Flavor Physics – Exercise Sheet 3 – SomSem 2014

Discussion: 16/05 during the tutorial

Exercise 1: Vector meson mixing angle

The physically observed vector mesons ω and ϕ are mixtures of the octet and singlet states ϕ_8 and ϕ_1:

$$\phi = \phi_1 \sin\theta - \phi_8 \cos\theta$$

$$\omega = \phi_8 \sin\theta + \phi_1 \cos\theta$$

Mass terms for a meson ψ in the Hamiltonian appear typically as $M_\psi^2 = \langle \psi \,|H|\, \psi \rangle$. Calculate the masses M_ϕ^2, M_ω^2 as functions of $M_1^2 = \langle \phi_1 \,|H|\, \phi_1 \rangle$, $M_8^2 = \langle \phi_8 \,|H|\, \phi_8 \rangle$ and $M_{18}^2 = \langle \phi_1 \,|H|\, \phi_8 \rangle = M_{81}^2 = \langle \phi_8 \,|H|\, \phi_1 \rangle$ from the above mixing. Since ω and ϕ are orthogonal the off-diagonal term $M_{\phi\omega}^2$ is zero but can also be expressed by M_1^2, M_8^2 and M_{18}^2 and leads to a third equation. By eliminating M_1^2 and M_{18}^2 one obtains an equation for $\tan\theta$. Calculate $\tan\theta$.

Using the *linear octet mass formula* one finds an expression for M_8^2,

$$M_8^2 = \frac{1}{3}\left(4M_{K^*}^2 - M_\rho^2\right)$$

Replace M_8^2 in the expression for $\tan\theta$ by the masses of the observed vector mesons and estimate the mixing angle θ from the measured masses.

Hint: For help, look at D.Perkins: Introduction to High Energy Physics.

Exercise 2: Ideal vector meson mixing

Show that if one uses the ideal mixing angle $\cos\theta = 1/\sqrt{3}$ in the above meson mixing one obtains pure flavor states:

$$\phi = s\bar{s}$$

$$\omega = \left(u\bar{u} + d\bar{d}\right)/\sqrt{2}$$

Exercise 3: Extending SU(3) to include Charm

How are the possible meson states grouped if in addition to iso-spin and strangeness also charm is considered as quantum number. How man states exist? For more information, look at the Particle Data Book (Chapter 14: Quark model).