

# FLAVOUR PHYSICS ASSESSMENT

To be returned to Tim Gershon ([T.J.Gershon@warwick.ac.uk](mailto:T.J.Gershon@warwick.ac.uk)) by April 30<sup>th</sup> 2010

You may use any reference material that you wish, but you are not intended to expend great effort in answering the questions.

Answer the following, each in 100 words or less (10 marks each).

1. How does the GIM mechanism suppress flavour-changing neutral currents?
2. Describe the quark content of the three light neutral vector mesons ( $\rho^0$ ,  $\omega$ ,  $\phi$ ), commenting on relevant symmetries.
3. How does the existence of three generations of quarks allow CP violation within the Standard Model?
4. Give the production and decay processes in which the J/ $\psi$  particle was discovered. Explain why the vector J/ $\psi$  was observed before its lighter pseudoscalar counterpart, the  $\eta_c$ .
5. Describe how the lifetime difference in the  $B_s$  meson system ( $\Delta\Gamma_s$ ) can be measured.

Give brief answers to the following (5 marks each). Use diagrams and calculations as appropriate.

6. Draw a Feynman diagram for the leptonic decay  $K^+ \rightarrow \mu^+ \nu$ . What property of the CKM matrix can be determined from the measurement of its branching fraction?
7. Estimate the maximum size of direct CP violation in  $B^0 \rightarrow D K^{*0}$  within the Standard Model.
8. The mass differences in the  $B_d$  and  $B_s$  systems are measured to be  $\Delta m_d = (0.511 \pm 0.005 \pm 0.006) \text{ ps}^{-1}$  and  $\Delta m_s = (17.77 \pm 0.10 \pm 0.07) \text{ ps}^{-1}$  respectively. Estimate the ratio of CKM matrix elements  $|V_{td}/V_{ts}|$ .
9. The phase of charm oscillations can in principle be measured in  $D \rightarrow K^+ K^-$  decays (in analogy to the measurement of  $\sin(2\beta)$  in  $B_d \rightarrow J/\psi K_S$  decays). Estimate its value within the Standard Model.
10. Sketch the phase space of  $B \rightarrow X_u l \bar{\nu}$  decays in the  $(m_X, q^2)$  plane (where  $m_X$  is the invariant mass of the hadronic system  $X_u$  produced from the  $b \rightarrow u$  transition, and  $q^2$  is the invariant mass squared of the lepton-neutrino system). Denote regions that are uncontaminated by background from  $b \rightarrow c$  transitions.

Finally, in as many words as you like (25 marks)

11. Describe existing constraints on a possible fourth generation of quarks, and discuss how such new particles might reveal themselves in flavour observables?