

Discussion questions
 School on Amplitude Analysis in Modern Physics:
 from hadron spectroscopy to CP phases
Precision Experiments / Data Analysis
 Tim Gershon

1. For each of the following decays, give some of the resonances that can contribute and describe which properties of the CKM matrix (Unitarity Triangle angles, etc.) they can be used to probe:
 - i. $B^0 \rightarrow J/\psi K_S \pi^0$
 - ii. $B^0 \rightarrow D_{CP} K^+ \pi^-$ (D_{CP} denotes a D meson reconstructed in a CP-eigenstate)
 - iii. $B^0 \rightarrow K_S \pi^+ \pi^-$
 - iv. $B^0 \rightarrow \pi^+ \pi^- \pi^0$
 - v. $B_s^0 \rightarrow J/\psi \pi^+ \pi^-$
 (draw and label Feynman diagrams with CKM matrix elements to illustrate the answers)
2. For each of the above decays, discuss the relative advantages and disadvantages of performing the measurement using B mesons produced in e^+e^- collisions (*e.g.* at BaBar) vs. hadron (pp or ppbar) collisions (*e.g.* at LHCb)
3. Discuss the main sources of background, and the methods used to control them, for the decay $B^0 \rightarrow K^+ \pi^- \pi^0$ when studied at BaBar or at LHCb. Which regions of the Dalitz plot will these background sources populate?
4. Give order-of-magnitude estimates for the level of CP violation, in the Standard Model, in the following observables
 - i. left-right asymmetry in $\eta \rightarrow \pi^+ \pi^- \pi^0$
 - ii. asymmetry (K^+/K^-) in slope parameter g in $K^\pm \rightarrow \pi^\pm \pi^+ \pi^-$
 - iii. difference (D^+/D^-) in relative phase between $D^\pm \rightarrow \phi \pi^\pm$ and $D^\pm \rightarrow K^{*0}(\text{bar})K^\pm$
 - iv. difference (D_s^+/D_s^-) in relative phase between $D_s^\pm \rightarrow \phi \pi^\pm$ and $D_s^\pm \rightarrow K^{*0}(\text{bar})K^\pm$
 - v. direct CP violation in the rate of the $B^0 \rightarrow K^{*+} \pi^-$ decay (and charge conjugate)
5. The angle γ of the CKM Unitarity Triangle can be determined from the decays $B^\pm \rightarrow DK^\pm$ with the subsequent decay $D \rightarrow K_S \pi^+ \pi^-$. Both model-dependent and model-independent approaches to the analysis of the Dalitz plot structure of the D decay are possible. Discuss the relative advantages and disadvantages of these different approaches.
6. Large samples of CP-tagged K mesons have been/are being/will be obtained from $\phi \rightarrow KK\text{bar}$ decays (*e.g.* at KLOE). Similarly, large samples of CP-tagged D mesons have been/are being/will be obtained from $\psi(3770) \rightarrow DD\text{bar}$ decays (*e.g.* at CLEOc and BES). Discuss the measurements that can be made with such samples.
7. Estimate the sizes of the CP-tagged B meson samples available in the datasets of BaBar and Belle.
8. “Incorrect modelling of a CP conserving complex amplitude cannot lead to a spurious signature for CP violation.” True or false? (*i.e.* discuss)
9. “The $\chi^2/\text{n.d.f}$ value of any fit must correspond to an acceptable p-value in order for the results of that fit to be considered reliable.” True or false? (*i.e.* discuss)