Theory of charm mixing

Marco Ciuchini

INFN Roma Tre

- Theory & phenomenology of charm mixing
- Results on mixing and CPV parameters
- Bounds on New Physics in the $\Delta C=2$ amplitude

Theory of meson mixing (i)

Time evolution of an unstable two-states system of CP-conjugated mesons:

$$i\hbar\frac{\partial}{\partial t}\begin{pmatrix} M \\ \bar{M} \end{pmatrix} = \left[\begin{pmatrix} m & m_{12} \\ m_{12}^* & m \end{pmatrix} - \frac{i}{2}\begin{pmatrix} \Gamma & \Gamma_{12} \\ \Gamma_{12}^* & \Gamma \end{pmatrix}\right]\begin{pmatrix} M \\ \bar{M} \end{pmatrix}$$

Eigenvectors:

$$|M_{1,2}\rangle = p|M\rangle \pm q|\bar{M}\rangle\,, \qquad \frac{q}{p} = -\sqrt{\frac{m_{12}^* - \frac{i}{2}\Gamma_{12}^*}{m_{12} - \frac{i}{2}\Gamma_{12}}}\,, \qquad |p|^2 + |q|^2 = 1$$

Eigenvalues:

$$m_{1,2} - \frac{i}{2}\Gamma_{1,2} = m - \frac{i}{2}\Gamma \mp \sqrt{\left(m_{12} - \frac{i}{2}\Gamma_{12}\right)\left(m_{12}^* - \frac{i}{2}\Gamma_{12}^*\right)}$$

$$\Gamma\,(x - i\,y) = 2\sqrt{\left(m_{12} - \frac{i}{2}\Gamma_{12}\right)\left(m_{12}^* - \frac{i}{2}\Gamma_{12}^*\right)}$$

$$\Gamma\,x = \Delta m = m_2 - m_1$$
$$2\Gamma\,y = \Delta\Gamma = \Gamma_2 - \Gamma_1$$

Meson mixing is characterized by three parameters

$$|m_{12}|\,, |\Gamma_{12}|\,, \Phi_{12} = \arg\left(\frac{\Gamma_{12}}{m_{12}}\right)$$

or

$$x\,, y\,, \left|\frac{q}{p}\right| \simeq 1 + \frac{1}{2}a_{\rm SL}$$

Theory of meson mixing (ii)

The two parametrizations are equivalent: one can pass from one to the other (with some effort)

$$x = \frac{\mathrm{sgn}(\cos\Phi_{12})}{\sqrt{2}\Gamma}\sqrt{4|m_{12}|^2 - |\Gamma_{12}|^2 + \sqrt{(4|m_{12}|^2 + |\Gamma_{12}|^2)^2 - 16|m_{12}|^2|\Gamma_{12}|^2\sin^2\Phi_{12}}}$$

$$y = \frac{1}{2\sqrt{2}\Gamma}\sqrt{|\Gamma_{12}|^2 - 4|m_{12}|^2 + \sqrt{(4|m_{12}|^2 + |\Gamma_{12}|^2)^2 - 16|m_{12}|^2|\Gamma_{12}|^2\sin^2\Phi_{12}}}$$

$$\left|\frac{q}{p}\right| = \sqrt{\frac{1-\delta}{1+\delta}}\,, \qquad \delta = \frac{2|m_{12}||\Gamma_{12}|\sin\Phi_{12}}{(\Gamma\, x)^2 + |\Gamma_{12}|^2}$$

CP conservation in mixing corresponds to $|q/p| = 1 \leftrightarrow \Phi_{12} = 0,\ \pi$

Notice that the phases of m_{12} (or Γ_{12}) and q/p are phase-convention dependent, thus not observable

Time-dependent rates

Meson mixing produces time-dependent decay rates ($\tau = \Gamma\, t$):

$$\begin{aligned}\Gamma\left(M(t) \to f\right) \quad = \quad & \frac{1}{2} e^{-\tau} |A_f|^2 \left[\left(1 + |\lambda_f|^2\right) \cosh(y\tau) \right. \\ & + \left(1 - |\lambda_f|^2\right) \cos(x\tau) + 2\, \mathrm{Re}(\lambda_f) \sinh(y\tau) \\ & \left. -2\, \mathrm{Im}(\lambda_f) \sin(x\tau) \right]\end{aligned}$$

In general, there are 4 rates ($M \to f\,, \bar{M} \to f\,, M \to \bar{f}\,, \bar{M} \to \bar{f}$):

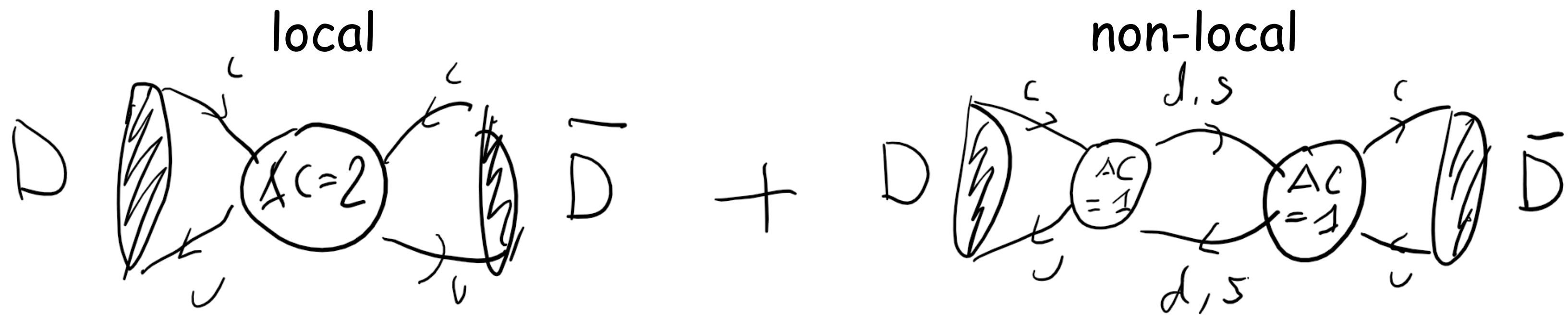
$i)\ M \to \bar{M}\ :\ A_f \to \bar{A}_f,\ \lambda_f \to \lambda_f^{-1}$ $\qquad$ $ii)\ f \to \bar{f}\ :\ A_f \to A_{\bar{f}},\ \lambda_f \to \lambda_{\bar{f}}$

Two more observable parameters: $\lambda_f = \dfrac{q}{p}\dfrac{\bar{A}_f}{A_f},\ \lambda_{\bar{f}} = \dfrac{q}{p}\dfrac{\bar{A}_{\bar{f}}}{A_{\bar{f}}}$

$\arg(\lambda_{f,\,\bar{f}}) \neq 0,\ \pi$

CP violation in the interference of mixed and unmixed decay amplitudes

Computing charm mixing



$$2M_D\left(m_{12}-\frac{i}{2}\Gamma_{12}\right)=\langle D|H_{\rm eff}^{\Delta C=2}|\bar D\rangle+\int d^4x\,\langle D|T\left(H_{\rm eff}^{\Delta C=1}(x)H_{\rm eff}^{\Delta C=1}(0)\right)|\bar D\rangle$$

* Γ_{12} comes from the non-local term, while both contribute to m_{12}

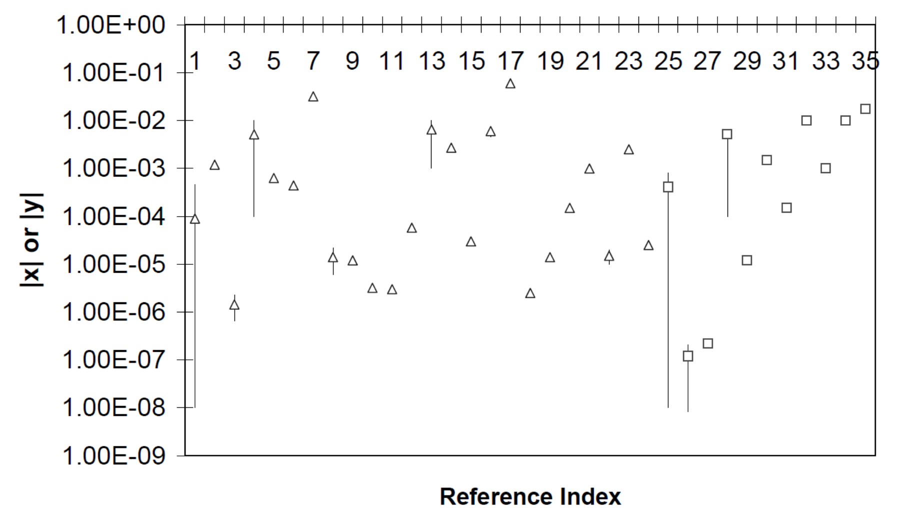
* $H_{eff}^{\Delta C=2}$ contains the contribution of heavy particles (*b*, NP)

Attempts at computing x and y:

- OPE in Λ_{QCD}/m_c, but $m_c \sim \Lambda_{QCD}$: convergence, q-h duality
- sum over hadronic states: too many states, needs assumptions

$x,\ y \le 10^{-2} \div 10^{-3} \ll 1$

A. Petrov, hep-ph/0611361



Flavour structure of the amplitude

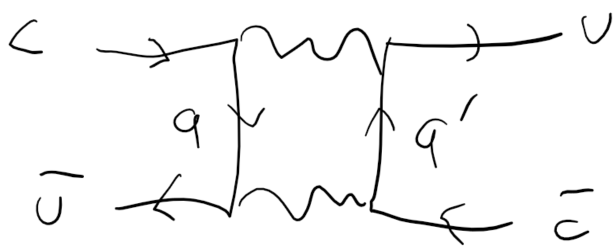
$$\lambda_q = V_{cq}^* V_{uq}$$

$$\lambda_s \sim \sin\theta_c$$

$$\lambda_b \sim (\sin\theta_c)^5$$

$$\lambda_d = -\lambda_s - \lambda_b$$

box diagram



$$= \lambda_q \lambda_{q'} D_{qq'}$$

$$A^{\Delta C=2} = \sum_{q,q'=d,s,b} \lambda_q \lambda_{q'} D_{qq'} = \lambda_s^2 (D_{ss} + D_{dd} - 2D_{sd}) +$$

$$2\lambda_s \lambda_b (D_{bs} + D_{dd} - D_{bd} - D_{sd}) + \mathcal{O}(\lambda_b^2)$$

i) GIM and SU(3) suppression coincide: the leading term is quadratic in the SU(3) breaking ε, while the subleading one is linear

A. Falk et al., hep-ph/0110317

$$\mathrm{A}^{\Delta C=2} \sim \lambda_s^2 \varepsilon^2 + 2\lambda_s \lambda_b \varepsilon + \mathcal{O}(\lambda_b^2)$$

ii) the leading term has no weak phase: **m_{12} and Γ_{12} are real** up to corrections suppressed by $\lambda_b/\lambda_s \times 1/\varepsilon \sim 10^{-3}$. **SM CP violation in mixing is negligible** (yet enhanced by SU(3) breaking w.r.t. the leading term)

Measuring the mixing parameters

The smallness of x, y, $\delta=(1-|q/p|^2)/(1+|q/p|^2)$, λ_b, $\arg(m_{12})$ and $\arg(\Gamma_{12})$ makes charm mixing and CP violation rather peculiar

i) the relations between theoretical and phenomenological parameters become:

$$|m_{12}| = 2\Gamma\, x + \mathcal{O}(\delta^2), \quad |\Gamma_{12}| = \Gamma\, y + \mathcal{O}(\delta^2), \quad \sin\Phi_{12} = \frac{x^2+y^2}{xy}\delta + \mathcal{O}(\delta^2)$$

ii) the decay rate time dependence can be expanded to the first few orders: for example, time-dependent decays to CP eigenstates become:

$$\Gamma\left(D(t)/\bar{D}(t) \to f\right) = e^{-\tau}|A_f|^2 \left[1 + \eta_{CP}\left|\frac{q}{p}\right|^{\pm 1}(y\cos\phi \mp x\sin\phi)\tau\right] = |A_f|^2 e^{-\Gamma_{D/\bar{D}\to f}t} + \mathcal{O}(x^2, y^2)$$

i.e. an exponential decay in terms of the effective rates

$$\Gamma_{D/\bar{D}\to f} = \Gamma\left[1 + \eta_{CP}\left|\frac{q}{p}\right|^{\pm 1}(y\cos\phi \mp x\sin\phi)\right]$$

which in turn are used to define the observables (e.g. $f = K^+K^-, \pi^+\pi^-$):

$$\boxed{y_{CP} = \eta_{CP}\frac{\Gamma_{\bar{D}\to f} + \Gamma_{D\to f}}{2\Gamma} - 1, \qquad A_\Gamma = \frac{\Gamma_{D\to f} - \Gamma_{\bar{D}\to f}}{2\Gamma}}$$

We are in the approximation and phase convention for which $\frac{\bar{A}_f}{A_f} = 1, \quad \lambda_f \to \frac{q}{p}$, so that CP violation in the interference of mixed and unmixed decays is controlled by $\phi = \arg\left(\frac{q}{p}\right)$

In the same approximation, assuming that Γ_{12} is dominated by Cabibbo-allowed decays, $\arg(\Gamma_{12}) = 0$, hence the relation

$\arg\left(\Gamma_{12}\frac{q}{p}\right) = \arg(y + i\delta x)$ becomes $\boxed{\phi = \arg(y + i\delta x)}$

MC et al., hep-ph/0703204; Kagan&Sokoloff, 0907.3917

CP violation in the interference of mixed and unmixed decays is directly related to CP violation in mixing. In particular, one finds that

$$\arg(\phi) = 0 \quad \leftrightarrow \quad \arg(\Phi_{12}) = 0 \quad \leftrightarrow \quad \left|\frac{q}{p}\right| = 1$$

Another example: time-dependent decays to "wrong-sign" non-CP eigenstate final states f. In general, 4 amplitudes:

$$A_f = T_f e^{i\phi_f}\left[1 + r_f e^{i(\Delta_f+\Phi_f)}\right], \qquad \overline{A}_{\bar f} = T_f e^{-i\phi_f}\left[1 + r_f e^{i(\Delta_f-\Phi_f)}\right],$$
$$A_{\bar f} = T_{\bar f} e^{i(\delta_f+\phi_{\bar f})}\left[1 + r_{\bar f} e^{i(\Delta_{\bar f}+\Phi_{\bar f})}\right], \quad \overline{A}_f = T_{\bar f} e^{i(\delta_f-\phi_{\bar f})}\left[1 + r_{\bar f} e^{i(\Delta_{\bar f}-\Phi_{\bar f})}\right]$$

Consider CF A_f and DCS $A_{\bar f}$ (e.g. $K^-\pi^+$): neglecting subleading terms (r_f, $r_{\bar f} = 0$), the weak phase difference of leading amplitudes ($\phi_f = \phi_{\bar f}$) and expanding for small x, y, $R_f = |T_{\bar f}/T_f|$, $\sin\theta_c$, the time-dependent decay rates become:

$$\Gamma(D(t)\to f) = e^{-\tau}|A_f|^2, \quad \Gamma(D(t)\to \bar f) = e^{-\tau}|A_f|^2\left(R_f^2 + R_f (y'_+)_f\tau + \frac{(x'_+)_f^2+(y'_+)_f^2}{4}\tau^2\right),$$
$$\Gamma(\bar D(t)\to \bar f) = e^{-\tau}|\bar A_{\bar f}|^2, \quad \Gamma(\bar D(t)\to f) = e^{-\tau}|\bar A_{\bar f}|^2\left(R_f^2 + R_f (y'_-)_f\tau + \frac{(x'_-)_f^2+(y'_-)_f^2}{4}\tau^2\right)$$

where $(x'_\pm)_f = \left|\frac{q}{p}\right|^{\pm1}(x'_f\cos\phi \pm y'_f\sin\phi)$, $\quad (y'_\pm)_f = \left|\frac{q}{p}\right|^{\pm1}(y'_f\cos\phi \mp x'_f\sin\phi)$ and

$$\begin{pmatrix} x'_f \\ y'_f \end{pmatrix} = \begin{pmatrix} \cos\delta_f & \sin\delta_f \\ -\sin\delta_f & \cos\delta_f \end{pmatrix}\begin{pmatrix} x \\ y \end{pmatrix}$$

Constrain the mixing parameters, but need two additional inputs: R_f, δ_f

	Observable	Value	Correlation Coeff.				
WA	y_{CP}	$(0.835 \pm 0.155)\%$					
WA	A_Γ	$(-0.059 \pm 0.040)\%$					
Belle	x	$(0.53 \pm 0.19 \pm 0.06 \pm 0.07)\%$	1	0.054	-0.074	-0.031	
	y	$(0.28 \pm 0.15 \pm 0.05 \pm 0.05)\%$	0.054	1	0.034	-0.019	
	$\lvert q/p \rvert$	$(0.91 \pm 0.16 \pm 0.5 \pm 0.6)$	-0.074	0.034	1	0.044	
	ϕ	$(-6 \pm 11 \pm 3 \pm 4)^\circ$	-0.031	-0.019	0.044	1	
BaBar	x	$(0.16 \pm 0.23 \pm 0.12 \pm 0.08)\%$	1	0.0615			
	y	$(0.57 \pm 0.20 \pm 0.13 \pm 0.07)\%$	0.0615	1			
WA	R_M	$(0.0130 \pm 0.0269)\%$					
BaBar	$(x'_+)_{K\pi\pi}$	$(2.48 \pm 0.59 \pm 0.39)\%$	1	-0.69			
	$(y'_+)_{K\pi\pi}$	$(-0.07 \pm 0.65 \pm 0.50)\%$	-0.69	1			
	$(x'_-)_{K\pi\pi}$	$(3.50 \pm 0.78 \pm 0.65)\%$	1	-0.66			
	$(y'_-)_{K\pi\pi}$	$(-0.82 \pm 0.68 \pm 0.41)\%$	-0.66	1			
CLEO	R_D	$(0.533 \pm 0.107 \pm 0.045)\%$	1	0	0	-0.42	0.01
	x^2	$(0.06 \pm 0.23 \pm 0.11)\%$	0	1	-0.73	0.39	0.02
	y	$(4.2 \pm 2 \pm 1)\%$	0.	-0.73	1	-0.53	-0.03
	$\cos\delta_{K\pi}$	$(0.84 \pm 0.2 \pm 0.06)$	-0.42	0.39	-0.53	1	0.04
	$\sin\delta_{K\pi}$	$(-0.01 \pm 0.41 \pm 0.04)$	0.01	0.02	-0.03	0.04	1
BaBar	R_D	$(0.3030 \pm 0.0189)\%$	1	0.77	-0.87		
	$(x'_+)^2_{K\pi}$	$(-0.024 \pm 0.052)\%$	0.77	1	-0.94		
	$(y'_+)_{K\pi}$	$(0.98 \pm 0.78)\%$	-0.87	-0.94	1		
BaBar	A_D	$(-2.1 \pm 5.4)\%$	1	0.77	-0.87		
	$(x'_-)^2_{K\pi}$	$(-0.020 \pm 0.050)\%$	0.77	1	-0.94		
	$(y'_-)_{K\pi}$	$(0.96 \pm 0.75)\%$	-0.87	-0.94	1		
Belle	R_D	$(0.364 \pm 0.018)\%$	1	0.655	-0.834		
	$(x'_+)^2_{K\pi}$	$(0.032 \pm 0.037)\%$	0.655	1	-0.909		
	$(y'_+)_{K\pi}$	$(-0.12 \pm 0.58)\%$	-0.834	-0.909	1		
Belle	A_D	$(2.3 \pm 4.7)\%$	1	0.655	-0.834		
	$(x'_-)^2_{K\pi}$	$(0.006 \pm 0.034)\%$	0.655	1	-0.909		
	$(y'_-)_{K\pi}$	$(0.20 \pm 0.54)\%$	-0.834	-0.909	1		
CDF	R_D	$(0.351 \pm 0.035)\%$	1	-0.967	0.900		
	$(y'_{CPA})_{K\pi}$	$(0.43 \pm 0.43)\%$	-0.967	1	-0.975		
	$(x'_{CPA})^2_{K\pi}$	$(0.008 \pm 0.018)\%$	0.900	-0.975	1		
LHCb	R_D	$(0.3568 \pm 0.0058 \pm 0.0033)\%$	1	-0.894	0.77	-0.895	0.772
	$(y'_+)_{K\pi}$	$(0.48 \pm 0.09 \pm 0.06)\%$	-0.894	1	-0.949	0.765	-0.662
	$(x'_+)^2_{K\pi}$	$(6.4 \pm 4.7 \pm 3)10^{-5}$	0.77	-0.949	1	-0.662	0.574
	$(y'_-)_{K\pi}$	$(0.48 \pm 0.09 \pm 0.06)\%$	-0.895	0.765	-0.662	1	-0.95
	$(x'_-)^2_{K\pi}$	$(4.6 \pm 4.6 \pm 3)10^{-5}$	0.772	-0.662	0.574	-0.95	1

Fitting the data

mostly from HFAG 2015, symmetrized errors

Different assumptions are possible:

i) no CPV

fit for x and y only

ii) no direct CPV

fit for x, y and $|q/p|$

iii) CPV fully allowed

fit for x, y, $|q/p|$, λ_f

\+ hadronic parameters

(strong phases, amp. ratios)

fit results – no direct CPV

parameter	result @ 68% prob.	95% prob. range
$\lvert M_{12}\rvert$ [ps^{-1}]	$(4.3 \pm 1.8)\cdot 10^{-3}$	$[0.6, 7.5]\cdot 10^{-3}$
$\lvert \Gamma_{12}\rvert$ [ps^{-1}]	$(14.1 \pm 1.4)\cdot 10^{-3}$	$[11.1, 17.3]\cdot 10^{-3}$
$\Phi_{M_{12}}$ [°]	(0.8 ± 2.6)	$[-5.8, 8.8]$
x	$(3.5 \pm 1.5)\cdot 10^{-3}$	$[0.5, 6.3]\cdot 10^{-3}$
y	$(5.8 \pm 0.6)\cdot 10^{-3}$	$[4.5, 7.1]\cdot 10^{-3}$
$\lvert q/p\rvert - 1$	0.007 ± 0.018	$[-0.030, 0.045]$
ϕ[°]	-0.21 ± 0.57	$[-1.53, 1.02]$

UTfit, 1402.1664, L. Silvestrini, CHARM 2015

- y well determined, x still uncertain
- $|q/p|$ is well compatible with 1
- phases are all compatible with 0

NO EVIDENCE FOR CPV

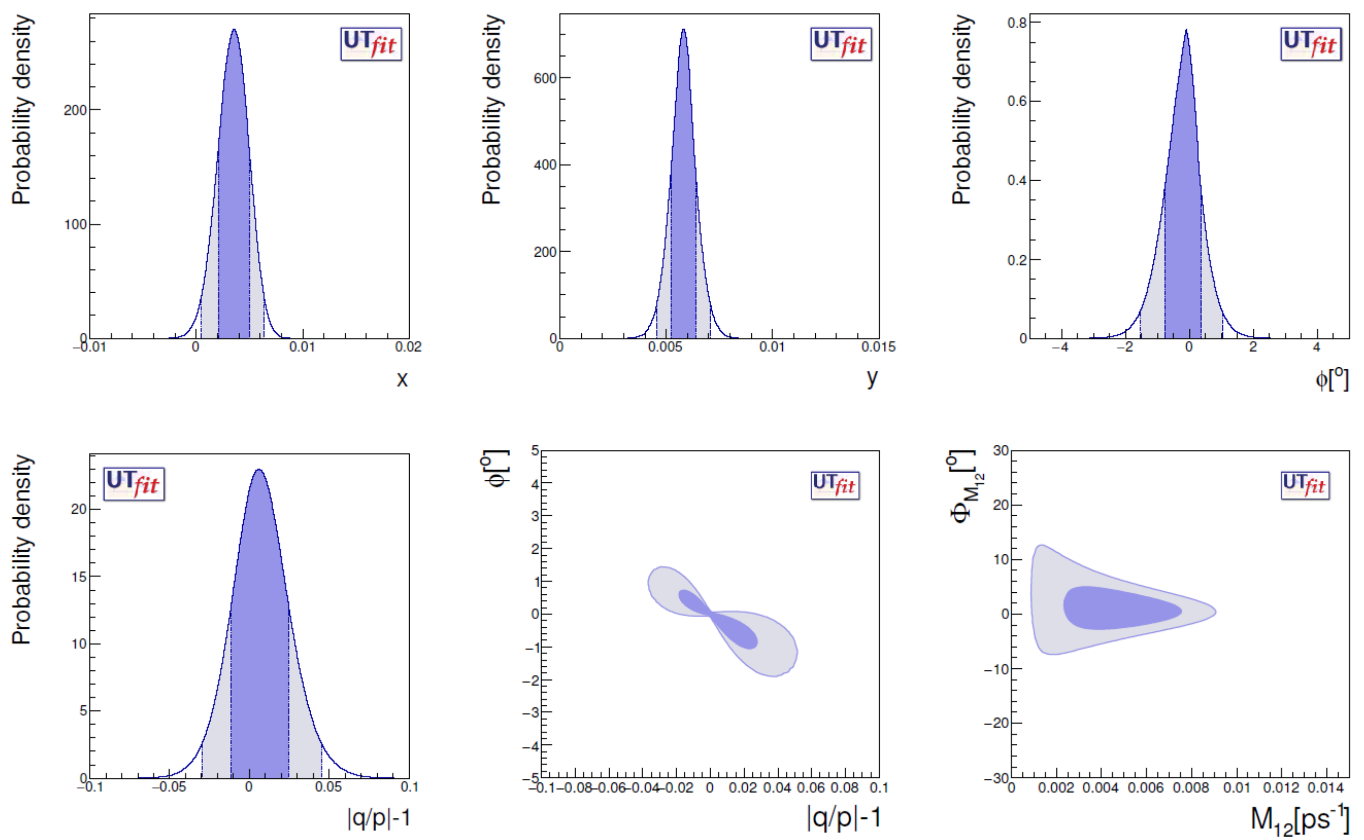
…YET…

Bayesian Fit

Floated parameters:

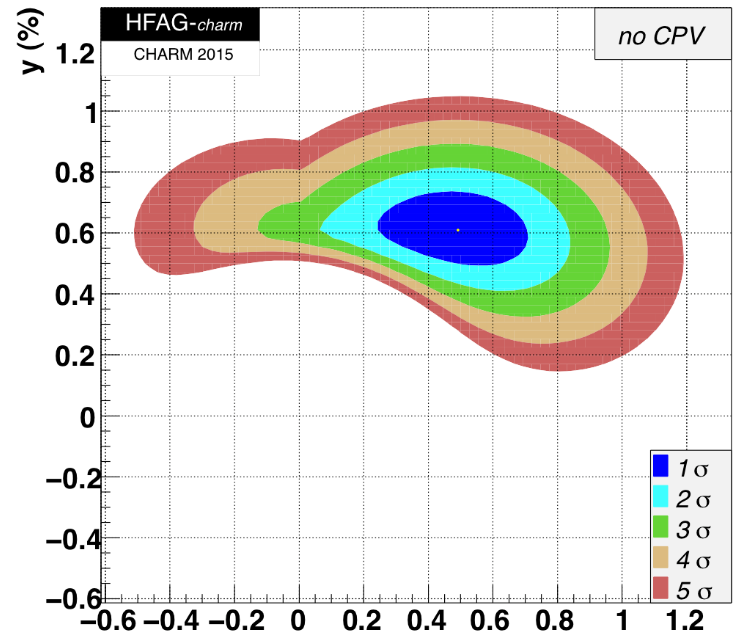
$$x,\ y,\ \left|\frac{q}{p}\right|,$$

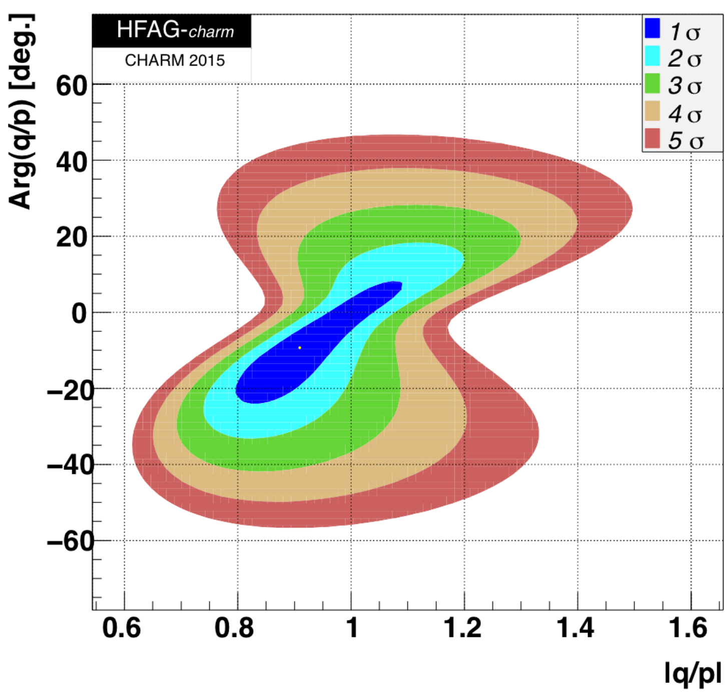
$$R_{K\pi},\ \delta_{K\pi},\ \delta_{K\pi\pi}$$



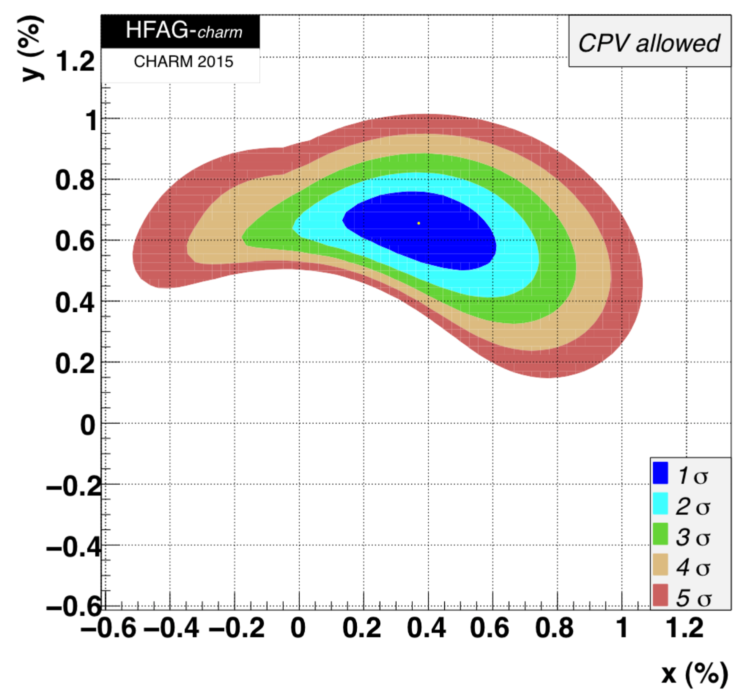
fit results – no CPV, full CPV

Parameter	No CPV	No direct CPV in DCS decays	CPV-allowed	95% CL Interval
x (%)	$0.49\,^{+0.14}_{-0.15}$	$0.44\,^{+0.14}_{-0.15}$	0.37 ± 0.16	[0.06, 0.67]
y (%)	0.61 ± 0.08	0.60 ± 0.07	$0.66\,^{+0.07}_{-0.10}$	[0.46, 0.79]
$\delta_{K\pi}$ (°)	$6.9\,^{+9.7}_{-11.2}$	$3.6\,^{+10.4}_{-12.1}$	$11.8\,^{+9.5}_{-14.7}$	[−21.1, 29.3]
R_D (%)	0.349 ± 0.004	0.348 ± 0.004	0.349 ± 0.004	[0.342, 0.357]
A_D (%)	–	–	$-0.39\,^{+1.01}_{-1.05}$	[−2.4, 1.5]
$\lvert q/p\rvert$	–	1.002 ± 0.014	$0.91\,^{+0.12}_{-0.08}$	[0.77, 1.14]
ϕ (°)	–	-0.07 ± 0.6	$-9.4\,^{+11.9}_{-9.8}$	[−28.3, 12.9]
$\delta_{K\pi\pi}$ (°)	$18.1\,^{+23.3}_{-23.8}$	$20.3\,^{+24.0}_{-24.3}$	$27.3\,^{+24.4}_{-25.4}$	[−23.3, 74.8]
A_π	–	0.10 ± 0.14	0.10 ± 0.15	[−0.19, 0.38]
A_K	–	-0.14 ± 0.13	-0.15 ± 0.14	[−0.42, 0.12]
x_{12} (%)	–	$0.44\,^{+0.14}_{-0.15}$		[0.13, 0.69]
y_{12} (%)	–	0.60 ± 0.07		[0.45, 0.74]
ϕ_{12}(°)	–	0.2 ± 1.7		[−4.1, 4.6]





HFAG 2015



New Physics in the ΔC=2 amplitude

NP enters through the local ME $\langle D|H_{eff}^{\Delta C=2}|\bar{D}\rangle$

$$H_{eff}^{\Delta C=2}=\sum_{i=1}^{5} C_i(\mu)Q_i(\mu)+\sum_{i=1}^{3}\tilde{C}_i(\mu)\tilde{Q}_i(\mu)+H.c.$$

$$Q_1=\bar{u}_L^\alpha \gamma_\mu c_L^\alpha\ \bar{u}_L^\beta \gamma^\mu c_L^\beta \qquad \text{(SM)}$$

$$Q_2=\bar{c}_R^\alpha u_L^\alpha\ \bar{c}_R^\beta u_L^\beta \qquad Q_3=\bar{c}_R^\alpha u_L^\beta\ \bar{c}_R^\beta u_L^\alpha$$

$$Q_4=\bar{c}_R^\alpha u_L^\alpha\ \bar{c}_L^\beta u_R^\beta \qquad Q_5=\bar{c}_R^\alpha u_L^\beta\ \bar{c}_L^\beta u_R^\alpha$$

$$\tilde{Q}_1=\bar{c}_R^\alpha \gamma_\mu u_R^\alpha\ \bar{c}_R^\beta \gamma^\mu u_R^\beta$$

$$\tilde{Q}_2=\bar{c}_L^\alpha u_R^\alpha\ \bar{c}_L^\beta u_R^\beta \qquad \tilde{Q}_3=\bar{c}_L^\alpha u_R^\beta\ \bar{c}_L^\beta u_R^\alpha$$

7 new operators beyond SM involving quarks with different chiralities

H_{eff} can be recast in terms of the high-scale $C_i(\Lambda)$

- $C_i(\Lambda)$ can be extracted from the data (one by one)

	95% upper limit (GeV^{-2})	Lower limit on Λ (TeV)
$\mathrm{Im}C_D^1$	$[-1.4, 2.0] \cdot 10^{-14}$	$7.1 \cdot 10^3$
$\mathrm{Im}C_D^2$	$[-2.5, 1.7] \cdot 10^{-15}$	$20.0 \cdot 10^3$
$\mathrm{Im}C_D^3$	$[-2.4, 3.5] \cdot 10^{-14}$	$5.3 \cdot 10^3$
$\mathrm{Im}C_D^4$	$[-5.2, 7.7] \cdot 10^{-16}$	$36.0 \cdot 10^3$
$\mathrm{Im}C_D^5$	$[-5.3, 7.9] \cdot 10^{-15}$	$11.2 \cdot 10^3$

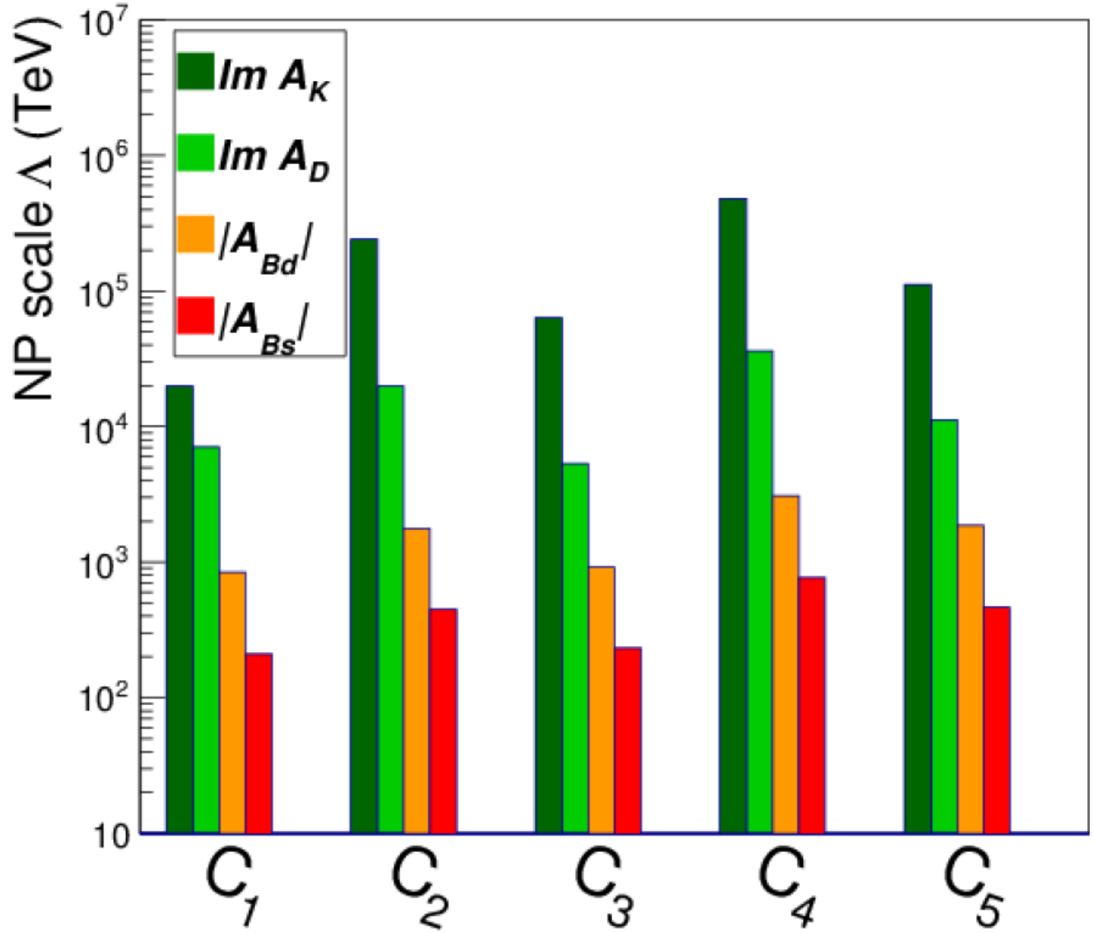
- the NP scale Λ is defined as:

$$\Lambda = \sqrt{\frac{L \times F_i}{C_i(\Lambda)}}$$

NP loop (L) and flavour (F_i) couplings are model dependent: shown NP scales assume L=1 and $|F_i|$=1 with arbitrary phases

Comparison with other meson mixing

Λ (TeV)	K CPV	D CPV	B_d CPC	B_s CPC
lower bound	4.8×10^5	3.6×10^4	3.1×10^3	760



Summary

A precise calculation of the D-$\bar{D}$ mixing parameters is not feasible at present. A technique for computing long-distance contributions is eagerly awaited

Yet the flavour structure of mixing and decay amplitudes is such that (i) SM CPV in mixing is very small, (ii) CPC measurements, CPV in mixing, and CPV in the interference of mixed and unmixed decays can all be combined to constrain the mixing parameters

No sign of deviation from the SM so far (i.e. no CPV in mixing found). Yet CPV in $\bar{D}$-D mixing shows its NP sensitivity by putting a strong lower bound on the scale of NP with generic flavour structure and O(1) couplings

Backup

Comparison with other meson mixing

Λ (TeV)	K	D	B_d	B_s
FC~1	5×10^5	3.5×10^4	3.3×10^3	880
FC~SM	113	8.5	21	27