

HW11

1 One-loop structure of QED

The Lagrangian is given by

$$\mathcal{L} = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} + i\bar{\psi}(\not{D} - m)\psi, \quad (1)$$

where covariant derivative is defined as

$$D_\mu = \partial_\mu + ieA_\mu. \quad (2)$$

Similarly to Yukawa find counter terms needed to render the theory finite at one loop level. To this end use the following propagators, for fermions

$$\text{—————} = \frac{i(\not{p} + m)}{p^2 - m^2 + i\varepsilon}, \quad (3)$$

and photons

$$\mu \text{ ~~~~~ } \nu = \frac{-i\eta_{\mu\nu}}{p^2 + i\varepsilon}. \quad (4)$$

- Diagrams contributing to fermionic 2-pt function:

$$\text{—————} \text{ (with a wavy loop) } + \text{—————} \otimes \text{—————} \quad (5)$$

- 3-pt function $A_\mu \bar{\psi} \gamma^\mu \psi$:

$$\text{Diagram 1: } \text{wavy line} \text{ --- } \text{fermion loop} \text{ --- } \text{fermion line} + \text{Diagram 2: } \text{wavy line} \otimes \text{fermion line} \quad (6)$$

- Diagrams contributing to bosonic 2-pt function:

$$\text{Diagram 1: } \text{wavy line} \text{ --- } \text{fermion loop} \text{ --- } \text{wavy line} + \text{Diagram 2: } \text{wavy line} \otimes \text{wavy line} \quad (7)$$

- What diagrams contribute to charge renormalization? Why? Compute the corresponding beta-function.