30. QUARK MODEL

30.1. Quantum numbers of the quarks

Each quark has spin 1/2 and baryon number 1/3. Table 30.1 gives the additive quantum numbers (other than baryon number) of the three generations of quarks. Our convention is that the *flavor* of a quark (I_z, S, C, B, or T) has the same sign as its *charge*. With this convention, any flavor carried by a *charged* meson has the same sign as its charge; *e.g.*, the strangeness of the K^+ is $+1$, the bottomness of the B^+ is $+1$, and the charm *and* strangeness of the D_s^- are each -1.

By convention, each quark is assigned positive parity. Then each antiquark has negative parity.

Table 1. Nonzero additive quantum numbers of the quarks.

$Q = -1/3$ quarks			$Q = +2/3$ quarks		
d	I_z	$= -1/2$	u	I_z	$= +1/2$
s	S	$= -1$	c	C	$= +1$
b	B	$= -1$	t	T	$= +1$

30.2. Mesons: $q\overline{q}$ states

Nearly all known mesons are bound states of a quark q and an antiquark $\overline{q}\,'$ (the flavors of q and q' may be different). If the orbital angular momentum of the $q\overline{q}\,'$ state is L, then the parity P is $(-1)^{L+1}$. A state $q\overline{q}$ of a quark and its own antiquark is also an eigenstate of charge conjugation, with $C = (-1)^{L+S}$, where the spin S is 0 or 1. The $L = 0$ states are the pseudoscalars, $J^P = 0^-$, and the vectors, $J^P = 1^-$. Assignments for many of the known mesons are given in Table 30.2. States in the "normal" spin-parity series, $P = (-1)^J$, must, according to the above, have $S = 1$ and hence $CP = +1$. Thus mesons with normal spin-parity and $CP = -1$ are forbidden in the $q\overline{q}\,'$ model. The $J^{PC} = 0^{--}$ state is forbidden as well. Mesons with such J^{PC} may exist, but would lie outside the $q\overline{q}\,'$ model.

The nine possible $q\overline{q}\,'$ combinations containing u, d, and s quarks group themselves into an octet and a singlet:

$$\mathbf{3} \otimes \overline{\mathbf{3}} = \mathbf{8} \oplus \mathbf{1} \tag{30.1}$$

States with the same IJ^P and additive quantum numbers can mix. (If they are eigenstates of charge conjugation, they must also have the same value of C.) Thus the $I = 0$ member of the ground-state pseudoscalar octet mixes with the corresponding pseudoscalar singlet to produce the η and η'. These appear as members of a nonet, which is shown as the middle plane in Fig. 30.1(a). Similarly, the ground-state vector nonet appears as the middle plane in Fig. 30.1(b).