Title: Lecture - QFT I, PHYS 601

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

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

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$$SO(1,3) \ltimes \mathbb{R}^{1,3} \supset SO(1,3) \supset SO(3) \sim S$$

HW1 tutorial

Poincare transformation $U(\varepsilon, \omega) =$

$$x'^{\mu} = \Lambda^{\mu}{}_{\nu} x^{\nu} + b^{\mu}$$

$$e^{i\epsilon_{\mu}P^{\mu} + \cdots}$$

$$T(\Lambda, b)$$

$(3) \sim SU(2)$

tutorial Friday ex

$U|x\rangle = |x'\rangle$

$[P^\mu, P^\nu] = 0$

$[P, J] = \ldots$

$[J, J] = \ldots$

$|p, s\rangle$

p^μ

$P^\mu |p, s\rangle = p^\mu |p, s\rangle$

$i\epsilon_\mu P^\mu + \frac{i}{2}\omega_{\mu\nu} J^{\mu\nu}$

$$U(1,b) = e^{ib_\mu p^\mu}$$

little group exercise

$$|p, s, n\rangle$$

name

$$\equiv |q\rangle$$

$$a + a^{\dagger}$$

promotion

$$[x, p] = i$$

non-local

$$a|0\rangle = 0$$

$$a^{\dagger}|0\rangle = |q\rangle$$

$$a \equiv (a^{\dagger})^{\dagger}$$

def adj

$$[a, a^{\dagger}]_{\mp} = \delta(q - q')$$

$a \cdot + a^{\times}$

promotion

$[x,p]=i$

non-local

$a|0\rangle = 0$

$a^\dagger|0\rangle = |q\rangle$

$a \equiv (a^\dagger)^\dagger$ def adj

$[a, a^\dagger]_\mp = \delta(q-q')$

Friday

pick a rep of Lorentz

spin → statistics

$|\alpha\rangle = |q_1, q_2, \ldots\rangle$

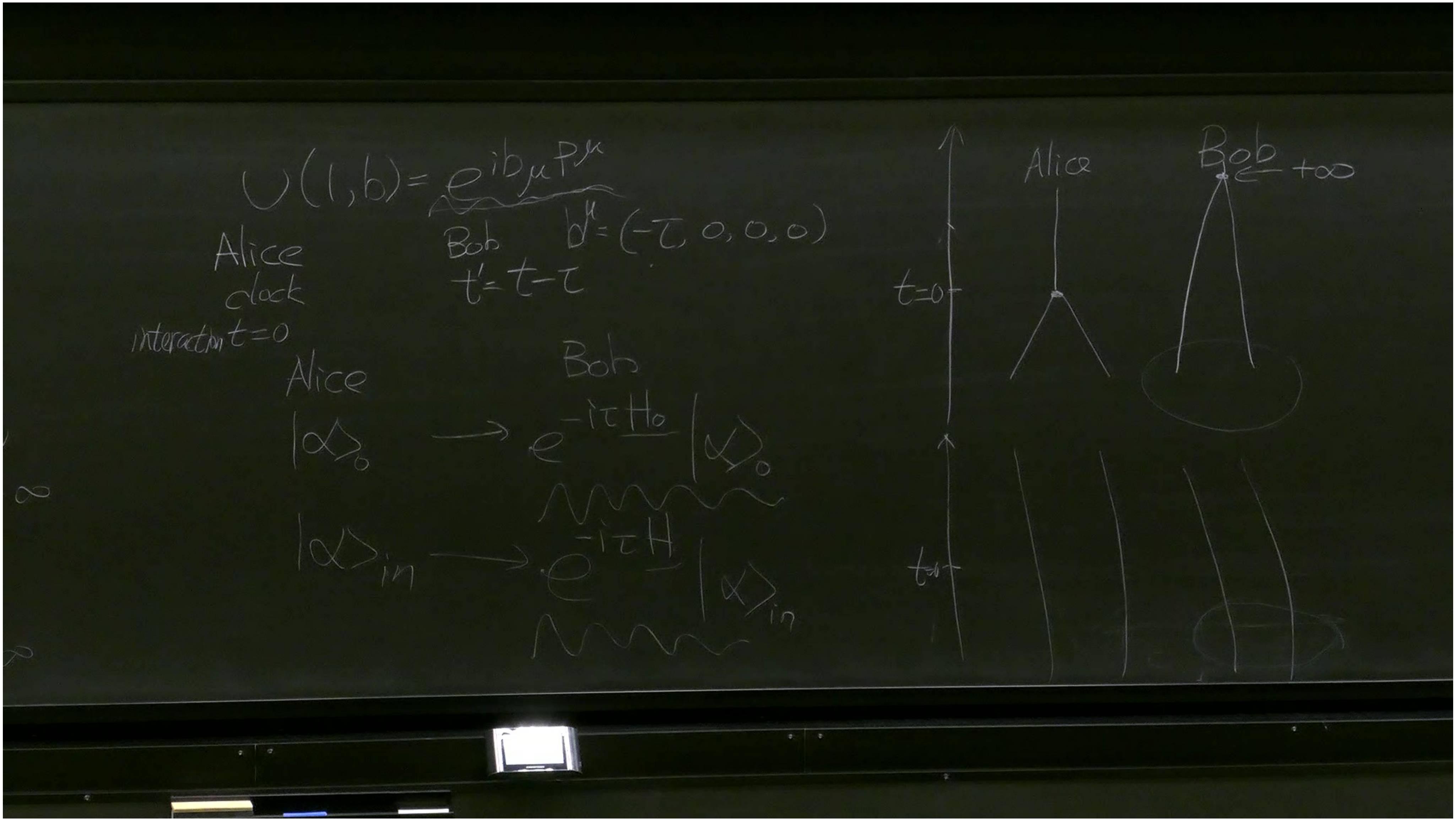
Scattering amplitude

$U(1,b) = e^{i b_\mu P^\mu}$

$S_{\beta\alpha} = {}_{out}\langle \beta | \alpha \rangle_{in}$

$|\alpha\rangle_{in} \sim |\alpha_0\rangle$ view from $t = -\infty$

$\langle \beta|_{out} \sim |\beta_0\rangle$ view from $+\infty$


$U(1,b) = e^{ib_\mu P^\mu}$
Alice
clock
interaction $t=0$
Bob
$b^\mu = (-\tau, 0, 0, 0)$
$t' = t - \tau$
Alice
Bob
$|\alpha\rangle_0 \longrightarrow e^{-i\tau H_0}|\alpha\rangle_0$
$|\alpha\rangle_{in} \longrightarrow e^{-i\tau H}|\alpha\rangle_{in}$
$t=0$
Alice
Bob
$+\infty$

$$\tau \to -\infty \quad e^{-i\tau H_0}|\alpha_0\rangle = e^{-i\tau H}|\alpha\rangle_{in}$$

$$|\alpha\rangle_{in} = \underbrace{e^{iH\tau}\, e^{-i\tau H_0}}_{\Omega(\tau)}\,|\alpha_0\rangle$$

$$= \Omega(-\infty)\,|\alpha_0\rangle$$

$$|\beta\rangle_{out} = \Omega(+\infty)\,|\beta_0\rangle$$

$$S_{\beta\alpha} = {}_0\langle\beta| \underbrace{\Omega^{\dagger}(+\infty)\,\Omega(-\infty)}_{S(+\infty,-\infty)} |\alpha\rangle_0$$

$$H - H_0 \equiv V(t)$$

$$S(+\infty,-\infty) = T\, e^{i\int_{-\infty}^{\infty} dt\, V(t)}$$

$$S(+\infty,-\infty)$$

$$H - H_0$$

$$S(+\infty,-\infty) \equiv T\, e^{i\int_{-\infty}^{\infty} dt\, V(t)}$$

$$V(t) = \int H_I(x)\, d^3x$$

$$c_4 \int a^{+} a^{+} a a$$

$$(x-y)^2 < 0$$

$$[H_I(x), H_I(y)] = 0 \text{ spacelike}$$