QUANTUM FIELD THEORY
PHY 655/461

ASSIGNMENT III

(1) What is the canonical energy-momentum tensor corresponding to the Lagrangian density

$$\mathcal{L} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu}$$

Is it symmetric ? [Extra : How would you make it symmetric if it is not.]

(2) Derive the below expressions that were utilised in the derivation of the LSZ reduction formula.

$$i\int d^4x e^{ipx}(\Box + m^2)\phi(x) = \sqrt{2\omega_p}\,[\hat{a}_p(\infty) - \hat{a}_p(-\infty)]$$

$$-i\int d^4x e^{-ipx}(\Box + m^2)\phi(x) = \sqrt{2\omega_p}\left[\hat{a}_p^\dagger(\infty) - \hat{a}_p^\dagger(-\infty)\right]$$

(3) Prove the mathematical identity

$$\lim_{\epsilon\to 0} -\frac{2\omega_k}{2\pi i}\int_{-\infty}^{\infty}\frac{d\omega}{\omega^2 - \omega_k^2 + i\epsilon}e^{i\omega\tau} = e^{-i\omega_k\tau}\Theta(\tau) + e^{i\omega_k\tau}\Theta(-\tau)$$

that we used in deriving the Feynman propagator for scalar fields.

(4) Show that

$$\frac{d^3p}{(2\pi)^3 2E_p}$$

is a lorentz-invariant, three-momentum integral measure.

(5) Review the derivation of the cross-section and decay rate, starting from the definition of the S-matrix.

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