Pomeron Physics and QCD

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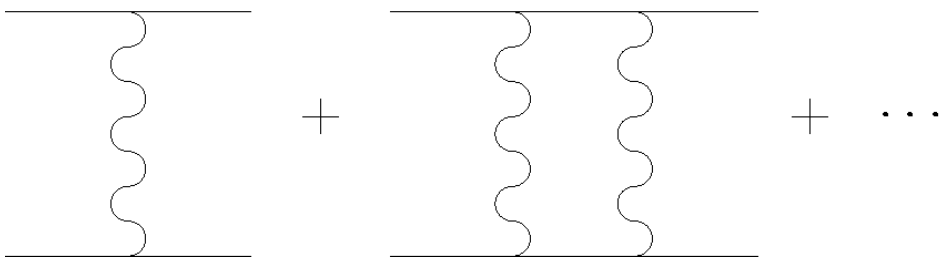
Electron-electron scattering

The charge on an electron is small – the dimensionless quantity $\alpha = \frac{e^2}{2\varepsilon_0 hc} =$ 1/137.0

According to relativistic quantum mechanics the force between two electrons is generated by photon exchange:



Because α is small the scattering probability can be calculated as a power series in powers of α and converges rapidly.

Quarks

The nuclei of atoms are made of protons and neutrons and they are made of quarks.

Protons are neutrons are composed of 3 quarks.

Mesons are composed of a quark and an antiquark.

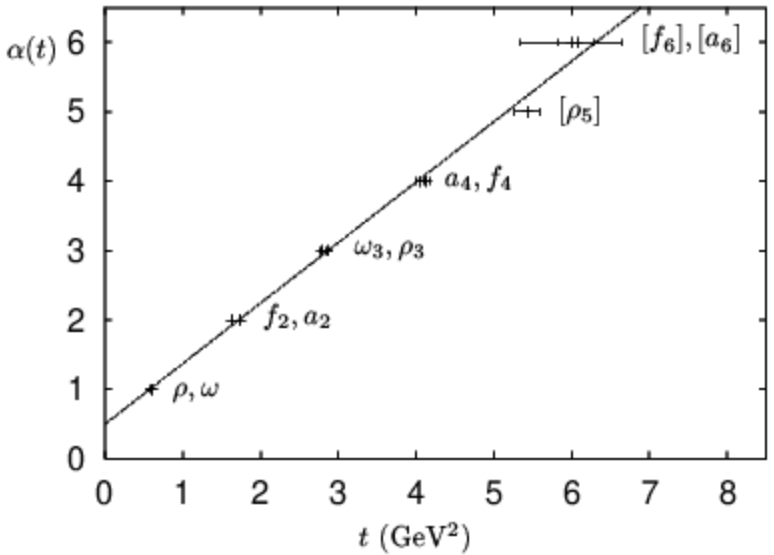
The lightest mesons are π ρ ω f a

Each quark comes in 3 identical versions, or “colours”. According to quantum chromodynamics (QCD) the force between quarks is generated by gluon exchange

But except for the rare events where the quarks come very close to each other the corresponding coupling α_S is large and so a power series does not converge.

Regge theory

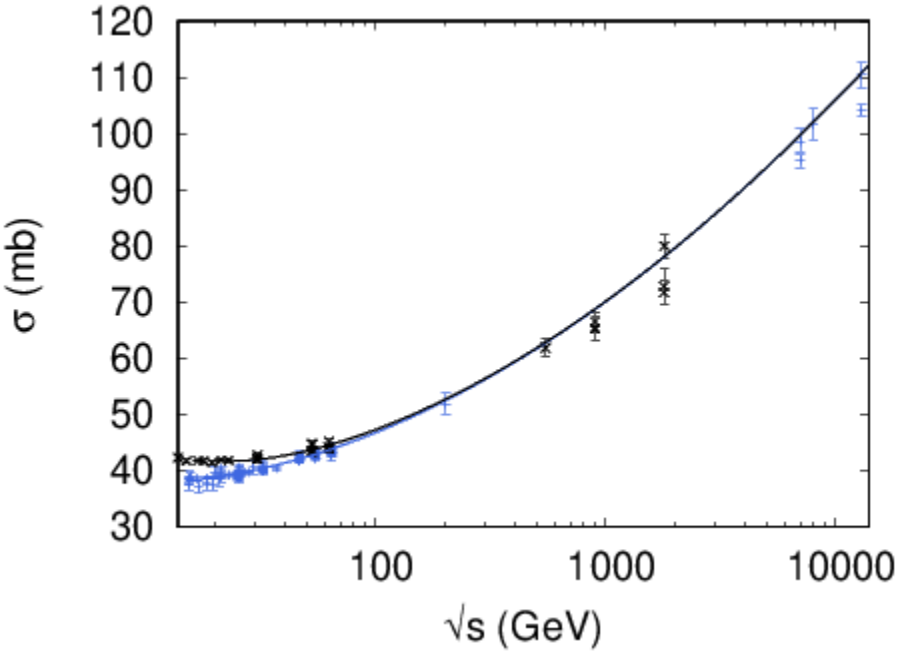
High-energy proton-proton scattering can be calculated from the exchange of mesons together with their higher-spin excited states



$t=m^2$

Contribution to the total cross section for proton-proton scattering is proportional to (energy)$^{\alpha(0)-1}$

That is 1/sqrt(energy)



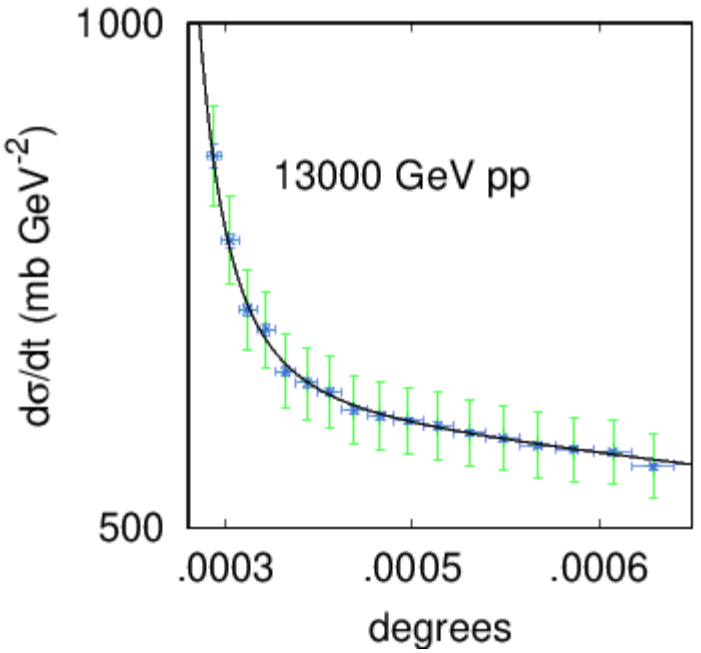
Blue is proton-proton scattering
Black is proton-antiproton

The difference between the two is well described by meson exchange

(For π, α(0) is close to 0 so the contribution is negligible)

Some other exchange must give the rise with energy. Called pomeron exchange after Isaak Pomeranchuk. It is believed to be the exchange of bound states of glueballs

Very small angle elastic scattering



Data from the large hadron collider at CERN