On hadron structure

A.C. Norman
anorman@bishopheber.cheshire.sch.uk

Warm-up problems

1. What is a *hadron*? Explain the difference between *mesons* and *baryons*, and give one example of each.

2. What can you tell about a hadron which has a *strangeness* of -1? How might it lose this strangeness, and what can you say about the interaction that is involved in this process?

Regular problems

3. There are ten possible combinations of the up, down and strange (u, d, and s) quarks which will make baryons. List these ten combinations.

4. The table below shows eleven baryons.

   (a) Using your list from 3, identify the quark structure in each of the baryons.

particle	Charge (Q) / e	Baryon number	Strangeness
p	$+1$	1	0
n	0	1	0
Λ	0	1	-1
Σ^+	$+1$	1	-1
Σ^0	0	1	-1
Σ^-	-1	1	-1
Δ^-	-1	1	0
Δ^{++}	$+2$	1	0
$\overline{\Xi}^0$	0	1	-2
Ξ^-	-1	1	-2
Ω^-	-1	1	-3

   (b) Which two baryons have the same quark structure?

   (c) How may they be different to each other?

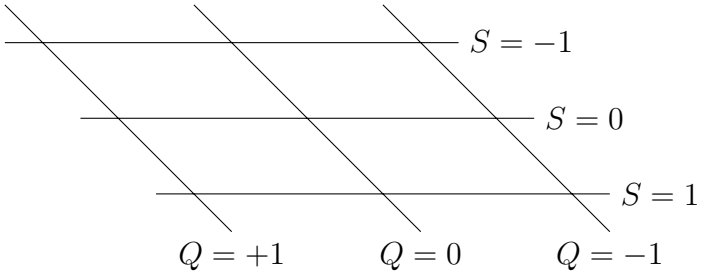
5. There are nine possible combinations of the up, down and strange (u, d, and s) quarks which will make mesons. List these nine combinations.

6. The table below shows eight mesons. Using your list from 5, identify the quark structure in each of the mesons. Remember that some mesons can be made up of more than one combination.

particle	Charge (Q) / e	Baryon number	Strangeness
π^+	$+1$	0	0
π^-	-1	0	0
π^0	0	0	0
K^+	$+1$	0	1
K^-	-1	0	-1
K^0	0	0	1
$\overline{\mathrm{K}}^0$	0	0	-1
η	0	0	0

Extension problems

7. The diagram below shows the *meson octet*.

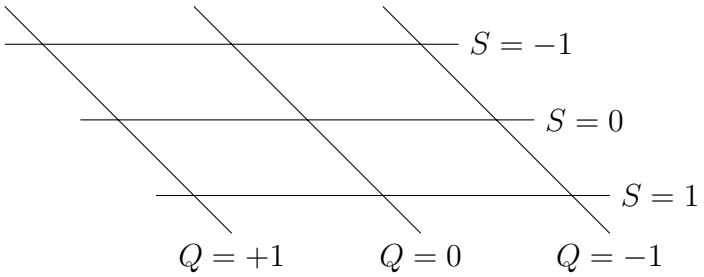


   (a) Copy the diagram, and add on the eight particles at the intersections of the lines.

   (b) Which two mesons occupy the same position on the diagram?

   (c) How may they be different to each other?

8. The diagram below is often called the *Baryon Octet*. Copy the diagram, and add on the eight particles at the intersections of the lines. (Don't put any Δs on this diagram.)



9. Why is there no particle with a strangeness of -2 and a charge of $+1$?