

Particle physics seminar

Chapter 1 ~ 2

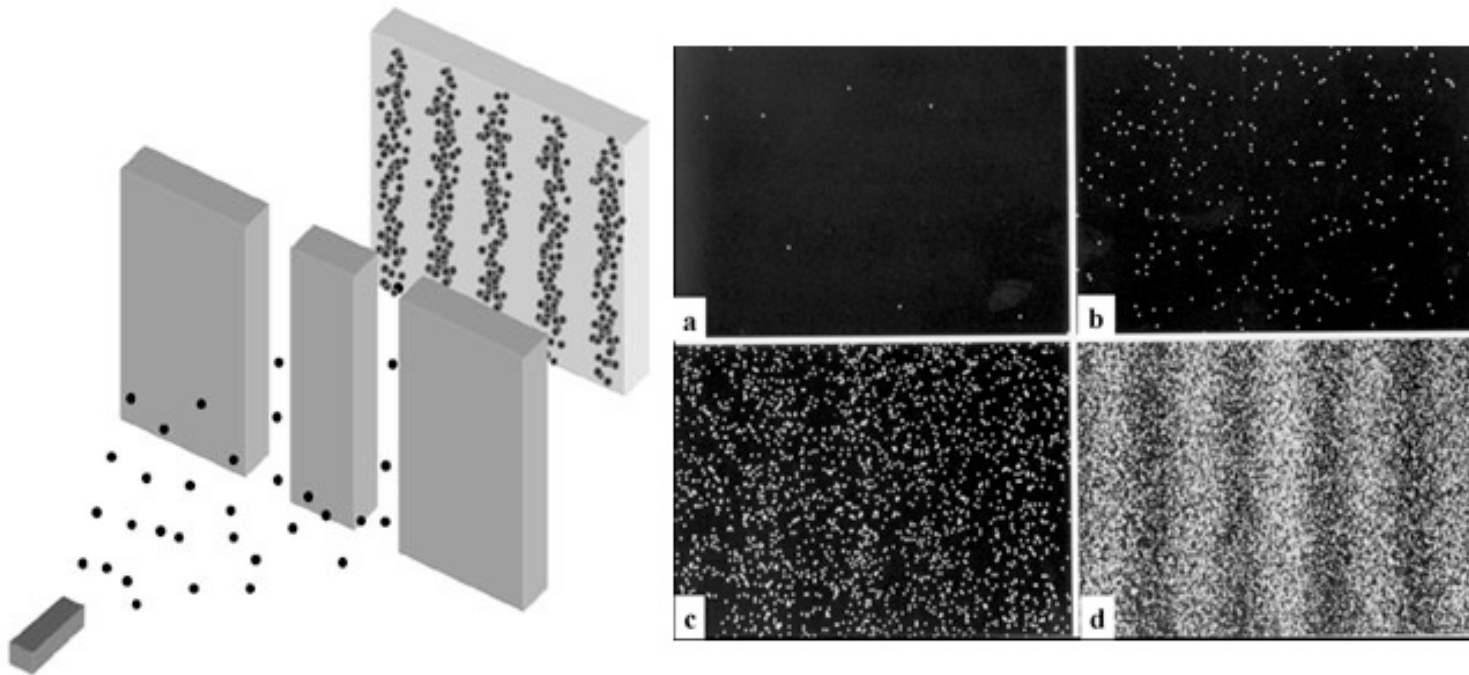
Yue Ma

▶ Chapter I



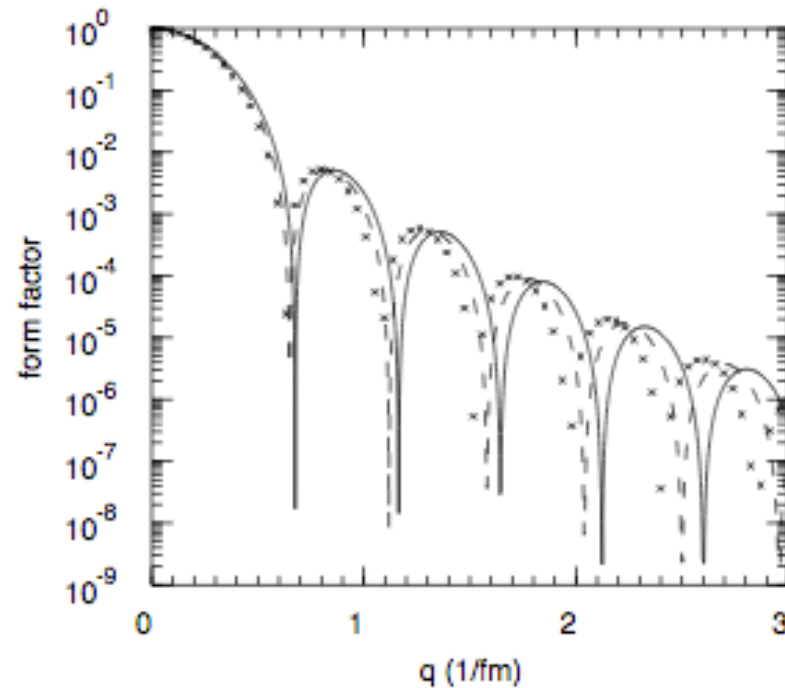
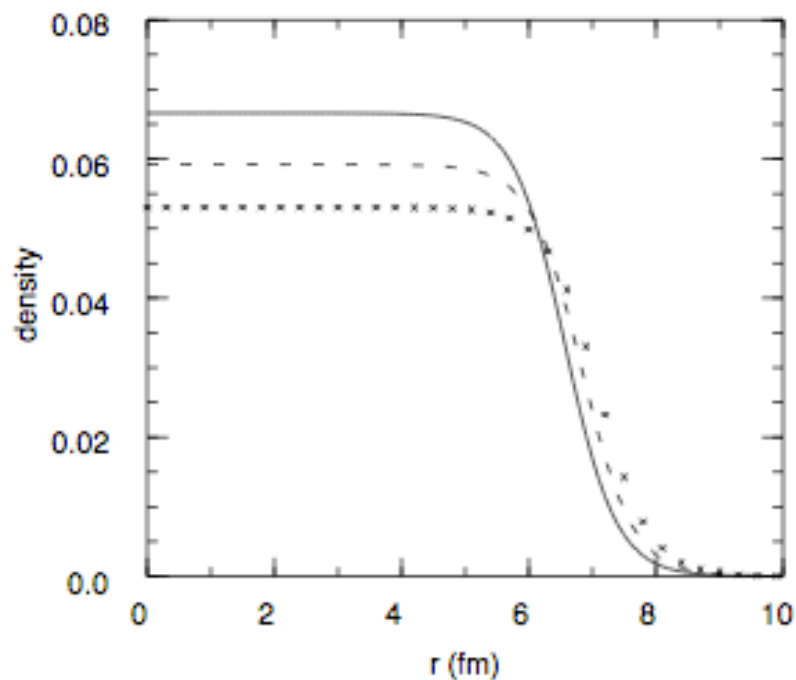
Some Quantum Mechanics

- ▶ State in Hilbert space: ket $|k\rangle$
- ▶ Representation $\langle x|k\rangle = \Psi(x)$
- ▶ Change of the representation: $\int \langle x|p\rangle \langle p|k\rangle dp$
- ▶ Interference:



Some Quantum Mechanics

- ▶ More words about interference:
- ▶ Molecule consists of a few hundreds of atoms still shows interference pattern → what is the limit of the quantum phenomena?
- ▶ Form factor is actually interference pattern:



Some Quantum Mechanics

- ▶ What quantities does NOT interfere?
- ▶ Helicity, angular momentum:

$$\psi(r, \theta) = A \left\{ e^{ikz} + \sum_{l=0}^{\infty} \sqrt{\frac{2l+1}{4\pi}} C_l h_l^{(1)}(kr) P_l(\cos \theta) \right\};$$

the scattering amplitude is

$$f(\theta) = \frac{1}{k} \sum_{l=0}^{\infty} (-i)^{l+1} \sqrt{\frac{2l+1}{4\pi}} C_l P_l(\cos \theta);$$

and the total cross-section is

$$\sigma = \frac{1}{k^2} \sum_{l=0}^{\infty} |C_l|^2.$$



Some Quantum Mechanics

- ▶ “A potential is a consequence of the local particle interactions and propagation.”
- ▶ Columb potential
- ▶ Hartree-Fock potential in Nuclear Physics

- ▶ What happens in a periodic potential like crystals?
- ▶ Smooth propagation of electrons → detector!



What do we measure?

- ▶ PDG!

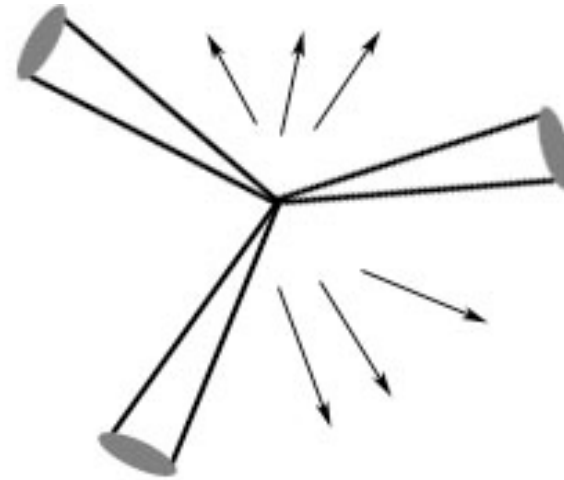
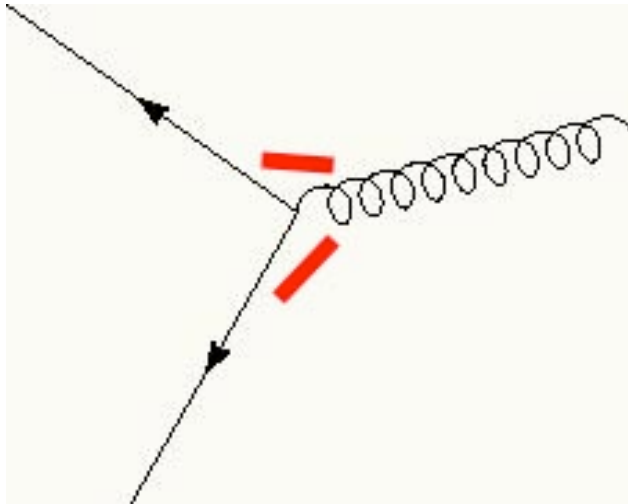


Group theory

- ▶ Continuous change \rightarrow Lorentz group
- ▶ Particle exchange \rightarrow spin statistics, flavor symmetry



Three jets events



Muon vs. Pion

- ▶ Where is the MDT in Panda and why?
- ▶ Muon was once mis-identified as Yukawa particle (pion)



Neutrino

- ▶ Neutrino mass \rightarrow oscillation

$$|\nu(t)\rangle = |\nu_1\rangle \cos \theta e^{-iE_1 t/\hbar} + |\nu_2\rangle \sin \theta e^{-iE_2 t/\hbar}$$

$$P_e(t) = |\langle \nu_e | \nu(t) \rangle|^2 = \left| \cos^2 \theta e^{-iE_1 t/\hbar} + \sin^2 \theta e^{-iE_2 t/\hbar} \right|^2$$

$$P_e(t) = 1 - \sin^2(2\theta) \sin^2 \left(\frac{(E_1 - E_2)t}{2\hbar} \right)$$

- ▶ Geo-Neutrino: new telescope to watch the core of the Earth
-



Weakness of weak interaction

- ▶ Classical picture of cross section:



Some Quantum Mechanics

- ▶ Which of the followings are due to uncertainty principle, which is due to derived relations?
 - a) $\Delta p \Delta x \sim \hbar$
 - b) $\Delta E \Delta t \sim \hbar$
 - c) $\Delta L_x \Delta L_y \sim \hbar$

What is the foundation of $q \Delta x \sim \hbar$?



Questions

▶ 1.6

▶ 1.7



▶ Chapter 2



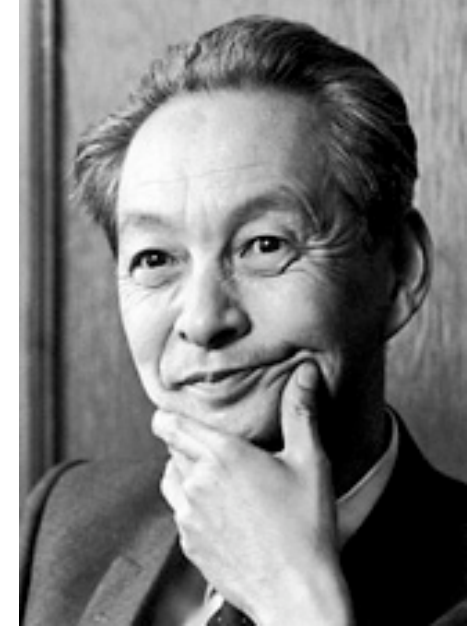
Why we need QFT?

- ▶ Combine Quantum Mechanics with special relativity
- ▶ x and t are treated differently in quantum mechanics
- ▶ $t \rightarrow$ operator: string theory
- ▶ $x \rightarrow$ parameter: QFT



Yukawa's approach

- ▶ A massive photon
- ▶ Pion field
- ▶ Coupling with nucleon
- ▶ “source”, “ L_{int} ”



“Modern” understanding of QFT

- ▶ Harmonic oscillator at each space time point
- ▶ Source is bouncing on the “Mattress”



Personal view of qft

- ▶ QFT is a formalism, a start point
- ▶ In order to study particle physics, we need parameters (types of particle, their mass) and interaction (gauge principle) and also build in as much as observed information with the language of qft (pseudo scalar)



Two approach to DO qft

- ▶ Canonical quantization
- ▶ Path integral \rightarrow favored one: adopt gauge principle

