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CP

Phys.Lett.B 684 (2010) 137-140

CP violation in $D \to VV$ decay

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The Menu

- Prologue
- Triple-product terms ⟺ T odd signals
- CP violating observables
- Potential at BES-III and super tau-charm

Experimental Status of $\not{CP}$ in D meson

http://www.slac.stanford.edu/xorg/hfag/

CLEO hep-ex/0102006

$$A_{CP}(K^+K^-) = (+0.05 \pm 2.18 \pm 0.84)\%$$

$$A_{CP}(\pi^+\pi^-) = (+2.0 \pm 3.2 \pm 0.8)\%$$

$$A_{CP}(K_S^0\pi^0) = (+0.1 \pm 1.3)\%$$

$$A_{CP}(\pi^0\pi^0) = (+0.1 \pm 4.8)\%$$

$$A_{CP}(K_S^0K_S^0) = (-23 \pm 19)\%$$

missing PV or VV?

We find no evidence of CP asymmetry in five different two-body decay modes of neutral D to pairs of light pseudo-scalar mesons.

BARBAR Phys. Rev. D 78,051002(R) (2008)

$$A_{CP}(\pi^+\pi^-\pi^0) = (-0.31 \pm 0.41 \pm 0.17)\%$$

$$A_{CP}(K^+K^-\pi^0) = (1.0 \pm 1.67 \pm 0.25)\%$$

We find no evidence of CP violation and hence no conflict with SM

E791 collaboration, Phys.Lett.B 403 (1997) 377

$$A_{CP}(\phi\pi) = -0.028 \pm 0.036$$

$$A_{CP}(K^*(892)K) = -0.010 \pm 0.050$$

Poor data for $D \rightarrow V_1 V_2$ in PDG

D^0 decay

Large branching ratios!

$\overline{K}^*(892)^0 \rho^0$	(1.50 ± 0.33) %	
$\overline{K}^*(892)^0 \rho^0$ transverse	(1.6 ± 0.5) %	
$\overline{K}^*(892)^0 \rho^0$ S-wave	(2.9 ± 0.6) %	
$\overline{K}^*(892)^0 \rho^0$ S-wave long.	< 3 $\times 10^{-3}$	CL=90%
$\overline{K}^*(892)^0 \rho^0$ P-wave	< 3 $\times 10^{-3}$	CL=90%
$\overline{K}^*(892)^0 \rho^0$ D-wave	(2.0 ± 0.6) %	
$K^*(892)^- \rho^+$	(6.4 ± 2.5) %	
$K^*(892)^- \rho^+$ longitudinal	(3.1 ± 1.2) %	
$K^*(892)^- \rho^+$ transverse	(3.4 ± 2.0) %	
$K^*(892)^- \rho^+$ P-wave	< 1.5 %	CL=90%

Missing modes

$\rho\rho$

$\rho\omega$

$\omega\omega$

D^+ decay

$\overline{K}^*(892)^0 \rho^+$ total	[ss]	(1.8 ±1.4) %	
$\overline{K}^*(892)^0 \rho^+$ S-wave	[ss]	(1.4 ±1.5) %	
$\overline{K}^*(892)^0 \rho^+$ P-wave		< 1 $\times 10^{-3}$	CL=90%
$\overline{K}^*(892)^0 \rho^+$ D-wave		(8 ±7) $\times 10^{-3}$	
$\overline{K}^*(892)^0 \rho^+$ D-wave longitudinal		< 7 $\times 10^{-3}$	CL=90%
$K^*(892)^+ \overline{K}^*(892)^0$		(2.6 ±1.1) %	

CP violation in the charm sector is tiny in SM, any significant CP violating signals will be evidence of NP.

Past work on CP in D meson in theoretical view:

Z.z.Xing,Phys.Rev.D 55 , 196 (1997) …

triple product asymmetry occurs.

J.G.Korner, K.Schilcher, Y.L.Wu, Z.Phys.C 55 (1992) 479.

by exploiting quantum correlation in $D^0\bar{D}^0$ pair

J.Charles, S.Descotes-Genon, X.W.Kang, H.B.Li, G.R.Lu, Phys.Rev.D**81**, 054032 (2010)

$$D^0\bar{D}^0 \to (V_1V_2)(V_3V_4)$$

$(0,\perp)$ $(\|,\perp)$ are allowed helicity combinations.

Can we probe the CP violation in D meson without the quantum correlation ?

Among the various kinds of D decay modes, $D \to VV$ and subsequently decaying to two pseudoscalars for each vector meson is a particularly interesting one in the perspective of the copious kinematics of final state interaction (FSI)

IMPORTANT:

We may construct the CP violating observables through the angular distribution.

G.Kramer et al,

Phys.Rev.D 45 (1992) 193.

Phys.Rev.D 46 (1992) 3197.

Phys.Lett.B 279 (1992) 181.

The idea of T odd "triple product correlation":

G.Valencia, Phys.Rev.D 39 (1989) 3339.

A.Datta and D.London, Int.J.Mod.A 19 (2004) 2505.

Under T, P, C transformation

Physical quantity	T	P	C
r	r	-r	r
t	-t	t	t
p	-p	-p	p
L	-L	L	L
s	-s	s	s
s · p	s · p	-s · p	s · p
$s\cdot(p_1\times p_2)$	$-s\cdot(p_1\times p_2)$	$s\cdot(p_1\times p_2)$	$s\cdot(p_1\times p_2)$

T odd

Let us consider the process

$$D(p) \rightarrow V_1(k_1, \varepsilon_1) V_2(k_2, \varepsilon_2)$$

momentum

polarization

The most general invariant amplitude can be expressed as:

$$p_\alpha \phi^\alpha(m) = 0$$

analyzing Lorentz structer

$$M \equiv as + bd + icp$$

mass

$$= a\varepsilon_1^* \cdot \varepsilon_2^* + \frac{b}{m_1 m_2}(p \cdot \varepsilon_1^*)(p \cdot \varepsilon_2^*) + i\frac{c}{m_1 m_2}\varepsilon^{\alpha\beta\gamma\delta}\varepsilon_{1\alpha}^*\varepsilon_{2\beta}^* k_\gamma p_\delta$$

The coefficients a, b and c are generally complex and can receive various contributions with different phase.

The parameterization of the coefficients:

a_j, b_j, c_j ⇕ the modular of the corresponding complex quantity.

$$a = \sum_j a_j e^{i\delta_{sj}} e^{i\phi_{sj}},$$

$$b = \sum_j b_j e^{i\delta_{dj}} e^{i\phi_{dj}},$$

$$c = \sum_j c_j e^{i\delta_{pj}} e^{i\phi_{pj}}.$$

δ ⟺ strong phase

ϕ ⟺ weak phase

note: the weak phase ϕ is the necessary condition for occuring of CP violation on the basis of CKM mechanism .

Square the matrix element: ⟵ It should be noted that a,b,c are complex.

$$|\mathcal{M}|^2 = |a|^2\left|\epsilon_1^* \cdot \epsilon_2^*\right|^2 + \frac{|b|^2}{m_1^2 m_2^2}\left|\left(k \cdot \epsilon_2^*\right)\left(q \cdot \epsilon_1^*\right)\right|^2$$

$$+ \frac{|c|^2}{m_1^2 m_2^2}\left|\epsilon^{\alpha\beta\gamma\delta}\epsilon_{1\alpha}^*\epsilon_{2\beta}^* k_\gamma p_\delta\right|^2$$

$$+ 2\frac{\mathrm{Re}(ab^*)}{m_1 m_2}\left(\epsilon_1^* \cdot \epsilon_2^*\right)\left(k \cdot \epsilon_2^*\right)\left(q \cdot \epsilon_1^*\right)$$

$$+ 2\frac{\mathrm{Im}(ac^*)}{m_1 m_2}\left(\epsilon_1^* \cdot \epsilon_2^*\right)\underline{\epsilon^{\alpha\beta\gamma\delta}\epsilon_{1\alpha}^*\epsilon_{2\beta}^* k_\gamma p_\delta}$$

$$+ 2\frac{\mathrm{Im}(bc^*)}{m_1^2 m_2^2}\left(k \cdot \epsilon_2^*\right)\left(q \cdot \epsilon_1^*\right)\underline{\epsilon^{\alpha\beta\gamma\delta}\epsilon_{1\alpha}^*\epsilon_{2\beta}^* k_\gamma p_\delta}.$$

↑ T odd triple-product term

From the rest frame, $\mathrm{p}_\delta = (\mathrm{E}, 0, 0, 0)$

it becomes $\varepsilon^{\alpha\beta\gamma\delta}\varepsilon_{1\alpha}^*\varepsilon_{2\beta}^*\mathrm{k}_\gamma = (\vec{\varepsilon}_1^* \times \vec{\varepsilon}_2^*) \cdot \vec{\mathrm{k}}$

Define the asymmetry $\mathcal{A}_T = \frac{N(\vec{k}\cdot\vec{\epsilon}_1^* \times \vec{\epsilon}_2^* > 0) - N(\vec{k}\cdot\vec{\epsilon}_1^* \times \vec{\epsilon}_2^* < 0)}{N_{total}},$

Equivalently one defines,

$$\mathcal{A}_T = \frac{\Gamma(\vec{k}\cdot\vec{\epsilon}_1^* \times \vec{\epsilon}_2^* > 0) - \Gamma(\vec{k}\cdot\vec{\epsilon}_1^* \times \vec{\epsilon}_2^* < 0)}{\Gamma(\vec{k}\cdot\vec{\epsilon}_1^* \times \vec{\epsilon}_2^* > 0) + \Gamma(\vec{k}\cdot\vec{\epsilon}_1^* \times \vec{\epsilon}_2^* > 0}.$$

Triple product correlation arises from the interference term and will be present if Im(ac*) (or Im(bc*)) is nonzero.

$$\mathcal{A}_T \propto \mathrm{Im}(ac^*) = \sum_{i,j} a_i c_j \sin[(\phi_{si} - \phi_{pj}) + (\delta_{si} - \delta_{pj})].$$

ϕ δ

phase difference

Note: the strong phase can also produce nonzero ,
even the weak phase are zero.

A nonzero triple correlation does not necessarily imply CP violation, since FSI can fack it. Comparing a TP for CP conjugate transitions allows to distinguish the genuine CPV from FSI.

For conjugate channel

$$\bar{D}(p') \to \bar{V}_1(k'_1, \varepsilon'_2)\bar{V}_2(k'_2, \varepsilon'_2)$$

the amplitude reads,

minus

$$\bar{M} = \bar{a}\varepsilon_1^* \cdot \varepsilon_2^* + \frac{\bar{b}}{m_1 m_2}(p\cdot\varepsilon_1^*)(p\cdot\varepsilon_2^*) - i\frac{\bar{c}}{m_1 m_2}\varepsilon^{\alpha\beta\gamma\delta}\varepsilon_{1\alpha}^*\varepsilon_{2\beta}^* k_\gamma p_\delta$$

where the coefficients are

$$\bar{a} = \sum_j a_j e^{i\delta_{sj}} e^{-i\phi_{sj}},$$

minus

$$\bar{b} = \sum_j b_j e^{i\delta_{sj}} e^{-i\phi_{dj}},$$

$$\bar{c} = \sum_j c_j e^{i\delta_{pj}} e^{-i\phi_{pj}}.$$

$$p^\alpha \to \bar{p}^\alpha = (p^0, -\vec{p})$$

Let a, b, c, d be any four-vector, using shorthand notations

$$(a\cdot b) = g_{\alpha\beta}a^\alpha b^\beta,$$

$$(abcd) = \varepsilon_{\alpha\beta\gamma\delta}a^\alpha b^\beta c^\gamma d^\delta.$$

one finds

$$(a\cdot b) = (\bar{a}\cdot\bar{b}),$$

$$(abcd) = -(\bar{a}\bar{b}\bar{c}\bar{d})$$

Define $e^\alpha = \varepsilon_{\alpha\beta\gamma\delta}b^\beta c^\gamma d^\delta$

$$e^\alpha \to -\bar{e}^\alpha = (-e_0, \vec{e})$$

Spin-1 wave function should be pseudo-vector as e.

$$\phi^\alpha(m) \to -\bar{\phi}^\alpha(m).$$

The minus sign will induce an interesting property between $|\mathrm{M}|^2$ and $|\bar{\mathrm{M}}|^2$

$$
\begin{aligned}
|\overline{\mathcal{M}}|^2 = {} & |\bar{a}|^2 \left|\epsilon_1^* \cdot \epsilon_2^*\right|^2 + \frac{|\bar{b}|^2}{m_1^2 m_2^2} \left|(k \cdot \epsilon_2^*)(q \cdot \epsilon_1^*)\right|^2 \\
& + \frac{|\bar{c}|^2}{m_1^2 m_2^2} \left|\epsilon^{\alpha\beta\gamma\delta} \epsilon_{1\alpha}^* \epsilon_{2\beta}^* k_\gamma p_\delta\right|^2 \\
& + 2\frac{\mathrm{Re}(\bar{a}\bar{b}^*)}{m_1 m_2} (\epsilon_1^* \cdot \epsilon_2^*)(k \cdot \epsilon_2^*)(q \cdot \epsilon_1^*) \\
& - 2\frac{\mathrm{Im}(\bar{a}\bar{c}^*)}{m_1 m_2} (\epsilon_1^* \cdot \epsilon_2^*) \epsilon^{\alpha\beta\gamma\delta} \epsilon_{1\alpha}^* \epsilon_{2\beta}^* k_\gamma p_\delta \\
& - 2\frac{\mathrm{Im}(\bar{b}\bar{c}^*)}{m_1^2 m_2^2} (k \cdot \epsilon_2^*)(q \cdot \epsilon_1^*) \epsilon^{\alpha\beta\gamma\delta} \epsilon_{1\alpha}^* \epsilon_{2\beta}^* k_\gamma p_\delta .
\end{aligned}
$$

$$\bar{A}_T \propto -\mathrm{Im}(\overline{ac}^*) = \sum_{i,j} a_i c_j \sin[\phi - \delta]$$

$$\frac{1}{2}(\mathcal{A}_{\mathcal{T}} + \bar{\mathcal{A}}_{\mathcal{T}}) \propto \frac{1}{2}[\mathrm{Im}(ac^*) - \mathrm{Im}(\bar{a}\bar{c}^*)]$$
$$= \sum_{i,j} a_i c_j \sin(\phi_{si} - \phi_{pj}) \cos(\delta_{si} - \delta_{pj}),$$

and

$$\frac{1}{2}(\mathcal{A}_{\mathcal{T}} - \bar{\mathcal{A}}_{\mathcal{T}}) \propto \frac{1}{2}[\mathrm{Im}(ac^*) + \mathrm{Im}(\bar{a}\bar{c}^*)]$$
$$= \sum_{i,j} a_i c_j \cos(\phi_{si} - \phi_{pj}) \sin(\delta_{si} - \delta_{pj}).$$

So far, a nonzero $\mathcal{A}_{\mathcal{T}} + \bar{\mathcal{A}}_{\mathcal{T}}$ will undoubtedly be a clean signal of CP non-conservation.

⇧

at least one nonzero weak phase exists.

$$\mathcal{A}_{dir} \propto \sin\phi \sin\delta,$$
$$\mathcal{A}_{\mathcal{T}} \propto \sin\phi \cos\delta.$$

→ more sensitive to NP !

if delta is small

A.S.Dighe et al, Phys.Lett.B 369 (196) 144-150.

As has been noted in B ->VV decay, the decay amplitude can be expressed as

$$A(D \to V_1 V_2) = A_0 (m_2/E_2) \varepsilon_1^{*L} \cdot \varepsilon_2^{*L} - \frac{A_{\parallel}}{\sqrt{2}} \vec{\varepsilon}_1^{\,*T} \cdot \vec{\varepsilon}_2^{\,*T} - i \frac{A_{\perp}}{\sqrt{2}} \vec{\varepsilon}_1^{\,*} \times \vec{\varepsilon}_2^{\,*} \cdot \hat{p}.$$

$\vec{\varepsilon}^{\,*}$: polarization three-vecotr

$\hat{p}$: a unit vector in the direction of the momentum of V2 in the rest frame of V1.

$$\varepsilon^{*L} \equiv \hat{p} \cdot \vec{\varepsilon}^{\,*}$$

$$\vec{\varepsilon}^{\,*T} = \vec{\varepsilon}^{\,*} - \varepsilon^{*L} \hat{p}$$

CP even $\vec{\varepsilon}_1^{\,*} \cdot \vec{\varepsilon}_2^{\,*}$ contributes to A_0 and $A_{\parallel}$

$\vec{\varepsilon}_1^{\,*} \cdot \hat{p} \varepsilon_2^{*} \cdot \hat{p} \equiv \varepsilon_1^{*L} \cdot \varepsilon_2^{*L}$ only to A_0

$\vec{\varepsilon}_1^{\,*} \times \vec{\varepsilon}_2^{\,*} \cdot \hat{p}$ contributes to $A_{\perp}$

Writing up the polarization four-vector in the rest frame fo V1, comparing the two sets of expressions for the decay amplitudes,

we find the helicities are the linear combination of the complex coefficients a ,b and c.

$$A_0 = -ax - b\left(x^2 - 1\right),$$

$$A_\parallel = \sqrt{2}a,$$

$$A_\perp = \sqrt{2}c\sqrt{x^2 - 1},$$

where

$$x = \frac{k \cdot q}{m_1 m_2} = \frac{m_D^2 - m_1^2 - m_2^2}{2m_1 m_2}$$

Let us first write out the full angular dependence of the process

$$D \to V_1 V_2 \to (P_1 P_2)(P_3 P_4)$$

For a cascade decay, an adequate formalism to treat the problem is the frame work of helicity amplitudes.

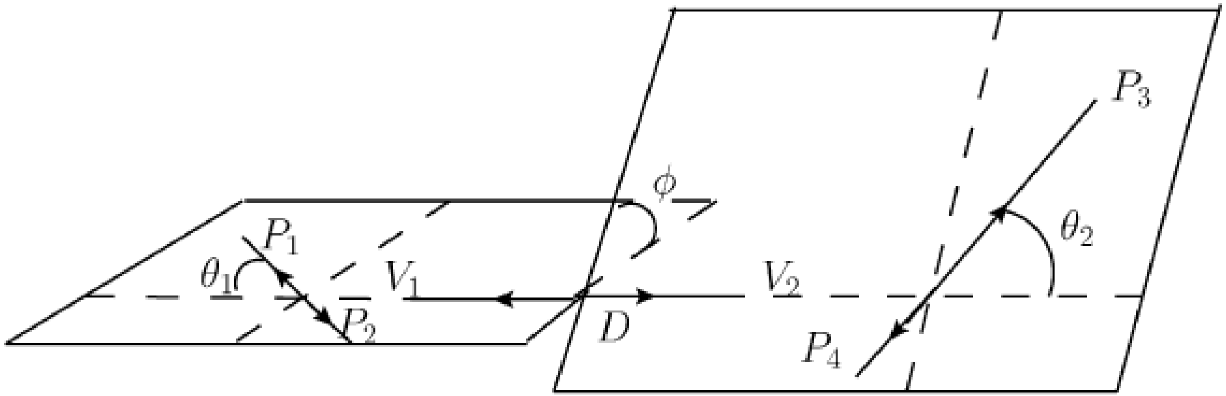


Fig. 1. Illustrative plot for the decay kinematics of process $D \to V_1 V_2 \to (P_1 P_2)(P_3 P_4)$ in the rest frame of $V_{1,2}$.

ϕ is the angle between the two decay planes of vector mesons in the D rest frame.

$$\frac{d\Gamma}{d\cos\theta_1\, d\cos\theta_2\, d\phi} \propto \frac{1}{2}\sin^2\theta_1 \sin^2\theta_2 \cos^2\phi |A_\parallel|^2 + \frac{1}{2}\sin^2\theta_1 \sin^2\theta_2 \sin^2\phi |A_\perp|^2 + \cos^2\theta_1 \cos^2\theta_2 |A_0|^2 - \frac{1}{2}\sin^2\theta_1 \sin^2\theta_2 \sin 2\phi \,\mathrm{Im}\left(A_\perp A_\parallel^*\right) - \frac{\sqrt{2}}{4}\sin 2\theta_1 \sin 2\theta_2 \cos\phi \,\mathrm{Re}\left(A_\parallel A_0^*\right) + \frac{\sqrt{2}}{4}\sin 2\theta_1 \sin 2\theta_2 \sin\phi \,\mathrm{Im}\left(A_\perp A_0^*\right),$$

We have introduced $\mathrm{A}_\perp$ with definite odd CP eigenvalue and the CP even partners $\mathrm{A}_0, \mathrm{A}_\parallel$

$$A_0 = A_0,$$

$$A_\parallel = \frac{1}{\sqrt{2}}(A_{11} + A_{-1-1}),$$

$$A_\perp = \frac{1}{\sqrt{2}}(A_{11} - A_{-1-1}),$$

J.G.Korner, G.R.Goldstein, Phys.Lett.B 89 (1979) 105.

M.Beneke, J.Rohre, and D.s.Yang Nucl.Phys.B774 (2007) 64.

As discussed previously, the TP asymmetry is connected with angular distribution, one can define the following T-odd quantities.

$$\mathcal{A}_T^0 \equiv \frac{\mathrm{Im}(A_\perp A_0^*)}{|A_0|^2 + |A_\perp|^2 + |A_\parallel|^2},$$

and

$$\mathcal{A}_T^\parallel \equiv \frac{\mathrm{Im}(A_\perp A_\parallel^*)}{|A_0|^2 + |A_\perp|^2 + |A_\parallel|^2},$$

thus we will derive the genuine CP violating observables,

$$\mathcal{A} = \frac{1}{2}(\mathcal{A}_T^0 + \bar{\mathcal{A}}_T^0)$$

$$= \frac{1}{2}\left(\frac{\mathrm{Im}(A_\perp A_0^*)}{|A_0|^2 + |A_\perp|^2 + |A_\parallel|^2} + \frac{\mathrm{Im}(\bar{A}_\perp \bar{A}_0^*)}{|\bar{A}_0|^2 + |\bar{A}_\perp|^2 + |\bar{A}_\parallel|^2}\right),$$

and

$$\mathcal{A}' = \frac{1}{2}(\mathcal{A}_T^\parallel + \bar{\mathcal{A}}_T^\parallel)$$

$$= \frac{1}{2}\left(\frac{\mathrm{Im}(A_\perp A_\parallel^*)}{|A_0|^2 + |A_\perp|^2 + |A_\parallel|^2} + \frac{\mathrm{Im}(\bar{A}_\perp \bar{A}_\parallel^*)}{|\bar{A}_0|^2 + |\bar{A}_\perp|^2 + |\bar{A}_\parallel|^2}\right).$$

Let us recall the related work in the past days.

1. The T odd momentum found in the rare mode $K_L \to \pi^+\pi^- e^+ e^-$ can teach us important lessons for future searches in charm decays.

Phys.Rev.D 46, 1035 (1992).

2. For D decays $\overset{(-)}{D} \to K\bar{K}\pi^+\pi^-$ can be treated in an analogous way.

Bigi, hep-ph/0703132

Defining ϕ as the angle between the $K\bar{K}$ and $\pi^+\pi^-$ planes, then one has

$$\frac{d\Gamma}{d\phi}(D \to K\bar{K}\pi^+\pi^-) = \Gamma_1 \cos^2\phi + \Gamma_2 \sin^2\phi + \Gamma_3 \cos\phi \sin\phi,$$

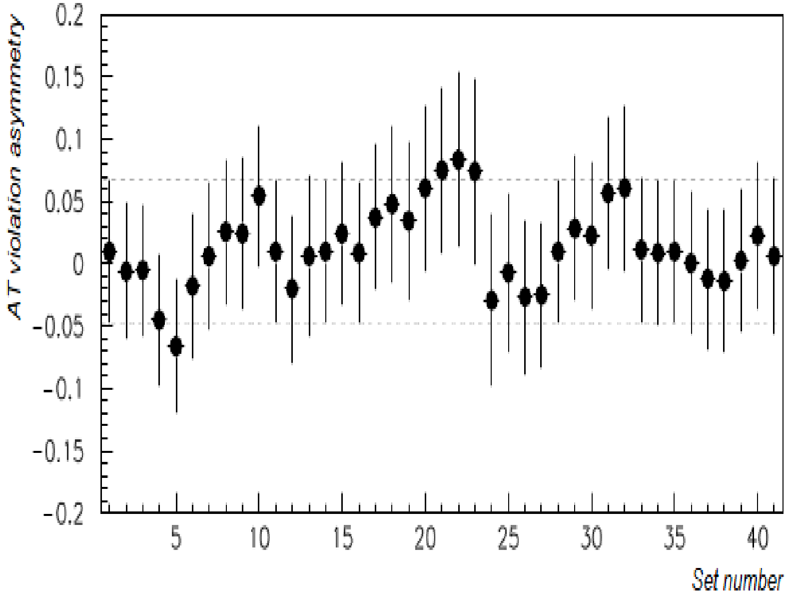
$$\frac{d\Gamma}{d\phi}(\bar{D} \to K\bar{K}\pi^+\pi^-) = \bar{\Gamma}_1 \cos^2\phi + \bar{\Gamma}_2 \sin^2\phi - \bar{\Gamma}_3 \cos\phi \sin\phi.$$

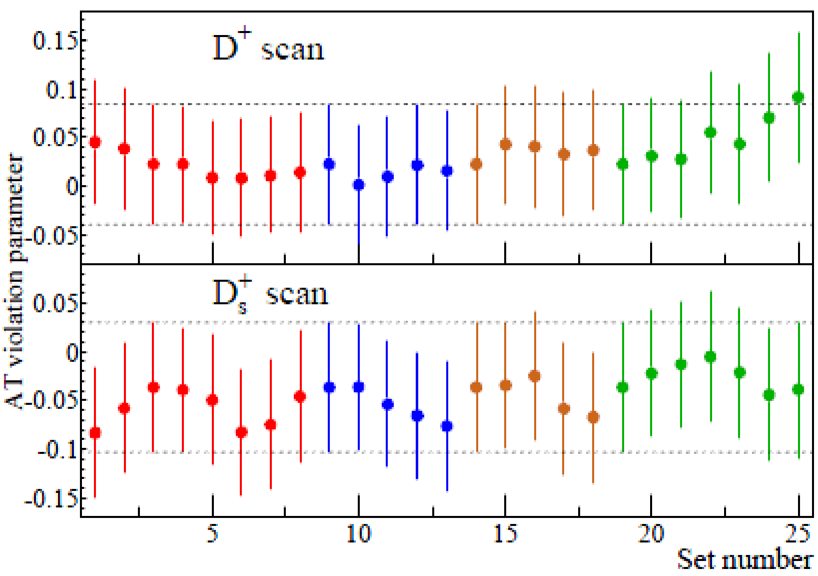
$\Gamma_1 \neq \bar{\Gamma}_1, \quad \Gamma_2 \neq \bar{\Gamma}_2$ → direct CP violation in the partial width

$\Gamma_3 \neq \bar{\Gamma}_3$ → CP violation!

The only reported experimental search for T odd asymmetries for D mesons.

J.M.Link et al, FOCUS collaboration, Phys.Lett.B 622 (2005) 239.





T asymmetry versus various set of cuts, the dashed lines show A_T the quoted $\pm 1\sigma$ asymmetry

Table 1
T violating asymmetries in *D* meson decays from the FOCUS experiment [25].

Decay mode	$\mathcal{A}$ (%)
$D^0 \to K^+K^-\pi^+\pi^-$	$1.0 \pm 5.7 \pm 3.7$
$D^+ \to K_S K^+\pi^+\pi^-$	$2.3 \pm 6.2 \pm 2.2$
$D_S^+ \to K_S K^+\pi^+\pi^-$	$-3.6 \pm 6.7 \pm 2.3$

large?

No evidence for a T asymmetry is observed !

The large BES-III data sample is expected to provide enhanced sensitivity to possible T asymmetry.

We will consider the potential sensitivity on the CP violating observalbes A and A′ at BES-III.

Table 2
The promising (*VV*) modes with large branching fractions, efficiencies and expected errors on the *T* asymmetry: the corresponding expected errors are estimated by assuming 20 fb^{-1} data at $\psi(3770)$ peak at BES-III; the branching fractions with asterisk are estimated according to Refs. [29–32]. The last row is from D^+ decay.

VV	Br (%)	Eff. (ϵ)	Expected errors
$\rho^0\rho^0 \to (\pi^+\pi^-)(\pi^+\pi^-)$	0.18	0.74	0.004
$\bar{K}^{*0}\rho^0 \to (K^-\pi^+)(\pi^+\pi^-)$	1.08	0.68	0.002
$\rho^0\phi \to (\pi^+\pi^-)(K^+K^-)$	0.14	0.26	0.006
$\rho^+\rho^- \to (\pi^+\pi^0)(\pi^-\pi^0)$	0.6*	0.55	0.002
$K^{*+}K^{*-} \to (K^+\pi^0)(K^-\pi^0)$	0.08*	0.55	0.006
$K^{*0}\bar{K}^{*0} \to (K^+\pi^-)(K^-\pi^+)$	0.048	0.62	0.002
$\bar{K}^{*0}\rho^+ \to (K^-\pi^+)(\pi^+\pi^0)$	1.33	0.59	0.001

the sensitivities (errors) can reach the magnitude of $O(10^{-3})$

neglect $D^0 - \bar{D}^0$ oscillation

1. The branching ratios with asterisks have not been measured yet, but some estimates combining naïve factorization and models for FSI are available.

2. The estimated efficiencies are average values for the various partial waves by assuming that the magnitude of the longitudinal polarization is half of decay rate.

Some issues in the experiments.

1. In the future, a careful measurements about both the efficiencies and the branching fractions for each partial wave are suggested.

2. A more realistic analysis requires a likelyhood fit to the full angular dependence.

3. Systematics will dominate the results.

- mis-reconstruction of PP as the events that actually come from other resonances.
- Non-resonance background contributions
- sizable width of the vector resonance.

The precise measurements are beyond the scope the this paper and are encouraged at BES-III and Super tau-charm factory.

Conclusions

- We studied the CP violation in D to VV decay in which the T odd triple-correlation is examined and the genuine CP violating observables are constructed.

$$\mathcal{A}_{dir} \propto \sin\phi \sin\delta,$$

$$\mathcal{A}_{\mathcal{T}} \propto \sin\phi \cos\delta.$$

Thank all!

- The T asymmetry is more sensitive to NP.

- Large D data sample will provide a great opportunity to perform it.

We would thank Z.z.Xing, C.D.Lv and D.s. Yang
for useful discussions.