8.5: Color Symmetry

So why don't we see fractional charges in nature? This is an important point! In so-called deep inelastic scattering we see pips inside the nucleon – these have been identified as the quarks. We do not see any direct signature of individual quarks. Furthermore, if quarks are fermions, as they are spin $1/2$ particles, what about antisymmetry of their wavefunction?

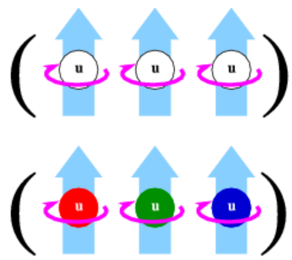

Figure 8.5.1: The Δ^{++} in the quark model.

Let us investigate the Δ^{++}, see Figure $8.5.1$, which consists of three u quarks with identical spin and flavor (isospin) and *symmetric* spatial wavefunction,

$$\psi_{\text{total}} = \psi_{\text{space}} \times \psi_{\text{spin}} \times \psi_{\text{flavour}}.$$

This would be symmetric under interchange, which is unacceptable. Actually there is a simple solution. We "just" assume that there is an additional quantity called colour, and take the colour wave function to be antisymmetric:

$$\psi_{\text{total}} = \psi_{\text{space}} \times \psi_{\text{spin}} \times \psi_{\text{flavour}} \times \psi_{\text{colour}}$$

We assume that quarks come in three colours. This naturally leads to yet another $SU(3)$ symmetry, which is actually related to the gauge symmetry of strong interactions, QCD. So we have shifted the question to: why can't we see colored particles?

This is a deep and very interesting problem. The only particles that have been seen are colour neutral ("white") ones. This leads to the assumption of confinement – We cannot liberate colored particles at "low" energies and temperatures! The question whether they are free at higher energies is an interesting question, and is currently under experimental consideration.