CP Violation in Charged Higgs Production

Jennifer Williams

Cavendish Laboratory, University of Cambridge

Rencontres de Moriond, 2005
Introduction

- CP violation in charged Higgs production?
- Origin is in soft susy breaking terms...

\[- \mathcal{L}_{soft} = \frac{1}{2} \left( M_3 \tilde{g} \tilde{g} + M_2 \tilde{W} \tilde{W} + M_1 \tilde{B} \tilde{B} + h.c. \right) + m_Q^2 \tilde{Q}^\dagger \tilde{Q} + m_U^2 \tilde{u}^c \tilde{u}^c + m_D^2 \tilde{d}^c \tilde{d}^c + m_L^2 \tilde{L}^\dagger \tilde{L} + m_e^2 \tilde{e}^c \tilde{e}^c + A_u \tilde{u}^c \tilde{Q} H_u - A_d \tilde{d}^c \tilde{Q} H_d - A_e \tilde{e}^c \tilde{L} H_d + h.c. + m_{H_u}^2 H_u^* H_u + m_{H_d}^2 H_d^* H_d + (b H_u H_d + h.c.)\]

- Need non trivial complex phases.
- Possible complex terms are $M_3$, $\mu$ and $A$.
- Choose to investigate $A_t$, keeping other phases zero.
The Process

- CP violation in loop correction to $tbH^\pm$ vertex.

- Decay done by Christova, Eberl, Kraml and Majerotto

- Decided to look at production

- Aim: combine production and decay

- Used SPS pt 1a for initial study

- Calculate CP asymmetry:

$$A_{CP} = \frac{\sigma(H^+) - \sigma(H^-)}{\sigma(H^+) + \sigma(H^-)}$$
The Decay

- To check my methods, computer code etc, did the decay.

- Agreed for subdominant loops, eg $\tilde{t}\tilde{b}\chi^0$ and $\tilde{\chi}^0\tilde{\chi}^{\pm}\tilde{t}/\tilde{b}$

- Discrepancy in dominant loop, due to conjugation error in other study.

- Result is less asymmetry than in other study.
Production

- Having checked decay, did production.
- Two main processes for the LHC —
  - Bottom – gluon fusion:
  
  \[
  \begin{align*}
  &\bar{b} \rightarrow H^+ + \bar{t} \\
  &b \rightarrow H^+ + t
  \end{align*}
  \]

  
  - Gluon – gluon fusion:

  \[
  \begin{align*}
  &\bar{b} \rightarrow H^+ + \bar{t} \\
  &b \rightarrow H^+ + t
  \end{align*}
  \]

- Dominant process is bottom – gluon fusion.
- Need to take care when combining to avoid double counting.
Production

- Worked out cross sections using FormCalc, by Thomas Hahn

- For parton level, get similar thresholds to decay case

- Production < decay and $\tilde{t}\tilde{b}\tilde{\chi}^0$ loop < $\tilde{t}\tilde{b}\tilde{g}$ loop
Production

Need to include pdfs to get hadronic cross section.

Did for varying charged Higgs mass to match decay.

Discrepancies when compared with D-W. Jung, K. Y. Lee and H. S. Song. \texttt{hep-ph/0307246}

These are under investigation!

Very small asymmetry — challenging to see at LHC.
Asymmetry at the LHC

- Cross section $\sim 0.050 \text{ pb}$ for low Higgs mass $\sim 400 \text{ GeV}$.
- Consistent with result from HERWIG.
- For integrated luminosity of $100 \text{ fb}^{-1} \rightarrow 5000$ events.
- Much reduced by acceptance level, say $5\% \rightarrow 250$ events.
- Not looking promising! Probably need to wait for luminosity upgrade.
Work in Progress

- Include gluon – gluon fusion.
- Explore other parts of parameter space:
  - Different SPS points — 1b partially completed
  - Vary different parameters — $\phi_{At}$ partially completed
  - Investigate other loops
de.g., self energy loops, box diagram

- Explore possibilities at International Linear Collider — cleaner environment