Package paracol: Yet Another Multi-Column Package to Typeset Columns in *Parallel*

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Abstract

This package provides a LaTeX environment named `paracol` in which you may *switch* and *synchronize* columns by a command `\switchcolumn` and by internal environments `column`, `nthcolumn`, `leftcolumn` and `rightcolumn`.

1 Introduction

This document describes the usage of yet another multi-column package named paracol. The unique feature of the package is that columns are typeset *in parallel*.

Suppose you are writing a bilingual document whose left column is written in a language, say English, and right column has the translation of the left column in another language, e.g. Japanese. With the paracol package you may write an English part of arbitrary length and then *switch* to its Japanese counterpart to place both parts side by side. Of course you may return to the English writing similarly.

The *column-switching* is always allowed when you complete an outermost level paragraph. You may be unaware whether a column is broken into multiple pages before switching because the package automatically goes back and forward to the correct page and vertical position when you switch the column. Moreover, you may *synchronize* columns so that the tops of the first paragraphs after switching in all columns are vertically aligned. At a synchronization point, you may give a single-column text, for example a common section header, optionally. You may also switch single-column and multi-column in a page arbitrary.

This manual itself is an example of two-column

```
\begin{paracol}{2}[\section{Introduction}]
\hbadness5000
This document describes the usage of yet
another multi-column package named
\textsf{paracol}.  The unique feature of
the package is that columns are typeset
{\em in parallel.}

Suppose you are writing a bilingual
document whose left column is written in a
language, say English, and right column has
the translation of the left column in
another language, e.g. Japanese.  With the
\textsf{paracol} package you may write an
English part of arbitrary length and then
{\em switch} to its Japanese counterpart to
place both parts side by side.  Of course
you may return to the English writing
similarly.

The column switching is always allowed when
you complete an outermost level paragraph.
You may be unaware whether a column is
broken into multiple pages before switching
because the package automatically goes back
and forward to the correct page and
```

documents typeset by paracol. Since the author is not familiar with languages other than English and Japanese and the latter should be hardly understood by most of readers, the right column is the translation of the left English column into a computational language. That is, the right column is the LaTeX source code of the left column[1].

```
vertical position when you switch the
column.  Moreover, you may {\em
synchronize} columns so that the tops of
the first paragraphs after switching in all
columns are vertically aligned.  At a
synchronization point, you may give a
single-column text, for example a common
section header, optionally.  You may also
switch single-column and multi-column in a
page arbitrary.

This manual itself is an example of
two-column documents typeset by
\textsf{paracol}.  Since the author is not
familiar with languages other than English
and Japanese and the latter should be
hardly understood by most of readers, the
right column is the translation of the left
English column into a computational
language.  That is, the right column is the
\LaTeX{} source code of the left column%
\footnote{Not really but its essence is
shown.}.

\switchcolumn

\begin{verbatim}
Here is the source of above.
\end{verbatim}[1]
```

2 Basic Usage

Loading the package is very simple. What you have to do is `\usepackage{paracol}` in the preamble. Note that paracol can be used with LaTeX 2$_\varepsilon$ and does not work with LaTeX 2.09.

The fundamental means of parallel-column typesetting are the environment `paracol` and the command `\switchcolumn`. The `paracol` environment needs an argument to specify the number of columns. Thus the following is the basic construct for two-parallel-column documents.

```
\begin{paracol}{2}
left column text
\switchcolumn
```

[1] Not really but its essence is shown.

```
\switchcolumn*[\section{Basic Usage}]
Loading the package is very simple.  What
you have to do is |\usepackage{paracol}|
in the preamble.  ...[2]
\switchcolumn
source
\switchcolumn*
The fundamental means of parallel-column
typesetting are the environment |paracol|
and the command |\switchcolumn|.  ...
\switchcolumn
source
```

[1] This `verbatim` construct is simply referred as to "*source*" hereafter.

[2] Hereafter, a part of the source code may be omitted like this.

right column text
`\switchcolumn`
left column text
`\switchcolumn`
right column text
`\switchcolumn`
⋮
`\end{paracol}`

The `\switchcolumn` command may have an optional argument to specify the column number (zero origin) to start. That is, `\switchcolumn[0]` means to switch to the leftmost column, `\switchcolumn[1]` is to start the second column and so on. Thus the `\switchcolumn` without the optional argument may be considered as `\switchcolumn[`$i+1 \bmod n$`]` where i is the ordinal of the column you are leaving from and n is the number of columns given to `paracol` environment.

```
\switchcolumn[1]*
source
\switchcolumn[0]
The |\switchcolumn| command may have an
optional argument to specify the column
number (zero origin) to start.  ...
```

3 Column Synchronization

The `\switchcolumn` command may also be followed by a '`*`' to *synchronize* columns. After you switch from a column to another by `\switchcolumn*` (or `\switchcolumn[`*i*`]*`), all the columns are vertically aligned at the bottom of the *deepest* one preceding the command. For example, the previous section has three `\switchcolumn*` commands at which left and right columns are vertically aligned.

The *starred* version of `\switchcolumn` may have an optional argument to specify a single-column *spanning text* whose bottom is the vertical alignment points of the columns. For example, `\section` commands in this manual are given as optional arguments of `\switchcolumn*` like;

```
\switchcolumn*[\section{Basic Usage}]
```

The `paracol` environment may also start with a spanning text by specifying it as the optional argument of `\begin{paracol}`. For example, at the beginning of this document, the author put;

```
\begin{paracol}{2}[\section{Introduction}]
```

```
\switchcolumn[0]*[%
  \section{Column Synchronization}
  \label{sec:sync}]
The |\switchcolumn| command may also be
followed by a '|*|' to {\em synchronize}
columns. ...

The {\em starred} version of
|\switchcolumn| may have an optional
argument to specify a multi-column text
whose bottom is the vertical alignment
points of the columns.  ...
\switchcolumn
source
```

4 Environments for Columns

4.1 Environment `column`

The `\switchcolumn` is simple but you may prefer to pack the contents of a column in an envi-

```
4.1  Environment column

\begin{column*}[%
  \section{Environments for Columns}
```

ronment. The `column` environment is available for this well-structurization of LaTeX sources for parallel-columned documents. A construct;

```
\begin{column}
text for a column
\end{column}
```

is (almost) equivalent to;

```
\switchcolumn
text for a column
```

The `column*` environment is also available for the column synchronization and may have an optional argument for spanning text.

4.2 Environment `nthcolumn`

The `\switchcolumn` can start an arbitrarily specified column with the column number given through its optional argument, but the `column` environment cannot do it. If you want to start i-th column, you have to do `\begin{nthcolumn}{`i`}` (or `nthcolumn*` with an optional argument to synchronize).

4.3 Environments `leftcolumn` and `rightcolumn`

The environments `leftcolumn` and `rightcolumn` (and their starred versions with an optional argument) are available as more convenient means than saying `\begin{nthcolumn}{0}` to switch to the left(most) column and `\begin{nthcolumn}{1}` to the right (but may not be rightmost) one.

```
  \label{sec:env}]
\subsection{Environment \texttt{column}}
The |\switchcolumn| is simple but you may
prefer to pack the contents of a column in
an environment.  ...
\end{column*}
\begin{column}
source
\end{column}
```

4.2 Environment nthcolumn

```
\begin{nthcolumn*}{1}
source
\end{nthcolumn*}

\begin{nthcolumn}{0}
\subsection{Environment \texttt{nthcolumn}}
The |\switchcolumn| can start an
arbitrarily specified column with the
column number given through its optional
argument, but the |column| environment
cannot do it. ...
\end{nthcolumn}
```

4.3 Environment leftcolumn and rightcolumn

```
\begin{leftcolumn*}
\subsection{%
  Environments \texttt{leftcolumn} and\\
  \texttt{rightcolumn}}
The environments |leftcolumn| and
|rightcolumn| (and their starred versions
with an optional argument) are available as
more convenient means than saying
|\begin{nthcolumn}{0}| to switch to the
left(most) column and ...
\begin{figure*}...\end{figure*}
\begin{figure}[t]...\end{figure}
\end{leftcolumn*}
\begin{rightcolumn}
source and a figure env
\end{rightcolumn}
```

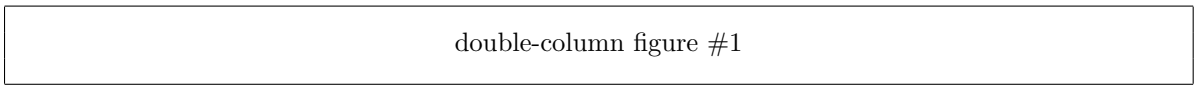

Figure 1: A Double-Column Figure

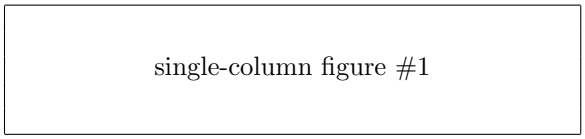

Figure 2: A Single-Column Figure

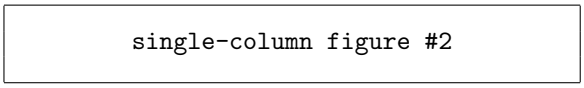

Figure 3: Another Single-Column Figure

5 Floats, Footnotes and Counters

5.1 Figures and Tables

As shown in this page, double-column figures/tables (or those spanned multiple columns if you have three or more) may be placed by `figure*` and `table*` environments as usual. A single-column figure/table will be placed in the column in which you put `figure` and `table`. For example, the contents of `figure` environment in a `leftcolumn` environment is *always* placed in a left column. That is, even if the column of the *current* page does not have enough room to place the figure, it will not thrown to the right column but will be placed in the left column of the next page[2].

Another caution about float placement is that you have to be careful when you try to put a top-float explicitly with `t`-option or implicitly without placement option (i.e., `tbp` in most classes) and to synchronize columns. The rule is as follows; after you synchronize columns in a page, the page cannot have top-floats any more. When you synchronize columns, paracol fixes a virtual horizontal line in the page as the synchronization barrier. Thus no top-floats cannot be added above the line[3]. Therefore, the author put two `figure` environments for the figures shown in this page into the `leftcolumn*` and `rightcolumn`

Table 1: A Single-Column Table

An	example	of
single	column	table

[2]Or some farther page if LaTeX cannot solve the placement problem wisely.

[3]Even if you have enough space above, sorry.

```
## 5.1 Figures and Tables

\begin{leftcolumn*}[\section{%
   Floats, Footnotes and Counters}]
\begin{table}[b]
\caption{A Single-Column Table}
\centerline{\begin{tabular}[t]{|l|c|r|}
  \hline
  An&example&of\\\hline
  single&column&table\\\hline
  \end{tabular}}
\end{table}
\subsection{Figures and Tables}
As shown in this page, double-column
figures\slash tables (or those spanned
multiple columns if you have three or more
columns) may be placed by |figure*| and
table* environments as usual[3].  ...
```

5.2 Footnotes and Marginal Notes

```
Footnotes are also put at the bottom of the
column in which |\footnote| commands and
their references reside (like
this\footnote{...}), as shown in page~2 and
this page. Marginal notes behave similarly
```

Table 2: Another Single-Column Table

Another	example
of	single
column	table

[3]Another example of footnote.

environment for the previous section.

5.2 Footnotes and Marginal Notes

Footnotes are also put at the bottom of the column in which `\footnote` commands and their references reside (like this[4]), as shown in page 2 and this page. Marginal notes behave similarly like what you are seeing in the left margin of this sentence and the right marginal note in this page[5].

An example of marginal note.

5.3 Local and Global Counters

You probably found that the numbering of figures and tables is *global* while that of footnotes are *local*. That is, the figure in the right column of the previous page has number 3 following its left-column counterpart Figure 2. The tables in the page are also numbered as 1 and 2 crossing the column boundary. However, the footnotes in each column have their own numbering sequence. Moreover, the footnote numbers in left columns are typeset in roman font while those in right columns have italic shapes. Similarly, subsection numbering is local and the headings in right columns have typewriter-face numbers.

This happens because the author declared the counters `figure` and `table` are *global* in the preamble of this document by saying;

```
\globalcounter{figure}
\globalcounter{table}
```

and do nothing about `footnote` and `subsection` counters. By default, all the counters except for `page` are local to columns. The value of a local counter of a column is saved somewhere when you leave the column, and it is restored when you revisit the column. The initial value of the local counters are the value they have at `\begin{paracol}`. After you close the `paracol` environment, the values of the left-most column are used for the rest of your document until you start new `paracol` environment. On a restart, local counters in a column have the values they had at the last `\end{paracol}`, except for those which

[4]Unless you specify to make footnotes *single-columned* as explained in Section 7.5 and 8.

[5]If you have three or more columns, marginal notes of the second or succeeding columns are placed just right of the column. Thus marginal notes of non-leftmost and non-rightmost columns will appear in the space separating columns rather than the margin of a page.

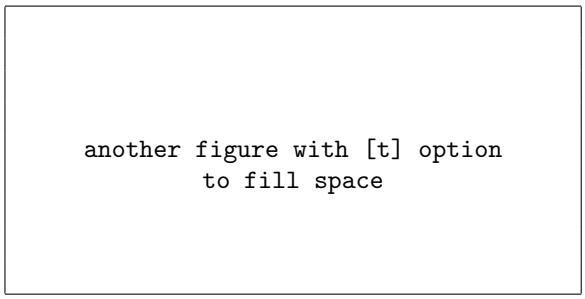

Figure 4: `Another Figure with [t] Option`

```
like what you are seeing in the left margin
of this sentense\marginpar{\raggedright
An example of marginal note.} and the right
marginal note in this
page\footnote{...}. ...
```

Another example of marginal note.

```
## 5.3 Local and Global Counters

You probably found that the numbering of
figures and tables is \emph{global} while
that of footnotes are \emph{local}. ...
\end{leftcolumn*}
\begin{rightcolumn}
source.
\end{rightcolumn}
```

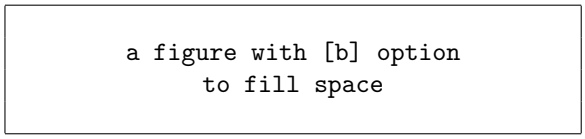

Figure 5: `A Figure with [b] Option`

have been modified outside the environment because the modifications are *broadcasted* to local counters in all columns. You will see the effect of this inter-environment counter value conservation in the footnote numbers in the right column in page 5 and 9.

This broadcasting of a local counter value can be done explicity in `paracol` environment by a command `\synccounter{`*ctr*`}`. This command makes *ctr* in all columns have the value of that in the column in which the command appears. In addition, another command `\syncallcounters` peforms this broadcasting for all local counters.

If you make a counter global by the command `\globalcounter`, the save/restore operations are not performed to the counter and thus it is globally incremented by `\[ref]stepcounter` or commands such as `\caption` and `\section`. Note that the value of a global counter depends on the place where it is incremented (or set) in the *source code* rather than where it appears in the output. Thus if the author put a `table` environment here to increment `table` counter, the right-column table at the bottom of page 5 would be Table 3 because its `table` environment does not appear yet in the source code. Note that, however, though the counter `page` is global as expected, its numbering is consistent among all columns as far as you refer to the value by `\pageref{`*label*`}` and/or see the values in table of contents, etc.

Another counter which the author made global in this documnet is `section`. As explained in Section 3, an optional spanning text of column-switching is considered as in the left-most column. Since `\section` commands in this document are always spanning texts, so far, it seems unnecessary to make `section` global because it is incremented correctly in the left-most column. However, the stepping `section` has a side effect to reset its decendent counter `subsection` and referred from `\thesubsection` command. Thus if `section` were local, the right-column subsections in Section 4 would be numbered as "0.1", "0.2" and "0.3" because the local value of `section` would be zero. Moreover, the right-column subsections of this section would be "0.4", "0.5" and "0.6" because stepping `section` local to the left column would not reset `subsection` local to the right column.

You may give a local appearance to a counter *ctr* for the *i*-th column (zero origin) by a command;

`\definethecounter{`*ctr*`}{`*i*`}{`*def*`}`

where *def* is to be the body of the local definition

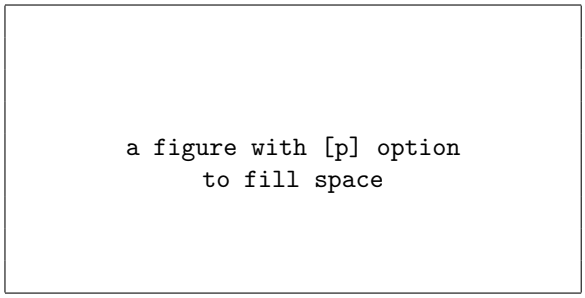

Figure 6: `A Figure with [p] Option`

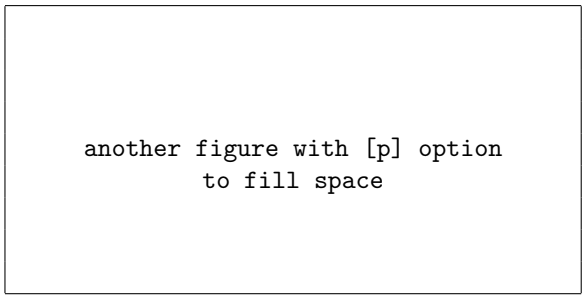

Figure 7: `Another Figure with [p] Option`

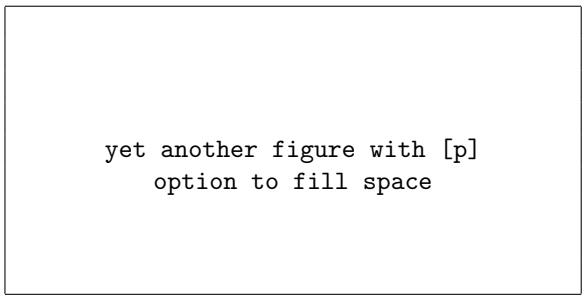

Figure 8: `Yet Another Figure with [p] Option`

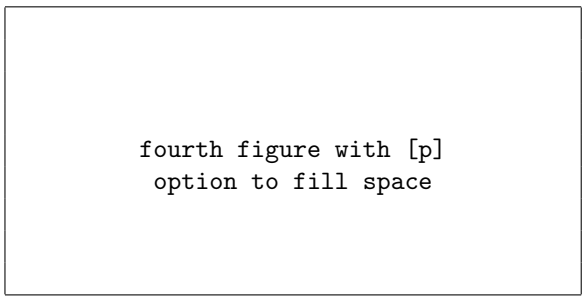

Figure 9: `Forth Figure with [p] Option`

of \the*ctr*. For example, the preamble of this document has the following to give non-default defitions to \thefootnote and \thesubsection for right columns.

```
\definethecounter{footnote}{1}{%
  \textit{\arabic{footnote}}}
\definethecounter{subsection}{1}{%
  \texttt{%
    \arabic{section}.\arabic{subsection}}}
```

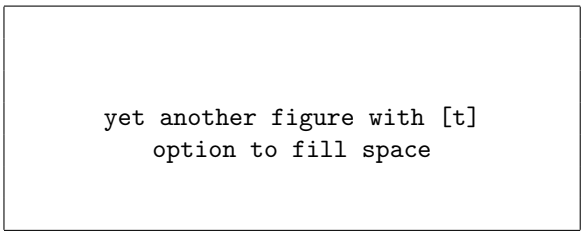

Figure 10: Yet Another Figure with [t] Option

6 Closing paracol Environment and Page Flushing

The final example shown here is this single-column text which the author put after paracol environment is closed. As you are seeing, paracol environment can be finished at any vertical position in a page and can be followed by ordinary single column texts.

The environment may also be restarted anywhere you like as shown here.

The last issue is to flush a page. The ordinary \newpage command works as you expect. If you say \newpage in the left column in a page, the contents following it will appear in the left column in the next page. Note that this does not affect the layout of the right column.

To flush all columns in a page, a command \flushpage is available. This command in i-th column is almost equivalent to;

```
\switchcolumn[i]*[\newpage]
```

but more robust[6]. The ordinary page breaking command \clearpage may also be used to flush all columns and to start a fresh page, but it has a side effect to put all figures and tables which are not yet output.

```
\begin{paracol}{2}
\begin{leftcolumn}
The environment may also be restarted
anywhere you like as shown here. ...
\end{leftcolumn}
\begin{rightcolumn}
source
\end{rightcolumn}
\end{paracol}
Now the aurthor will do ...
```

Now the aurthor will do \flushpage shortly to start a real binlingual example from the next page, after showing another example of closing paracol environment in this sentence and of restarting in the next one, in which *unbalanced column width* is demonstrated using \columnratio command shown in Section 7.3.

O.K., we have restarted paracol environment and we will see the effect of \flushpage now!!

```
\columnratio{0.6}
\begin{paracol}{2}
\begin{leftcolumn}
O.K., we have restarted |paracol|
environment...
\end{leftcolumn}
\begin{rightcolumn}
source
\end{rightcolumn}
```

[6]For example \switchcolumn* may flush a page for the synchronization and thus \newpage may leave an empty page.

An Die Freude/To Joy

Friedrich Schiller

The following is the libretto of the fourth movement of Beethoven's Ninth Symphony, his adaptation of Schiller's ode "An Die Freude" (or "To Joy" in English). Beethoven's additions and revisions are indicated in italics.

O Freunde, nicht diese Töne!
Sondern laßt uns angenehmere anstimmen und freudenvollere[7].

Oh friends, no more of these sad tones!
Let us rather raise our voices together
In more pleasant and joyful tones[4].

Freude!
Freude, schöner Götterfunken Tochter aus Elysium,
Wir betreten feuertrunken, Himmlische, dein Heiligtum!
Deine Zauber binden wieder, *Was die Mode streng geteilt;*
Alle Menschen werden Brüder[8], Wo dein sanfter Flügel weilt

Joy!
Joy, thou shining spark of God,
Daughter of Elysium,
With fiery rapture, goddess,
We approach thy shrine.
Your magic reunites
That which stern custom has parted;
All humans will become brothers[5]
Under your protective wing.

Wem der große Wurf gelungen, eines Freundes Freund zu sein;
Wer ein holdes Weib errungen, mische seinen Jubel ein!
Ja, wer auch nur eine Seele sein nennt auf dem Erdenrund!
Und wer's nie gekonnt, der stehle weinend sich aus diesem Bund!

Let the man who has had the fortune
To be a helper to his friend,
And the man who has won a noble woman,
Join in our chorus of jubilation!
Yes, even if he holds but one soul
As his own in all the world!
But let the man who knows nothing of this
Steal away alone and in sorrow.

Freude trinken alle Wesen an den Brüsten der Natur;
Alle Guten, alle Bösen folgen ihrer Rosenspur.
Küsse gab sie uns und Reben, einen Freund, geprüft im Tod;
Wollust ward dem Wurm gegeben, und der Cherub steht vor Gott.

All the world's creatures drink
From the breasts of nature;
Both the good and the evil
Follow her trail of roses.
She gave us kisses and wine
And a friend loyal unto death;
She gave the joy of life to the lowliest,
And to the angels who dwell with God.

Froh, wie seine Sonnen fliegen durch des Himmels prächt'gen Plan,
Laufet, Brüder, eure Bahn, freudig, wie ein Held zum Siegen.

Joyous, as his suns speed
Through the glorious order of Heaven,
Hasten, brothers, on your way,
Joyful as a hero to victory.

Seid umschlungen, Millionen! Diesen Kuß der ganzen Welt!

Be embraced, all ye millions!
With a kiss for all the world!

[7] If I had been a good student in my German class, this footnote would say "This part was added by Beethoven." in German.

[8] Original: Was der Mode Schwert geteilt;
Bettler werden Fürstenbrüder,

[4] This part was added by Beethoven.

[5] Original: What custom's sword has parted;
Beggars become princes' brothers

Brüder, über'm Sternenzelt muß ein lieber Vater wohnen.

Ihr stürzt nieder, Millionen? Ahnest du den Schöpfer, Welt?
Such'ihn überm Sternenzelt! Über Sternen muß er wohnen.

Brothers, beyond the stars
Surely dwells a loving Father.

Do you kneel before him, oh millions?
Do you sense the Creator's presence?
Seek him beyond the stars!
He must dwell beyond the stars.

7 Reference Manual

7.1 Environment `paracol`

`\begin{paracol}{`*num*`}[`*text*`]` *body* `\end{paracol}`

The environment `paracol` contains *body* typeset in *num* columns in parallel. The optional *text* is put spanning all columns prior to the multi-columned *body*.

- The environment may start from *any* vertical position in a page, i.e., not necessary at the top of a page. The single-column *pre-environment stuff* of the *starting page* in which `\begin{paracol}` lies are naturally connected to the beginning part of *body* in each column, unless the page has footnotes[9] or bottom floats. If these kind of bottom stuff exist, they are put above the multi-columned *body*, or the spanning *text* if provided, with a vertical skip of `\textfloatsep` separating them if bottom floats exist. The *deferred* floats which have not yet appeared in the starting page and thus will appear in the next or succeeding pages are considered as page-wise floats given in the environment.
- The environment can be enclosed in a `list`-*like environment* such as `enumerate`, `itemize` and `description`. If so, `\item`s in each column are typeset using the parameters of the surrounding environment such as `\leftmargin` and `\rightmargin`. For example, the following short `paracol` environment is included in an `itemize` for this and other `\item`s in this page.
  - This is the first `\item` in the left column.
  - This is the second `\item` in the left column followed by a `\switchcolumn`[10].

  - This is the first `\item` in the right column.
  - This is the second `\item` in the right column.
  - This is the third and last `\item` in the right column.

  You are now seeing the switching to/from multi-columned and `itemize`d texts are naturally connected with the last and this single-columned sentences. You may feel the space between two columns above is too large but it simply results from the large total `\leftmargin`s of the outer `description` and this `itemize`, which make the right column shifted right. A simple remedy for this large space is to make `\columnsep` narrower, for example 0 pt as shown below.
  - This `\item` is wider than the last `\item` above because `\columnsep` is 0 pt.

  - Therefore, this `\item` is shifted left a little bit to make inter-column spece narrower.
- All local counters in all columns are initialized to have the values at `\begin{paracol}` on its first occurence. On the second and succeeding occurences of `\begin{paracol}`, the local counters in each column have the value at the last `\end{paracol}`, unless they are modified after the `\end{paracol}`. If a counter is modified (or declared by `\newcounter`) after the `\end{paracol}`, the local versions of the counter in all column commonly have the value at `\begin{paracol}`.
- The environment may end at *any* vertical position in a page, i.e., the *post-environment stuff* being the single-column texts and others following `\end{paracol}` in the *last page* of the environment may not start from the top of a page. If any columns don't have deferred column-wise floats and the most advanced *leading column* at `\end{paracol}` has neither of footnotes[11] nor bottom floats, its bottom is naturally connected to the post-environment stuff. If the leading column has these kinds of bottom stuff, they are put above the post-environment stuff, with a vertical skip of `\textfloatsep` separating them if bottom floats exist. All deferred column-wise floats given in the environment are

[9] With merged footnotes setting shown in Section 7.5, the footnotes in the single-column contents are merged with those in `paracol` environment and are put at the bottom of the starting page together as shown in this page.

[10] This footnote is to show the footnotes in this page are merged.

[11] With merged-footnote setting shown in Section 7.5, the footnotes in the closing `paracol` environment are merged with those in post-environment stuff and are put at the bottom of the page together as shown in this page.

flushed before the post-environment stuff appears, possibly creating *float columns* only with floats. On the other hand, deferred page-wise floats given in the environment are considered as deferred (single-) column-wise floats given just after `\end{paracol}`.

- The values of all local counters in the leftmost column are used as the initial values of them in the post-environment stuff.
- The `paracol` environment cannot be nested, or you will have an error message of illegal nesting.
- The commands `\switchcolumn`, `\synccounter`, `\syncallcounters` and `\flushpage`, and environments `column(*)`, `nthcolumn(*)`, `leftcolumn(*)` and `rightcolumn(*)` are *local* to `paracol` environment and thus undefined outside the environment[12]. The command `\clearpage` is of course usable outside and inside the environment but its function inside is a little bit different from outside.

7.2 Column-Switching Command and Environments

`\switchcolumn[`*col*`]`
`\switchcolumn[`*col*`]*[`*text*`]`

The command switches columns from i to j where i and j is the zero-origin ordinals of the columns from/to which we are leaving/visiting respectively. Without the optional *col*, $j = i + 1 \bmod n$ where n is the number of columns given to `\begin{paracol}`, while $j =$ *col* with the optional argument. If the command (or `[`*col*`]` if specified) is followed by a `*`, the column-switching takes place after synchronization and, if specified, the optional spanning *text* is put.

- Using `\switchcolumn` in a `list`-like environment *included* in a `paracol` environment causes an ugly result without any error/warning messages. This caution is effectual for all column-switching environments too.
- If *col* $\notin [0, n)$, an error is reported and, if you dare to continue, you will switch to the leftmost column 0.
- The synchronization point is set just below the last line of the leading column in a page p, partly taking deferred floats into account. That is, all deferred floats are put in the pages up to $p-1$ and at the top of p if possible. Then, if a non-leading column has footnotes and/or bottom floats and they cannot be pushed down below the synchronization point, the point is moved to the next page top[13].
- In a page having one or more synchronization points, stretch and shrink factors of all vertical spaces, such as those surrounding sectionning commands, are ingonred. Therefore, even if you specify `\flushbottom`, the page is typeset as if `\raggedbottom` were specified.
- After a synchronization point is set, top floats will not be put in the page having the point any more and thus will be deferred to the next or a succeeding page.

`\begin{column}` *body* `\end{column}`
`\begin{column*}[`*text*`]` *body* `\end{column*}`

The environment `column` contains *body* for the column next to what we are in just before `\begin{column}`. The starred version `column*` does the same after synchronization and, if specified, the optional spanning *text* is put.

- The environments are almost equivalent to;

  `{\switchcolumn` *body* `\par}`
  `{\switchcolumn*[`*text*`]` *body* `\par}`

[12] Unless you dare to define them.
[13] Or below top floats deferred to the page.

except for their first occurences which don't switch to the column 1 (i.e., right column if two-columned) but stay in the leftmost column 0. More precicesly, `\begin{column(*)}` does not make column-switching if it is not preceded by `\switchcolumn` nor other column-switching environments.

- The *body* of the environments cannot have `\switchcolumn` nor column-switching environments including `column(*)` themselves, or you will have an error message of illegal use of command/ environment.
- Column-switching does not take place at `\end{column(*)}`. Therefore, texts following the environments are put in the column in which *body* resides until a column-switching commnad/environment is given.

`\begin{nthcolumn}{`*col*`}` *body* `\end{nthcolumn}`
`\begin{nthcolumn*}{`*col*`}[`*text*`]` *body* `\end{nthcolumn*}`

The environment `nthcolumn` contains *body* for the column *col*. The starred version `nthcolumn*` does the same after synchronization and, if specified, the optional spanning *text* is put.

- The environments are equivalent to;

  `{\switchcolumn[`*col*`]` *body* `\par}`
  `{\switchcolumn[`*col*`]*[`*text*`]` *body* `\par}`

- The *body* of the environments cannot have `\switchcolumn` nor column-switching environments including `nthcolumn(*)` themselves, or you will have an error message of illegal use of command/ environment.
- Column-switching does not take place at `\end{nthcolumn(*)}`. Therefore, texts following the environments are put in the column in which *body* resides until a column-switching commnad/environment is given.

`\begin{leftcolumn}` *body* `\end{leftcolumn}`
`\begin{leftcolumn*}[`*text*`]` *body* `\end{leftcolumn*}`
`\begin{rightcolumn}` *body* `\end{rightcolumn}`
`\begin{rightcolumn*}[`*text*`]` *body* `\end{rightcolumn*}`

The environment `leftcolumn` contains *body* for the leftmost column 0, while `rightcolumn` for the column 1 being the right column in two-column typesetting. The starred versions `leftcolumn*` and `rightcolumn*` do the same after synchronization and, if specified, the optional spanning *text* is put.

- The environments `leftcolumn(*)` are equivalent to;

  `\begin{nthcolumn}{0}` *body* `\end{nthcolumn}`
  `\begin{nthcolumn*}{0}[`*text*`]` *body* `\end{nthcolumn*}`

  while `rightcolumn(*)` are equivalent to;

  `\begin{nthcolumn}{1}` *body* `\end{nthcolumn}`
  `\begin{nthcolumn*}{1}[`*text*`]` *body* `\end{nthcolumn*}`

7.3 Commands for Column Width, Position and Color

`\columnratio{`$r_0, r_1, \cdots, r_k$`}`

The command defines the width of each column by the fraction r_i to specify the portion which i-th ($i = 0$ for the leftmost) column occupies. More specifically, the width w_i of the i-th column is defined as follows,

where W is `\textwidth`, S is `\columnsep`, and n is the number of columns given to `\begin{paracol}`.

$$W' = W - (n-1)S$$
$$w_i = \begin{cases} r_i W' & i \le k \\ \dfrac{(1 - \sum_{j=0}^{k} r_j)W'}{n-(k+1)} & i > k \end{cases}$$

- The equations above imply that $k < n-1$, $r_i > 0$ and $\sum_{j=0}^{k} r_j < 1$. If $k \ge n-1$, k is assumed to be $n-2$ and all r_i such that $i \ge n-1$ are ignored. If r_i or its sum does not satisfy the conditions, you will have an ugly result with "Overful" messages.
- The argument $r_0, r_1, \cdots, r_k$ can be empty to mean $k = -1$ to let all column widths be W'/n as default.
- The setting of column width by the command takes effect in the `paracol` environments following the command[14]. Therefore, though placing the command in the preamble is the most natural way[15], you may place this command between two `paracol` environments to change the column layout for the second one even when they appear in a page as shown in Section 6.
- In the i-th column, `\columnwidth` has w_i and, for outermost paragraphs in the column, `\hsize` has w_i as well. As for `\linewidth`, it has $w_i - (\texttt{\textwidth} - l)$ where l is what `\linewidth` had at `\begin{paracol}`, i.e., the `\linewidth` for the `list`-like environment surrounding `paracol` if any, or `\textwidth` otherwise.

`\swapcolumninevenpages`
`\noswapcolumninevenpages`

In a book with unbalanced parallel columns, sometimes it is preferable that, for example, wider columns are always *inside* while narrower ones are *outside*. This *column-swapping* to *print* columns in even pages in reverse order is enabled by `\swapcolumninevenpages`. The other command `\noswapcolumninevenpages` disables this function to give the default setting.

- The column-swapping affects not only columns but also marginal notes and, more subtlely, the column to which spanning texts is put. That is, with the natural ordering of column printing, column-0 accommodate spanning texts and its marginal notes go to left margin while those of other columns are placed at their right, but with reverse ordering the role of column-0 is delegated to column-$(n-1)$ in n-parallel-column typesetting. Since the printing position of each column is decided *after* the page number for columns are fixed, columns are placed always correctly. As for marginal notes and spanning texts, however, we have to decide which column is the leftmost *before* the page in which they reside is fixed. Therefore, the paracol can misunderstand the page parity to misplace these items. In particular, it is almost impossible to produce a good result when a spanning text crosses a page boundary to lie in two pages whose parities of course disagree. Therefore, you are requested to insert `\newpage` before the such stuff if you have weird results.
- The commands have to be outside of `paracol` environments to decide the action in the environments following them. If they appear in a `paracol` environment, you will have a warning message saying they are ignored.
- *This narrower, outside and italicized column-1 is at first in left*
- Here is an example of column swapping. Since this page 14 is even, this wider column-0 with roman font is placed

[14] If the command is in a `paracol` environment, the command does not affect the column widths of the environment but does the next ones, though such usage is very unusual.

[15] Or second most to not using it at all, of course.

in right side and thus inside at the begining, but now we are in a odd page in which this column is in left side.

side but the page break has changed the position to the right.

`\columncolor[`*mode*`]{`*color*`}[`*col*`]`
`\normalcolumncolor[`*col*`]`

The command `\columncolor` declares that the *default color* of a column is *color* or what it specifies by the combination with the optional *mode*. The command `\normalcolumncolor` declares the default color is what `\normalcolor` specifies, i.e., black usually. The target column of these commands is that in which the commands reside, or *col* if it specified.

- The command may be outside of `paracol` environment. If so and *col* is not provided, the target column is the leftmost 0.
- The default color declaration is *global*. Therefore, even if the command appears in a `paracol` environment (and even in some grouping structure in it), the declaration will be kept effective after `\end{paracol}` to determine the default color of the specified column in succeeding `paracol` environments.
- To give a color to texts (and maybe other stuff) in a column correctly, you need to load color package or its relative (e.g., xcolor) which the implementation of coloring in paracol relies on.
- Coloring with `\color[`*mode*`]{`*color*`}` and other coloring commands in `paracol` environments is of course allowed. One caution is that the `\color` decides the color for following texts until other specificatoin is given or the group surrounding the command is closed. Therefore, `\switchcolumn` does not affect the coloring but a color given to the texts in a column is also applied to the texts in the column to be switched to. This irrelativeness of coloring and column-switching is shown in the example below.

  This column is colored blue because `\columncolor{blue}` is specfied. Here we have a `\switchcolumn`.

  The color of this paragraph is green because we are still in the environment of green coloring, which we are now closing.

  Since the coloring environment has been closed, the color of this paragraph is the default blue. Now we have yet another and the last `\switchcolumn` to the right.

  This column is colored red because `\columncolor{red}` is specified.

  Now the color of the right column is changed to green because `\begin{color}{green}` is given prior to this paragraph. Now we have another `\switchcolumn` to go back to the left.

  Since this paragraph is outside of the coloring environment, its color is the default red.

  The default coloring of columns does not affect anything outside of `paracol` environment of course, and thus this sentence is not colored[16].

7.4 Commands for Counters

`\globalcounter{`*ctr*`}`

The command declares that the counter *ctr* is global to all columns. An update of a global counter in a column is seen by any other columns.

- All column-local values of a descendant local counter of a global counter are zero-cleared when the global counter is explicitly stepped by `\stepcounter` or `\refstepcounter`, or implicitly by a sectioning command and so on.

[16] Or colred black as `\normalcolor` specifies.

- The counter `page` is always global but an explicit update of it by e.g., `\setcounter` in a non-leftmost column is not seen by other columns and is canceled even for the column itself after a column-switching or a page break in the column. Therefore, if you want to make a *jump* of `page`, it must be done in the leftmost column 0. Note that a jump from a page p to q can be seen in other columns even if they have gone beyond p *before* the column 0 makes the jump, as far as `page` having q (or its successor) is referred to by `\pageref` or through *contents* files such as `.toc`[17].
- Globalizing a *ctr* being already global is just ignored without any complaints.

`\localcounter{`*ctr*`}`

The command declares that the counter *ctr* is local for each column.

- Though this command is intended for localizing a *ctr* which is once globalized, localizing a local counter does not causes any error but is just ignored. Localizing the permanently global `page` is also just ignored without any complaints.

`\definethecounter{`*ctr*`}{`*col*`}{`*rep*`}`

The command defines `\the`*ctr* being `{`*rep*`}` for the local use in the column *col*. That is, `\the`*ctr* in the column *col* acts as if it is defined by `\renewcommand{\the`*ctr*`}{`*rep*`}`.

`\synccounter{`*ctr*`}`

The command *broadcasts* the value of the local counter *ctr* in the column in which the command appears to the values in all other columns.

`\syncallcounters`

The command broadcasts the values of all local counters in the column in which the command appears to the values in all other columns.

7.5 Single-Columned Footnotes

`\singlecolumnfootnotes`
`\mergedfootnotes`
`\multicolumnfootnotes`

The command `\singlecolumnfootnotes` makes footnotes in `paracol` environments *single-columned* so that footnotes in all columns are gathered to be typeset spanning all columns, i.e., single-columned, and are put at the bottom of the page in which they appear. The command `\mergedfootnotes` also makes footnotes single-columned and *merges* them with footnotes in outside of the environment but in the same page, i.e., those in pre-environment and post-environment stuff, while with `\singlecolumnfootnotes` pre-environment footnotes are put above multi-columns and those in the last page of the environment is put below multi-columns to separate single- and multi-column stuff. The command `\multicolumnfootnotes` is to choose the default *multi-columned* footnote typesetting, i.e., footnotes in each column are put below the column itself and are separated from pre-environment and post-environment footnotes.

- An example of merged footnote is found in p. 11 while you will see many of them in Section 8[18].
- In any styles of footnote typesetting, a footnote cannot have page breaks in it, i.e., a footnote is always put in a page as a whole. This makes it impossible to have a footnote taller than `\textheight` and thus you will see a warning message if you give a very long footnote which will be printed intruding into the area for page footer (or out of the paper bound).

[17] Direct reference to `page` may give an inconsisent result, as you might have in ordinary LaTeX documents.

[18] The left-column footnote 6 in p. 8 looks like a merged footnote because it is at the bottom of the page and the marked text is above the single-column text. However, it is an ordinary multi-columned one produced by a trick with `\footnotemark` and `\footnotetext` in different `paracol` environments.

- The commands `\singlecolumnfootnotes` and `\mergedfootnotes` make `footnote` counter global and perform `\fncounteradjustment` shown below inside them. The command `\multicolumnfootnotes` does the opperations oppositely, i.e., localizes `footnote` and does `\nofncounteradjustment`. Though these settings are usually appropriate for each footnote typesetting but you can override them by explictly using commands like `\localcounter{footnote}`.

`\footnote*[`*num*`]{`*text*`}`
`\footnotemark*[`*num*`]`
`\footnotetext*[`*num*`]{`*text*`}`

The starred version of `\footnote`, `\footnotemark` and `\footnotetext` are for the adjustment of the footnote numbering, the order of footnote marks in main texts, and the stacking order of footnotes at page bottom. Their usages with various examples are given in Section 8.

`\fncounteradjustment`
`\nofncounteradjustment`

The maintenance of `footnote` with the starred footnote commands such as `\footnote*` shown above causes out-of-order progress of the counter to make it hard to have a consistent counter value at `\end{paracol}`. The command `\fncounteradjustment` is to let `\end{paracol}` adjust the value of the counter based on its value at `\begin{paracol}` and the number of footnote commands in the environment. The command `\nofncounteradjustment` is to tell `\end{paracol}` to do nothing as in default.

- Though `\singlecolumnfootnotes` and `\mergedfootnotes` do `\fncounteradjustment` and `\multicolumnfootnotes` does `\nofncounteradjustment` inside of them, you can override these settings by explicitly putting a counter adjustment command after a footnote typesetting command.
- The effect of `\fncounteradjustment` is shown in Section 8.

7.6 Control of Contents Output

`\addcontentsonly{`*file*`}{`*col*`}`

The command inhibits the output of contents information to *file* $\in$ {`toc`, `lof`, `lot`} from columns other than *col*.

- For example, if this manual had the table of contents, `\addcontentsonly{toc}{0}` should be specified to inhibit the contents information output from `\subsection` commands in Section 4 and 5, or the table should have duplicated entries of sub-sections.
- It must be *file* $\in$ {`toc`, `lof`, `lot`}, or you will have an error message of illegal type of contents file.

7.7 Page Flushing Commands

`\flushpage`

The command flushes pages up to the *top page* in which the leading column resides. Deferred floats which can be put in the pages up to the top page are also flushed.

`\clearpage`

The command does what `\flushpage` does and then flushes all floats still deferred if any. The deferred float flushing beyond the top page takes place at first for column-wise ones creating float columns for them, and then for page-wise ones creating *float pages* only with page-wise floats, as LaTeX's `\clearpage` does outside `paracol` environment.

8 Numbering and Placement of Single-Columned Footnotes

Here we have a simple example of single-columned but not-merged footnotes[19].

[19]Because of the non-merged typesetting, this footnote is put above the example.

First left-column paragraph . . . . . with a footnote[20] . . . . . in it.

Second left-column paragraph . . . . . with a footnote[21] . . . . . in it.

First right-column paragraph . . . . . with a footnote[22] . . . . . in it.

Second right-column paragraph . . . . . with a footnote[23] . . . . . in it.

[20]First left-column footnote.
[21]Second left-column footnote.
[22]First right-column footnote.
[23]Second right-column footnote. This and all other footnotes above are single-columned and, since footnote typesetting is non-merged, they are put above the post-environment stuff.

As shown above, it is easy to have a reasonable result of footnote numbering and placement as far as your `paracol` environment is completely included in a page and you accept the numbering in left-column-first manner constructing the environment as follows exploiting the fact `footnote` is made global, where b is the value of `footnote` counter at `\begin{paracol}`, i.e., the number given to the footnote just preceding the environment, and thus $b = 19$ in the example above.

```
\begin{paracol}{2}
left-column stuff having n footnotes numbered b + 1, b + 2, . . . , b + n
\switchcolumn
right-column stuff having m footnotes numbered b + n + 1, b + n + 2, . . . , b + n + m
\end{paracol}
```

The real life is, however, togher than that with the too optimistic assumptions above, as described in the following subsections.

8.1 Multiple `\switchcolumn` in a Page

Here we have an example with three `\switchcolumn` commands in a page having six footnotes. Hereafter, footnotes are typeset with `\mergedfootnotes`[24].

First left-column paragraph . . . . . with a footnote[25] . . . . . in it.

Second left-column paragraph . . . . . with a footnote[26] . . . . . in it.

It is followed by a `\switchcolumn`.

Third and synchroized left-column paragraph . . . . . with a footnote[28] . . . . . in it.

It is followed by a `\switchcolumn`.

First right-column paragraph . . . . . with a footnote[27] . . . . . in it.

It is followed by a `\switchcolumn*`.

Second and synchronized right-column paragraph . . . . . with a footnote[29] . . . . . in it.

Third right-column paragraph . . . . . with a footnote[30] . . . . . in it.

[24]And thus this footnote is merged with those in the `paracol` environment.
[25]First left-column footnote.
[26]Second left-column footnote.
[27]First right-column footnote but following the second left-column one.
[28]Third left-column footnote but following the first right-column one.
[29]Second right-column footnote but following the third left-column one.
[30]Third right-column footnote.

The example in the previous page should look weird because the order of the third footnote in the left column 28 and the first in the right 27 are reversed in their numbers and in the stack at the page bottom. However, the result is *natural* because they are numbered and stacked in the order of occurence in the source `.tex` as always done in any documents without paracol and with it but multi-columned typesetting. Since the paracol cannot maintain the order automatically[31], you have to maitain it by yourself.

The problem is partly solved by using `\footnote` with its optional argument `[`*num*`]` to number the first right-column and the third left-column footnotes explicitly, i.e., to give *num* = 28 to the former and *num* = 27 to the latter. One caution is that you have to remember that `\footnote` with the optional *num* does not update `footnote` counter and thus you have to do `\setcounter{footnote}{28}` or `\addtocounter{footnote}{2}` after the third left-column footnote.

This remeady, however, cannot change the stacking order of these two footnotes of cource. Therefore, you need another trick with `\footnotemark` and `\footnotetext` to stack the third left-column footnote above the first right-column one. More specifically, you can solve the problem inserting

`\footnotetext[27]{`*text for the third left footnote*`}`

somewhere between `\footnote` commands for the second left-column and the first right-column ones, e.g., at the end of the second left-column paragraph, and attaching its mark to the appropriate word for the footnote by `\footnotemark[27]`, to have the following.

First left-column paragraph . . . . . with a footnote[32] . . . . . in it.
Second left-column paragraph . . . . . with a footnote[33] . . . . . in it.
It is followed by `\footnotetext[34]{`*text*`}` and a `\switchcolumn`.
Third and synchroized left-column paragraph . . . . . with a footnote whose mark here[34] . . . . . is given by `\footnotemark[34]` . . . . . in it.
It is followed by `\addtocounter{footnote}{2}` and a `\switchcolumn`.

First right-column paragraph . . . . . with a footnote[35] . . . . . in it.
It is followed by a `\switchcolumn*`.

Second and synchronized right-column paragraph . . . . . with a footnote[36] . . . . . in it.
Third right-column paragraph . . . . . with a footnote[37] . . . . . in it.

Though this solution gives a good result, however, it has the following two problems. First, you have to explicitly specify the footnote number through the optional arguments `[`*num*`]` of `\footnote`, `\footnotetext` and `\footnotemark`. This problem is quite severe because, for example, if you add a footnote somewhere preceeding the `paracol` environment in question, you have to modify all `[`*num*`]` arguments of footnote-related commands in the environment. This means that when the footnote addition is done in the first page of a 100-page document having `paracol` environments with explicitly numbered footnotes in every page, you have to make the corrections for environments in 99 pages. The other a little bit less severe problem is that you have to keep `footnote` counter having correct value by `\setcounter`, `\addtocounter` or `\stepcounter` for footnotes following those with explicit numbering so that their numbers are given by the default action of `\footnote`.

To cope with these two problems, paracol provides you with the *starred* versions of `\footnote` and its relatives as introduced in Section 7.5 and detailedly explained in the next Section 8.2.

[31] So far, because the maintenace is extremely tough. But since it is not impossible, some day you could have an improved version of paracol with the automatic ordering.
[32] First left-column footnote.
[33] Second left-column footnote.
[34] Third left-column footntoe given by `\footnotetext[34]{`*text*`}` placed at the end of the second left-column paragraph.
[35] First right-column footnote whose number 35 is explicitly given by `\footnote[35]{`*text*`}`.
[36] Second right-column footnote correctly following the first right-column one.
[37] Third right-column footnote.

8.2 Commands \footnote* and Relatives

\footnote*[+*disp*]{*text*}
\footnote*[-*disp*]{*text*}
\footnote*[*disp*]{*text*}

The command is similar to its non-starred counterpart but the expicit numbering with the optional argument is done in *self-relative* or *base-displacemnt* style. That is, if the optional argument has a leading '+' or '-', the number given to the footnote is $f + disp$ or $f - disp$ respectively where f is the value of `footnote` counter, or in other words the number given to the last footnote[38]. Otherwise, i.e., the optioal argument is a number without +/- sign, the number given to the footnote is $b + disp$ where b is the base value of `footnote` counter at `\begin{paracol}` for the environment in which the command appears, or in other words the number given to the last pre-environment footnote[39].

In addition, unlike the non-starred version, this command updates `footnote` counter with the number given to the footnote, i.e., $f \leftarrow f + disp$, $f \leftarrow f - disp$ or $f \leftarrow b + disp$ is performed, so that following `\footnote` without explicit numbering option have numbers $f + 1$, $f + 2$ and so on with new f.

- If the optional argument is not provided, it is assumed that `[+1]` is given and thus `\footnote*{`*text*`}` acts as `\footnote{`*text*`}`.

\footnotemark*[[+-]*disp*]

This command is a mixture of its non-starred counterpart and `\footnote*`. That is the number for the footnote mark is calculated in the way of `\footnote*` and `footnote` counter is updated.

\footnotetext*[[+-]*disp*]{*text*}

Without the optional argument `[[+-]`*disp*`]`, this command does what `\footnotetext{`*text*`}` does but in addition increments `footnote` counter before that. With the optional argument, on the other hand, the number given to the footntoe *text* is calculated as done in `\footnote`, but the `footnote` counter is not updated.

With these starred commands, you can produce the following using the base-displacement mechanism without worrying about the absolute value of `\footnote` counter and its change.

First left-column paragraph .... with a footnote[40] ..... in it.
Second left-column paragraph .... with a footnote[41] ..... in it.
It is followed by `\footnotetext*[3]{`*text*`}` and a `\switchcolumn`.
Third and synchroized left-column paragraph... ..... with a footnote whose mark here[42] ..... is given by `\footnotemark*[3]` because $42 = 39+3$.
It is followed by a `\switchcolumn`.

First right-column paragraph..... ..... with a footnote[43] ..... in it.
It is followed by a `\switchcolumn*`.
Second and synchronized right-column paragraph ..... with a footnote[44] ..... in it.
Third right-column paragraph..... ..... with a footnote[45] ..... in it.

[38] If it is put by the ordinary `\footnote`.
[39] Or the last footnote in the previous `paracol` environment, etc.
[40] First left-column footnote.
[41] Second left-column footnote.
[42] Third left-column footntoe given by `\footnotetext*[3]{`*text*`}` placed at the end of the second left-column paragraph to have $42 = 39 + 3$.
[43] First right-column footnote whose number 43 is given by `\footnote*[4]{`*text*`}` because $43 = 39 + 4$.
[44] Second right-column footnote produced by `\footnote*[5]{`*text*`}` because $44 = 39 + 5$.
[45] Third right-column footnote procdued by `\footnote{`*text*`}` because $45 = 44 + 1$.

The other way to produce the same result except for the absolute footnote numbers is to use the self-relative mechansim and to exploit the progress of `footnote` counter as follows.

First left-column paragraph . . . . . with a footnote[46] . . . . . in it.
Second left-column paragraph . . . . . with a footnote[47] . . . . . in it.
It is followed by `\footnotetext*{`*text*`}` and a `\switchcolumn`.

Third and synchroized left-column paragraph . . . . . with a footnote whose mark here[48] . . . . . is given by `\footnotemark*[-1]` because $48 = 49 - 1$. It is followed by a `\switchcolumn`.

First right-column paragraph . . . . . with a footnote[49] . . . . . in it.
It is followed by a `\switchcolumn*`.

Second and synchronized right-column paragraph . . . . . with a footnote[50] . . . . . in it.
Third right-column paragraph . . . . . with a footnote[51] . . . . . in it.

It depends on the structure of your document which of the base-displacement and self-relative is better. If your document has frequent switching between single- and multi-column text typesettings and thus the contents of a `paracol` environment is relatively small, the base-displacement is a good choice because you may concentrate on one base value of `footnote` counter. Otherwise, especially when your document consists of one single and large `paracol` environment, the base-displacement is almost equivalent to maitaining absolute values and thus the self-relative should be preferred.

Note that if the last `\footnote` or `\footnotemark` in a `paracol` environment is starred, the command lets `footnote` counter have some value smaller than that for the last stacked footnote. For example, if the second and third right-column footnotes 50 and 51 are omitted from the example above, the last footnote-related command will be `\footnotemark*[-1]` which makes the counter at `\end{paracol}` 48 rather than 49. You may not worry about this problem, however, becaues `\end{paracol}` automatically maintains the counter letting it have $b+n$ where n is the number of `\footnote` and `\footnotemark` in the environment, if the maintenance is ordered by the command `\fncounteradjustment` which is automatically executed by `\singlecolumnfootnotes` and `\mergedfootnotes`.

8.3 Page Break

When a `paracol` environment with footnotes lays accross a page boundary, you could have some weird result even if the environment have just one `\switchcolumn` as shown below.

First left-column paragraph . . . . . with a footnote[52] . . . . . in it.

First right-column paragraph . . . . . with a footnote[54] . . . . . in it.

---

[46] First left-column footnote.
[47] Second left-column footnote.
[48] Third left-column footntoe given by `\footnotetext*{`*text*`}` placed at the end of the second left-column paragraph because it follows the second footnote 47.
[49] First right-column footnote whose number 49 is given by `\footnote{`*text*`}` because $49 = 48 + 1$ and `\footnotetext*` for 48 lets `footnote` have the value.
[50] Second right-column footnote produced by `\footnote*[+2]{`*text*`}` because $50 = 48 + 2$.
[51] Third right-column footnote procdued by `\footnote{`*text*`}` because $51 = 50 + 1$.
[52] First left-column footnote.

Second left-column paragraph .....
..... with a footnote[53] ..... in it.

Second right-column paragraph .....
..... with a footnote[55] ..... in it.

Since the part of the source `.tex` for this example above is foundamentally same as that in p. 18 at the beginning of this Section 8, footnotes are simply numbered in left-column-first manner without any trickes. However it results in giving an impression that two paragraphs in each of both columns at the bottom of the last page has footnote marks of inconsecutive numbers 52 and 54 due to the second left-column paragraph and the footnote 53 in it. More weirdly, the first right-column footnote 54 is not put in the last page where its mark is shown but is stacked below 53 in this page.

The resason why this happens is that a footnote is not immediately put to the bottom of the page where its mark resides but to the page constructing at the time when the footnote is processed at the end of the paragraph in which the corresponding `\footnote` (or `\footnotetext`) occurs[56]. Therefore, it may happen even in an ordinary single-column document or a `paracol`ed multi-column one with multi-columned footnotes that a footnote is thrown to the page $p + 1$ next to the page p in which its mark is left, when the mark is placed around the bottom of the page p.

This footnote placement mechanism becomes clearly visible in the example above in which the footnote 54 is processed *after* the second left-column paragraph is processed to complete the last page giving no chance to the footnote placed in the page[57]. Therefore, the solution of this placement problem is to let the first right-column footnote processed *before* the page is broken by the progress of the left-column. That is, in the solution shown below the author inserted `\switchcolumn` after the first left-column paragraph to let the first right-column paragraph and its footnote are processed, and then did `\switchcolumn` again after the right-column paragraph to go back to the left-column.

First left-column paragraph .....
.....with a footnote[58] .....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
..... in it.
It is followed by a `\switchcolumn`.

First right-column paragraph .....
.....with a footnote[59] .....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
.....
..... in it.
It is followed by a `\switchcolumn` to go back to the left column.

[53] Second left-column footnote.
[54] First right-column footnote weirdly placed here while the footnoted main text is in the previous page.
[55] Second right-column footnote whose mark in the main text gives impression that footnote numbering jumps from 53 to 55.
[56] More accurately, the footnote is kept in a place in TEX together with other preceding but still unprocessed footnotes and then TEX examines them at the end of a paragraph in which a page break is found to decide whether each of them is included in the page just being completed.
[57] In fact, even `\footnote` for the footnote is processed after the page break in this case.
[58] First left-column footnote.
[59] First right-column footnote which is now placed in this page where its mark 59 resides.

Second left-column paragraph .... with a footnote[60] ..... in it. It is also followed by a `\switchcolumn`.

Second right-column paragraph .... with a footnote[61] ..... in it.

Unfortunately, this tactics does not always solve the problem. If a left-column paragraph has a page break in it and a footnote before the break, doing `\switchcolumn` after the paragraph is too late to let right-column footnotes reside in the page just having been broken, while inserting `\switchcolumn` before the paragraph should cause incorrect stacking order.

The remedy for this problem is similar to that shown in Section 8.1 to cope with multiple `\switchcolumn` in a `paracol` environment. Here it is shown a little bit more formally. Suppose we have a page in a `paracol` environment in which a page break occurs in p_l-th and p_r-th paragraphs in the left and right columns respecitively. Thus we have $p_l - 1$ and $p_r - 1$ completed paragraphs in each of both columns. Let n_l (resp. n_r) be the number of footnotes in the pre-break left-column (resp. right-column) paragraphs, and m_l (resp. m_r) be the number of pre-break footnotes in the p_l-th (resp. p_r-th) paragraph. Thus we have $n_l + m_l$ (resp. $n_r + m_r$) footnotes in the left (resp. right) column of the page before the break. The following construct assures that those footnotes are properly numbered and stacked at the bottom of the page.

First to $(p_l - 1)$*-th paragraphs with* n_l *footnotes in total given by* `\footnote{`*text*`}`*.*
`\footnotetext*{`*1st footnote in* p_l*-th paragraph*`}`
...
`\footnotetext*{`m_l*-th footnote in* p_l*-th paragraph*`}`
`\switchcolumn`
First to $(p_r - 1)$*-th paragraphs with* n_r *footnotes in total given by* `\footnote{`*text*`}`*.*
`\footnotetext*{`*1st footnote in* p_r*-th paragraph*`}`
...
`\footnotetext*{`m_r*-th footnote in* p_r*-th paragraph*`}`
`\switchcolumn`
p_l*-th paragraph whose first footnote mark is given by* `\footnotemark*[-(`$m_l+n_r+m_r-1$`)]`*, while second to* m_l*-th ones are given by* `\footnotemark` *without* `*` *nor optional* `[`*num*`]`*. The first subsequent footnotes beyond the page break, if any, is given by* `\footnote*[+(`n_r+m_r+1`)]{`*text*`}` *while further subsequent ones are given by* `\footnote{`*text*`}`*.*
`\switchcolumn`
p_r*-th paragraph whose first footnote mark is given by* `\footnotemark*[-(`m_r+k_l-1`)]` *where* k_l *is the number of left-column footnotes beyond the break, while second to* m_r*-th ones are given by* `\footnotemark`*. The first subsequent footnotes beyond the page break, if any, is given by* `\footnote*[+(`k_l+1`)]{`*text*`}`*, while further subsequent ones are given by* `\footnote{`*text*`}`*.*

The example shown in the next two pages is for the case of $p_l = p_r = n_l = n_r = m_l = m_r = k_l = 2$.

[60] Second left-column footnote whose number 60 follows the righ-column footnote 59 in the last page.
[61] Second right-column footnote whose number 61 follows the left-column footnote 60.

First left-column paragraph with two footnotes ... here[62] by `\footnote{`*text*`}` .... and here[63] also by `\footnote{`*text*`}` ..... followed by a series of `\footnotetext*{`*text*`}` and then a `\switchcolumn`.

Second left-column paragraph across two pages ... with two prebreak footnotes .... here[64] by `\footnotemark*[-5]` because $m_l+n_r+m_r-1=2+2+2-1=5$ and thus $64=69-5$... ... and here[65] by `\footnotemark` .....

[62]First left-column footnote given by `\footnote{`*text*`}`.
[63]Second left-column footnote also given by `\footnote{`*text*`}`.
[64]Third left-column footnote given by `\footnote*{`*text*`}`.
[65]Fourth left-column footnote given by `\footnote*{`*text*`}`.

First right-column paragraph with two footnotes ... here[66] by `\footnote{`*text*`}` .... and here[67] also by `\footnote{`*text*`}` ..... followed by a series of `\footnotetext*{`*text*`}` and then a `\switchcolumn`.

Second right-column paragraph across two pages ... with two prebreak footnotes .... here[68] by `\footnotemark*[-3]` because $m_r+k_l-1=2+2-1=3$ and thus $68=71-3$ .... and here[69] by `\footnotemark` .....

[66]First right-column footnote given by `\footnote{`*text*`}`.
[67]Second right-column footnote also given by `\footnote{`*text*`}`.
[68]Third right-column footnote given by `\footnote*{`*text*`}`.
[69]Fourth right-column footnote given by `\footnote*{`*text*`}`.

...and two post-break footnotes.....
...here[70] by \footnote*[+5]{*text*}.....
...and here[71] by \footnote{*text*}.....
followed by a \switchcolumn.

...and two post-break footnotes.....
...here[72] by \footnote*[+3]{*text*}.....
...and here[73] by \footnote{*text*}.....

Note that though the remedy works well as shown above, it is not a good idea to do that when you are writing draft versions of your document because page break points go up and down by your modifications to the document. Therefore, it is recommended to put all footnotes by non-starred \footnote until your document become perfect except for footnote numbering and placement and then to adjust them by the techique described in this section.

9 Known and Unknown Problems

Here a few problems you could face in the use of paracol are summerized.

- If your (e.g.,) left column goes ahead too farther than the right column, LaTeX could stop with the following error message.

  ```
  ! Package paracol Error: Too many unprocessed columns/floats.
  ```

  This usually means that the internal space to keep materials in the left column is exhosted. More specifically, suppose at some point in your .tex your left column is in the page p while the right is in $q < p$. We need $(p - q)$ *boxes* to keep the left column contents in the pages q, $q + 1$, ..., $p - 1$ because these pages cannot be *printed* yet until the right column fills them. In addition, we also need two boxes for the left column in p and the right column in q so that you make column-switching between them keeping unprinted contents in them. Therefore, at least we need to have $(p - q) + 2$ boxes, while the number of them provided by LaTeX is only 18[74]. Therefore, paracol cannot continue its work if $(p - q)$ reaches 17. Furthermore, other stuff also consumes the boxes as follows.

  - If there are n pages in q, $q + 1$, ..., p having pre-environment stuff or page-wise floats, n boxes are consumed by them. Similarly, if m pages in them have single-columned footnotes, m boxes are given to them.
  - If the left (resp. right) column has multi-columned footnotes in p (resp. q), a box is used for them.
  - If the left (resp. right) column has k floats to be placed in p (resp. q) or to be deferred to $p+1$ (resp. $q + 1$) or a succeeding page, k boxes are reserved for them.

  Therefore, it should be safe to keep $(p-q)$ from exceeding 10 or so placing \switchcolumn in both columns fairly frequently.

- As discussed in Section 7.2, setting a synchronization point in a page brings the following side effects.

  - Stretch and shrink factors of all vertical skips in the page are nullified. The nullification of stretch factors could make a sparse column in the page have a vertical space at its bottom as if \raggedbottom setting is in effect even with \flushbottom one, rather than distributing the amount of the space to the skips so that the bottom line is aligned at the page bottom. As for the nullification of shrink

[70] Fifth left-column footnote given by \footnote*[+5] because $n_r + m_r + 1 = 2 + 2 + 1 = 5$ and thus $70 = 65 + 5$.
[71] Sixth left-column foootnote given by \footnote{*text*}.
[72] Fifth right-column footnote given by \footnote*[+3] because $k_l + 1 = 3$ and thus $72 = 69 + 3$.
[73] Sixth right-column foootnote given by \footnote{*text*}.
[74] Readers who is acquainted with LaTeX implementation will understand that 18 is the cardinarity of the set {\bx@A, ..., \bx@R} for floats aquired by \newinsert.

factors, it makes the page have lines a little bit less than that it would have without synchronization because lines above the (last) synchronization point cannot be compressed. The other effect is a little bit subtle because the shrink factors below the last synchronization point are taken care of by TEX's page builder when it examine the appropriateness of each breakable point, but they are nullified when the page is printed. That is, if TEX finds a good break point which needs that the stuff between the synchronization and break points is compressed a little bit, the stuff is printed without compression making its bottom edge a little bit below the page bottom.

– After a synchronization point is set, columns in the page cannot have top floats any more even if a column has space above the synchronization point and large enough to place the float. Therefore, if you like to exploit the space, you have to place the `figure` or `table` environment in question prior to the column-switching command or environment for the synchronization.

- As confessed in Section 7.3, paracol can misplace marginal notes and/or spanning texts if column-swapping is in effect by `\swapcolumninevenpages` and these stuff appear near the bottom edge of a page[75].
- As shown in Section 8, it is not easy to have good numbering and stacking order of single-columned footnotes even with the supports from `\footnote*` and its relatives. In addition, a footnote in a `paracol` environment cannot be broken into two (or more) pages.
- Vertical lines separating columns will *not* be printed even if you let `\columnseprule` have non-zero width. This is because the author has not yet find a good solution to prevent the lines from overlaying spanning texts[76].

In addition to the problems above known to the author, there may be (or should be, honestly speaking) other unknown problems in paracol because it cannot be perfect though the author has made his best effort for debugging it. Particulally, sometimes it is very tough, if not impossible, to make paracol combatible with other packages, especially with those having dark magic as paracol has in it[77]. Therefore, though reporting incompatibleness with a package you use is very welcome[78], you should kindly understand the toughness of the compatibility issue.

Furthermore, even without such problematic packages, paracol might produce weird results due to its bug. If your document has something to make unknown bugs visible, you might have one (or more) of the followings which the author encountered in his debugging work.

- A page, a column, a footnote and/or a float disappear[79].
- A page, a column, a footnote and/or a float are duplicated.
- A message like "`Overfull \vbox (1.23456pt too high) has occurred while \ouptut is active`" is shown.
- A message "`Underfull \vbox (badness 10000) has occurred while \ouptut is active`" is shown.

If you encounter anything like them (or whatever you cannot solve by yourself), don't hesitate to report it to the author with minimum source file to produce the problem[80].

[75] The author has an idea to solve the problem for spanning texts, and plans to implement the solutoin in the next version 1.3.

[76] But the solution for the placement of spanning texts with column-swapping seems to give us the solution of this problem as well, and thus maybe version 1.3 allows non-zero `\columnseprule`

[77] For example, the author knows it is almost impossible to make paracol with one of the author's own package available in CTAN.

[78] For example, paracol is now compatible with color package thanks to a report from a user.

[79] In fact, a bug fixed in version 1.2 caused page losing though it happens very very rarely but an unlucky user encountered it.

[80] And with patience because your problem might not be solved quickly.

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For the implementation of the style file, the author referred to the base implementations of `\output`, `\newcounter` and related macros of LaTeX 2_ε written by Leslie Lamport, Johannes Braams and other authors.

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Underlined number refers to the page where the specification of corresponding entry is described, while italicized number is for the page in which the usage of the entry is explained.

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