NUCLEAR AND PARTICLE PHYSICS
PHY 422/622

ASSIGNMENT III

(1) Find explicitly, the position independent and plane wave solutions to the Dirac equation.

(2) What is meant by gauge invariance? How does this manifest in the definition of the field A^μ?

(3) Prove or verify the following
   (a) Dirac equations satisfied by $\bar{u}$ and $\bar{v}$.

$$\begin{aligned} \bar{u}\left(\not{p} - m\right) &= 0 \\ \bar{v}\left(\not{p} + m\right) &= 0 \end{aligned}$$

   (b) Completeness relation.

$$\begin{aligned} \sum_s u^{(s)}\bar{u}^{(s)} &= \not{p} + m \\ \sum_s v^{(s)}\bar{v}^{(s)} &= \not{p} - m \end{aligned}$$

   (c) Dirac matrix identities.

$$\begin{aligned} \gamma^\mu\gamma_\mu &= 4 \\ \gamma_\mu\gamma^\nu\gamma^\mu &= -2\gamma^\nu \\ Tr\left(\text{odd number of } \gamma \text{ matrices}\right) &= 0 \\ Tr\left(\gamma^\mu\gamma^\nu\right) &= 4g^{\mu\nu} \\ Tr\left(\gamma^\mu\gamma^\nu\gamma^\alpha\gamma^\beta\right) &= 4\left[g^{\mu\nu}g^{\alpha\beta} + g^{\mu\beta}g^{\alpha\nu} - g^{\mu\alpha}g^{\nu\beta}\right] \end{aligned}$$

(4) Compute the differential cross-section in the centre-of-mass frame for the following QED processes.
   (a) $e - \mu$ scattering.

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(b) Möller scattering.
(c) Bhabha scattering