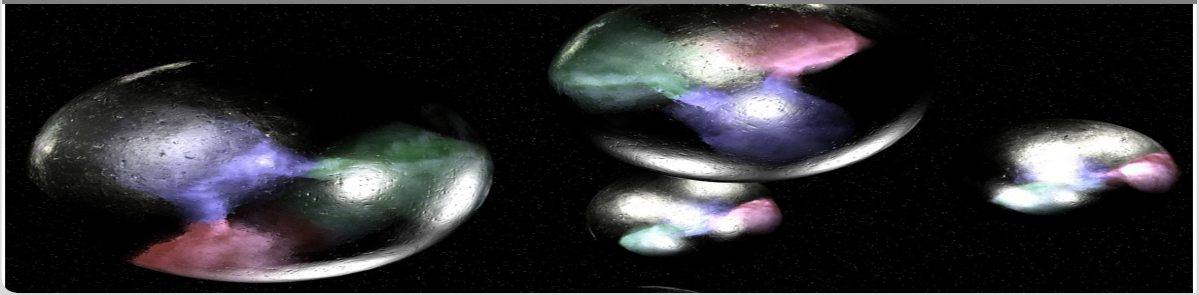
Observation of *CP* violation in charm decays

Tracking Meeting

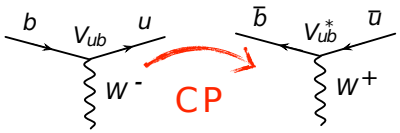
Michael Eliachevitch(michael.eliachevitch@kit.edu) | 25 June 2019

INSTITUT FÜR EXPERIMENTELLE TEILCHENPHYSIK (ETP) – KIT



CP violation in the Standard Model

- *CP*-violation (CPV): breaking of the invariance with respect to the combined transformation **charge conjugation (*C*)** and **parity inversion (*P*)**
- Sakharov: theoretical requirement for **baryon-asymmetry** of the universe
- arises in SM from a non-vanishing complex phase for a **quark mixing** matrix with 3 (V_{CKM}) or more generations
- **suppressed for charm** $\mathcal{O}(A_{CP}) = 10^{-4} - 10^{-3}$



$$\begin{array}{c} \\ u \\ c \\ t \end{array} \begin{array}{c} \begin{array}{ccc} d & s & b \end{array} \\ \begin{pmatrix} 1 & \lambda & \lambda^3 e^{i\phi} \\ -\lambda & 1 & \lambda^2 \\ -\lambda^3 e^{-i\phi} & -\lambda^2 & 1 \end{pmatrix} \end{array}$$

$(\lambda \approx 0.22)$

Reminder: Different types of CPV

CPV in decay (direct):

$$\Gamma(M \to f) \neq \Gamma(\bar{M} \to \bar{f})$$

CPV from mixing (indirect)

$$\Gamma(M^0 \to \bar{M}^0) \neq \Gamma(\bar{M}^0 \to M^0)$$

CPV from interference of mixing and decay

$$\Gamma(M^0 \to f_{CP}) \neq \Gamma(\bar{M}^0 \to f_{CP})$$

Motivation: Why bother?

CPV discoveries so far

1956 Wu: Discovery of parity violation

1964 Cronin, Fitch: CPV in K decays

1973 Kobayashi, Mask's: CKM matrix

2001 BaBar and Belle: CPV in B^0

$\Rightarrow$ CPV well-established

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Motivation for charm studies

- CPV **too low in SM** to explain baryon-asymmetry
  $\rightarrow$ NP contributions?
- small SM CPV in charm $\rightarrow$ **sensitive to NP**
- CPV with **up-type quarks**
- theory challenge: low-energy QCD

The LHCb Experiment and used dataset

- single-arm forward spectrometer
- specialized flavor-physics experiment at CERN
- pp@13 TeV: large cross-section for

$D^0 \to h^+h^-(h \in K, \pi)$ decays at LHCb

Analysis strategy: What is ΔA_{CP} and why use it?

$D^0/\overline{D}^0$ flavor tagging

Event selection

Fitting method

Fit results

Systematic uncertainties

Results

SM comparison