CHAPTER OVERVIEW

5: Quantum Electrodynamics

This chapter gives an introduction to **quantum electrodynamics**, the quantum theory of the electromagnetic field and its interactions with electrons and other charged particles. We begin by formulating a quantum Hamiltonian for an electron in a classical electromagnetic field. Then we study how to quantize Maxwell's equations, arriving at a quantum field theory in which the elementary excitations are photons—particles of light. The final step is to formulate a theory in which electrons and photons are treated on the same quantum mechanical footing, as excitations of underlying quantum fields. Along the way, we will see how relativity can be accommodated with quantum theory.

Quantum electrodynamics is an extremely rich and intricate theory, and we will leave out many important topics. Interested readers are referred to are Dyson's 1951 lecture notes on quantum electrodynamics (Dyson 1951), and Zee's textbook *Quantum Field Theory in a Nutshell* (Zee 2010).

Thumbnail: A Feynman diagram showing the radiation of a gluon when an electron and positron are annihilated. (CC BY-SA 3.0; Joel Holdsworth).
