Model INDEPENDENT study of T-VIOLATION (and CPT)

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Summary

- Theoretical motivation.
  - Why is interesting this test?
  - How we build the asymmetry?
- Analysis strategy.
- Idea based on:
  - M.C. Bañuls, J.Bernabeu, Phys. Lett. B 464,117(1999),[arXiv::hep-ph/9908353].
  - M.C. Bañuls, J.Bernabeu, Nucl. Phys. B 590,19(2000),[arXiv::hep-ph/0005323].
  - M.C. Bañuls, J.Bernabeu, JHEP 9906:032(1999),[arXiv::hep-ph/9807430].

Why? Independent

- Although CPT is a good symmetry is interesting the observation of T-violation INDEPENDENT of CP-Violation.
- Problem with Kabir asymmetry in:

$$K^0 - \overline{K}^0 \qquad \xrightarrow{\text{CPT}} \qquad K^0 - \overline{K}^0$$
$$B^0 - \overline{B}^0 \qquad\qquad\qquad B^0 - \overline{B}^0$$

CP-LEAR

B-Factories

CPT EVEN!!!!!!

References:

- T.Nakada, Discrete '08 Conference, Valencia 2008', J.Phys.Conf.Ser.171:011001,2009.
- Search For T, CP, and CPT Violation in B0-0 Mixing with Inclusive Dilepton Events, Phys. Rev. Lett. 96, 251802 (2006**).**

Why? Independent

- Moreover for the measurement of the sin(2β) it is a CP and T dependent measurement.
- So we are looking for an odd and GENUINE T-violation observable.

  – References:
    - L.Wolfenstein, Int. J. Mod. Phys E 8, 501 (1999)
    - H.R. Quinn, Discrete ‘08 Conference, Valencia 2008, J.Phys.Conf.Ser. 171:011001,2009

Why? Genuine

- Discard effects that are odd under time t to –t:

Non GENUINE T-Violation

Not an exchange of “in” states into “out” states

$\Delta t = TRV \leftrightarrow$ Theory with CPT invariance and absence of absorptive part

How?

- Main ingredient:
  - EPR entanglement produced by decay of Υ(4S):
    - Between neutral B-mesons.
    - Between CP-tag (B_+-B_-)

$$|i>= \frac{1}{\sqrt{2}}[B^0(t_1)\overline{B}^0(t_2) - \overline{B}^0(t_1)B^0(t_2)]$$

$$= \frac{1}{\sqrt{2}}[B_+(t_1)B_-(t_2) - B_-(t_1)B_+(t_2)]$$

How?

- We chose the following processes as reference to generate CP, T and CPT transformations (model independent):

$$B_+ \longrightarrow B^0$$
$$B_- \longrightarrow B^0$$
$$\overline{B}^0 \longrightarrow B_+$$
$$\overline{B}^0 \longrightarrow B_-$$

How?

X: tagging side
Y: reco side.

Process I:

Transition	$B_+ \to B^0$	$B_+ \to \bar{B}^0$	$\bar{B}^0 \to B_+$	$B^0 \to B_+$
(X,Y)	$(J/\psi K_S, l^+)$	$(J/\psi K_S, l^-)$	$(l^+, J/\psi K_L)$	$(l^-, J/\psi K_L)$
Transformation	Reference	CP	CPT	T

TABLE 1. Transitions and symmetry transformations related to process I tag as reference

Process II:

Transition	$B_- \to B^0$	$B_- \to \bar{B}^0$	$\bar{B}^0 \to B_-$	$B^0 \to B_-$
(X,Y)	$(J/\psi K_L, l^+)$	$(J/\psi K_L, l^-)$	$(l^+, J/\psi K_S)$	$(l^-, J/\psi K_S)$
Transformation	Reference	CP	CPT	T

TABLE 2. Transitions and symmetry transformations related to process II tag as reference

How?

Process III:

Transition	$B^0 \to B_+$	$B^0 \to B_+$	$B_+ \to B^0$	$B_+ \to B^0$
(X,Y)	$(l^+, J/\psi K_L)$	$(l^-, J/\psi K_L)$	$(J/\psi K_S, l^+)$	$(J/\psi K_S, l^-)$
Transformation	Reference	CP	CPT	T

TABLE 3. Transitions and symmetry transformations related to process III tag as reference

Process IV:

Transition	$B^0 \to B_-$	$B_- \to B^0$	$B_- \to B^0$
(X,Y)	$(l^-, J/\psi K_S)$	$(J/\psi K_L, l^+)$	$(J/\psi K_L, l^-)$
Transformation	CP	CPT	T

TABLE 4. Transitions and symmetry transformations related to process IV tag as reference

How?

- Asymmetries for T-Violation:

$$A_1 = \frac{I(J/\psi K_S, l^+) - I(l^-, J/\Psi K_L)}{I(J/\psi K_S, l^+) + I(l^-, J/\Psi K_L)}$$

$$A_2 = \frac{I(J/\psi K_L, l^+) - I(l^-, J/\Psi K_S)}{I(J/\psi K_L, l^+) + I(l^-, J/\Psi K_S)}$$

$$A_3 = \frac{I(l^+, J/\Psi K_L) - I(J/\Psi K_S, l^-)}{I(l^+, J/\Psi K_L) + I(J/\Psi K_S, l^-)}$$

$$A_4 = \frac{I(l^+, J/\Psi K_S) - I(J/\Psi K_L, l^-)}{I(l^+, J/\Psi K_S) + I(J/\Psi K_L, l^-)}$$

Analysis Strategy:

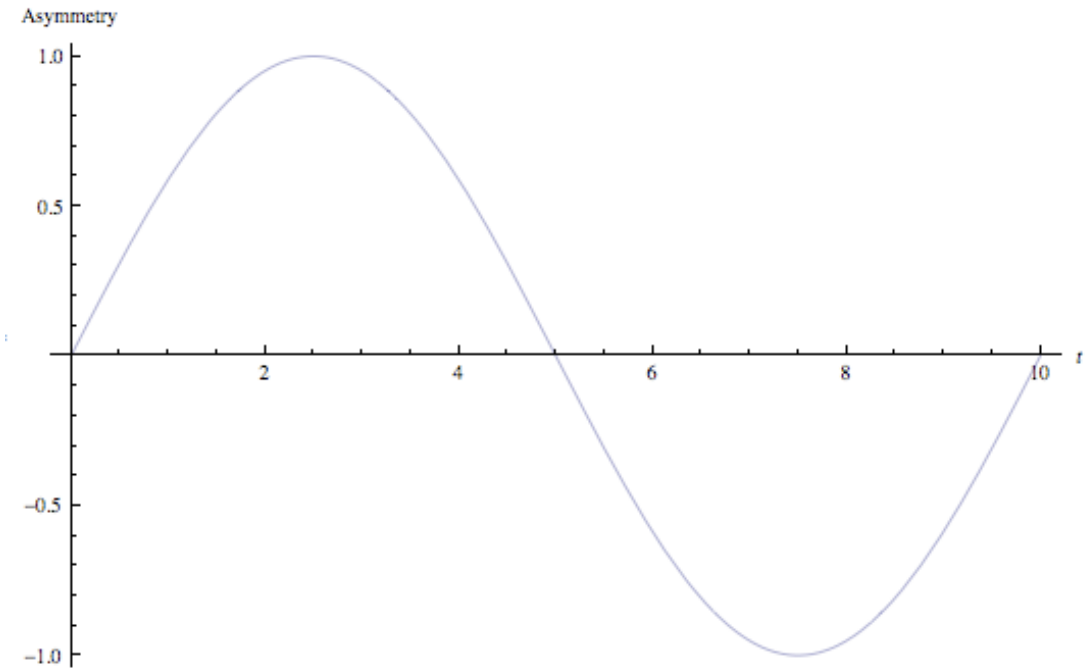
- Details of the experimental analysis similar to the previous Publications:

  - Limits on the Decay-Rate Difference of Neutral B Mesons and on CP, T, and CPT Violation in B0$\overline{B}$ 0 Oscillation, Phys. Rev. Lett. 92, 181801 (2004).

  - Limits on the Decay-Rate Difference of Neutral B Mesons and on CP, T, and CPT Violation in B0B0bar Oscillations, PRD 70, 012007 (2004).

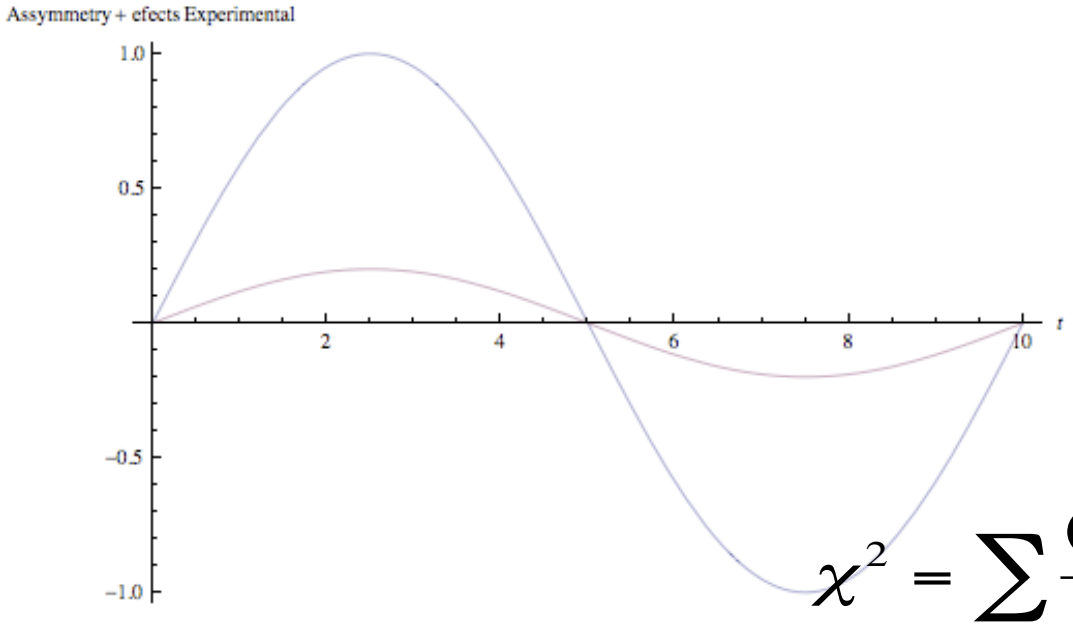
Analysis Strategy:

- We will build the asymmetries:



Analysis Strategy

- As extracted in the usual way from the B_{reco} mixing fit.



$$\chi^2 = \sum_{t_i} \frac{(A_{t_i}(t_i) - A_{t_i,\exp}(t_i))^2}{\sigma^2_{A_{t_i}(t_i)} + \sigma^2_{A_{t_i,\exp}(t_i)}} \forall A_{t_i}$$