T-odd correlation effects and top pair production at LHC

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Outline

- Introduction
- Model
- Numerical Analysis
- Observations and Outlook
Motivation

Evolution of Universe

big bang
matter
anti-matter

amount of matter = amount of anti-matter

our universe only with matter
First observation of CP-violation was in the kaon decay

LHC Experiment will look for CP-violation beyond the SM in Particle world.
CP-violation has been observed in strange, bottom and top quark.

Top quark is the only hope to search for direct CP violation in quark sector.

- It is much heavier than the other quarks.
- It has lifetime lesser than a quark takes to hadronise.
We consider the $t\bar{t}$ pair production at the LHC which could take place via the gluon fusion or $q\bar{q}$ annihilation.

\[ gg \rightarrow t\bar{t} \rightarrow (bl^+\nu_l)(\bar{b}l^-\bar{\nu}_l) \]

The $t\bar{t}$ production cross-section is modified by the interaction Lagrangian

\[ L_{int} = -i \frac{g_s}{2} \frac{d_g}{\Lambda} \bar{t} \sigma_{\mu\nu} \gamma_5 \, G^{\mu\nu} \, t \]
Observables

\[ C_1 = \epsilon(p_b, p_{\bar{b}}, p_{l^+}, p_{l^-}) \]
\[ C_2 = \tilde{q} \cdot (p_{l^+} - p_{l^-}) \epsilon(p_{l^+}, p_{l^-}, p_b + p_{\bar{b}}, \tilde{q}) \]
\[ C_3 = \tilde{q} \cdot (p_{l^+} - p_{l^-}) \epsilon(p_b, p_{\bar{b}}, p_{l^+} + p_{l^-}, \tilde{q}) \]
\[ C_4 = \epsilon(p, p_b - p_{\bar{b}}, p_{l^+}, p_{l^-}) \]
\[ C_5 = \epsilon(p_t, p_{\bar{t}}, p_b + p_{\bar{b}}, p_{l^+} - p_{l^-}) \]

In \( bb \) CM frame

\[ C_1 = \epsilon(P_b, P_{\bar{b}}, P_{l^+}, P_{l^-}) \xrightarrow{(bb)_{CM}} \propto P_b \cdot (P_{l^+} \times P_{l^-}) \]

Now \( P_b \cdot (P_{l^+} \times P_{l^-}) \xrightarrow{C} P_b \cdot (P_{l^-} \times P_{l^+}) = -P_b \cdot (P_{l^+} \times P_{l^-}) = P_b \cdot (P_{l^+} \times P_{l^-}) \)

\( P_b \cdot (P_{l^+} \times P_{l^-}) \xrightarrow{P} -P_b \cdot (-P_{l^+} \times -P_{l^-}) = -P_b \cdot (P_{l^+} \times P_{l^-}) \)
Asymmetry is calculated using the formula

\[ A_{CP} = \frac{N_{\text{events}}(C_i > 0) - N_{\text{events}}(C_i < 0)}{N_{\text{events}}(C_i > 0) + N_{\text{events}}(C_i < 0)} \]
# Observations

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<th>$\Lambda$</th>
<th>$d_g$</th>
<th>$A_1$</th>
<th>$A_3$</th>
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\[ \sqrt{s} = 13 \text{ TeV} \]

![Graph](image.png)
Outlook

- Top quark could be an effective tool to measure a CP Asymmetry present at the Large Hadron Collider through $t\bar{t}$ pair production.
- An LHC sensitivity of $5\sigma$ would be $|d_t| = \left| \frac{d_g}{\Lambda} m_t \right| \leq 0.01$ at 13 TeV LHC energy for an integrated luminosity of $36.1 \, fb^{-1}$.
Thanks