Classification of particles: Meson Hadrons

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Quark structure of hadrons

In the early 1960s, the number of known hadrons was large enough for physicists to start to make patterns and reduce the large numbers to a simpler scheme. and George Zweig put together the theory that the hadrons were made up of smaller constituents named quarks.

It was initially thought that there were only three flavours of quark: . Current theory suggests there are . The properties of the first three quarks to be discovered are as follows (lepton numbers are all zero):

Quark	Charge (Q) / e	Baryon number (B)	Strangeness (S)
up (u)			
antiup			
down (d)			
antidown ($\bar{\text{d}}$)			
strange (s)			
antistrange ($\bar{\text{s}}$)			

Quark combinations

1. Baryons are composed of three quarks (qqq) and are composed of three ($\bar{\text{q}}\bar{\text{q}}\bar{\text{q}}$).
2. Mesons are composed of a quark and an antiquark ($\text{q}\bar{\text{q}}$).

The actual quarks involved in a particular particle can be calculated from the quantum numbers of that particle, although the proton and neutron should be known.

Particle	Quark content	Antiparticle	Quark content
p		$\bar{\text{p}}$	
n		$\bar{\text{n}}$	
π^+	$\text{u}\bar{\text{d}}$	π^-	$\bar{\text{u}}\text{d}$
π^0	$\text{u}\bar{\text{u}}, \text{d}\bar{\text{d}}$	π^0	$\text{u}\bar{\text{u}}, \text{d}\bar{\text{d}}$
K^-	$\text{u}\bar{\text{s}}$	K^-	$\bar{\text{u}}\text{s}$
K^0	$\text{d}\bar{\text{s}}$	$\bar{\text{K}}^0$	$\bar{\text{d}}\text{s}$

Mesons ($q\bar{q}$)

Mesons have a   of zero, and a lepton number of   . They are made up of a quark and an   . None of the mesons are stable.

When a meson is made of a quark-antiquark pair (e.g. $u\bar{u}$) these quarks do not   , as they have another property ([1]) which is different for the two quarks.

Name	Symbol	Charge (Q)	Baryon No. (B)	Strangeness (S)
Pions				
pi-zero				
antipi-zero	π^0	0	0	0
pi-plus	π^+	+1	0	0
pi-minus*	π^-	-1	0	0
Kaons				
K-zero	K^0	0	0	1
antiK-zero				
K-plus	K^+	+1	0	1
K-minus*				

*Due to their composition, the antiparticles of the pi-plus and the K-plus are not the antipi-plus and K-plus (as might be expected), but are instead the pi-minus and K-minus.

The π^0 is actually a combination of $u\bar{u} + d\bar{d}$, but can be regarded as just one of these. Although the u and $\bar{u}$ appear to be antiparticles, there are three 'colours' of quarks, so the u and $\bar{u}$ in a π^0, having different colours, do not annihilate.

There are many

[1]Colour is just a label – not a real colour! – for the charge of the strong interaction. Unlike electric charge (+ or −), the strong charge comes in three colours: R, G and B.