Massachusetts Institute of Technology

Department of Physics

Course:	8.701 – Introduction to Nuclear and Particle Physics
Term:	Fall 2020
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Discussion Problems

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Problem 1: γ-matrices

By considering the three cases $\mu = \nu = 0$, $\mu = \nu \neq 0$, and $\mu \neq \nu$ show that $\gamma^\mu\gamma^\nu + \gamma^\nu\gamma^\mu = 2g^{\mu\nu}$.

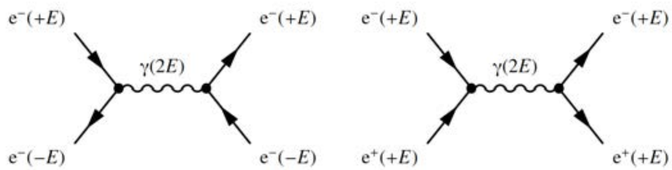
- Just consider the cases, $\mu = \nu = 0$, $\mu = \nu = k = 1, 2, 3$ and $\mu \neq \nu$ and use the commutation relations.

Problem 2: Negative energy solutions

Consider the $e^+e- \to \gamma \to e^+e-$ annihilation process in the center-of-mass frame where the energy of the photon is $2E$. Discuss energy and charge conservation for the two cases where:
(a) the negative energy solutions of the Dirac equation are interpreted as negative energy particles propagating backwards in time;
(b) the negative energy solutions of the Dirac equation are interpreted as positive energy antiparticles propagating forwards in time.

- (a) In the first interpretation (left diagram), the intial-state positive e^- of energy +E emits a photon of energy 2E. To conserve energy it is now a negative energy e^- and therefore propagates backwards in time. At the other vertex, the photon interacts with a negative energy e^-, which is propagating backwards in time and scattering results in a positive energy e^-.

(b) In the Feynman-Stückelberg interpretation (right diagram), the intial-state positive e^- of energy +E annihilates with a positive energy e^+ to produce a photon of energy 2E. At the second vertex the photon produces an e^+e^- pair. All particles propagate forwards in time



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