physical entities. An excellent paper [12] predicted what would be seen in deep inelastic scattering of electrons and protons if the quarks did physically exist. Essentially, the idea was to replicate the idea of Rutherford Scattering by firing electrons at the protons and neutrons in nuclei and analyzing the resulting scattering pattern. The experiment was performed at the Stanford Linear Accelerator Center (SLAC) in 1969. The results matched the theoretical predictions, and since then quarks have been embraced as physical entities. [13] contains a good review of this experimental evidence.

1.2.1 The QCD Lagrangian

The QCD Lagrangian is given by [14]

$$\begin{aligned} \mathcal{L} &= \bar{\psi}\left(i\partial_\nu\gamma^\nu + gA^a_\mu\gamma^\mu t^a - m\right)\psi - \frac{1}{4}F^a_{\mu\nu}F^{\mu\nu a} \\ F^a_{\mu\nu} &= \partial_\mu A^a_\nu - \partial_\nu A^a_\mu + gf^{abc}A^b_\mu A^c_\nu \end{aligned} \tag{1.1}$$

Mathematically ψ is a Dirac fermion in the fundamental representation of SU(3), A is the gauge field, which is in the adjoint representation of SU(3), f^{abc} are the structure constants of SU(3), g is a number and m is a mass. Physically, ψ represents the quarks, with m being their mass. A represents the gluons, and g is the QCD coupling constant. Greek letters label space-time indices, and Roman letters label gauge group indices.

The Lagrangian fully describes QCD. It is deceptively simple, and like a fractal that on close inspection is ever more complex, so too is QCD. For example, it is not immediately clear from (1.1) how to calculate hadron masses, decay constants or scattering cross-sections. In what follows we choose to mention those aspects which will be of relevance in this thesis.