

*Technical Report***L^AT_EX – A documentation package for book, article and journal publication****Author name,¹ Author name,² Author name,³ and Author name⁴**¹*Affiliation1 details for first author to appear here, Illinois 60439, USA*²*Affiliation2 details for second author to appear here, Illinois 60637, USA*²*Affiliation2 details for second author to appear here, Cairo 11566, Egypt*³*Affiliation3 details for third author to appear here, P.O. Box 43, Egypt*⁴*Affiliation4 details for fourth author to appear here, California 92521, USA**Corresponding author: Author name**Email address: XXXXXXXX***Abstract**

We are experiencing an era of profound technological transformations that will significantly change the organization of our society. Even basic scientific research will be able to face the challenges of the next decades only if adequate instruments will be available in laboratories all over the world to carry out increasingly complicated measurements and experiments. How can we forget that it was the development of the telescope that gave rise to the Galilean revolution towards our modern vision of the universe?

Keywords: machine learning, artificial intelligence, computer science*DOI:* 10.31526/JAIS.2022.ID**1. INTRODUCTION TO L^AT_EX**

- What is L^AT_EX?
- Basic usage and syntax
- Modes and environments
- Newcommands
- Cross-referencing
- Packages
- Importing graphics
- Tables and figures
- Pictures
- Where to learn more

2. WHAT IS L^AT_EX?*What L^AT_EX is NOT:*

- A word-processor that allows the user to view a document as it is created in a “what you see is what you get” format (e.g., MS-Word)
- A word-processor associated with a certain operating system (e.g., Windows)
- A word-processor in which creation of *highly technical mathematical content* is a big pain in the neck
- A product that the user must purchase

What \LaTeX IS:

- A *freely-available, powerful typesetting language*
- *Supremely well-suited* to creation of documents with *heavy technical and mathematical content*
- The standard typesetting language used by *major publishers of books* in the sciences (e.g., Springer, CRC Press, Wiley, etc.)
- The standard typesetting language used by most *journals* in the sciences (including *Journal of the American Statistical Association, Biometrics*, etc.)
- The popular way to produce a *dissertation* document in the preferred NCSU format (later...)

What \LaTeX IS:

- Versions available for UNIX, Linux, Windows, etc.
- The *overwhelming choice* of most people in math, statistics, physics, computer science, engineering, and many other disciplines to produce articles, reports, books, letters, visual presentation materials, and more

Basic premise:

- A \LaTeX document must be *processed* in order for the final version of the document to be viewed
- The user creates a *file* with a `.tex` extension that contains the text of the document and special *commands* that control
 - * style (e.g., article, letter, report)
 - * organization into sections, subsections, etc.
 - * mathematical content (e.g., equations, tables, symbols)
 - * incorporation of graphics
 - * automatic cross-referencing of equations, figures, tables, references
 - * *And MUCH MORE!*
- After the file is processed, the result may be *viewed* (using *freely available* software) and the file modified as necessary
- *Postscript* or *pdf* versions of the final document are easily created

3. BASIC USAGE AND SYNTAX

Some basic steps for creating a document: On a UNIX or Linux platform

- Create a `.tex` file using any text editor (e.g., `emacs`, `Nedit`); the content should be *plain text*
- Run the file through the \LaTeX program to create a *device independent* (`.dvi`) file containing the typesetting instructions (can be viewed with a `.dvi` previewer)
- Run a program to convert the `.dvi` file to a postscript file containing the *finished document*, which can be viewed with a postscript viewer or printed
- If desired, convert the postscript file to pdf format
- (Alternatively, a program called `pdf \LaTeX` can be used to create pdf documents directly; this is not discussed here)

For example: The `.tex` file used to create these slides is called `latex1.tex` (available on the class web page)

Commands used to process: To create the `.dvi` file and then a postscript file

```
stat% add tetex
stat% latex latex1
stat% dvips latex1
stat% ghostview latex1.ps &
```

- `add tetex` allows access on unity to a comprehensive distribution of \LaTeX called `tetex` (optional)
- Here, `ghostview` is used to view the final document
- Using instead `dvips -P pdf latex1` creates a postscript file that is optimal if the a pdf file is to be created, e.g., using `acrobat` distiller or the `ps2pdf` utility

```
stat% distill latex1.ps OR stat% ps2pdf latex1.ps
```

Structure of a .tex file:

- *Preamble*
 - Specify *document class* (article, report, book, letter, etc.)
 - Add any “*packages*” used (e.g., to import graphics, create headers and footers, etc.)
 - Specify *margins, indentation, spacing*, etc.
 - Define “*new commands*” (coming up...)
- *Document body*
 - The actual document content

Fun facts:

- % symbol is used to document the file or “*comment out*” text; anything to the right of a % does not appear in the document
- \LaTeX commands start with \
- \LaTeX is case sensitive

For example: Here is a sample preamble and document body for an article (See the web page for a full template file)

```
\documentclass[12pt]{article} % type size: also 10pt or 11pt
% commands to set margins and spacing -- all have defaults
\setlength{\textheight}{9in} % height of text on a page
\setlength{\textwidth}{6.5in} % width of text on a page
\setlength{\parskip}{2.3ex} % space between paragraphs
% commands to invoke packages
\usepackage{graphicx,psfig,epsf} % no limit to how many
% user-defined newcommands
\newcommand{\betahat}{\hat{\beta}} % more on this shortly
% start of document body

\begin{document}
\section{Introduction} % sectioning command
This is the introduction...
\end{document}
```

Syntax: Some commands have arguments in braces { }, some do not

Some commands with no argument:

\ldots, \dag, \ddag, \%, \&, \#, \{ \}, \today, \LaTeX

..., †, ‡, %, &, #, { }, February 20, 2023, \LaTeX

Commands with arguments: \setlength{ ... },
\section{ ... }, \subsection{ ... }, \hspace{ ... },
\vspace{ ... }

4. MODES AND ENVIRONMENTS

Modes: At any point in a \LaTeX file, there is a current “*mode*” in effect

- *Paragraph mode* – the default text mode, with line wrap. A space between lines signals the start of a new paragraph
- *Math mode* – math symbols and commands may be used, and mathematical expressions result
- *LR mode* – “left-to-right” mode, lines do not automatically wrap around

Note on math mode: Math symbols and commands only work in math mode; if they are used in other modes, an *error* will result

Environments: Often, there is also an *environment* in effect that determines how material is displayed – the basic structure is

```
\begin{environment-name}
...
\end{environment-name}
```

For example: The math environment

the linear model

```
\begin{math}Y = X\backslash\beta + \backslash\epsilon\backslashend{math}.
```

the linear model $Y = X\beta + \epsilon$.

- The popular shortcuts are to use \$... \$ or \ (... \), e.g.

the linear model $Y = X\backslash\beta + \backslash\epsilon$.

For example: Creating a numbered list

```
\begin{enumerate}
\item This is the first entry
\item This is the second entry
\item This is the third entry
\end{enumerate}
```

1. This is the first entry
2. This is the second entry
3. This is the third entry

Some popular environments:	Environment	Mode	Description
	math	math	in-text mathematical expressions
	displaymath	math	displayed mathematical expressions
	equation	math	displayed expressions w/ line number
	eqnarray	math	lines up equal signs, line numbers
	eqnarray*	math	lines up equal signs, no line numbers
	array	math	matrices and arrays
	itemize	paragraph	list with bullets
	enumerate	paragraph	list with numbers
	description	paragraph	list with indentation
	tabular	LR	align text in columns
	table	paragraph	number and position table
	figure	paragraph	number and position figure
	center	paragraph	center text
	mbox	LR	write text while in math mode

Math: \LaTeX is tailor-made for writing involving high mathematical content! And it's easy!

- Subscripts, superscripts, roots

$e^y, x_{ij}, \sqrt{x+y}, \sum_{i=1}^n$

$e^y, x_{ij}, \sqrt{x+y}, \sum_{i=1}^n$

- Greek

$\backslash\alpha, \backslash\beta, \backslash\gamma, \backslash\delta, \backslash\epsilon, \backslash\eta, \backslash\theta, \backslash\lambda$

$\alpha, \beta, \gamma, \delta, \epsilon, \eta, \theta, \lambda$

$\backslash\Gamma, \backslash\Delta, \backslash\Theta, \backslash\Lambda, \backslash\Omega, \backslash\Sigma$

$\Gamma, \Delta, \Theta, \Lambda, \Omega, \Sigma$

- Roofs

$\backslash\hat{\alpha}, \backslash\tilde{\alpha}, \backslash\dot{x}, \backslash\overline{x}, \backslash\bar{x}$

$\hat{\alpha}, \tilde{\alpha}, \dot{x}, \bar{x}, \bar{x}$

Math, continued:

- Binary operations

$\backslash\pm, \backslash\times, \backslash\div, \backslash\cup, \backslash\otimes$

$\pm, \times, \div, \cup, \otimes$

- *Relation symbols*

$\backslash leq, \backslash subset, \backslash in, \backslash geq, \backslash equiv, \backslash sim, \backslash approx, \backslash neq, \backslash perp$

$\leq, \subset, \in, \geq, \equiv, \sim, \approx, \neq, \perp$

- *Arrows*

$\backslash rightharpoonup, \backslash Leftarrow, \backslash Leftrightarrow, \backslash uparrow$

$\rightarrow, \Leftarrow, \Leftrightarrow, \uparrow$

- *Miscellaneous*

$\backslash forall, \backslash exists, \backslash Re, \backslash sum, \backslash prod, \backslash int$

$\forall, \exists, \Re, \Sigma, \Pi, \int$

Math, continued: `textstyle` vs. `displaystyle`

- Math *displayed* as equations may be carried out using the `displaymath`, `equation`, `eqnarray*`, `eqnarray` environments
- *Shortcuts* when equations are *not* numbered: `$$... $$` or `\[... \]`; e.g.,

`$$\sum_{i=1}^n x_i^2 (Y_{ij} - z_i \beta)$$`

$$\sum_{i=1}^n x_i^2 (Y_{ij} - z_i \beta)$$

- Some symbols appear *differently* depending on whether they are in the text or displayed; e.g.,

`$$\sum_{i=1}^n$$` VS. `$$\sum_{i=1}^n$$$`

$\sum_{i=1}^n$ VS. $\sum_{i=1}^n$

- Can be *overridden* with `textstyle{ }` and `\displaystyle{ }`

Math, continued:

- *Products, integrals, unions*

`$$\prod_{j=1}^n, \hspace{0.1in} \int_t^\infty f(u) du, \hspace{0.1in} \bigcup_{A: A \in \Omega}$$$`

$$\prod_{j=1}^n, \int_t^\infty f(u) du, \bigcup_{A: A \in \Omega}$$

- *Special functions*

$\exp(x)$, $\log y$, $\sin(k\pi)$, $\min_x f(x)$

$\exp(x), \log y, \sin(k\pi), \min_x f(x)$

- Fractions, partial derivatives

$\frac{\exp(x^T \beta)}{1 + \exp(x^T \beta)}$,
 $\frac{\partial u}{\partial x}$

$$\frac{\exp(x^T \beta)}{1 + \exp(x^T \beta)} \frac{\partial u}{\partial x}$$

Note: Use `\displaystyle` for fractions; otherwise they are too small

Math, continued: There are different ways to present math in **boldface**; here are two

- \mathbf{X} , output X
 Σ , output Σ
- \mathbf{X} , Σ

Math, continued: array and eqnarray environments

- (2×3) matrix:

```
\left( \begin{array}{ccc}
x_{11} & x_{12} & x_{13} \\
x_{21} & x_{22} & x_{23}
\end{array} \right)
```

$$\begin{pmatrix} x_{11} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \end{pmatrix}$$

- Determinant of (2×2) matrix:

```
\left| \begin{array}{cc}
a_{11} & a_{12} \\
a_{21} & a_{22}
\end{array} \right|
```

$$\begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix}$$

Math, continued: array and eqnarray environments

- Braces

```
x = \left\{ \begin{array}{l}
\sin x \text{ if } y < 3, \\
\cos x \text{ if } y \geq 3
\end{array} \right.
```

$$x = \begin{cases} \sin x & \text{if } y < 3, \\ \cos x & \text{if } y \geq 3 \end{cases}$$

- Binomial coefficients: $\binom{N}{y}$

$$\binom{N}{y}$$

Math, continued: array and eqnarray environments

- Equation with several lines, = signs lined up

```
\begin{eqnarray*}
\Delta_i &= & \sum_j \sum_{k \neq j} \mbox{Corr}(Y_{ij}, Y_{ik}) \\\
&= & \sum_j \sum_{k \neq j} \rho_i^{\parallel j-k \parallel} \\\
&= & \frac{2}{\rho_i} \left( \rho_i - \frac{\rho_i^{n_i-1}}{1-\rho_i} \right)
\end{eqnarray*}
```

$$\begin{aligned} \Delta_i &= \sum_j \sum_{k \neq j} \text{Corr}(Y_{ij}, Y_{ik}) \\ &= \sum_j \sum_{k \neq j} \rho_i^{\parallel j-k \parallel} \\ &= \frac{2\rho_i}{1-\rho_i} \left\{ n_i - 1 - \frac{\rho_i(1-\rho_i^{n_i-1})}{1-\rho_i} \right\} \end{aligned}$$

The tabular environment:

- As with array, separate *elements* with &, make *new line* with \\
- Specify *number of columns* and type of *justification* at top, add *vertical* and *horizontal* lines

```
\begin{tabular}{c|rr}
& \multicolumn{2}{c}{Results} \\\
Parameter & \multicolumn{1}{c}{Bias} & \multicolumn{1}{c}{SE} \\\
\hline
$\beta_0$ & $-0.030$ & $0.12$ \\\
$\beta_1$ & $0.002$ & $0.07$
\end{tabular}
```

Parameter	Results	
	Bias	SE
β_0	-0.030	0.12
β_1	0.002	0.07

5. NEWCOMMANDS

Motivation: In technical typing, the same (nasty) expression may appear *frequently*

- A *newcommand* is like a “*shortcut*” to produce the expression easily
- `\newcommand{keyword}{text}`
- A *newcommand* declaration may appear *anywhere* in a \LaTeX source file (preamble or body) and is defined thereafter
- A *newcommand* keyword may *not* contain numbers

Examples: Some *newcommand* definitions and their usage

```
\newcommand{\bbeta}{\mbox{\boldmath $\beta$}}
\newcommand{\betahatj}{\widehat{\bbeta}_j}
\newcommand{\var}{\mbox{var}}
\newcommand{\sumjn}{\sum_{j=1}^n}
```

- Note that a *previously-defined newcommand* may be used in defining a *new newcommand*

$\sum_{j=1}^n \text{var}(\hat{\beta}_j)$

$$\sum_{j=1}^n \text{var}(\hat{\beta}_j)$$

6. CROSS REFERENCES

Advantage: A *built-in* feature of \LaTeX is that it *automatically* keeps track of sections, numbered equations, pages, and so on

- Sections, equations, tables, figures, pages etc. may be *labeled* and referred to by the label
- If new labeled entities are added, \LaTeX *renumbers* them automatically
- It is even possible to generate a *table of contents* and *index* for a document
- To set up cross references correctly, must process a document *twice*

`\LaTeX Warning: Label(s) may have changed.`

Rerun to get cross-references right.

Examples:

- Numbered equation

```
\begin{equation}
\var(\alpha) = \sum_j n \var(\betahat_j)
\label{eq:alpha}
\end{equation}
```

In equation~\ref{eq:alpha}, we see that...

Examples, continued:

- Section label

```
\section{Introduction}
\label{s:intro}
```

...As discussed in Section~\ref{s:intro},
kurtosis...

- Page label

```
Thus, we see that calculation of the variance is
straightforward \label{p:var}
```

...On page~\pageref{p:var}, the variance
calculation...

7. PACKAGES

Useful utilities: \LaTeX is much more *powerful* than the intrinsic features would suggest

- A *huge* user community
- Contributed *document classes*, “*add-ons*” to allow different capabilities and customization
- “*Packages*”
- Define new commands, syntax, etc.
- Visit CTAN (see slide 12)

Example: `fancyheadings.sty` – make “*fancy*” document *headers* and *footers*

- In preamble

```
\usepackage{fancyheadings}
\lhead{\footnotesize \bf CHAPTER \thesection}
\rhead{\footnotesize \bf ST 762, M. DAVIDIAN}
\cfoot{\footnotesize PAGE \rm\thepage}
```


- See <http://www.stat.ncsu.edu/~st762.info/> for results

Example: `shadow.sty` – make “*shadowboxes*”

- In preamble

```
\usepackage{shadow}
```

```
\shabox{This stuff}
```

This stuff

In addition: There are also user-defined, alternative *document classes*

- *Journals, book publishers* may have their own class to create articles, pages with a specific format

Dissertations:

At NCSU, dissertations may be created in \LaTeX using special a special style; to learn more, visit

<http://www2.acs.ncsu.edu/grad/ETD/tutorial/latex.htm>

[http://www.stat.ncsu.edu/computing/howto/latex/
session_2/session2.html](http://www.stat.ncsu.edu/computing/howto/latex/session_2/session2.html)

8. IMPORTING GRAPHICS

Numerous options:

We discuss three of these

- `psfig` – `\usepackage{psfig}`

```
\psfig{figure=dental.ps,height=2.5in}
```

- `epsf` – `\usepackage{epsf}`

```
\epsfysize=2.5in  
\epsfbox{dental.ps}
```

- `graphicx` – `\usepackage{graphicx}`

- Can also import other formats (pdf, jpg, etc)

```
\includegraphics[height=2.5in]{dental.ps}
```

9. TABLES AND FIGURES

Two standard \LaTeX environments:

table and figure

- Automatically *numbers* tables and figures
- Allow tables and figures to be formatted and *referenced* within a document
- Allow *captions*

```
\begin{table}[h!]  
\tbl{Results of the simulation.\label{t:simresults}}{%  
\begin{tabular}{crr}  
\toprule  
& \multicolumn{2}{c}{Results} \\  
Parameter & \multicolumn{1}{c}{Bias} & \multicolumn{1}{c}{SE} \\  
\colrule  
$\beta_0$ & 0.030 & 0.12 \\  
$\beta_1$ & 0.002 & 0.07 \\  
\botrule  
\end{tabular}}  
\end{table}
```

Parameter	Results	
	Bias	SE
β_0	0.030	0.12
β_1	0.002	0.07

TABLE 1: Results of the simulation.

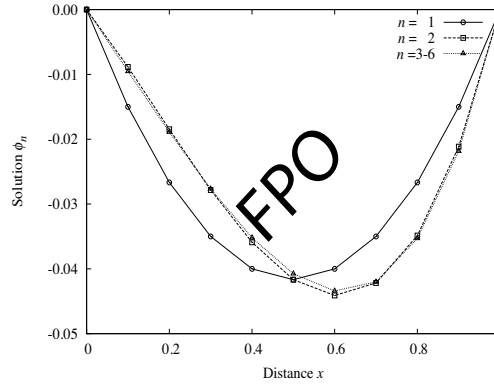


FIGURE 1: The dental data of Pothoff and Roy.

- Reference – In Table~\ref{t:simresults}, we see that...
- In Table 1, we see that...

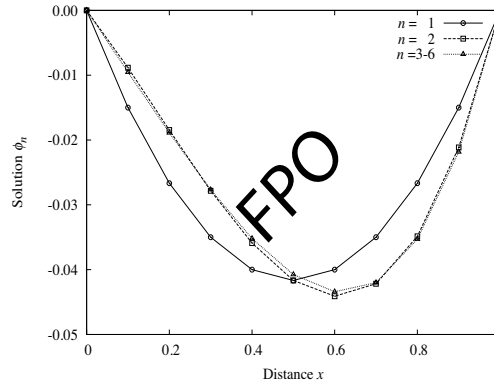


FIGURE 2: The dental data of Pothoff and Roy.

Useful package:

subfigure – \usepackage{subfigure}

- Create a “multipanel” figure from several files with each panel labeled

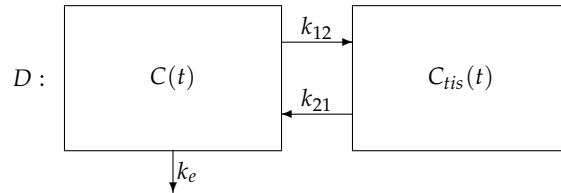
```
\begin{figure}
  \centering \subfigure[] {
    \includegraphics[width=1.5in]{dental.ps}
    \hspace*{0.1in}
    \subfigure[] {
      \includegraphics[width=1.5in]{dental.ps}
    }
  }
\caption{(a) The dental data of Pothoff and Roy. (b) The dental
data of Pothoff and Roy, again.}
\label{f:dental2}
\end{figure}
```

10. PICTURES

\LaTeX can “draw”:

- picture environment
- The following is a *simple* picture – circles, curves, ovals, etc are also possible (see the documentation)

Two-compartment open model with IV administration:



$$\begin{aligned}\frac{dC(t)}{dt} &= k_{21}C_{tis}(t) - k_{12}C(t) - k_eC(t), \\ \frac{C_{tis}(t)}{dt} &= k_{12}C(t) - k_{21}C_{tis}(t), \quad C_{tis}(0) = 0\end{aligned}$$

Picture was made with:

```
\setlength{\unitlength}{1in}
\begin{picture}(5,1)
\put(0.5,0.5){\framebox(1.5,1){$C(t)$}}
\put(2,1.25){\vector(1,0){0.5}}
\put(2.25,1.35){\makebox(0,0){$k_{12}$}}
\put(2.5,0.75){\vector(-1,0){0.5}}
\put(2.25,0.85){\makebox(0,0){$k_{21}$}}
\put(2.5,0.5){\framebox(1.5,1){$C_{tis}(t)$}}
\put(0.25,1){\makebox(0,0){$D:$}}
\put(1.25,0.5){\vector(0,-1){0.3}}
\put(1.35,0.35){\makebox(0,0){$k_e$}}
\end{picture}
\end{center}
```

Other “drawing” resources:

- The pstricks package – really *intricate stuff* like grids, plots of functions, etc (see class web page for link to documentation)
- xfig

11. WHERE TO LEARN MORE

Books and guides:

- Lamport, L. (1994) *\LaTeX : A Documentation Preparation System, User’s Guide and Reference Manual* (The creator of \LaTeX)
- Goossens, M. et al. (1994) *The \LaTeX Companion*
- Kopka, H. (1999) *A Guide to \LaTeX : Document Preparation for Beginners & Advanced Users*
- Hahn, J. (1993) *\LaTeX for Everyone: A Reference Guide and Tutorial for Typesetting Documents Using a Computer*
- Oetiker, T. et al. (2002) *The Not So Short Introduction to \LaTeX 2_ε* (Available on the class web page)

Resources online and on the Web:

- The *Comprehensive T_EX Archive Network* (CTAN) <http://www.ctan.org> – a repository of tons of style files, packages, etc.
- Several *free* guides available on unity at [/afs/bp.ncsu.edu/contrib/tetex107/share/texmf/doc/latex/general](http://afs/bp.ncsu.edu/contrib/tetex107/share/texmf/doc/latex/general) (as .dvi or .ps files)
- Local intro tutorial http://www.stat.ncsu.edu/computing/howto/latex/session_1/

ACKNOWLEDGEMENTS

This work is supported in part by XXX.

References

- [1] E. Ma and G. Rajasekaran, Phys. Rev. **D64**, 113012 (2001).
- [2] E. Ma, Phys. Rev. **D70**, 031901 (2004).
- [3] B. Aharmim *et al.*, Phys. Rev. **C72**, 055502 (2005).
- [4] For a recent review, see for example H. Ishimori, T. Kobayashi, H. Ohki, H. Okada, Y. Shimizu, and M. Tanimoto, Prog. Theor. Phys. Suppl. **183**, 1 (2010).
- [5] For a recent review, see for example G. Altarelli and F. Feruglio, Rev. Mod. Phys. **82**, 2701 (2010).
- [6] G. Altarelli and F. Feruglio, Nucl. Phys. **B720**, 64 (2005).
- [7] K. S. Babu and X.-G. He, hep-ph/0507217 (2005).
- [8] N. Cabibbo, Phys. Lett. **72**, 333 (1978).
- [9] L. Wolfenstein, Phys. Rev. **D18**, 958 (1978).
- [10] E. Ma, Mod. Phys. Lett. **A25**, 2215 (2010).
- [11] E. Ma, Mod. Phys. Lett. **A21**, 2931 (2006).
- [12] E. Ma and U. Sarkar, Phys. Rev. Lett. **80**, 5716 (1998).
- [13] C. Luhn, S. Nasri, and P. Ramond, Phys. Lett. **B652**, 27 (2007); C. Hagedorn, M. A. Schmidt, and A. Yu. Smirnov, Phys. Rev. **D79** 036002 (2009); S. F. King and C. Luhn, JHEP **0910**, 093 (2009).
- [14] See for example K. Huitu, S. Khalil, H. Okada, and S. K. Rai, Phys. Rev. Lett. **101**, 181802 (2008).
- [15] E. Ma, Mod. Phys. Lett. **A21**, 1917 (2006); I. de Medeiros Varzielas, S. F. King, and G. G. Ross, Phys. Lett. **B648**, 201 (2007); E. Ma, Phys. Lett. **B660**, 505 (2008).