_i + m\gamma^0 \right) \psi$$

$$\psi = (m - \not{\partial}) \psi$$

④ ψ : complex $\times 4$

1 d classical particle

phase space

$$\text{dof} = \frac{1 + 1}{2} = 1$$

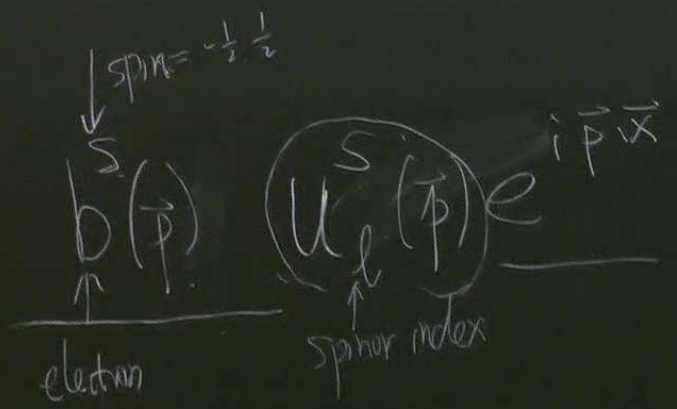
$$= i \psi^\dagger \not{\partial} \psi$$

ψ

mode expansion

$$\psi(\vec{x}, t=0) = \int dV_p \psi_p$$

↑
spinor index



$$\psi = u e^{-i p \cdot x}$$

$$+ c^{*s}(\vec{p}) v_l^s(\vec{p}) e^{-i \vec{p} \cdot \vec{x}}$$

↑
positron

$$H = \int dV_{\vec{p}} E_{\vec{p}} (b^{*s}(\vec{p}) b^s(\vec{p}) - c^s(\vec{p}) c^{s*}(\vec{p}))$$

$$\hat{H} = \int dV_{\vec{p}} E_{\vec{p}} \left(\begin{array}{c|c} \downarrow \text{promotion} & \\ \hline b_{\vec{p}}^{+s} & b_{\vec{p}}^s \\ \hline & -c^s(\vec{p}) c_{\vec{p}}^{st} \end{array} \right)$$

$$- \left([c_{\vec{p}}^s, c_{\vec{p}}^{st}] + c_{\vec{p}}^{st} c_{\vec{p}}^s \right)$$

$$H = \int dV_{\vec{p}} E_{\vec{p}} \left(b_{\vec{p}}^{+s} b_{\vec{p}}^s - c_{\vec{p}}^{st} c_{\vec{p}}^s \right) = \int dV_{\vec{p}} E_{\vec{p}} (N_b - N_c)$$

$$H = \int dV_p E_p \left(\underbrace{b_p^{+s} b_p^s + c_p^{+s} c_p^s}_{N_b + N_c} - c_p^{+s} c_p^s - c_p^s c_p^{s+} \right)$$

$$= \int dV_p E_p (N_b + N_c)$$

$$+ \int dV_p E_p (- \{ c_p^s, c_p^{s+} \})$$

Dirac field
is fermion

normal ordering

$$:C_P^S C_P^{+S}: = -C_P^{+S} C_P^S$$

Causality

$$O_1 = \bar{\Psi}_a \Gamma_{ab} \Psi_b$$

spacelike $[O_1, O_2] = 0$

$$\bar{\Psi}_a \{ \Psi_b, \Psi_c \} \Psi_d$$

$\int b. \delta^3(x-y) D(x-y)$