The package witharrows*

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Abstract

The LaTeX package witharrows provides environments `{WithArrows}` and `{DispWithArrows}` similar to the environments `{aligned}` and `{align}` of amsmath but with the possibility to draw arrows on the right side of the alignment. These arrows are usually used to give explanations concerning the mathematical calculus presented.

This package can be used with `xelatex`, `lualatex`, `pdflatex` but also by the classical workflow `latex-dvips-ps2pdf` (or Adobe Distiller). Two compilations may be necessary. This package requires the packages expl3, xparse and tikz. The Tikz libraries arrows.meta and bending are also required.

This package provides an environment `{WithArrows}` to construct alignments of equations with arrows for the explanations on the right side:

```
$\begin{WithArrows}
A & = (a+1)^2 \Arrow{we expand} \\
  & = a^2 + 2a + 1
\end{WithArrows}$
```

$$\begin{aligned} A &= (a+1)^2 \\ &= a^2+2a+1 \end{aligned} \quad \Big\downarrow \textit{we expand}$$

The arrow has been drawn with the command `\Arrow` on the row from which it starts. The command `\Arrow` must be used in the second column (the best way is to put it at the end of the second cell of the row as in the previous example).

The environment `{WithArrows}` bears similarities with the environment `{aligned}` of `amsmath` (and `mathtools`). The extension witharrows also provides an environment `{DispWithArrows}` which is similar to the environment `{align}` of `amsmath`: cf. p. 14.

1 Options for the shape of the arrows

The command `\Arrow` has several options. These options can be put between square brackets, before, or after the mandatory argument.
The option `jump` gives the number[1] of rows the arrow must jump (the default value is, of course, 1).

```
$\begin{WithArrows}
A & = \bigl((a+b)+1\bigr)^2 \Arrow[jump=2]{we expand} \\
  & = (a+b)^2 +  2(a+b) +1 \\
  & = a^2 + 2ab + b^2 + 2a + 2b +1
\end{WithArrows}$
```

*This document corresponds to the version 1.12 of witharrows, at the date of 2018/11/26.

[1] It's not possible to give a non-positive value to `jump`. See below (p. 2) the way to draw an arrow which goes backwards.

$$\begin{aligned} A &= \bigl((a+b)+1\bigr)^2 \\ &= (a+b)^2+2(a+b)+1 && \text{we expand} \\ &= a^2+2ab+b^2+2a+2b+1 \end{aligned}$$

It’s possible to put several arrows which start from the same row.

```
$\begin{WithArrows}
A & = \bigl((a+b)+1\bigr)^2 \Arrow{}\Arrow{}[jump=2] \\
  & = (a+b)^2 + 2(a+b) +1 \\
  & = a^2 + 2ab + b^2 + 2a + 2b +1
\end{WithArrows}$
```

$$\begin{aligned} A &= \bigl((a+b)+1\bigr)^2 \\ &= (a+b)^2+2(a+b)+1 \\ &= a^2+2ab+b^2+2a+2b+1 \end{aligned}$$

The option `xoffset` shifts the arrows to the right (we usually don’t want the arrows to be stucked on the text). The default value of `xoffset` is 3 mm.

```
$\begin{WithArrows}
A & = \bigl((a+b)+1\bigr)^2
\Arrow[xoffset=1cm]{with \texttt{xoffset=1cm}} \\
  & = (a+b)^2 + 2(a+b) +1
\end{WithArrows}$
```

$$\begin{aligned} A &= \bigl((a+b)+1\bigr)^2 && \qquad\text{with }\texttt{xoffset=1cm} \\ &= (a+b)^2+2(a+b)+1 \end{aligned}$$

The arrows are drawn with Tikz. That’s why the command `\Arrow` has an option `tikz` which can be used to give to the arrow (in fact, the command `\path` of Tikz) the options proposed by Tikz for such an arrow. The following example gives an thick arrow.

```
$\begin{WithArrows}
A & = (a+1)^2 \Arrow[tikz=thick]{we expand} \\
  & = a^2 + 2a + 1
\end{WithArrows}$
```

$$\begin{aligned} A &= (a+1)^2 && \text{we expand} \\ &= a^2+2a+1 \end{aligned}$$

It’s also possible to change the arrowheads. For example, we can draw an arrow which goes backwards with the Tikz option `<-`.

```
$\begin{WithArrows}
A & = (a+1)^2 \Arrow[tikz=<-]{we factorize} \\
  & = a^2 + 2a + 1
\end{WithArrows}$
```

$$\begin{aligned} A &= (a+1)^2 && \text{we factorize} \\ &= a^2+2a+1 \end{aligned}$$

It’s also possible to suppress both tips of the arrow with the Tikz option `-`.

```
$\begin{WithArrows}
A & = (a+1)^2 \Arrow[tikz=-]{very classical} \\
  & = a^2 + 2a + 1
\end{WithArrows}$
```

$$\begin{aligned} A &= (a+1)^2 \\ &= a^2 + 2a + 1 \end{aligned} \quad \curvearrowright \textit{ very classical}$$

In order to have straight arrows instead of curved ones, we must use the Tikz option "`bend left = 0`".

```
$\begin{WithArrows}
A & = (a+1)^2 \Arrow[tikz={bend left=0}]{we expand} \\
  & = a^2 + 2a + 1
\end{WithArrows}$
```

$$\begin{aligned} A &= (a+1)^2 \\ &= a^2 + 2a + 1 \end{aligned} \quad \Big\downarrow \textit{we expand}$$

In fact, it's possible to change more drastically the shape or the arrows with the option `TikzCode` presented p. 18.

One of the most useful options is "`text width`" to control the width of the text associated to the arrow.

```
$\begin{WithArrows}
A & = \bigl((a+b)+1\bigr)^2
\Arrow[jump=2,tikz={text width=5.3cm}]{We have done...} \\
  & = (a+b)^2 + 2(a+b) +1 \\
  & = a^2 + 2ab + b^2 + 2a + 2b +1
\end{WithArrows}$
```

$$\begin{aligned} A &= \bigl((a+b)+1\bigr)^2 \\ &= (a+b)^2 + 2(a+b) + 1 \\ &= a^2 + 2ab + b^2 + 2a + 2b + 1 \end{aligned} \quad \curvearrowright \begin{array}{l} \textit{We have done a two-stages expansion} \\ \textit{but it would have been clever to ex-} \\ \textit{pand with the multinomial theorem.} \end{array}$$

In the environments `{DispWithArrows}` and `{DispWithArrows*}`, there is an option `wrap-lines`. With this option, the lines of the labels are automatically wrapped on the right: see p. 17.

If we want to change the font of the text associated to the arrow, we can, of course, put a command like `\bfseries`, `\large` or `\sffamily` at the beginning of the text. But, by default, the texts are composed with a combination of `\small` and `\itshape`. When adding `\bfseries` at the beginning of the text, we won't suppress the `\small` and the `\itshape` and we will consequently have a text in a bold, italic and small font.

```
$\begin{WithArrows}
A & = (a+1)^2 \Arrow{\bfseries we expand} \\
  & = a^2 + 2a + 1
\end{WithArrows}$
```

$$\begin{aligned} A &= (a+1)^2 \\ &= a^2 + 2a + 1 \end{aligned} \quad \curvearrowright \textit{\textbf{ we expand}}$$

It's possible to put commands `\\` in the text to force new lines[2]. However, if we put a `\\` , a command of font placed in the beginning of the text will have effect only until the first command `\\` (like in an environment `{tabular}`). That's why Tikz gives an option `font` to modify the font of the whole text. Nevertheless, if we use the option `tikz={font={\bfseries}}`, the default specification of `\small` and `\itshape` will be overwritten.

[2] By default, this is not possible in a Tikz node. However, in witharrows, the nodes are created with the option `align=left`, and, thus, it becomes possible.

```
$\begin{WithArrows}
A & = (a+1)^2 \Arrow[tikz={font={\bfseries}}]{we expand} \\
  & = a^2 + 2a + 1
\end{WithArrows}$
```

$$\begin{aligned} A &= (a+1)^2 \\ &= a^2+2a+1 \end{aligned}$$

we expand

If we want exactly the same result as previously, we have to give to the option `font` the value `{\itshape\small\bfseries}`.

Almost all the options can be given directly to the environment `{WithArrows}` (between square brackets). In this case, they apply to all the arrows of the environment.[3]

```
$\begin{WithArrows}[tikz=blue]
A & = \bigl((a+b)+1\bigr)^2 \Arrow{First expansion.} \\
  & = (a+b)^2 + 2(a+b) +1 \Arrow{Second expansion.} \\
  & = a^2 + 2ab + b^2 + 2a + 2b +1
\end{WithArrows}$
```

$$\begin{aligned} A &= \bigl((a+b)+1\bigr)^2 \\ &= (a+b)^2+2(a+b)+1 \\ &= a^2+2ab+b^2+2a+2b+1 \end{aligned}$$

First expansion.

Second expansion.

The environment `{WithArrows}` has an option `displaystyle`. With this option, all the elements are composed in `\displaystyle` (like in an environment `{aligned}` of `amsmath`).

Without the option `displaystyle`:

```
$\begin{WithArrows}
\int_0^1 (x+1)^2 dx
& = \int_0^1 (x^2+2x+1) dx
\Arrow{linearity of integration}      \\
& = \int_0^1 x^2 dx + 2 \int_0^1 x dx + \int_0^1 dx \\
& = \frac13 + 2\frac12 + 1 \\
& = \frac73
\end{WithArrows}$
```

$$\begin{aligned} \textstyle\int_0^1 (x+1)^2 dx &= \textstyle\int_0^1 (x^2+2x+1) dx \\ &= \textstyle\int_0^1 x^2 dx + 2\int_0^1 x dx + \int_0^1 dx \\ &= \tfrac13 + 2\tfrac12 + 1 \\ &= \tfrac73 \end{aligned}$$

linearity of integration

The same example with the option `displaystyle`:

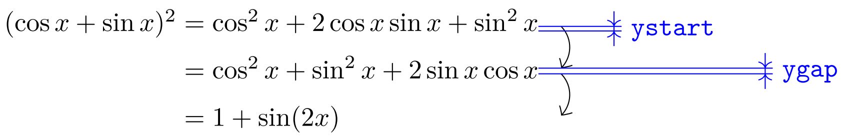
$$\begin{aligned} \int_0^1 (x+1)^2 dx &= \int_0^1 (x^2+2x+1) dx \\ &= \int_0^1 x^2 dx + 2\int_0^1 x dx + \int_0^1 dx \\ &= \frac13 + 2\frac12 + 1 \\ &= \frac73 \end{aligned}$$

linearity of integration

There are also two options for a fine tuning of the arrows:

[3] They also apply to the nested environments `{WithArrows}` (with the logical exceptions of `interline`, `CodeBefore` and `CodeAfter`).

- the option `ystart` sets the vertical distance between the base line of the text and the start of the arrow (default value: 0.4 ex);
- the option `ygap` sets the vertical distance between two consecutive arrows (default value: 0.4 ex).



Remark: It's also possible to use the options "`shorten <`" and "`shorten >`" of Tikz (via the option `tikz` of witharrows).

Almost all the options can also be set at the document level with the command `\WithArrowsOptions`. In this case, the scope of the declarations is the current TeX group (these declarations are "semi-global"). For example, if we want all the environments `{WithArrows}` composed in `\displaystyle` with blue arrows, we can write `\WithArrowsOptions{displaystyle,tikz=blue}`.[4]

```
\WithArrowsOptions{displaystyle,tikz=blue}
$\begin{WithArrows}
\sum_{i=1}^n (x_i+1)^2
& = \sum_{i=1}^n (x_i^2+2x_i+1) \Arrow{by linearity}\\
& = \sum_{i=1}^n x_i^2 + 2\sum_{i=1}^nx_i+ n
\end{WithArrows}$
```

$$\begin{aligned}\sum_{i=1}^n (x_i+1)^2 &= \sum_{i=1}^n (x_i^2+2x_i+1) \\ &= \sum_{i=1}^n x_i^2 + 2\sum_{i=1}^n x_i + n \end{aligned} \quad \textit{by linearity}$$

The command `\Arrow` is recognized only in the environments `{WithArrows}`. If we have a command `\Arrow` previously defined, it's possible to go on using it outside the environments `{WithArrows}`.

However, a previouly defined command `\Arrow` may still be useful in an environment `{WithArrows}`. If we want to use it in such an environment, it's possible to change the name of the command `\Arrow` of the package witharrows: there is an option `CommandName` for this purpose. The new name of the command must be given to the option *without* the leading backslash.

```
\NewDocumentCommand {\Arrow} {} {\longmapsto}
$\begin{WithArrows}[CommandName=Explanation]
f & = \bigl(x \Arrow (x+1)^2\bigr)
\Explanation{we work directly on fonctions}\\
& = \bigl(x \Arrow x^2+2x+1\bigr)
\end{WithArrows}$
```

$$\begin{aligned} f &= \bigl(x \longmapsto (x+1)^2\bigr) \\ &= \bigl(x \longmapsto x^2+2x+1\bigr) \end{aligned} \quad \textit{we work directly on fonctions}$$

The environment `{WithArrows}` gives also two options `CodeBefore` and `CodeAfter` for LaTeX code that will be executed at the beginning and at the end of the environment. Theses options are not designed to be hooks (they are avalaible only at the environment level and they are not applied to the nested environments).

[4] It's also possible to configure witharrows by modifying the Tikz style `WithArrows/arrow` which is the style used by witharrows when drawing an arrow. For example, to have the labels in blue with roman (upright) types, one can use the following instruction: `\tikzset{WithArrows/arrow/.append style = {blue, font = {}}}`.

```
$\begin{WithArrows}[CodeBefore = \color{blue}]
A & = (a+b)^2 \Arrow{we expand} \\
  & = a^2 + 2ab + b^2
\end{WithArrows}$
```

$$\begin{aligned} A &= (a+b)^2 \\ &= a^2 + 2ab + b^2 \end{aligned} \quad \Big\downarrow \textit{ we expand}$$

Special commands are available in `CodeAfter`: a command `\WithArrowsNbLines` which gives the number of lines (=rows) of the current environment (this is a command and not a counter), a special form of the command `\Arrow` and the command `\MultiArrow`: these commands are described in the section concerning the nested environments, p. 11.

2 Precise positioning of the arrows

The environment `{WithArrows}` defines, during the composition of the array, two series of nodes materialized in red in the following example.[5]

$$\begin{aligned}
I &= \int_{\frac{\pi}{4}}^{0} \ln\Big(1+\tan\left(\tfrac{\pi}{4}-u\right)\Big)(-du) \\
&= \int_{0}^{\frac{\pi}{4}} \ln\Big(1+\tan\left(\tfrac{\pi}{4}-u\right)\Big)du \\
&= \int_{0}^{\frac{\pi}{4}} \ln\left(1+\frac{1-\tan u}{1+\tan u}\right)du \\
&= \int_{0}^{\frac{\pi}{4}} \ln\left(\frac{1+\tan u+1-\tan u}{1+\tan u}\right)du \\
&= \int_{0}^{\frac{\pi}{4}} \ln\left(\frac{2}{1+\tan u}\right)du \\
&= \int_{0}^{\frac{\pi}{4}} \big(\ln 2-\ln(1+\tan u)\big)\,du \\
&= \frac{\pi}{4}\ln 2-\int_{0}^{\frac{\pi}{4}} \ln(1+\tan u)\,du \\
&= \frac{\pi}{4}\ln 2 - I
\end{aligned}$$

The nodes of the left are at the end of each line of text. These nodes will be called *left nodes*. The nodes of the right side are aligned vertically on the right side of the array. These nodes will be called *right nodes*.
By default, the arrows use the right nodes. We will say that they are in `rr` mode (*r* for *right*). These arrows are `vertical` (we will say that an arrow is *vertical* when its two ends have the same abscissa).

However, it's possible to use the left nodes, or a combination of left and right nodes, with one of the options `lr`, `rl` and `ll` (*l* for *left*). Those arrows are, usually, not vertical.

[5] The option `shownodes` can be used to materialize the nodes. The nodes are in fact Tikz nodes of shape "rectangle", but with zero width. An arrow between two nodes starts at the *south* anchor of the first node and arrives at the *north* anchor of the second node.

$$\begin{aligned}
\text{Therefore } I &= \int_{\frac{\pi}{4}}^{0} \ln\Bigl(1+\tan\left(\tfrac{\pi}{4}-u\right)\Bigr)(-du) && \textit{This arrow uses the } \texttt{lr} \textit{ option.} \\
&= \int_{0}^{\frac{\pi}{4}} \ln\Bigl(1+\tan\left(\tfrac{\pi}{4}-u\right)\Bigr)du \\
&= \int_{0}^{\frac{\pi}{4}} \ln\left(1+\frac{1-\tan u}{1+\tan u}\right)\,du \\
&= \int_{0}^{\frac{\pi}{4}} \ln\left(\frac{1+\tan u+1-\tan u}{1+\tan u}\right)du \\
&= \int_{0}^{\frac{\pi}{4}} \ln\left(\frac{2}{1+\tan u}\right)\,du && \textit{This arrow uses a } \texttt{ll} \textit{ option and a} \\
&= \int_{0}^{\frac{\pi}{4}} \bigl(\ln 2-\ln(1+\tan u)\bigr)\,du && \texttt{jump} \textit{ equal to } 2 \\
&= \frac{\pi}{4}\ln 2-\int_{0}^{\frac{\pi}{4}} \ln(1+\tan u)\,du \\
&= \frac{\pi}{4}\ln 2 - I
\end{aligned}$$

There is also an option called `i` (*i* for *intermediate*). With this option, the arrow is vertical and at the leftmost position.

```
$\begin{WithArrows}
(a+b)(a+ib)(a-b)(a-ib)
& = (a+b)(a-b)\cdot(a+ib)(a-ib) \\
& = (a^2-b^2)(a^2+b^2) \Arrow[i]{because $(x-y)(x+y)=x^2-y^2$}\\
& = a^4-b^4
\end{WithArrows}$
```

$$\begin{aligned}
(a+b)(a+ib)(a-b)(a-ib) &= (a+b)(a-b)\cdot(a+ib)(a-ib) \\
&= (a^2-b^2)(a^2+b^2) && \textit{because } (x-y)(x+y)=x^2-y^2 \\
&= a^4-b^4
\end{aligned}$$

The environment `{WithArrows}` gives also a `group` option. With this option, *all* the arrows of the environment are grouped on a same vertical line and at a leftmost position.

```
$\begin{WithArrows}[displaystyle,group]
2xy'-3y=\sqrt x
& \Longleftrightarrow 2x(K'y_0+Ky_0')-3Ky_0 = \sqrt x \\
& \Longleftrightarrow 2xK'y_0 + K(2xy_0'-3y_0) = \sqrt x \\
& \Longleftrightarrow 2x K'y_0 = \sqrt x \Arrow{...}\\
...
\end{WithArrows}$
```

$$\begin{aligned}
2xy'-3y=\sqrt{x} &\Longleftrightarrow 2x(K'y_0+Ky_0')-3Ky_0=\sqrt{x} \\
&\Longleftrightarrow 2xK'y_0+K(2xy_0'-3y_0)=\sqrt{x} \\
&\Longleftrightarrow 2xK'y_0=\sqrt{x} && \textit{we replace } y_0 \textit{ by its value} \\
&\Longleftrightarrow 2xK'x^{\frac{3}{2}}=x^{\frac{1}{2}} && \textit{simplification of the } x \\
&\Longleftrightarrow K'=\tfrac{1}{2x^2} && \textit{antiderivation} \\
&\Longleftrightarrow K=-\tfrac{1}{2x}
\end{aligned}$$

The environment `{WithArrows}` gives also a `groups` option (with a *s* in the name). With this option, the arrows are divided into several “groups”. Each group is a set of connected[6] arrows. All the arrows of a given group are grouped on a same vertical line and at a leftmost position.

[6] More precisely: for each arrow a, we note $i(a)$ the number of its initial row and $f(a)$ the number of its final line; for two arrows a and b, we say that $a \sim b$ when $[\![i(a),f(a)]\!] \cap [\![i(b),f(b)]\!] \neq \varnothing$; the groups are the equivalence classes of the transitive closure of $\sim$.

$$\begin{aligned}
A &= B \\
&\qquad\qquad \downarrow \textit{one} \\
&= C + D \\
&\qquad\qquad \downarrow \textit{two} \\
&= D' \\
&= E + F + G + H + I \\
&= K + L + M \\
&\qquad\qquad\qquad \downarrow \textit{three} \\
&= N \\
&\qquad\qquad\qquad \downarrow \textit{four} \\
&= O
\end{aligned}$$

In an environment which uses the option `group` or the option `groups`, it's still possible to give an option of position (`ll`, `lr`, `rl`, `rr` or `i`) to an individual arrow. Such arrow will be drawn irrespective of the groups.

If desired, the option `group` or the option `groups` can be given to the command `\WithArrowsOptions` so that it will become the default value. In this case, it's still possible to come back to the default behaviour for a given environment `{WithArrows}` with the option `rr`: `\begin{WithArrows}[rr]`

In the following example, we have used the option `group` for the environment and the option `rr` for the last arrow (that's why the last arrow is not aligned with the others).

$$\begin{aligned}
\sum_{k=0}^{n} \frac{\cos kx}{\cos^k x} &= \sum_{k=0}^{n} \frac{\Re(e^{ikx})}{(\cos x)^k} \\
&\qquad\qquad\qquad \downarrow (\cos x)^k \textit{ is real} \\
&= \sum_{k=0}^{n} \Re\left(\frac{e^{ikx}}{(\cos x)^k}\right) \\
&\qquad\qquad\qquad \downarrow \Re(z+z') = \Re(z) + \Re(z') \\
&= \Re\left(\sum_{k=0}^{n} \left(\frac{e^{ix}}{\cos x}\right)^k\right) \\
&\qquad\qquad\qquad \downarrow \textit{sum of terms of a geometric progression} \\
&= \Re\left(\frac{1-\left(\frac{e^{ix}}{\cos x}\right)^{n+1}}{1-\frac{e^{ix}}{\cos x}}\right) \\
&\qquad\qquad\qquad \downarrow \textit{algebraic calculation} \\
&= \Re\left(\frac{1-\frac{e^{i(n+1)x}}{\cos^{n+1} x}}{1-\frac{e^{ix}}{\cos x}}\right) \\
&\qquad\qquad\qquad \downarrow \textit{reduction to common denominator} \\
&= \Re\left(\frac{\frac{\cos^{n+1} x - e^{i(n+1)x}}{\cos^{n+1} x}}{\frac{\cos x - e^{ix}}{\cos x}}\right) \\
&\qquad\qquad\qquad \downarrow \Re(kz) = k \cdot \Re(z) \textit{ if } k \textit{ is real} \\
&= \frac{1}{\cos^n x} \Re\left(\frac{\cos^{n+1} x - e^{i(n+1)x}}{\cos x - e^{ix}}\right) \\
&\qquad\qquad\qquad\qquad \downarrow \textit{algebraic form of the complexes} \\
&= \frac{1}{\cos^n x} \Re\left(\frac{\cos^{n+1} x - (\cos(n+1)x + i\sin(n+1)x)}{\cos x - (\cos x + i\sin x)}\right) \\
&= \frac{1}{\cos^n x} \Re\left(\frac{(\cos^{n+1} x - \cos(n+1)x) - i\sin(n+1)x}{-i\sin x}\right) \\
&= \frac{1}{\cos^n x} \cdot \frac{\sin(n+1)x}{\sin x}
\end{aligned}$$

3 Comparison with the environment {aligned}

`{WithArrows}` bears similarities with the environment `{aligned}` of the extension amsmath. These are only similarities because `{WithArrows}` has not been written upon the environment `{aligned}`.[7]

As in the environments of amsmath, it's possible to change the spacing between two given rows with the option of the command `\\` of end of line (it's also possible to use `\\*` but is has exactly the same effect as `\\` since an environment `{WithArrows}` is always unbreakable).

```
$\begin{WithArrows}
A & = (a+1)^2 \Arrow{we expand} \\[2ex]
```

[7] In fact, it's possible to use the package witharrows without the package amsmath.

```
  & = a^2 + 2a + 1
\end{WithArrows}$
```

$$\begin{aligned} A &= (a+1)^2 && \\ & && \textit{we expand} \\ &= a^2 + 2a + 1 && \end{aligned}$$

In the environments of amsmath (or mathtools), the spacing between rows is fixed by a parameter called `\jot` (it's a dimension and not a skip). That's also the case for the environment `{WithArrows}`. An option `jot` has been given to the environment `{WithArrows}` in order to change the value of this parameter `\jot` for an given environment.[8]

```
$\begin{WithArrows}[displaystyle,jot=2ex]
F & = \frac12G     \Arrow{we expand}\\
  & = H + \frac12K \Arrow{we go on}\\
  & = K
\end{WithArrows}$
```

$$\begin{aligned} F &= \frac{1}{2}G && \\ & && \textit{we expand} \\ &= H + \frac{1}{2}K && \\ & && \textit{we go on} \\ &= K && \end{aligned}$$

However, this new value of `\jot` will also be used in other alignments included in the environment `{WithArrows}`:

```
$\begin{WithArrows}[jot=2ex]
\varphi(x,y) = 0  & \Leftrightarrow (x+y)^2 + (x+2y)^2 = 0
\Arrow{$x$ and $y$ are real}\\
& \Leftrightarrow \left\{
\begin{aligned}
x+y & = 0 \\
x+2y & = 0
\end{aligned}
\right.
\end{WithArrows}$
```

$$\begin{aligned} \varphi(x,y) = 0 &\Leftrightarrow (x+y)^2 + (x+2y)^2 = 0 && \\ & && x \textit{ and } y \textit{ are real} \\ &\Leftrightarrow \left\{ \begin{aligned} x+y &= 0 \\[2ex] x+2y &= 0 \end{aligned} \right. && \end{aligned}$$

Maybe this doesn't correspond to the desired outcome. That's why an option `interline` is proposed. It's possible to use a skip (=glue) for this option.

```
$\begin{WithArrows}[interline=2ex]
\varphi(x,y) = 0  & \Leftrightarrow (x+y)^2 + (x+2y)^2 = 0
\Arrow{$x$ and $y$ are real}\\
& \Leftrightarrow \left\{
\begin{aligned}
x+y & = 0 \\
x+2y & = 0 \\
\end{aligned}
\right.
\end{WithArrows}$
```

[8] It's also possible to change `\jot` with the environment `{spreadlines}` of mathtools.

$$\begin{aligned} \varphi(x,y)=0 &\Leftrightarrow (x+y)^2+(x+2y)^2=0 \\ &\Leftrightarrow \begin{cases} x+y=0 \\ x+2y=0 \end{cases} \end{aligned} \qquad \textit{x and y are real}$$

Like the environment `{aligned}`, `{WithArrows}` has an option of placement which can assume the values `t`, `c` or `b`. However, the default value is not `c` but `t`. If desired, it's possible to have the `c` value as the default with the command `\WithArrowsOptions{c}` at the beginning of the document.

```
So\enskip
$\begin{WithArrows}
A & = (a+1)^2 \Arrow{we expand} \\
  & = a^2 + 2a + 1
\end{WithArrows}$
```

So $\begin{aligned}[t] A &= (a+1)^2 \\ &= a^2+2a+1 \end{aligned} \quad \textit{we expand}$

The value `c` may be useful, for example, if we want to add curly braces:

```
On pose\enskip $\left\{
\begin{WithArrows}[c]
f(x) & = 3x^3+2x^2-x+4
\Arrow[tikz=-]{both are polynoms}\\
g(x) & = 5x^2-5x+6
\end{WithArrows}
\right.$
```

On pose $\left\{ \begin{aligned} f(x) &= 3x^3+2x^2-x+4 \\ g(x) &= 5x^2-5x+6 \end{aligned} \right. \quad \textit{both are polynoms}$

Unlike `{aligned}`, the environment `{WithArrows}` uses `\textstyle` by default.
Once again, it's possible to change this behaviour with `\WithArrowsOptions`:
`\WithArrowsOptions{displaystyle}`.

The following example is composed with `{aligned}`:

$$\left\{ \begin{aligned} \sum_{i=1}^n (x_i+1)^2 &= \sum_{i=1}^n (x_i^2+2x_i+1) \\ &= \sum_{i=1}^n x_i^2 + 2\sum_{i=1}^n x_i + n \end{aligned} \right.$$

The following is composed with `{WithArrows}[c,displaystyle]`. The results are strictly identical.[9]

$$\left\{ \begin{aligned} \sum_{i=1}^n (x_i+1)^2 &= \sum_{i=1}^n (x_i^2+2x_i+1) \\ &= \sum_{i=1}^n x_i^2 + 2\sum_{i=1}^n x_i + n \end{aligned} \right.$$

[9] In versions of amsmath older than the 5 nov. 2016, a thin space was added on the left of an environment `{aligned}`. The new versions do not add this space and neither do `{WithArrows}`.

4 Arrows in nested environments

The environments `{WithArrows}` can be nested. In this case, the options given to the encompassing environment applies also to the inner ones (with logical exceptions for `interline`, `CodeBefore` and `CodeAfter`). The command `Arrow` can be used as usual in each environment `{WithArrows}`.

```
$\begin{WithArrows}
\varphi(x,y)=0
  & \Leftrightarrow (x+2y)^2+(2x+4y)^2 = 0 \Arrow{the numbers are real}\\
  & \Leftrightarrow
  \left\{\begin{WithArrows}[c]
  x+2y & = 0 \\
  2x+4y & = 0
  \end{WithArrows}\right. \\
  & \Leftrightarrow
  \left\{\begin{WithArrows}[c]
  x+2y & = 0 \Arrow[tikz=-]{the same equation}\\
  x+2y & = 0
  \end{WithArrows}\right. \\
  & \Leftrightarrow x+2y=0
\end{WithArrows}$
```

$$\begin{aligned}
\varphi(x,y)=0 &\Leftrightarrow (x+2y)^2+(2x+4y)^2=0 && \quad \textit{the numbers are real}\\
&\Leftrightarrow \left\{\begin{aligned} x+2y&=0\\ 2x+4y&=0\end{aligned}\right.\\
&\Leftrightarrow \left\{\begin{aligned} x+2y&=0\\ x+2y&=0\end{aligned}\right. \quad \textit{the same equation}\\
&\Leftrightarrow x+2y=0
\end{aligned}$$

However, one may want to draw an arrow between rows that are not in the same environment. For example, one may want to draw the following arrow :

$$\begin{aligned}
\varphi(x,y)=0 &\Leftrightarrow (x+2y)^2+(2x+4y)^2=0\\
&\Leftrightarrow \left\{\begin{aligned} x+2y&=0\\ 2x+4y&=0\end{aligned}\right.\\
&\Leftrightarrow \left\{\begin{aligned} x+2y&=0\\ x+2y&=0\end{aligned}\right. \quad \textit{division by } 2\\
&\Leftrightarrow x+2y=0
\end{aligned}$$

Such a construction is possible by using `\Arrow` in the `CodeAfter` option. Indeed, in `CodeAfter`, a special version of `\Arrow` is available (we will call it "`\Arrow` in `CodeAfter`").

A command `\Arrow` in `CodeAfter` takes three arguments :

- a specification of the start row of the arrow ;
- a specification of the end row of the arrow ;
- the label of the arrow.

As usual, it's also possible to give options within square brackets before or after the three arguments. However, these options are limited (see below).

The specification of the row is constructed with the position of the concerned environment in the nesting tree, followed (after an hyphen) by the number of the row.

In the previous example, there are two environments `{WithArrows}` nested in the main environment `{WithArrows}`.

$$\begin{aligned}\varphi(x,y)=0 &\Leftrightarrow (x+2y)^2+(2x+4y)^2=0\\ &\Leftrightarrow \begin{cases} \;\; x+2y=0\\ 2x+4y=0\end{cases} \qquad \textit{environment number 1}\\ &\Leftrightarrow \begin{cases} x+2y=0\\ x+2y=0\end{cases} \qquad \textit{environment number 2}\\ &\Leftrightarrow x+2y=0\end{aligned}$$

The arrow we want to draw starts in the row 2 of the sub-environment number 1 (and therefore, the specification is `1-2`) and ends in the row 2 of the sub-environment number 2 (and therefore, the specification is `2-2`). We can draw the arrow with the following command `\Arrow` in `CodeAfter` :

```
$\begin{WithArrows}[CodeAfter = {\Arrow{1-2}{2-2}{division by $2$}}]
\varphi(x,y)=0
  & \Leftrightarrow (x+2y)^2+(2x+4y)^2 = 0 \\
.........
\end{WithArrows}$
```

$$\begin{aligned}\varphi(x,y)=0 &\Leftrightarrow (x+2y)^2+(2x+4y)^2=0\\ &\Leftrightarrow \begin{cases} \;\; x+2y=0\\ 2x+4y=0\end{cases}\\ &\Leftrightarrow \begin{cases} x+2y=0\\ x+2y=0\end{cases} \qquad \textit{division by } 2\\ &\Leftrightarrow x+2y=0\end{aligned}$$

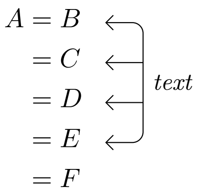
The options allowed for a command `\Arrow` in `CodeAfter` are : `ll`, `lr`, `rl`, `rr`, `v`, `xoffset`, `tikz` and `TikzCode`. Except `v`, which is specific to `\Arrow` in `CodeAfter`, all these options have their usual meaning.
With the option `v`, the arrow drawn is vertical to an abscissa computed with the start row and the end row only : the intermediate lines are not taken into account unlike with the option `i`. Currently, the option `i` is not available for the command `\Arrow` in `CodeAfter`. However, it's always possible to translate an arrow with `xoffset` (or `xshift` of Tikz).

```
$\begin{WithArrows}[CodeAfter = {\Arrow[v]{1-2}{2-2}{division by $2$}}]
\varphi(x,y)=0
  & \Leftrightarrow (x+2y)^2+(2x+4y)^2 = 0 \\
.........
\end{WithArrows}$
```

$$\begin{aligned}\varphi(x,y)=0 &\Leftrightarrow (x+2y)^2+(2x+4y)^2=0\\ &\Leftrightarrow \begin{cases} \;\; x+2y=0\\ 2x+4y=0\end{cases}\\ &\Leftrightarrow \begin{cases} x+2y=0\\ x+2y=0\end{cases} \qquad \textit{division by } 2\\ &\Leftrightarrow x+2y=0\end{aligned}$$

The package witharrows gives also another command available only in `CodeAfter`: the command `\MultiArrow`. This command draws a "rak". The list of the rows of the environment concerned by this rak are given in the first argument of the command `\MultiArrow`. This list is given with the syntax of the list in a `\foreach` command of pgfkeys.

```
$\begin{WithArrows}[tikz = rounded corners,
                    CodeAfter = {\MultiArrow{1,...,4}{text}}]
A & = B \\
  & = C \\
  & = D \\
  & = E \\
  & = F
\end{WithArrows}$
```

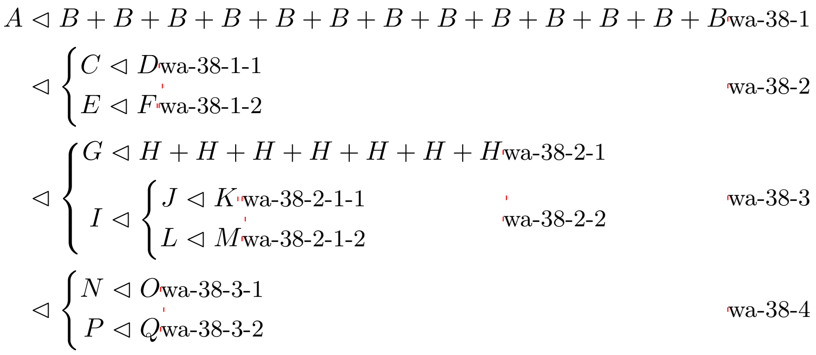


As of now, there is no option available for the command `\MultiArrow` (maybe in a future release).

5 Arrows from outside environments {WithArrows}

If someone wants to draw arrows from outside the environments `{WithArrows}`, he can use the Tikz nodes created in the environments.
The Tikz name of a node created by witharrows is prefixed by `wa-`. Then, we have a list of numbers which give the position in the nesting tree and the row number in the environment. At the end, we have the suffixe `l` for a "left node" and `r` for a "right node".

For illustrative purposes, we give an example of nested environments `{WithArrows}`, and, for each "right node", the name of that node.[10]



The package witharrows provides some tools facilitating the use of these nodes:

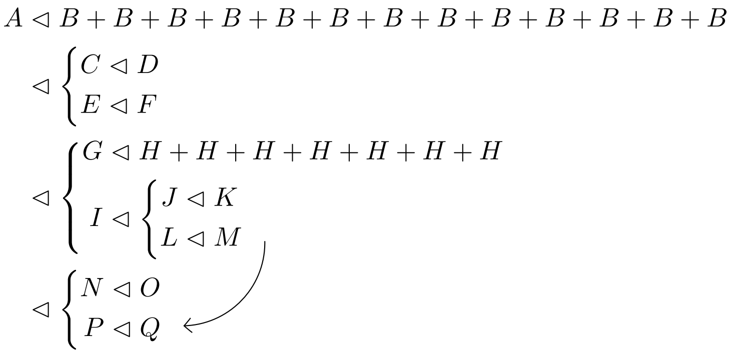
- the command `\WithArrowsLastEnv` gives the number of the last environment of level 0;
- a name can be given to a given environment with the option `name` and, in this case, the nodes created in the environment will have aliases constructed with this name;
- the Tikz style `WithArrows/arrow` is the style used by witharrows when drawing an arrow[11];
- the Tikz style `WithArrows/arrow/tips` is the style for the tip of the arrow (loaded by `WithArrows/arrow`).

For example, we can draw an arrow from `wa-38-2-1-2-r.south` to `wa-38-3-2-r.north` with the following Tikz command.

```
\begin{tikzpicture}[remember picture,overlay]
\draw [WithArrows/arrow]
      ([xshift=3mm]wa-\WithArrowsLastEnv-2-1-2-r.south)
   to ([xshift=3mm]wa-\WithArrowsLastEnv-3-2-r.north) ;
\end{tikzpicture}
```

[10] There is an option `shownodenames` to show the names of these nodes.

[11] More precisely, this style is given to the Tikz option "`every path`" before drawing the arrow with the code of the option `TikzCode`. This style is modified (in TeX scopes) by the option `tikz` of witharrows.


$A \triangleleft B+B+B+B+B+B+B+B+B+B+B+B+B$
$\triangleleft \begin{cases} C \triangleleft D \\ E \triangleleft F \end{cases}$
$\triangleleft \begin{cases} G \triangleleft H+H+H+H+H+H+H \\ I \triangleleft \begin{cases} J \triangleleft K \\ L \triangleleft M \end{cases} \end{cases}$
$\triangleleft \begin{cases} N \triangleleft O \\ P \triangleleft Q \end{cases}$

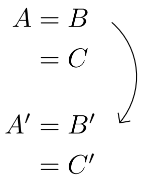
In this case, it would be easier to use a command `\Arrow` in `CodeAfter` but this is an example to explain how the Tikz nodes created by `witharrows` can be used.

In the following example, we create two environments `{WithArrows}` named "`first`" and "`second`" and we draw a line between a node of the first and a node of the second.

```
$\begin{WithArrows}[name=first]
A & = B \\
  & = C
\end{WithArrows}$

\bigskip
$\begin{WithArrows}[name=second]
A' & = B' \\
   & = C'
\end{WithArrows}$

\begin{tikzpicture}[remember picture,overlay]
\draw [WithArrows/arrow]
      ([xshift=3mm]first-1-r.south)
   to ([xshift=3mm]second-1-r.north) ;
\end{tikzpicture}
```



6 The environment {DispWithArrows}

As previously said, the environment `{WithArrows}` bears similarities with the environment `{aligned}` of `amsmath` (and `mathtools`). This extension also provides an environment `{DispWithArrows}` which is similar to the environments `{align}` and `{flalign}` of `amsmath`.

The environment `{DispWithArrows}` must be used *outside* math mode. Like `{align}`, it should be used in horizontal mode.

```
\begin{DispWithArrows}
A & = (a+1)^2 \Arrow{we expand} \\
  & = a^2 + 2a + 1
\end{DispWithArrows}
```

$$\begin{align} A &= (a+1)^2 && \Big\downarrow \textit{we expand} \tag{1}\\ &= a^2+2a+1 \tag{2}\end{align}$$

It's possible to use the command `\notag` (or `\nonumber`) to suppress a tag.
It's possible to use the command `\tag` to put a special tag (e.g. $\star$).
It's also possible to put a label to the line of an equation with the command `\label`.
These commands must be in the second column of the environment.

```
\begin{DispWithArrows}
A & = (a+1)^2 \Arrow{we expand} \notag \\
  & = a^2 + 2a + 1 \tag{$\star$} \label{my-equation}
\end{DispWithArrows}
```

$$\begin{align} A &= (a+1)^2 && \Big\downarrow \textit{we expand} \notag\\ &= a^2+2a+1 \tag{$\star$}\end{align}$$

A link to the equation ($\star$). This link has been composed with `\eqref{my-equation}` (the command `\eqref` is a command of amsmath).

If amsmath (or mathtools) is loaded, it's also possible to use `\tag*` which, as in amsmath, typesets the tag without the parenthesis. For example, it's possible to use it to put the symbol `\square` (of amssymb). This symbol is often used to mark the end of a proof.

```
\begin{DispWithArrows}
A & = (a+1)^2 \Arrow{we expand} \notag \\
  & = a^2 + 2a + 1 \tag*{$\square$}
\end{DispWithArrows}
```

$$\begin{align} A &= (a+1)^2 && \Big\downarrow \textit{we expand} \notag\\ &= a^2+2a+1 \tag*{$\square$}\end{align}$$

It's also possible to suppress all the autogenerated numbers with the boolean option `notag` (or `nonumber`), at the global or environment level. There is also an environment `{DispWithArrows*}` which suppresses all these numbers.[12]

```
\begin{DispWithArrows*}
A & = (a+1)^2 \Arrow{we expand} \\
  & = a^2 + 2a + 1
\end{DispWithArrows*}
```

$$\begin{aligned} A &= (a+1)^2 && \Big\downarrow \textit{we expand} \\ &= a^2+2a+1 \end{aligned}$$

In fact, there is also another option `tagged-lines` which can be used to control the lines that will be tagged. The value of this option is a list of the numbers of the lines that must to be tagged. For example, with the option `tagged-lines = {first,3,last}`, only the first, the third and the last line of the environment will be tagged. There is also the special value `all` which means that all the lines will be tagged.

```
\begin{DispWithArrows}[tagged-lines = last]
A & = A_1 \Arrow{first stage} \\
  & = A_2 \Arrow{second stage} \\
  & = A_3
\end{DispWithArrows}
```

[12] Even in this case, it's possible to put a "manual tag" with the command `\tag`.

$$\begin{aligned} A &= A_1 && \textit{first stage} \\ &= A_2 && \textit{second stage} \\ &= A_3 \end{aligned} \tag{3}$$

With the option `fleqn`, the environment is composed flush left (in a way similar to the option `fleqn` of the standard classes of LaTeX). In this case, the left margin can be controlled with the option `mathindent` (with a name inspired by the parameter `\mathindent` of standard LaTeX). The default value of this parameter is 25 pt.

```
\begin{DispWithArrows}[fleqn,mathindent = 1cm]
A & = (a+1)^2 \Arrow{we expand} \\
  & = a^2 + 2a + 1
\end{DispWithArrows}
```

$$A = (a+1)^2 \tag{4}$$

$$= a^2 + 2a + 1 \quad \textit{we expand} \tag{5}$$

Remark : By design, the option `fleqn` of witharrows is independant of the option `fleqn` of LaTeX. Indeed, since the environments of witharrows are meant to be used with arrows on the right side, the user may want to use witharrows with the option `fleqn` (in order to have more space on the right of the equations for the arrows) while still centering the classical equations.

If the package amsmath is loaded, it's possible to use the environment `{subequations}` and the command `\intertext` in the environments `{DispWithArrows}` and `{DispWithArrows*}` (and even the `\intertext` of nccmath if this package is loaded).
If the option `leqno` is used as a class option, the labels will be composed on the left also for the environments `{DispWithArrows}` and `{DispWithArrows*}`.[13]

If there is not enough space to put the tag at the end of a line, there is no automatic positioning of the label on the next line (as in the environments of amsmath). However, in `{DispWithArrows}`, the user can use the command `\tagnextline` to manually require the composition of the tag on the following line.

```
\begin{DispWithArrows}[displaystyle]
S_{2(p+1)}
& =\sum_{k=1}^{2(p+1)} (-1)^k k^2 \\
& \smash[b]{=\sum_{k=1}^{2p}(-1)^kk²
   +(-1)^{2p+1}(2p+1)^2+(-1)^{2p+2}(2p+2)^2} \tagnextline \\
&= S_{2p}-(2p+1)^2+(2p+2)^2\\
&=p(2p+1)-(2p+1)^2+(2p+2)^2\\
&= 2p^2+5p+3
\end{DispWithArrows}
```

$$S_{2(p+1)} = \sum_{k=1}^{2(p+1)} (-1)^k k^2 \tag{6}$$

$$= \sum_{k=1}^{2p}(-1)^k k^2 + (-1)^{2p+1}(2p+1)^2 + (-1)^{2p+2}(2p+2)^2 \tag{7}$$

$$= S_{2p} - (2p+1)^2 + (2p+2)^2 \tag{8}$$

$$= 2p^2 + p - 4p^2 - 4p - 1 + 4p^2 + 8p + 4 \tag{9}$$

$$= 2p^2 + 5p + 3 \tag{10}$$

[13] The package amsmath has an option `leqno` but witharrows, of course, is not aware of that option: witharrows only checks the option `leqno` of the document class.

The environment {DispWithArrows} is similar to the environment {align} of amsmath. However, {DispWithArrows} is not constructed upon {align} (in fact, it's possible to use witharrows without amsmath).
There are differences between {DispWithArrows} and {align}.

- The environment {DispWithArrows} allows only two columns.
- The environment {DispWithArrows} can not be inserted in an environment {gather} of amsmath.
- An environment {DispWithArrows} is always unbreakable (even with \allowdisplaybreaks of amsmath).
- The commands \label, \tag, \notag and \nonumber are allowed only in the second column.
- **Last but not least, by default, the elements of a {DispWithArrows} are composed in textstyle and not in displaystyle (it's possible to change this point with the option displaystyle).**

Concerning the references, the package witharrows is compatible with the extensions autonum, cleveref, fancyref, fncylab, hyperref, listlbls, prettyref, refstyle, refcheck, showlabels, smartref, typedref and varioref, and with the options showonlyrefs and showmanualtags of mathtools.[14]
It is not compatible with showkeys (not all the labels are shown).

The environments {DispWithArrows} and {DispWithArrows*} provide an option wrap-lines. With this option, the lines of the label are automatically wrapped on the right.

```
\begin{DispWithArrows*}[displaystyle,wrap-lines]
S_n
& = \frac1n \Re \left(\sum_{k=0}^{n-1}\bigl(e^{i\frac{\pi}{2n}}\bigr)^k\right)
\Arrow{sum of terms of a geometric progression of ratio $e^{i\frac{2\pi}n}$}\\
& = \frac1n \Re \left( \frac{1-\bigl(e^{i\frac{\pi}{2n}}\bigr)^n}
                            {1-e^{i\frac{\pi}{2n}}}\right)
\Arrow{This line has been wrapped automatically.} \\
& = \frac1n \Re \left(\frac{1-i}{1-e^{i\frac{\pi}{2n}}}\right)
\end{DispWithArrows*}
```

$$\begin{aligned} S_n &= \frac{1}{n}\Re\left(\sum_{k=0}^{n-1}\bigl(e^{i\frac{\pi}{2n}}\bigr)^k\right) \\ &= \frac{1}{n}\Re\left(\frac{1-\bigl(e^{i\frac{\pi}{2n}}\bigr)^n}{1-e^{i\frac{\pi}{2n}}}\right) \\ &= \frac{1}{n}\Re\left(\frac{1-i}{1-e^{i\frac{\pi}{2n}}}\right) \end{aligned}$$

sum of terms of a geometric progression of ratio $e^{i\frac{2\pi}{n}}$

This line has been wrapped automatically.

The option wrap-lines doesn't apply to the environments {WithArrows} nested in an environment {DispWithArrows} or {DispWithArrows*}. However, it applies to the instructions \Arrow and \MultiArrow of the CodeAfter of the environments {DispWithArrows} or {DispWithArrows*}.

[14] We recall that varioref, hyperref, cleveref and autonum must be loaded in this order. The package witharrows can be loaded anywhere.

7 Advanced features

7.1 The option TikzCode : how to change the shape of the arrows

The option `TikzCode` allows the user to change the shape of the arrows.[15]

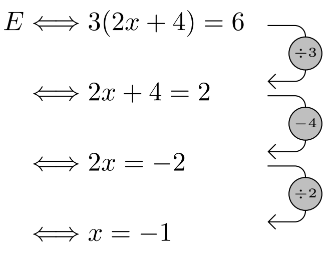
The value of this option must be a valid Tikz drawing instruction (with the final semi-colon) with three markers `#1`, `#2` and `#3` for the start point, the end point and the label of the arrow.

By default, the value is the following:

```
\draw (#1) to node {#3} (#2) ;
```

In the following example, we replace this default path by a path with three segments (and the node overwriting the second segment).

```
\begin{WithArrows}[ygap=5pt,interline=4mm,
      TikzCode = {\draw[rounded corners]
                       (#1) -- ([xshift=5mm]#1)
                       -- node[circle,
                               draw,
                               auto = false,
                               fill = gray!50,
                               inner sep = 1pt] {\tiny #3}
                       ([xshift=5mm]#2)
                       -- (#2) ; }]
E & \Longleftrightarrow 3 (2x+4) = 6   \Arrow{$\div 3$} \\
  & \Longleftrightarrow 2x+4 = 2       \Arrow{$-4$}     \\
  & \Longleftrightarrow 2x = -2        \Arrow{$\div 2$} \\
  & \Longleftrightarrow  x = -1
\end{WithArrows}
```


$E \Longleftrightarrow 3(2x+4)=6$
$\div 3$
$\Longleftrightarrow 2x+4=2$
-4
$\Longleftrightarrow 2x=-2$
$\div 2$
$\Longleftrightarrow x=-1$

The environments `{DispWithArrows}` and its starred version `{DispWithArrows*}` provide a command `\WithArrowsRightX` which can be used in a definition of `TikzCode`. This command gives the x-value of the right side of the composition box (taking into account the eventual tags of the equations). For an example of use, see p. 21.

7.2 The command WithArrowsNewStyle

The extension witharrows provides a command `\WithArrowsNewStyle` to define styles in a way similar to the "styles" of Tikz.

The command `\WithArrowsNewStyle` takes two mandatory arguments. The first is the name of the style and the second is a list of key-value pairs. The scope of the definition done by `\WithArrowsNewStyle` is the current TeX scope.

The style can be used as a key at the document level (with `\WithArrowsOptions`) or at the environment level (in the optional arguments of `{WithArrows}` and `{DispWithArrows}`).

For an example of use, see p. 21.

[15] If the option `wrap-lines` is used in an environment `{DispWithArrows}` or `{DispWithArrows*}`, the option `TikzCode` will have no effect for the arrows of this environment but only for the arrows in the nested environments `{WithArrows}`.

7.3 Footnotes in the environments of witharrows

If you want to put footnotes in an environment `{WithArrows}` or `{DispWithArrows}`, you can use a pair `\footnotemark`–`\footnotetext`.

It's also possible to extract the footnotes with the help of the package footnote or the package footnotehyper.

If witharrows is loaded with the option `footnote` (with `\usepackage[footnote]{witharrows}` or with `\PassOptionsToPackage`), the package footnote is loaded (if it is not yet loaded) and it is used to extract the footnotes.

If witharrows is loaded with the option `footnotehyper`, the package footnotehyper is loaded (if it is not yet loaded) ant it is used to extract footnotes.

Caution: The packages footnote and footnotehyper are incompatible. The package footnotehyper is the successor of the package footnote and should be used preferently. The package footnote has some drawbacks, in particular: it must be loaded after the package xcolor and it is not perfectly compatible with hyperref.

In this document, the package witharrows has been loaded with the option `footnotehyper` and we give an example with a footnote in the label of an arrow:

$$\begin{aligned} A &= (a+b)^2 \\ &= a^2+b^2+2ab \end{aligned} \qquad \textit{We expand}$$ [16]

8 Examples

8.1 With only one column

It's possible to use the environment `{WithArrows}` with making use of the left column only, or the right column only.

```
$\begin{WithArrows}
&f(x) \ge g(x) \Arrow{by squaring both sides} \\
& f(x)^2 \ge g(x)^2 \Arrow{by moving to left side} \\
& f(x)^2 - g(x)^2 \ge 0
\end{WithArrows}$
```

$$\begin{array}{ll} f(x) \ge g(x) & \\ & \textit{by squaring both sides} \\ f(x)^2 \ge g(x)^2 & \\ & \textit{by moving to left side} \\ f(x)^2 - g(x)^2 \ge 0 & \end{array}$$

8.2 MoveEqLeft

It's possible to use `\MoveEqLeft` of mathtools (if we don't want ampersand on the first line):

```
$\begin{WithArrows}[interline=0.5ex]
\MoveEqLeft \arccos(x) = \arcsin \frac45 + \arcsin \frac5{13}
\Arrow{because both are in $[-\frac{\pi}2,\frac{\pi}2]$} \\
& \Leftrightarrow x = \sin\left(\arcsin\frac45 + \arcsin\frac5{13}\right) \\
& \Leftrightarrow x = \frac45\cos\arcsin\frac5{13} + \frac5{13} \cos\arcsin\frac45
\Arrow{$\forall x \in [-1,1], \cos(\arcsin x) = \sqrt{1-x^2}$} \\
& \Leftrightarrow x = \frac45\sqrt{1-\bigl(\frac5{13}\bigr)^2}
+ \frac5{13}\sqrt{1-\bigl(\frac45\bigr)^2}
\end{WithArrows}$
```

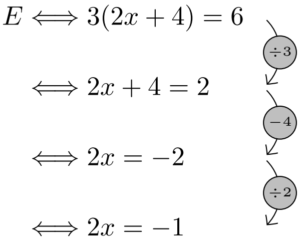
$$\begin{array}{ll} \arccos(x) = \arcsin\frac45 + \arcsin\frac5{13} & \\ & \textit{because both are in } [-\frac{\pi}{2},\frac{\pi}{2}] \\ \qquad \Leftrightarrow x = \sin\left(\arcsin\frac45 + \arcsin\frac5{13}\right) & \\ \qquad \Leftrightarrow x = \frac45\cos\arcsin\frac5{13} + \frac5{13}\cos\arcsin\frac45 & \\ & \forall x \in [-1,1], \cos(\arcsin x) = \sqrt{1-x^2} \\ \qquad \Leftrightarrow x = \frac45\sqrt{1-\bigl(\frac5{13}\bigr)^2} + \frac5{13}\sqrt{1-\bigl(\frac45\bigr)^2} & \end{array}$$

[16] A footnote.

8.3 Modifying the shape of the nodes

It's possible to change the shape of the labels, which are Tikz nodes, by modifying the key "`every node`" of Tikz.

```
\begin{WithArrows}[%
      interline = 4mm,
      tikz = {every node/.style = {circle,
                                   draw,
                                   auto = false,
                                   fill = gray!50,
                                   inner sep = 1pt,
                                   font = \tiny}}]
E & \Longleftrightarrow 3 (2x+4) = 6
\Arrow{$\div 3$}\\
  & \Longleftrightarrow 2x+4 = 2
\Arrow{$-4$}\\
  & \Longleftrightarrow 2x = -2
\Arrow{$\div 2$} \\
  & \Longleftrightarrow 2x = -1
\end{WithArrows}
```


$$\begin{aligned} E &\Longleftrightarrow 3(2x+4)=6 \\ &\Longleftrightarrow 2x+4=2 \\ &\Longleftrightarrow 2x=-2 \\ &\Longleftrightarrow 2x=-1 \end{aligned}$$

8.4 Examples with the option TikzCode

We recall that the option `TikzCode` is the Tikz code used by witharrows to draw the arrows.[17]

The value by defaut of `TikzCode` is `\draw (#1) to node {#3} (#2) ;` where the three markers `#1`, `#2` and `#3` represent the start row, the end row and the label of the arrow.

8.4.1 Example 1

In the following example, we define the value of `TikzCode` with two instructions `\path` : the first instruction draws the arrow itself and the second puts the label in a Tikz node in the rectangle delimited by the arrow.

```
\begin{DispWithArrows*}[
       displaystyle,
       ygap = 2mm,
       ystart = 0mm,
       TikzCode = {\draw (#1) -- ++(4.5cm,0) |- (#2) ;
                   \path (#1) -- (#2)
                          node[text width = 4.2cm, right, midway] {#3} ;}]
S_n
& = \frac1n \sum_{k=0}^{n-1}\cos\bigl(\tfrac{\pi}2\cdot\tfrac kn\bigr)
...........
```

[17] If an environment `{DispWithArrows}` or `{DispWithArrows*}` is used with the option `wrap-lines`, the value of the option `TikzCode` is not used for this environment (but is used for the environments nested inside).

$$\begin{aligned}
S_n &= \frac{1}{n}\sum_{k=0}^{n-1}\cos\bigl(\tfrac{\pi}{2}\cdot\tfrac{k}{n}\bigr) \\
&= \frac{1}{n}\sum_{k=0}^{n-1}\Re\left(e^{i\frac{k\pi}{2n}}\right) \\
&= \frac{1}{n}\Re\left(\sum_{k=0}^{n-1}e^{i\frac{k\pi}{2n}}\right) \\
&= \frac{1}{n}\Re\left(\sum_{k=0}^{n-1}\left(e^{i\frac{\pi}{2n}}\right)^k\right) \\
&= \frac{1}{n}\Re\left(\frac{1-\left(e^{i\frac{\pi}{2n}}\right)^n}{1-e^{i\frac{\pi}{2n}}}\right) \\
&= \frac{1}{n}\Re\left(\frac{1-i}{1-e^{i\frac{\pi}{2n}}}\right)
\end{aligned}$$

$\cos x = \Re(e^{ix})$

$\Re(z+z') = \Re(z) + \Re(z')$

$\exp$ *is a morphism for* $\times$ *et* $+$

sum of terms of a geometric progression of ratio $e^{i\frac{2\pi}{n}}$

8.4.2 Example 2

It's possible to modify the previous example to have the "`text width`" automatically computed with the right margin (in a way similar as the `wrap-lines` option) in the environments `{DispWithArrows}` and `{DispWithArrows*}`. In the definition of `TikzCode`, we use the command `\WithArrowsRightX` which is the x-value of the right margin of the current composition box (it's a TeX command and not a dimension). For lisibility, we use a style. This example requires the Tikz library `calc`.

```
\WithArrowsNewStyle{MyStyle}%
  {displaystyle,
   ygap = 2mm,
   xoffset = 0pt,
   ystart = 0mm,
   TikzCode = {\path let \p1 = (##1)
                     in (##1)
                        -- node [anchor = west,
                                 text width = {\WithArrowsRightX - \x1 - 0.5 em}]
                                {##3}
                       (##2) ;
               \draw let \p1 = (##1)
                     in (##1) -- ++(\WithArrowsRightX - \x1,0) |- (##2) ; }}
```

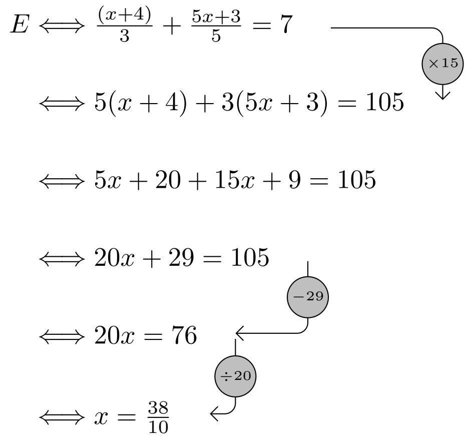
```
begin{DispWithArrows}[MyStyle]
  S_n
  & = \frac1n \sum_{k=0}^{n-1}\cos\bigl(\tfrac{\pi}2\cdot\tfrac kn\bigr)
  \Arrow{$\cos x = \Re(e^{ix})$}\\
...........
```

$$
\begin{aligned}
S_n &= \frac{1}{n}\sum_{k=0}^{n-1}\cos\left(\tfrac{\pi}{2}\cdot\tfrac{k}{n}\right) && \tag{11}\\
& && \cos x = \Re(e^{ix}) \\
&= \frac{1}{n}\sum_{k=0}^{n-1}\Re\left(e^{i\frac{k\pi}{2n}}\right) && \tag{12}\\
& && \Re(z+z') = \Re(z)+\Re(z') \\
&= \frac{1}{n}\Re\left(\sum_{k=0}^{n-1}e^{i\frac{k\pi}{2n}}\right) && \tag{13}\\
& && \exp\ \textit{is a morphism for} \times \textit{ et } + \\
&= \frac{1}{n}\Re\left(\sum_{k=0}^{n-1}\left(e^{i\frac{\pi}{2n}}\right)^k\right) && \tag{14}\\
& && \textit{sum of terms of a geometric progression of ratio } e^{i\frac{2\pi}{n}} \\
&= \frac{1}{n}\Re\left(\frac{1-\left(e^{i\frac{\pi}{2n}}\right)^n}{1-e^{i\frac{\pi}{2n}}}\right) && \tag{15}\\
&= \frac{1}{n}\Re\left(\frac{1-i}{1-e^{i\frac{\pi}{2n}}}\right) && \tag{16}
\end{aligned}
$$

8.4.3 Example 3

In the following example, we change the shape of the arrow depending on wether the start row is longer than the end row or not. This example requires the Tikz library calc.

```
\begin{WithArrows}[ll,interline=5mm,xoffset=5mm,
      TikzCode  = {\draw[rounded corners,
                         every node/.style = {circle,
                                              draw,
                                              auto = false,
                                              inner sep = 1pt,
                                              fill = gray!50,
                                              font = \tiny }]
                         let \p1 = (#1),
                             \p2 = (#2)
                         in \ifdim \x1 > \x2
                              (\p1) -- node {#3} (\x1,\y2) -- (\p2)
                            \else
                              (\p1) -- (\x2,\y1) -- node {#3} (\p2)
                            \fi ;}]
E & \Longleftrightarrow \frac{(x+4)}3 + \frac{5x+3}5 = 7
\Arrow{$\times 15$}\\
  & \Longleftrightarrow 5(x+4) + 3(5x+3) = 105 \\
  & \Longleftrightarrow 5x+20 + 15x+9 = 105 \\
  & \Longleftrightarrow 20x+29 = 105
\Arrow{$-29$}\\
  & \Longleftrightarrow 20x = 76
\Arrow{$\div 20$}\\
  & \Longleftrightarrow x = \frac{38}{10}
\end{WithArrows}
```



$$\begin{aligned} E &\iff \frac{(x+4)}{3} + \frac{5x+3}{5} = 7 \\ &\iff 5(x+4)+3(5x+3)=105 \\ &\iff 5x+20+15x+9=105 \\ &\iff 20x+29=105 \\ &\iff 20x=76 \\ &\iff x=\frac{38}{10} \end{aligned}$$

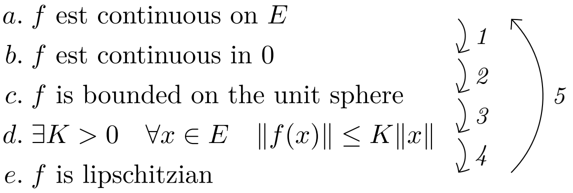
8.5 Automatic numbered loop

Assume we want to draw a loop of numbered arrows. In this purpose, it's possible to write a dedicated command `\NumberedLoop` which will do the job when used in `CodeAfter`. In the following example, we write this command with `\NewDocumentCommand` of `xparse` and `\foreach` of `pgffor` (both packages are loaded when `witharrows` is loaded).

```
\NewDocumentCommand \NumberedLoop {}
        {\foreach \j in {2,...,\WithArrowsNbLines}
              { \pgfmathtruncatemacro{\i}{\j-1}
                \Arrow[rr]{\i}{\j}{\i} }
         \Arrow[rr,xoffset=1cm,tikz=<-]{1}{\WithArrowsNbLines}{\WithArrowsNbLines}}
```

The command `\WithArrowsNbLines` is a command available in `CodeAfter` which gives the total number of lines (=rows) of the current environment (it's a command and not a counter).

```
$\begin{WithArrows}[CodeAfter = \NumberedLoop]
a.\;& f \text{ est continuous on } E \\
b.\;& f \text{ est continuous in } 0 \\
c.\;& f \text{ is bounded on the unit sphere} \\
d.\;& \exists K > 0\quad \forall x \in E\quad \|f(x)\| \le K \|x\| \\
e.\;& f \text{ is lipschitzian}
\end{WithArrows}$
```



$a.\;f$ est continuous on E

$b.\;f$ est continuous in 0

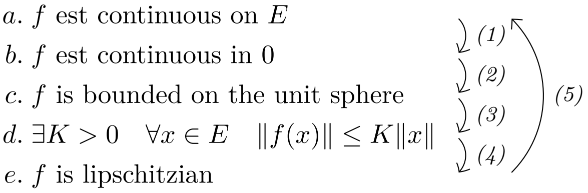
$c.\;f$ is bounded on the unit sphere

$d.\;\exists K > 0\quad \forall x \in E\quad \|f(x)\| \le K\|x\|$

$e.\;f$ is lipschitzian

As usual, it's possible to change the characteristic of both arrows and nodes with the option `tikz`. However, if we want to change the style to have, for example, numbers in parenthesis, the best way is to change the value of `TikzCode`:

```
TikzCode = {\draw (#1) to node {\footnotesize (#3)} (#2) ;}
```



$a.\;f$ est continuous on E

$b.\;f$ est continuous in 0

$c.\;f$ is bounded on the unit sphere

$d.\;\exists K > 0\quad \forall x \in E\quad \|f(x)\| \le K\|x\|$

$e.\;f$ is lipschitzian

9 Implementation

9.1 Declaration of the package and extensions loaded

First, tikz and some Tikz libraries are loaded before the \ProvidesExplPackage. They are loaded this way because \usetikzlibrary in expl3 code fails.[18]

```
\RequirePackage{tikz}
\usetikzlibrary{arrows.meta,bending}
```

Then, we can give the traditional declaration of a package written with expl3:

```
\RequirePackage{l3keys2e}
\ProvidesExplPackage
  {witharrows}
  {\myfiledate}
  {\myfileversion}
  {Draws arrows for explanations on the right}
```

The package xparse will be used to define the environments {WithArrows}, {DispWithArrows}, {DispWithArrows*} and the document-level commands \Arrow and \WithArrowsOptions.

```
\RequirePackage{xparse}
```

9.2 The packages footnote and footnotehyper

A few options can be given to the package witharrows when it is loaded (with \usepackage, \RequirePackage or \PassOptionsToPackage). Currently (version 1.12), there are two such options: footnote and footnotehyper. With the option footnote, witharrows loads footnote and uses it to extract the footnotes from the environments {WithArrows}. Idem for the option footnotehyper.

The boolean \g_@@_footnotehyper_bool will indicate if the option footnotehyper is used.

```
\bool_new:N \g_@@_footnotehyper_bool
```

The boolean \g_@@_footnote_bool will indicate if the option footnote is used, but quicky, it will also be set to true if the option footnotehyper is used.

```
\bool_new:N \g_@@_footnote_bool
```

We define a set of keys WithArrows/package for these options. However, first, we define a "level of options" \l_@@_level_int even if, in the version 1.12 of witharrows, this integer is not used by the options of the set WithArrows/package.

```
\int_new:N \l_@@_level_int
\keys_define:nn {WithArrows/package}
      {footnote      .bool_gset:N = \g_@@_footnote_bool,
       footnotehyper .bool_gset:N = \g_@@_footnotehyper_bool,
       unknown       .code:n      = \msg_fatal:nn {witharrows}
                                     {Option~unknown~for~package}}
\msg_new:nnn {witharrows}
             {Option~unknown~for~package}
             {You~can't~use~the~option~"\tl_use:N\l_keys_key_tl"~when~loading~the~
              package~witharrows.}
```

We process the options when the package is loaded (with \usepackage).

```
\ProcessKeysOptions {WithArrows/package}
```

```
\msg_new:nnn {witharrows}
             {Option~incompatible~with~Beamer}
             {The~option~"\tl_use:N \l_keys_key_tl"\ is~incompatible~
              with~Beamer~because~Beamer~has~its~own~system~to~extract~footnotes.}
```

[18] cf. tex.stackexchange.com/questions/57424/using-of-usetikzlibrary-in-an-expl3-package-fails

```
\msg_new:nnn {witharrows}
            {footnote~with~footnotehyper~package}
            {You~can't~use~the~option~footnote~because~the~package~
             footnotehyper~has~already~been~loaded.~
             If~you~want,~you~can~use~the~option~"footnotehyper"~and~the~footnotes~
             within~the~environments~{WithArrows}~will~be~extracted~with~the~tools~
             of~the~package~footnotehyper.}
\msg_new:nnn {witharrows}
            {footnotehyper~with~footnote~package}
            {You~can't~use~the~option~"footnotehyper"~because~the~package~
             footnote~has~already~been~loaded.~
             If~you~want,~you~can~use~the~option~"footnote"~and~the~footnotes~
             within~the~environments~{WithArrows}~will~be~extracted~with~the~tools~
             of~the~package~footnote.}

\bool_if:NT \g_@@_footnote_bool
      {\@ifclassloaded {beamer}
               {\msg_fatal:nn {witharrows}
                             {Option~incompatible~with~Beamer}}
               {}
       \@ifpackageloaded{footnotehyper}
          {\msg_fatal:nn {witharrows}
                        {footnote~with~footnotehyper~package}}
          {}
       \usepackage{footnote}}
\bool_if:NT \g_@@_footnotehyper_bool
      {\@ifclassloaded {beamer}
               {\msg_fatal:nn {witharrows}
                             {Option~incompatible~with~Beamer}}
               {}
       \@ifpackageloaded{footnote}
          {\msg_fatal:nn {witharrows}
                        {footnotehyper~with~footnote~package}}
          {}
       \usepackage{footnotehyper}
       \bool_gset_true:N \g_@@_footnote_bool}
```

The flag `\g_@@_footnote_bool` is raised and so, we will only have to test `\g_@@_footnote_bool` in order to known if we have to insert an environnement `{savenotes}` (the `\begin{savenotes}` is in `\@@_pre_environment:n` and `\end{savenotes}` in `\@@_post_environment:` which are executed at the beginning and at the end of the environments `{WithArrows}` and `{DispWithArrows}`).

9.3 The class option leqno

The boolean `\c_@@_leqno_bool` will indicate if the class option `leqno` is used. When this option is used in LaTeX, the command `\@eqnnum` is redefined (as one can see in the file `leqno.clo`). That's enough to put the labels on the left in our environments `{DispWithArrows}` and `{DispWithArrows*}`. However, that's not enough when our option `wrap-lines` is used. That's why we have to know if this option is used as a class option. With the following programmation, `leqno` *can't* be given as an option of witharrows (by design).

```
\bool_new:N \c_@@_leqno_bool
\DeclareOption {leqno} {\bool_set_true:N \c_@@_leqno_bool}
\DeclareOption* {}
\ProcessOptions*
```

9.4 Some technical definitions

```
\cs_new_protected:Nn \@@_error:n
        {\msg_error:nn {witharrows} {#1}}
\cs_new_protected:Nn \@@_error:nn
        {\msg_error:nnn {witharrows} {#1} {#2}}
```

```
\cs_new_protected:Nn \@@_bool_new:N
      {\bool_if_exist:NTF #1
         {\bool_set_false:N #1}
         {\bool_new:N #1}}
```

We create booleans in order to know if some packages are loaded. For example, for the package amsmath, the boolean is called `\c_@@_amsmath_loaded_bool`.[19]

```
\AtBeginDocument
      {\clist_map_inline:nn
            {amsmath,mathtools,autonum,cleveref,hyperref,typedref,showlabels,amsthm}
            {\bool_new:c {c_@@_#1_loaded_bool}
             \@ifpackageloaded {#1}
                   {\bool_set_true:c {c_@@_#1_loaded_bool}}
                   {}}}
```

The following variant will be used in the following command.

```
\cs_generate_variant:Nn \seq_set_split:Nnn {Nxx}
```

The command `\@@_save:N` saves a expl3 variable by creating a global version of the variable. For a variable named `\l_`*`name_type`*, the corresponding global variable will be named `\g_`*`name_type`*. The type of the variable is determinated by the suffix *`type`* and is used to apply the corresponding expl3 commands.

```
\cs_new_protected:Nn \@@_save:N
   {\seq_set_split:Nxx \l_tmpa_seq {\char_generate:nn {`_} {12}} {\cs_to_str:N #1}
    \seq_pop_left:NN \l_tmpa_seq \l_tmpa_tl
```

The string `\l_tmpa_str` will contains the *type* of the variable.

```
    \str_set:Nx \l_tmpa_str {\seq_item:Nn \l_tmpa_seq {-1}}
    \use:c {\l_tmpa_str _if_exist:cF}
           {g_\seq_use:Nnnn \l_tmpa_seq _ _ _ }
           {\use:c {\l_tmpa_str _new:c}
                      {g_\seq_use:Nnnn \l_tmpa_seq _ _ _ } }
    \use:c {\l_tmpa_str _gset_eq:cN}
           {g_\seq_use:Nnnn \l_tmpa_seq _ _ _ } #1 }
```

The command `\@@_restore:N` affects to the expl3 variable the value of the (previously) set value of the corresponding *global* variable.

```
\cs_new_protected:Nn \@@_restore:N
   {\seq_set_split:Nxx \l_tmpa_seq {\char_generate:nn {`_} {12}} {\cs_to_str:N #1}
    \seq_pop_left:NN \l_tmpa_seq \l_tmpa_tl
    \str_set:Nx \l_tmpa_str {\seq_item:Nn \l_tmpa_seq {-1}}
    \use:c {\l_tmpa_str _set_eq:Nc}
           #1 {g_\seq_use:Nnnn \l_tmpa_seq _ _ _ } }
```

We define a Tikz style `@@_node_style` for the `l`-nodes and `r`-nodes that will be created in the `\halign`. These nodes are Tikz nodes of shape "rectangle" but with zero width. An arrow between two nodes starts from the *south* anchor of the first node and arrives at the *north* anchor of the second node.

```
\tikzset{@@_node_style/.style= {
               above = \l_@@_ystart_dim,
               inner~sep = 0 pt,
               minimum~width = 0pt,
               minimum~height = \l_@@_ygap_dim,
               red,
               \bool_if:NT \l_@@_shownodes_bool {draw} }}
```

[19] It's not possible to use `\@ifpackageloaded` in the core of the functions because `\@ifpackageloaded` is available only in the preamble.

The color of the nodes is red, but in fact, the nodes will be drawn only when the option shownodes is used (this option is useful for debugging).[20]

The style @@_standard is load in standard in the {tikzpicture} we need. The names of the nodes are prefixed by wa (by security) but also by a prefix which is the position-in-the-tree of the nested environments.

```
\tikzset{@@_standard/.style= { remember~picture,
                               overlay,
                               name~prefix = wa-\l_@@_prefix_str- }}
```

We also define a style for the tips of arrow. The final user of the extension witharrows will use this style if he wants to draw an arrow directly with a Tikz command in his document (probably using the Tikz nodes created by {WithArrows} in the \halign).

```
\tikzset{WithArrows/arrow/tips/.style = { > = {Straight~Barb[scale=1.2,bend]} }}
```

The style WithArrows/arrow will be used to draw the arrow (more precisely, it will be pass to every~path).

```
\tikzset{WithArrows/arrow/.style  = { align = left,
```

We have put the option align = left because we want to give the user the possibility of using \\ in the labels.

```
                                      auto = left,
                                      font = \small\itshape,
                                      WithArrows/arrow/tips,
                                      bend~left = 45,
                                      -> }}
```

In order to increase the interline in the environments {WithArrows}, {DispWithArrows}, etc., we will use the command \spread@equation of amsmath. When used, this command becomes no-op (in the current TeX group). Therefore, it will be possible to use the environments of amsmath (e.g. {aligned}) in an environment {WithArrows}.
Nevertheless, we want the extension witharrows available without amsmath. That's why we give a definition of \spread@equation if amsmath is not loaded (you put the code in a \AtBeginDocument because the flag \c_@@_amsmath_loaded_bool is itself set in a \AtBeginDocument).

```
\AtBeginDocument
    {\bool_if:NF \c_@@_amsmath_loaded_bool
       {\cs_set_protected:Npn \spread@equation
           {\openup\jot
            \cs_set_protected:Npn \spread@equation {}}}}
```

Don't put \cs_set_eq:NN \spread@equation \prog_do_nothing: in the last line because this would raise errors with nested environments.

9.5 Variables

The boolean \l_@@_in_WithArrows_bool will be raised in an environment {WithArrows} and the boolean \l_@@_in_dispwitharrows_bool in a an environment {DispWithArrows} or {DispWithArrows*}.

```
\bool_new:N \l_@@_in_WithArrows_bool
\bool_new:N \l_@@_in_DispWithArrows_bool
```

The following sequence is the position of the last environment {WithArrows} in the tree of the nested environments {WithArrows}.

```
\seq_new:N \g_@@_position_in_the_tree_seq
\seq_gput_right:Nn \g_@@_position_in_the_tree_seq 1
```

The following counter will give the number of the last environment {WithArrows} of level 0. This counter will be used only in the definition of \WithArrowsLastEnv.

```
\int_new:N \g_@@_last_env_int
```

[20] The v-nodes, created near the end of line in {DispWithArrows} are not shown with this option.

The following skip (=glue) is the vertical space inserted between two lines (=rows) of the \halign.

```
\skip_new:N \l_@@_interline_skip
```

The following integer indicates the position of the box that will be created: 0 (=t=\vtop), 1 (=c=\vcenter) or 2 (=b=\vbox).

```
\int_new:N \l_@@_pos_env_int
```

```
\dim_new:N \l_@@_xoffset_dim
\dim_set:Nn \l_@@_xoffset_dim {3mm}
```

The integer \l_@@_pos_arrows_int indicates the position of the arrows with the following code (the option v is accessible only for the arrows in CodeAfter where the options i, group et groups are not available).

option	rr	ll	rl	lr	v	i	group	groups
\l_@@_pos_arrows_int	0	1	2	3	4	5	6	7

The option v can be used only in \Arrow in CodeAfter (see below).

```
\int_new:N \l_@@_pos_arrows_int
```

When we scan a list of options, we want to be able to raise an error if two options of position of the arrows are present. That's why we keep the code of the first option of position in a variable called \l_@@_previous_pos_arrows_int. This variable will be set to -1 each time we start the scanning of a list of options.

```
\int_new:N \l_@@_previous_pos_arrows_int
```

At each possible level for the options (*global*, *environment* or *local*: see below), the new values will be appended on the right of this token list.

The dimension \l_@@_x_dim will be used to compute the x-value for some vertical arrows when one of the options i, group and groups (values 5, 6 and 7 of \l_@@_pos_arrows_int) is used.

```
\dim_new:N \l_@@_x_dim
```

In the \halign of an environment {WithArrows}, we will have to use two counters:

- \g_@@_arrow_int to count the arrows created in the environment ;
- \g_@@_line_int to count the lines of the \halign.

These counters will be incremented in a cell of the \halign and, therefore, the incrementation must be global. However, we want to be able to include a {WithArrows} in another {WithArrows}. To do so, we must restore the previous value of these counters at the end of an environment {WithArrows} and we decide to manage a stack for each of these counters.

```
\seq_new:N \g_@@_arrow_int_seq
\int_new:N \g_@@_arrow_int
\seq_new:N \g_@@_line_int_seq
\int_new:N \g_@@_line_int
```

The token list \l_@@_name_tl will contain the name of the environment (given with the option name). This name will be used to create aliases for the names of the nodes.

```
\tl_new:N \l_@@_name_tl
```

The boolean \l_@@_fleqn_bool indicates wether the environments {DispWithArrows} must be composed flush left or centered. It corresponds to the option fleqn.

```
\bool_new:N \l_@@_fleqn_bool
```

The dimension `\l_@@_mathindent_dim` is used only by the environments `{DispWithArrows}`: it's the left margin of the environments `{DispWithArrows}` if the environment `{DispWithArrows}` is composed flush left (option `fleqn`).

```
\dim_new:N \l_@@_mathindent_dim
\dim_set:Nn \l_@@_mathindent_dim {25pt}
```

The boolean `\l_@@_wrap_lines_bool` corresponds to the option `wrap-lines`.

```
\bool_new:N \l_@@_wrap_lines_bool
```

For the environment `{DispWithArrows}`, the comma list `\l_@@_tags_clist` will be the list of the numbers of lines to be tagged (with the counter `equation` of LaTeX). In fact, `\l_@@_tags_clist` may contain non negative integers but also three special values, `first`, `last` and `all`.

```
\clist_new:N \l_@@_tags_clist
\clist_set:Nn \l_@@_tags_clist {all}
```

The token list `\l_@@_tag_tl` will contain the argument of the command `\tag`.

```
\tl_new:N \l_@@_tag_tl
```

The boolean `\l_@@_tag_star_bool` will be raised if the user uses the command `\tag` with a star.

```
\bool_new:N \l_@@_tag_star_bool
```

The boolean `\l_@@_in_first_column_bool` will be used to known wether we are in the first column of the environment `{WithArrows}` or `{DispWithArrows}`.

```
\bool_new:N \l_@@_in_first_column_bool
```

```
\bool_new:N \l_@@_initial_r_bool
\bool_new:N \l_@@_initial_l_bool
```

9.6 The definition of the options

There are four levels where options can be set:

- with `\usepackage[...]{witharrows}`: this level will be called *package* level (number 0);
- with `\WithArrowsOptions{...}`: this level will be called *global* level[21] (number 1);
- with `\begin{WithArrows}[...]`: this level will be called *environment* level (number 2);
- with `\Arrow[...]` (included in `CodeAfter`): this level will be called *local* level (number 3).

The level is specified in the variable `\l_@@_level_int` and the code attached to the options can use this information to alter its actions.

```
\int_set:Nn \l_@@_level_int 1
```

We start with a submodule which will be loaded only at the global or the environment level.

The options `t`, `c` and `b` indicate if we will create a `\vtop`, a `\vcenter` or a `\vbox`. This information is stored in the variable `\l_@@_pos_env_int`. Of course, they are available only in `{WithArrows}` and not in `{DispWithArrows}` or `{DispWithArrows*}`

```
\keys_define:nn {WithArrows/GlobalOrEnv}
  { t   .code:n           = {\bool_if:NTF \l_@@_in_DispWithArrows_bool
                                 {\@@_error:n {Option~will~be~ignored}
                                 {\int_set:Nn \l_@@_pos_env_int 0}}},
```

[21] This level is called *global level* but the settings done by `\WithArrowsOptions` are local in the TeX sense: their scope corresponds to the current TeX group.

```
    t   .value_forbidden:n = true,
    c   .code:n            = {\bool_if:NTF \l_@@_in_DispWithArrows_bool
                                {\@@_error:n {Option~will~be~ignored}}
                                {\int_set:Nn \l_@@_pos_env_int 1}},
    c   .value_forbidden:n = true,
    b   .code:n            = {\bool_if:NTF \l_@@_in_DispWithArrows_bool
                                {\@@_error:n {Option~will~be~ignored}}
                                {\int_set:Nn \l_@@_pos_env_int 2}},
    b   .value_forbidden:n = true,
```

The gap between two consecutive arrows.

```
    ygap .dim_set:N        = \l_@@_ygap_dim,
    ygap .value_required:n = true,
    ygap .initial:n        = 0.4 ex,
```

The vertical position of the start point of an arrow.

```
    ystart .dim_set:N        = \l_@@_ystart_dim,
    ystart .value_required:n = true,
    ystart .initial:n        = 0.4 ex,
```

Usually, the number of columns in a {WithArrows} environment is limited to 2. Nevertheless, it's possible to have more columns with the option MoreColumns.

```
    MoreColumns .code:n            = { \msg_redirect_name:nnn
                                       {witharrows}
                                       {Third~column~in~an~environment~{WithArrows}}
                                       {none} },
    MoreColumns .value_forbidden:n = true,
```

The option AllowLineWithoutAmpersand is obsolete and will be deleted in a future version.

```
    AllowLineWithoutAmpersand .code:n = { \msg_error:nn
                                          {witharrows}
                                          {AllowLineWithoutAmpersand}},
    AllowLineWithoutAmpersand .value_forbidden:n = true,
```

If the user wants to give a new name to the \Arrow command (and the name \Arrow remains free).

```
    CommandName .tl_set:N         = \l_@@_CommandName_tl,
    CommandName .initial:n        = Arrow ,
    CommandName .value_required:n = true,
```

```
    TikzCode .tl_set:N         = \l_@@_tikz_code_tl,
    TikzCode .initial:n        = \draw~(#1)~to~node{#3}~(#2)~; ,
    TikzCode .value_required:n = true,
```

With the option displaystyle, the environments will be composed in \displaystyle.

```
    displaystyle .bool_set:N     = \l_@@_displaystyle_bool,
    displaystyle .initial:n      = false,
```

With the option shownodes, the nodes will be drawn in red (useful only for debugging).

```
    shownodes .bool_set:N        = \l_@@_shownodes_bool,
    shownodes .initial:n         = false,
```

With the option shownodenames, the name of the "right nodes" will be written in the document (useful only for debugging).

```
    shownodenames .bool_set:N    = \l_@@_shownodenames_bool,
    shownodenames .initial:n     = false,
```

With the option group, *all* the arrows of the environment are vertical with the same abscissa and at a leftmost position.

```
      group    .code:n    = {\int_compare:nNnT \l_@@_previous_pos_arrows_int > {-1}
                                     {\@@_error:n {Two~options~are~incompatible}}
                              \int_set:Nn \l_@@_previous_pos_arrows_int 6
                              \int_set:Nn \l_@@_pos_arrows_int 6} ,
      group    .value_forbidden:n = true,
```

With the option groups (with a *s*), the arrows of the environment are divided in groups by an argument of connexity, and, in each group, the arrows are vertical with the same abscissa and at a leftmost position. When the option group or groups is used, it's not possible to specify another option of position like ll, lr, etc. for a individual key.

```
      groups   .code:n   = {\int_compare:nNnT \l_@@_previous_pos_arrows_int > {-1}
                                    {\@@_error:n {Two~options~are~incompatible}}
                             \int_set:Nn \l_@@_previous_pos_arrows_int 7
                             \int_set:Nn \l_@@_pos_arrows_int 7} ,
      groups   .value_forbidden:n = true,
```

The option CodeBefore gives a code that is executed at the beginning of the environment {WithArrows} (after the eventual \begin{savenotes}).

```
      CodeBefore  .code:n = {\int_compare:nNnTF \l_@@_level_int = 1
                              {\@@_error:n {Option~will~be~ignored}}
                              {\tl_put_right:Nn \l_@@_code_before_tl {#1}}} ,
      CodeBefore  .value_required:n = true,
```

The option CodeAfter gives a code that is executed at the end of the environment {WithArrows} (after the eventual \end{savenotes}).

```
      CodeAfter .code:n = {\int_compare:nNnTF \l_@@_level_int = 1
                              {\@@_error:n {Option~will~be~ignored}}
                              {\tl_put_right:Nn \l_@@_code_after_tl {#1}}} ,
      CodeAfter .value_required:n = true,
```

The option name is a name given to the environment. If this option is used, the nodes created in the environment will have aliases constructed with this name (and it will be easier to use these nodes from outside the environment).

```
      name .code:n = {\int_compare:nNnTF \l_@@_level_int = 1
                              {\@@_error:n {Option~will~be~ignored}}
                              {\tl_set:Nn \l_@@_name_tl {#1}}} ,
      name .value_required:n = true,
```

The option fleqn indicates wether the environments {DispWithArrows} are composed centered or flush left.

```
      fleqn   .code:n = {\bool_if:NTF \l_@@_in_WithArrows_bool
                             {\@@_error:n {Option~will~be~ignored}}
                             {\tl_if_eq:nnTF {#1} {true}
                                 {\bool_set_true:N \l_@@_fleqn_bool}
                                 {\bool_set_false:N \l_@@_fleqn_bool}}},
      fleqn   .default:n = true,
```

The option mathindent is the left margin of the environments {DispWithArrows} when the option fleqn is used.

```
      mathindent   .code:n = {\bool_if:NTF \l_@@_in_WithArrows_bool
                               {\@@_error:n {Option~will~be~ignored}}
                               {\dim_set:Nn \l_@@_mathindent_dim {#1}}},
      mathindent   .value_required:n = true,
```

The option notag indicates wether the environments {DispWithArrows} will be without tags (like {DispWithArrows*}).

```
      notag   .code:n = {\bool_if:NTF \l_@@_in_WithArrows_bool
                           {\@@_error:n {Option~will~be~ignored}}
                           {\tl_if_eq:nnTF {#1} {true}
                               {\clist_clear:N \l_@@_tags_clist}
                               {\clist_set:Nn \l_@@_tags_clist {all}}}},
      notag   .default:n = true,
      nonumber .meta:n   = notag,
```

The option AllowMultipleLabels indicates wether multiple labels are allowed for the same line of an environment {DispWithArrows} or {DispWithArrows*}.

```
      AllowMultipleLabels .code:n = {\bool_if:NTF \l_@@_in_WithArrows_bool
                                       {\@@_error:n {Option~will~be~ignored}}
                                       {\msg_redirect_name:nnn {witharrows}
                                                         {Multiple~labels}
                                                         {none}}},
      AllowMultipleLabels .value_forbidden:n = true,
```

With the option wrap-lines, a special TikzCode is used in the environments {DispWithArrows} and {DispWithArrows*} and, with this TikzCode, the lines of the labels are automatically wrapped on the right.

```
      wrap-lines   .code:n = {\bool_if:NTF \l_@@_in_WithArrows_bool
                             {\@@_error:n {Option~will~be~ignored}}
                             {\tl_if_eq:nnTF {#1} {true}
                                 {\bool_set_true:N \l_@@_wrap_lines_bool}
                                 {\bool_set_false:N \l_@@_wrap_lines_bool}}},
      wrap-lines   .default:n = true,
```

```
      tagged-lines .code:n = {\bool_if:NTF \l_@@_in_WithArrows_bool
                            {\@@_error:n {Option~will~be~ignored}}
                            {\clist_set:Nn \l_@@_tags_clist {#1}
```

In the list given as value for the key tagged-lines, the user may use first as synonymous of 1. We do the replacement.

```
                             \clist_if_in:NnT \l_@@_tags_clist {first}
                                {\clist_remove_all:Nn \l_@@_tags_clist {first}
                                 \clist_put_left:Nn \l_@@_tags_clist 1 }}},
      tagged-lines .value_required:n = true,
      unknown .code:n  = \@@_error:n {Option~unknown}
     }
```

Then we define the main module called WithArrows/General which will be loaded at all the levels.

The option tikz gives Tikz parameters that will be given to the arrow when it is drawn (more precisely, the parameters will be given to the command \path of Tikz).

```
\keys_define:nn {WithArrows/General}
     {tikz     .code:n            = \tikzset {WithArrows/arrow/.append~style = {#1}},
      tikz     .initial:n         = {},
      tikz     .value_required:n  = true,
```

The other options are for the position of the arrows. The treatment is the same for the options ll, rr, lr, lr and i and that's why a dedicated fonction \@@_analyze_option_position:n has been written (see below).

```
      rr       .value_forbidden:n = true,
      rr       .code:n            = \@@_analyze_option_position:n 0 ,
      ll       .value_forbidden:n = true,
      ll       .code:n            = \@@_analyze_option_position:n 1 ,
      rl       .value_forbidden:n = true,
      rl       .code:n            = \@@_analyze_option_position:n 2 ,
      lr       .value_forbidden:n = true,
      lr       .code:n            = \@@_analyze_option_position:n 3 ,
      i        .value_forbidden:n = true,
      i        .code:n            = \@@_analyze_option_position:n 5 ,
```

The option `xoffset` change the x-offset of the arrows (towards the right). It's a dimension and not a skip. It's not possible to change the value of this parameter for a individual arrow if the option `group` or the option `groups` is used. When we will treat an individual arrow, we will give it the option `tikz={xshift=\l_@@_xoffset_dim}` (we can't to it at the global or the environment level because the Tikz options `xshift` are cumulative.

```
      xoffset  .code:n  = {\bool_if:nTF {\int_compare_p:nNn \l_@@_level_int = 3 &&
                                        \int_compare_p:nNn \l_@@_pos_arrows_int > 5}
                               {\@@_error:n {Option~incompatible~with~"group(s)"}}
                               {\dim_set:Nn \l_@@_xoffset_dim {#1}}} ,
      xoffset  .value_required:n  = true,
```

The option `jot` exists for compatibility. It changes directly the value of the parameter `\jot`, which is a LaTeX parameter and not a parameter specific to `witharrows`. It's allowed only at the level of the environment (maybe we should suppress completely this option in the future).

```
      jot       .code:n     = {\int_compare:nNnTF \l_@@_level_int = 2
                                  {\dim_set:Nn \jot {#1}}
                                  {\@@_error:n {Option~will~be~ignored}}} ,
      jot       .value_required:n  = true,
```

The option `interline` gives the vertical skip (=glue) inserted between two lines (independently of `\jot`). It's accepted only at the level of the environment (this last point is a kind of security). Futhermore, this option has a particular behaviour: it applies only to the current environment and doesn't apply to the nested environments.

```
      interline   .code:n       = {\int_compare:nNnTF \l_@@_level_int = 2
                                      {\skip_set:Nn \l_@@_interline_skip {#1}}
                                      {\@@_error:n {Option~will~be~ignored}}} ,
      interline   .value_required:n = true,
```

Eventually, a key `jump` (see below) and a key for unknown keys.

```
      jump    .code:n  = {\int_compare:nNnF \l_@@_level_int = 3
                             {\@@_error:n {Option~will~be~ignored}}} ,
      unknown .code:n  = \@@_error:n {Option~unknown}
}
```

The key `jump` indicates the number of lines jumped by the arrow (1 by default). This key will be extracted when the command `\Arrow` will be executed. That's why there is a special module for this key. The key `jump` is extracted in the command `\Arrow` because we want to compute right away the final line of the arrow (this will be useful for the options `group` and `groups`).

```
\keys_define:nn {WithArrows/Arrow}
     {jump  .code:n = {\int_set:Nn \l_@@_jump_int {#1}
                       \int_compare:nNnF \l_@@_jump_int > 0
                           {\@@_error:n {The~option~"jump"~must~be~non~negative}}} ,
      jump  .value_required:n  = true,
      rr       .value_forbidden:n = true,
      rr       .code:n            = \@@_analyze_option_position:n 0 ,
      ll       .value_forbidden:n = true,
      ll       .code:n            = \@@_analyze_option_position:n 1 ,
      rl       .value_forbidden:n = true,
      rl       .code:n            = \@@_analyze_option_position:n 2 ,
      lr       .value_forbidden:n = true,
      lr       .code:n            = \@@_analyze_option_position:n 3 ,
      i        .value_forbidden:n = true,
      i        .code:n            = \@@_analyze_option_position:n 5 }
```

The following command is for technical reasons. It's used for the following options of position: `ll`, `lr`, `rl`, `rr` and `i`. The argument is the corresponding code for the position of the arrows.

```
\cs_new_protected:Nn \@@_analyze_option_position:n
     {\int_compare:nNnT \l_@@_previous_pos_arrows_int > {-1}
        {\@@_error:n {Two~options~are~incompatible}}
      \int_set:Nn \l_@@_previous_pos_arrows_int {#1}
      \int_set:Nn \l_@@_pos_arrows_int {#1}}
```

`\WithArrowsOptions` is the command of the `witharrows` package to fix options at the document level.

```
\NewDocumentCommand \WithArrowsOptions {m}
    {\int_set:Nn \l_@@_previous_pos_arrows_int {-1}
     \keys_set_known:nnN {WithArrows/General} {#1} \l_tmpa_tl
     \keys_set:nV {WithArrows/GlobalOrEnv} \l_tmpa_tl}
```

9.7 The command Arrow

In fact, the internal command is not named `\Arrow` but `\@@_Arrow`. Usually, at the beginning of an environment `{WithArrows}`, `\Arrow` is set to be equivalent to `\@@_Arrow`. However, the user can change the name with the option `CommandName` and the user command for `\@@_Arrow` will be different. This mechanism can be useful when the user has already a command named `\Arrow` he wants to still be able to use in the environment `{WithArrows}`.

```
\NewDocumentCommand \@@_Arrow {O{} m O{}}
         {
```

The counter `\g_@@_arrow_int` counts the arrows in the environment. The incrementation must be global (`gincr`) because the command `\Arrow` will be used in the cell of a `\halign`. It's recalled that we manage a stack for this counter.

```
          \int_gincr:N \g_@@_arrow_int
```

We will extract immediately the options `ll`, `rr`, `lr`, `rl`, `i` and `jump`. For the position, we use the integer `\l_@@_pos_arrows_int` locally in the cell of the `\halign`: we won't change the exterior evalue of `\l_@@_pos_arrows_int` set by the environment `{WithArrows}` of by the command `\WithArrowsOptions`. The default value of `\l_@@_pos_arrows_int` will be -1 for an arrow without option of position.

```
          \int_set:Nn \l_@@_previous_pos_arrows_int {-1}
          \int_set:Nn \l_@@_pos_arrows_int {-1}
```

The level of options is set to 3 which is the level for the options in a command `\Arrow`.

```
          \int_set:Nn \l_@@_level_int 3
```

The options `ll`, `rr`, `lr`, `rl`, `i` and `jump` are extracted. The other options are stored in `\l_tmpa_tl` and will be stored in the field "options" of the property list later.

```
          \keys_set_known:nnN {WithArrows/Arrow} {#1,#3} \l_tmpa_tl
```

We will construct a global property list to store the informations of the considered arrow. The five fields of this property list are "initial", "final", "position", "options" and "label".

1. First, the line from which the arrow starts:

   ```
               \prop_put:NnV \l_tmpa_prop {initial} \g_@@_line_int
   ```

2. The line where the arrow ends (that's why it was necessary to extract the key `jump`):

   ```
               \int_set:Nn \l_tmpa_int {\g_@@_line_int + \l_@@_jump_int}
               \prop_put:NnV \l_tmpa_prop {final} \l_tmpa_int
   ```

3. The "position" of the arrow. If the arrow has no option of position, the default value -1 is stored in that field.

   ```
               \prop_put:NnV \l_tmpa_prop {position} \l_@@_pos_arrows_int
   ```

4. The other options of the arrow (it's a token list):

```
            \prop_put:NnV \l_tmpa_prop {options} \l_tmpa_tl
```

5. The label of the arrow (it's also a token list):

```
            \prop_put:Nnn \l_tmpa_prop {label} {#2}
```

The property list has been created in a local variable for convenience. Now, it will be stored in a global variable indicating both the position-in-the-tree and the number of the arrow.

```
       \prop_gclear_new:c
             {g_@@_arrow_\l_@@_prefix_str _\int_use:N\g_@@_arrow_int _prop}
       \prop_gset_eq:cN
             {g_@@_arrow_\l_@@_prefix_str _\int_use:N\g_@@_arrow_int _prop}
             \l_tmpa_prop
       }
```

```
\cs_new_protected:Nn \@@_Arrow_first_column:
```

All messages of LaTeX3 must be *fully expandable* and that's why we do the affectation (necessary for a comparison) before the `\@@_error:n`.

```
            {\tl_set:Nn \l_tmpa_tl {Arrow}
             \@@_error:n {Arrow~in~first~column}
             \@@_Arrow}
```

9.8 The environment {WithArrows}

The command `\@@_pre_environement:` is a code common to the environments `{WithArrows}` and `{DispWithArrows}`. The argument is the list of options given to the environment.

```
\cs_new_protected:Nn \@@_pre_environment:n
```

First the initialisation of the counters `\g_@@_arrow_int` and `\g_@@_line_int`. However, we have to save their previous values with the two stacks created for this end.

```
      { \seq_gput_right:NV \g_@@_arrow_int_seq \g_@@_arrow_int
        \int_gzero:N \g_@@_arrow_int
        \seq_gput_right:NV \g_@@_line_int_seq \g_@@_line_int
        \int_gzero:N \g_@@_line_int
```

We also have to update the position on the nesting tree.

```
        \seq_gput_right:Nn \g_@@_position_in_the_tree_seq 1
```

The nesting tree is used to create a prefix which will be used in the names of the Tikz nodes and in the names of the arrows (each arrow is a property list of four fields). If we are in the second environment `{WithArrows}` nested in the third environment `{WithArrows}` of the document, the prefix will be `3-2` (although the position in the tree is $[3, 2, 1]$ since such a position always ends with a 1). First, we do a copy of the position-in-the-tree and then we pop the last element of this copy (in order to drop the last 1).

```
        \seq_set_eq:NN \l_tmpa_seq \g_@@_position_in_the_tree_seq
        \seq_pop_right:NN \l_tmpa_seq \l_tmpa_tl
        \str_clear_new:N \l_@@_prefix_str
        \str_set:Nx \l_@@_prefix_str {\seq_use:Nnnn \l_tmpa_seq {-} {-} {-}}
```

We define the command `\\` to be the command `\@@_cr:` (defined below).

```
        \cs_set_eq:NN \\ \@@_cr:
        \dim_zero:N \mathsurround
```

These counters will be used later as variables.

```
           \int_zero_new:N \l_@@_initial_int
           \int_zero_new:N \l_@@_final_int
           \int_zero_new:N \l_@@_arrow_int
           \int_zero_new:N \l_@@_pos_of_arrow_int
           \int_zero_new:N \l_@@_jump_int
           \int_set:Nn \l_@@_jump_int 1
```

In (the second column of) `{DispWithArrows}`, it's possible to put several labels (for the same number of equation). That's why these labels will be stored in a sequence `\l_@@_labels_seq`.

```
           \seq_clear_new:N \l_@@_labels_seq
```

```
           \@@_bool_new:N \l_@@_tag_next_line_bool
```

The value corresponding to the key `interline` is put to zero before the treatment of the options of the environment.[22]

```
           \skip_zero:N \l_@@_interline_skip
```

The value corresponding to the key `CodeBefore` is put to nil before the treatment of the options of the environment, because, of course, we don't want the code executed at the beginning of all the nested environments `{WithArrows}`. Idem for `CodeAfter`.

```
           \tl_clear_new:N \l_@@_code_before_tl
           \tl_clear_new:N \l_@@_code_after_tl
```

We process the options given to the `{WithArrows}` environment. The level of options is set to 1.

```
           \int_set:Nn \l_@@_previous_pos_arrows_int {-1}
           \int_set:Nn \l_@@_level_int 2
           \keys_set_known:nnN {WithArrows/General} {#1} \l_tmpa_tl
           \keys_set:nV {WithArrows/GlobalOrEnv} \l_tmpa_tl
```

If the option `footnote` or the option `footnotehyper` is used, then we extract the footnotes with an environment `{savenotes}` (of the package footnote or the package footnotehyper).

```
           \bool_if:NT \g_@@_footnote_bool {\savenotes}
```

We execute the code `\l_@@_code_before_tl` of the option `CodeBefore` of the environment after the eventual `\begin{savenotes}` and, symetricaly, we will execute the `\l_@@_code_after_tl` before the eventual `\end{savenotes}` (we have a good reason for the last point : we want to extract the footnotes of the arrows executed in the `CodeAfter`).

```
           \l_@@_code_before_tl
```

If the user has given a value for the option `CommandName` (at the global or at the *environment* level), a command with this name is defined locally in the environment with meaning `\@@_Arrow`. The default value of the option `CommandName` is "`Arrow`" and thus, by default, the name of the command will be `\Arrow`.

```
           \cs_set_eq:cN \l_@@_CommandName_tl \@@_Arrow}
```

This is the end of `\@@_pre_environment:n`.

Now, we begin the environment `{WithArrows}`.

```
\NewDocumentEnvironment {WithArrows} {O{}}
         { \bool_set_true:N \l_@@_in_WithArrows_bool
           \bool_set_false:N \l_@@_in_DispWithArrows_bool
           \reverse_if:N \if_mode_math:
                             \@@_error:n {{WithArrows}~used~outside~math~mode}
                         \fi:
           \@@_pre_environment:n {#1}
           \cs_set_eq:NN \notag \@@_notag:
```

[22] It's recalled that, by design, the option `interline` of an environment doesn't apply in the nested environments.

```
\cs_set_eq:NN \nonumber \@@_notag:
\cs_set_eq:NN \tag \@@_tag
\cs_set_eq:NN \label \@@_label:n
\cs_set_eq:NN \tagnextline \@@_tagnextline:
```

The environment begins with a `\vtop`, a `\vcenter` or a `\vbox`[23] depending of the value of `\l_@@_pos_env_int` (fixed by the options `t`, `c` or `b`). The environment `{WithArrows}` must be used in math mode[24] and therefore, we can use `\vcenter`.

```
\int_case:nn \l_@@_pos_env_int
        {0 \vtop
         1 \vcenter
         2 \vbox}
\bgroup
```

The command `\spread@equation` is the command used by amsmath in the beginning of an alignment to fix the interline. When used, it becomes no-op. However, it's possible to use witharrows without amsmath since we have redefined `\spread@equation` (if it is not defined yet).

```
\spread@equation
```

We begin the `\halign` and the preamble.

```
\ialign\bgroup
```

We increment the counter `\g_@@_line_int` which will be used in the names of the Tikz nodes created in the array. This incrementation must be global (`gincr`) because we are in the cell of a `\halign`. It's recalled that we manage a stack for this counter.

```
\int_gincr:N \g_@@_line_int
\cs_set_eq:cN \l_@@_CommandName_tl \@@_Arrow_first_column:
\bool_set_true:N \l_@@_in_first_column_bool
\strut\hfil
$\bool_if:NT \l_@@_displaystyle_bool \displaystyle {##}$
&


$\bool_if:NT \l_@@_displaystyle_bool \displaystyle {{}##}$
```

We create the "left node" of the line (when using macros in Tikz node names, the macros have to be fully expandable: here, `\tl_use:N` and `\int_use:N` are fully expandable).

```
\tikz [remember~picture,overlay]
      \node [@@_node_style,
             name = wa-\l_@@_prefix_str-\int_use:N\g_@@_line_int-l,
             alias = {\tl_if_empty:NF \l_@@_name_tl
                          {\l_@@_name_tl-\int_use:N\g_@@_line_int-l}} ] {} ;
\hfil
```

Now, after the `\hfil`, we create the "right node" and, if the option `shownodenames` is raised, the name of the node is written in the document (useful for debugging).

```
\tikz [remember~picture,overlay]
      \node [@@_node_style,
             name = wa-\l_@@_prefix_str-\int_use:N\g_@@_line_int-r,
             alias = {\tl_if_empty:NF \l_@@_name_tl
                        {\l_@@_name_tl-\int_use:N\g_@@_line_int-r}} ] {} ;
\bool_if:NT \l_@@_shownodenames_bool
     {\hbox_overlap_right:n {\small wa-\l_@@_prefix_str
                                     -\int_use:N\g_@@_line_int}}
```

[23] Notice that the use of `\vtop` seems color-safe here...

[24] An error is raised if the environment is used outside math mode.

Usually, the `\halign` of an environment `{WithArrows}` will have exactly two columns. Nevertheless, if the user wants to use more columns (without arrows) it's possible with the option `MoreColumns`.

```
           && \@@_error:n {Third~column~in~an~environment~{WithArrows}}
           $\bool_if:NT \l_@@_displaystyle_bool \displaystyle {##}$
           \cr
          }
```

We begin the second part of the environment `{WithArrows}`. We have two `\egroup`: one for the `\halign` and one for the `\vtop` (or `\vcenter` or `\vbox`).

```
          {\crcr
           \egroup
           \egroup
           \@@_post_environment:
```

If the option `footnote` or the option `footnotehyper` is used, then we extract the footnotes with an environment `{footnote}` (of the package footnote or the package footnotehyper).

```
           \bool_if:NT \g_@@_footnote_bool {\endsavenotes}
}
```

This is the end of the environment `{WithArrows}`.

The command `\@@_post_environment:` is a code common to the second part of the environment `{WithArrows}` and the environment `{DispWithArrows}`.

```
\cs_new_protected:Nn \@@_post_environment:
```

The command `\WithArrowsRightX` is not used by witharrows. It's only a convenience given to the user.

```
          {\cs_set:Npn \WithArrowsRightX {\g_@@_right_x_dim}
```

It there is really arrows in the environment, we draw the arrows:

- if neither option `group` or `groups` is used, we can draw directly ;
- if option `group` or option `groups` is used (`\l_@@_pos_arrows_int` > 5), we have to draw the arrows group by group ; the macro `\@@_draw_arrows:` does the work.

```
           \int_compare:nNnT \g_@@_arrow_int > 0
                  {\int_compare:nNnTF \l_@@_pos_arrows_int > 5
                    \@@_draw_arrows:
                    {\@@_draw_arrows:nn 1 \g_@@_arrow_int}}
```

We will execute the code specified in the option `CodeAfter`, after some settings.

```
           \group_begin:
           \tikzset{every~picture/.style = @@_standard}
```

The command `\WithArrowsNbLines` is not used by witharrows. It's only a convenience given to the user.

```
           \cs_set:Npn \WithArrowsNbLines {\int_use:N \g_@@_line_int}
```

The command `\MultiArrow` is available in `CodeAfter`, and we have a special version of `\Arrow`, called "`\Arrow` in `CodeAfter`" in the documentation.[25]

```
           \cs_set_eq:NN \MultiArrow \@@_MultiArrow:nn
           \cs_set_eq:cN \l_@@_CommandName_tl \@@_Arrow_code_after
           \l_@@_code_after_tl
           \group_end:
```

[25] As for now, `\MultiArrow` has no option, and that's why its internal name is a name of expl3 with the signature `:nn` whereas `\Arrow` in `CodeAfter` provides options and has the name of a function defined with `\NewDocumentCommand`.

We update the position-in-the-tree. First, we drop the last component and then we increment the last element.

```
           \seq_gpop_right:NN \g_@@_position_in_the_tree_seq \l_tmpa_tl
           \seq_gpop_right:NN \g_@@_position_in_the_tree_seq \l_tmpa_tl
           \seq_gput_right:Nx \g_@@_position_in_the_tree_seq
                             {\int_eval:n {\l_tmpa_tl+1}}
```

We update the value of the counter `\g_@@_last_env_int`. This counter is used only by the user function `\WithArrowsLastEnv`.

```
           \int_compare:nNnT {\seq_count:N \g_@@_position_in_the_tree_seq} = 1
                      {\int_gincr:N \g_@@_last_env_int}
```

Finally, we restore the previous values of the counters `\g_@@_arrow_int` and `\g_@@_line_int` It is recalled that we manage three stacks in order to be able to do such a restoration.

```
           \seq_gpop_right:NN \g_@@_arrow_int_seq {\l_tmpa_tl}
           \int_gset:Nn \g_@@_arrow_int {\l_tmpa_tl}
           \seq_gpop_right:NN \g_@@_line_int_seq \l_tmpa_tl
           \int_gset:Nn \g_@@_line_int {\l_tmpa_tl}
           }
```

That's the end of the command `\@@_post_environment:`.

We give now the definition of `\@@_cr:` which is the definition of `\\` in an environment `{WithArrows}`. The two expl3 commands `\group_align_safe_begin:` and `\group_align_safe_end:` are specifically designed for this purpose: test the token that follows in a `\halign` structure.
First, we remove an eventual token `*` since the commands `\\` and `\\*` are equivalent in an environment `{WithArrows}` (an environment `{WithArrows}`, like an environment `{aligned}` of amsmath, is always unbreakable).

```
\cs_new_protected:Nn \@@_cr:
      {\scan_stop:
% \bigskip
%   \begin{macrocode}
       \bool_if:NT \l_@@_in_first_column_bool {& {} }
       \group_align_safe_begin:
       \peek_meaning_remove:NTF * \@@_cr_i: \@@_cr_i:}
```

Then, we peek the next token to see if it's a `[`. In this case, the command `\\` has an optional argument which is the vertical skip (=glue) to put.

```
\cs_new_protected:Nn \@@_cr_i:
      {\peek_meaning:NTF [ {\@@_cr_ii:} {\@@_cr_ii:[\c_zero_dim]} }
\cs_new_protected:Npn \@@_cr_ii:[#1]
      {\group_align_safe_end:
```

For the environment `{DispWithArrows}`, the behaviour of `\\` is different because we add the third column which is the column for the tag (number of the equation). Even if there is no tag, the third column is used for the v-nodes.

```
       \bool_if:NT \l_@@_in_DispWithArrows_bool
```

At this stage, we know that we have a tag to put if (and only if) the value of `\l_@@_tags_clist` is the comma list `all` (only one element). Maybe, previously, the value of `\l_@@_tags_clist` was, for example, `1,last` (which means that only the first line and the last line must be tagged). However, in this case, the comparison with the number of line has be done before and, now, if we are in a line to tag, the value of `\l_@@_tags_clist` is `all`.

```
           {\clist_if_in:NnTF \l_@@_tags_clist {all}
                {
```

Here, we can't use `\refstepcounter{equation}` because if the user has issued a `\tag` command, we have to use `\l_@@_tag_tl` and not `\theequation`. That's why we have to do the job done by `\refstepcounter` manually.
First, the incrementation of the counter (potentially).

```
                 \tl_if_empty:NT \l_@@_tag_tl
                    {\int_gincr:N \c@equation}
```

We store in \g_tmpa_tl the tag we will have to compose at the end of the line. We use a global variable because we will use it in the *next* cell (after the &).

```
                \cs_gset:Npx \g_tmpa_tl
                     {\tl_if_empty:NTF \l_@@_tag_tl
                         \theequation
                         \l_@@_tag_tl}
```

It's possible to put several labels for the same line (it's not possible in the environments of amsmath). That's why the differents labels of a same line are stored in a sequence \l_@@_labels_seq.

```
                \seq_if_empty:NF \l_@@_labels_seq
                     {
```

Now, we do the job done by \refstepcounter and by the redefinitions of \refstepcounter done by some packages (the incrementation of the counter has been done yet).
First an action which is in the definition of \refstepcounter. The command \p@equation is redefined by some extensions like fncylab.

```
                      \cs_set:Npx \@currentlabel {\p@equation \g_tmpa_tl}
```

Then, an action done by hyperref in its redefinition of \refstepcounter.

```
                      \bool_if:NT \c_@@_hyperref_loaded_bool
                           {\cs_set:Npn \This@name {equation}
                            \hyper@refstepcounter{equation}}
```

Then, an action done by cleveref in its redefinition of \refstepcounter. The package cleveref creates in the aux file a command \cref@currentlabel similar to \@currentlabel but with more informations.

```
                      \bool_if:NT \c_@@_cleveref_loaded_bool
                          {\cref@constructprefix{equation}{\cref@result}
                           \@ifundefined{cref@equation@alias}
                                  {\def\@tempa{equation}}
                                  {\def\@tempa{\csname cref@equation@alias\endcsname}}
                           \protected@edef\cref@currentlabel
                                              {[\@tempa][\arabic{equation}][\cref@result]
                                               \p@equation \g_tmpa_tl}}
```

Then, an action done by typedref in its redefinition of \refstepcounter. The command \sr@name is a prefix added to the name of the label by the redefinition of \label done by typedref.

```
                      \bool_if:NT \c_@@_typedref_loaded_bool
                         {\cs_set:Npn \sr@name {equation}}
```

Now, we can issue the command \label (some packages may have redefined \label, for example typedref) for each item in the sequence of the labels (it's possible to put several labels to the same line and that's why the labels are in the sequence \l_@@_labels_seq).

```
                      \seq_map_function:NN \l_@@_labels_seq \@@_old_label}
```

We save the booleans \l_@@_tag_star_bool and \l_@@_qedhere_bool because they will be used in the *next* cell (after the &). We recall that the cells of a \halign are TeX groups.

```
                \@@_save:N \l_@@_tag_star_bool
                \@@_save:N \l_@@_qedhere_bool
                \bool_if:NT \l_@@_tag_next_line_bool
                           { \openup -\jot
                             \bool_set_false:N \l_@@_tag_next_line_bool
                             \notag \\ & }
                & \@@_restore:N \l_@@_tag_star_bool
                  \@@_restore:N \l_@@_qedhere_bool
                  \bool_if:NT \l_@@_qedhere_bool
                        {\hbox_overlap_left:n {\@@_qedhere_i:}}
                  \cs_set_eq:NN \theequation \g_tmpa_tl
                  \bool_if:NT \l_@@_tag_star_bool {\cs_set:Npn \tagform@ {}}
```

We use \@eqnnum (we recall that there are two definitions of \@eqnnum, a standard definition and another, loaded if the class option leqno is used). However, of course, the position of the v-node is not the same wether the option leqno is used or not. That's here that we use the flag \c_@@_leqno_bool.

```
                  \hbox_overlap_left:n
                    {\bool_if:NF \c_@@_leqno_bool
```

```
                        {\tikz [@@_standard] \coordinate (\int_use:N\g_@@_line_int-v) ;}
                      \quad
                      \@eqnnum }
                   \bool_if:NT \c_@@_leqno_bool
                      {\tikz [@@_standard] \coordinate (\int_use:N \g_@@_line_int-v) ;}}
                {\@@_save:N \l_@@_qedhere_bool
                 & \@@_restore:N \l_@@_qedhere_bool
                   \bool_if:NT \l_@@_qedhere_bool
                         {\hbox_overlap_left:n {\@@_qedhere_i:}}
                   \tikz [@@_standard] \coordinate (\int_use:N\g_@@_line_int-v)  ; }
             }
       \cr\noalign{\skip_vertical:n {#1 + \l_@@_interline_skip}
       \scan_stop:}}
```

According to the documentation of expl3, the previous addition in "#1 + \l_@@_interline_skip" is really an addition of skips (=glues).

9.9 The commands tag, notag, label, tagnextline and qedhere for DispWithArrows

```
\cs_new_protected:Nn \@@_if_in_second_col_of_disp:nn
     {\bool_if:NTF \l_@@_in_WithArrows_bool
          {\msg_error:nnn {witharrows}
                          {Command~not~allowed~in~{WithArrows}}
                          {#1}}
          {\bool_if:NTF \l_@@_in_first_column_bool
             {\msg_error:nnn {witharrows}
                             {Command~not~allowed~in~{DispWithArrows}}
                             {#1}}
             {#2}}}
```

The command \@@_notag: will be linked to \notag and \nonumber in the environments {WithArrows} and {DispWithArrows}.

```
\cs_new_protected:Nn \@@_notag:
     {\@@_if_in_second_col_of_disp:nn {\notag}
             {\clist_clear:N \l_@@_tags_clist}}
```

The command \@@_tag will be linked to \tag in the environments {WithArrows} and {DispWithArrows}. We use \NewDocumentCommand because this command has a starred version.

```
\NewDocumentCommand \@@_tag {sm}
     {\@@_if_in_second_col_of_disp:nn {\tag}
             {\tl_if_empty:NF \l_@@_tag_tl
                   {\msg_error:nnn {witharrows} {Multiple~tags} {#2}}
              \clist_set:Nn \l_@@_tags_clist {all}
              \bool_if:nT \c_@@_mathtools_loaded_bool
                    {\MH_if_boolean:nT {show_only_refs}
                         {\MH_if_boolean:nF {show_manual_tags}
                             {\clist_clear:N \l_@@_tags_clist}}}
              \tl_set:Nn \l_@@_tag_tl {#2}
              \bool_set:Nn \l_@@_tag_star_bool {#1}
```

The starred version \tag* can't be used if amsmath has not been loaded because this version does the job by desactivating the command \tagform@ inserted by amsmath in the (two versions of the) command \@eqnnum.[26]

```
             \bool_if:nT {#1 && ! \bool_if_p:N \c_@@_amsmath_loaded_bool}
                  { \@@_error:n {tag*~without~amsmath} }}
    }
```

The command \@@_label:n will be linked to \label in the environments {WithArrows} and {DispWithArrows}. In these environments, it's possible to put several labels for the same line (it's

[26] There are two versions of @eqnnum, a standard version and a version for the option leqno.

not possible in the environments of amsmath). That's why we store the differents labels of a same line in a sequence `\l_@@_labels_seq`.

```
\cs_new_protected:Nn \@@_label:n
     {\@@_if_in_second_col_of_disp:nn {\label}
             {\seq_if_empty:NF \l_@@_labels_seq
                 {\bool_if:NTF \c_@@_cleveref_loaded_bool
                    {\@@_error:n {Multiple~labels~with~cleveref}}
                    {\@@_error:n {Multiple~labels}}}
              \seq_put_right:Nn \l_@@_labels_seq {#1}
              \bool_if:nT \c_@@_mathtools_loaded_bool
                 {\MH_if_boolean:nT {show_only_refs}
                     {\cs_if_exist:cTF {MT_r_#1}
                       {\clist_set:Nn \l_@@_tags_clist {all}}
                       {\clist_clear:N \l_@@_tags_clist}}}
              \bool_if:nT \c_@@_autonum_loaded_bool
                     {\cs_if_exist:cTF {autonum@#1Referenced}
                       {\clist_set:Nn \l_@@_tags_clist {all}}
                       {\clist_clear:N \l_@@_tags_clist}}}}
```

The command `\@@_tagnextline:` will be linked to `\tagnextline` in the environments `{WithArrows}` and `{DispWithArrows}`.

```
\cs_new_protected:Nn \@@_tagnextline:
        {\@@_if_in_second_col_of_disp:nn {\tagnextline}
             {\bool_set_true:N \l_@@_tag_next_line_bool}}
```

The environments `{DispWithArrows}` and `{DispWithArrows*}` are compliant with the command `\qedhere` of amsthm. However, this compatibility requires a special version of `\qedhere`.
This special version is called `\@@_qedhere:` and will be linked with `\qedhere` in the second column of the environment `{DispWithArrows}` (only if the package amsthm has been loaded). `\@@_qedhere:` raises the boolean `\l_@@_qedhere_bool`.

```
\bool_new:N \l_@@_qedhere_bool
\cs_new_protected:Nn \@@_qedhere: {\bool_set_true:N \l_@@_qedhere_bool}
```

In the third column of the `\halign` of `{DispWithArrows}`, a command `\@@_qedhere_i:` will be issued if the flag `\l_@@_qedhere_bool` has been raised. The code of this command is a adaptation of the code of `\qedhere` in amsthm.

```
\cs_new_protected:Nn \@@_qedhere_i: {\group_begin:
                                       \cs_set_eq:NN \qed \qedsymbol
```

The line `\cs_set_eq:NN \qed@elt \setQED@elt` is a preparation for an action on the QED stack. Despite its form, the instruction `\QED@stack` executes an operation on the stack. This operation prints the QED symbol and nullify the top of the stack.

```
                                       \cs_set_eq:NN \qed@elt \setQED@elt
                                       \QED@stack\relax\relax
                                     \group_end: }
```

9.10 The environment {DispWithArrows}

For the environment `{DispWithArrows}`, the construction is a construction of the type:
`\[\vcenter{\halign to \displaywith {...}}\]`
The purpose of the `\vcenter` is to have an environment unbreakable.

```
\NewDocumentEnvironment {DispWithArrows} {O{}}
         {
```

If mathtools has been loaded with the option `showonlyrefs`, we disable the code of mathtools for the option `showonlyrefs` with the command `\MT_showonlyrefs_false:` (it will be reactivated at the end of the environment).

```
          \bool_if:nT \c_@@_mathtools_loaded_bool
                 {\MH_if_boolean:nT {show_only_refs}
                    {\MT_showonlyrefs_false:
```

However, we have to re-raise the flag {show_only_refs} of mhsetup because it has been switched off by \MT_showonlyrefs_false: and we will use it in the code of the new version of \label.

```
           \MH_set_boolean_T:n {show_only_refs}}}
```

The command \intertext@ is a command of amsmath which loads the definition of \intertext.

```
\bool_if:NT \c_@@_amsmath_loaded_bool \intertext@
\if_mode_math:
    \@@_error:n {{DispWithArrows}~used~in~math~mode}
\fi:
\bool_set_true:N \l_@@_in_DispWithArrows_bool
\@@_pre_environment:n {#1}
```

We don't use \[of LaTeX because some extensions, like autonum, do a redefinition of \[. However, we put the following lines which are in the definition of \[even though they are in case of misuse.

```
\if_mode_vertical:
  \nointerlineskip
  \makebox[.6\linewidth]{}
\fi:
$$
```

We use a \vcenter in order to prevent page breaks in the environment.

```
\vcenter \bgroup
\spread@equation
\bool_if:NTF \l_@@_fleqn_bool
       {\tabskip = \c_zero_skip}
       {\tabskip = 0 pt plus 1000 pt minus 1000 pt}
\cs_set_eq:NN \@@_old_label \label
\cs_set_eq:NN \notag \@@_notag:
\cs_set_eq:NN \nonumber \@@_notag:
\cs_set_eq:NN \tag \@@_tag
\cs_set_eq:NN \label \@@_label:n
\cs_set_eq:NN \tagnextline \@@_tagnextline:
\halign to \displaywidth \bgroup
  \int_gincr:N \g_@@_line_int
  \cs_set_eq:cN \l_@@_CommandName_tl \@@_Arrow_first_column:
  \bool_set_true:N \l_@@_in_first_column_bool
  \strut
  \bool_if:NT \l_@@_fleqn_bool
        {\skip_horizontal:n \l_@@_mathindent_dim}
  \hfil
  $\bool_if:NT \l_@@_displaystyle_bool \displaystyle {##}$
  \tabskip = \c_zero_skip
 &
  \clist_if_in:NVT \l_@@_tags_clist \g_@@_line_int
       {\clist_set:Nn \l_@@_tags_clist {all}}
```

The command \qedhere of amsthm is redefined here.

```
  \bool_if:NT \c_@@_amsthm_loaded_bool {\cs_set_eq:NN \qedhere \@@_qedhere:}
  $\bool_if:NT \l_@@_displaystyle_bool \displaystyle {{}##}$
  \tabskip = 0 pt plus 1000 pt minus 1000 pt
  \tikz [remember~picture,overlay]
       \node [_@@_node_style,
              name = wa-\l_@@_prefix_str-\int_use:N\g_@@_line_int-l,
              alias = {\tl_if_empty:NF \l_@@_name_tl
                         {\l_@@_name_tl-\int_use:N\g_@@_line_int-l}} ] {} ;
  \hfil
  \tikz [remember~picture,overlay]
        \node [_@@_node_style,
               name = wa-\l_@@_prefix_str-\int_use:N\g_@@_line_int-r,
               alias = {\tl_if_empty:NF \l_@@_name_tl
                          {\l_@@_name_tl-\int_use:N\g_@@_line_int-r}} ] {} ;
  \bool_if:NT \l_@@_shownodenames_bool
       {\hbox_overlap_right:n {\small wa-\l_@@_prefix_str
                                        -\int_use:N\g_@@_line_int}}
 & ##
```

```
             \tabskip = \c_zero_skip
            && \@@_error:n {Third~column~in~an~environment~{DispWithArrows}}
               \iffalse ## \fi
             \cr}
```

We begin the second part of the environment {DispWithArrows}.

```
          {\clist_if_in:NnT \l_@@_tags_clist {last}
                   {\clist_set:Nn \l_@@_tags_clist {all}}
           \\
```

The following \egroup is for the \halign.

```
           \egroup
```

The following \egroup is for the \vcenter (aimed to prevent page breaks).

```
           \egroup
```

If we are in an environment {DispWithArrows} or {DispWithArrows*}, we compute the dimension \g_@@_right_x_dim. As a first approximation, \g_@@_right_x_dim is the x-value of the right side of the current composition box. In fact, we must take into account the potential labels of the equations. That's why we compute \g_@@_right_x_dim with the v-nodes of each row specifically built in this goal. \g_@@_right_x_dim is the minimal value of the x-value of these nodes.

```
           \bool_if:NT \l_@@_in_DispWithArrows_bool
             {\dim_gzero_new:N \g_@@_right_x_dim
              \dim_gset:Nn \g_@@_right_x_dim \c_max_dim
              \begin{tikzpicture} [@@_standard]
              \int_step_variable:nnnNn 1 1 \g_@@_line_int \l_tmpa_int
                    {\tikz@parse@node\pgfutil@firstofone (\l_tmpa_int-v)
                     \dim_set:Nn \l_tmpa_dim \pgf@x
                     \dim_compare:nNnT \l_tmpa_dim < \g_@@_right_x_dim
                            {\dim_gset:Nn \g_@@_right_x_dim \l_tmpa_dim} }
              \end{tikzpicture}}
```

The code in \@@_post_environment: is common to {WithArrows} and {DispWithArrows}.

```
           \@@_post_environment:
```

If mathtools has been loaded with the option showonlyrefs, we reactivate the code of mathtools for the option showonlyrefs with the command \MT_showonlyrefs_true: (it has been desactivated in the beginning of the environment).

```
           \bool_if:nT \c_@@_mathtools_loaded_bool
                    {\MH_if_boolean:nT {show_only_refs}
                          \MT_showonlyrefs_true:}
           $$
```

If the option footnote or the option footnotehyper is used, then we extract the footnotes with an environment {footnote} (of the package footnote or the package footnotehyper).

```
           \bool_if:NT \g_@@_footnote_bool {\endsavenotes}
           \ignorespacesafterend
           }
```

With the environment {DispWithArrows*}, the equations are not numbered. We don't put \begin{DispWithArrows} and \end{DispWithArrows} because there is a \@currenvir in an error message.

```
\NewDocumentEnvironment {DispWithArrows*} {}
     {\WithArrowsOptions{notag}
      \DispWithArrows}
     {\endDispWithArrows}
```

9.11 We draw the arrows

\@@_draw_arrows: draws the arrows when the option group or the option groups is used. In both cases, we have to compute the x-value of a group of arrows before actually drawing the arrows of that group. The arrows will actually be drawn by the macro \@@_draw_arrows:nn.
If an environment {WithArrows} is composed with the option group or the option groups, it's still possible to put arrows with their option of position (ll, rr, rl, lr or i). Such arrows will be said to be "independant".

```
\cs_new_protected:Nn \@@_draw_arrows:
  { \group_begin:
```

\l_@@_first_arrow_of_group_int will be the first arrow of the current group.
\l_@@_first_line_of_group_int will be the first line involved in the group of arrows (equal to the initial line of the first arrow of the group because the option jump is always positive).
\l_@@_last_line_of_group_int will be the last line involved in the group (impossible to guess in advance).

```
    \int_zero_new:N \l_@@_first_arrow_of_group_int
    \int_zero_new:N \l_@@_first_line_of_group_int
    \int_zero_new:N \l_@@_last_line_of_group_int
    \bool_set_true:N \l_@@_new_group_bool
```

We begin a loop over all the arrows of the environment. Inside this loop, if a group is finished, we will draw the lines of that group.

```
    \int_set:Nn \l_@@_arrow_int 1
    \int_until_do:nNnn \l_@@_arrow_int > \g_@@_arrow_int
     {
```

We extract from the property list of the current arrow the fields "initial", "final" and "position" and we store these values in \l_@@_initial_int, \l_@@_final_int and \l_@@_pos_of_arrow_int. However, we have to do a conversion because the components of a property list are token lists.

```
       \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str _\int_use:N\l_@@_arrow_int _prop}
                     {initial} \l_tmpa_tl
       \int_set:Nn \l_@@_initial_int {\l_tmpa_tl}
       \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str _\int_use:N\l_@@_arrow_int _prop}
                     {final} \l_tmpa_tl
       \int_set:Nn \l_@@_final_int {\l_tmpa_tl}
       \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str _\int_use:N\l_@@_arrow_int _prop}
                     {position} \l_tmpa_tl
       \int_set:Nn \l_@@_pos_of_arrow_int \l_tmpa_tl
```

If the arrow arrives after the last line of the environment we raise an error (we recall that, after the construction of the \halign, \g_@@_line_int is the total number of lines of the environment). The arrow will be completely ignored, even for the computation of \l_@@_x_dim.

```
       \int_compare:nNnTF \l_@@_final_int > \g_@@_line_int
          {\@@_error:n {Too~few~lines~for~an~arrow}}
```

We test if the previous arrow was in fact the last arrow of a group. In this case, we have to draw all the arrows of that group (with the x-value computed in \l_@@_x_dim).

```
          {\bool_if:nT {     \int_compare_p:nNn \l_@@_pos_arrows_int = 7
                         && \int_compare_p:nNn \l_@@_arrow_int > 1
                         && \int_compare_p:nNn
                                    \l_@@_initial_int > \l_@@_last_line_of_group_int}
                 {\@@_draw_arrows:nn \l_@@_first_arrow_of_group_int {\l_@@_arrow_int - 1}
                  \bool_set_true:N \l_@@_new_group_bool}
```

The flag \l_@@_new_group_bool indicates if we have to begin a new group of arrows. In fact, we have to begin a new group in two circonstancies: if we are at the first arrow of the environment (that's why the flag is raised before the beginning of the loop) and if we have just finished a group (that's why the flag is raised in the previous conditionnal). At the beginning of a group, we have to initialize four variables: \l_@@_first_arrow_int, \l_@@_first_line_of_group_int, \l_@@_last_line_of_group and \l_@@_x_dim. The last two will evolve during the construction of the group.

```
           \bool_if:nTF \l_@@_new_group_bool
                 {\bool_set_false:N \l_@@_new_group_bool
                  \int_set:Nn \l_@@_first_arrow_of_group_int \l_@@_arrow_int
                  \int_set:Nn \l_@@_first_line_of_group_int \l_@@_initial_int
                  \int_set:Nn \l_@@_last_line_of_group_int \l_@@_final_int
                  \dim_set:Nn \l_@@_x_dim {-\c_max_dim}
                  }
```

If we are not at the beginning of a new group, we actualize \l_@@_last_line_of_group_int. If the arrow is independant (\l_@@_pos_of_arrow_int non negative) we don't take into account this arrow for the detection of the end of the group.

```
                 {\int_compare:nNnT \l_@@_pos_of_arrow_int = {-1}
                     {\int_set:Nn \l_@@_last_line_of_group_int
                        {\int_max:nn \l_@@_last_line_of_group_int \l_@@_final_int}}}
```

If the arrow is independant (\l_@@_pos_of_arrow_int non negative), you update the current x-value (in \l_@@_x_dim) with the dedicated command \@@_update_x_value:nn.

```
           \int_compare:nNnT \l_@@_pos_of_arrow_int = {-1}
              {\@@_update_x_value:nn \l_@@_initial_int \l_@@_final_int} }
```

Incrementation of the index of the loop (and end of the loop).

```
       \int_incr:N \l_@@_arrow_int
     }
```

After the last arrow of the environment, we have to draw the last group of arrows.

```
     \@@_draw_arrows:nn \l_@@_first_arrow_of_group_int \g_@@_arrow_int
     \group_end:
  }
```

The following code is necessary because we will have to expand an argument exactly 3 times.

```
\cs_generate_variant:Nn \keys_set:nn {no}
\cs_new_protected:Nn \@@_keys_set: {\keys_set:no {WithArrows/General}}
```

The macro \@@_draw_arrows:nn draws all the arrows whose numbers are between #1 and #2. #1 and #2 must be expressions that expands to an integer (they are expanded in the beginning of the macro).

```
\cs_new_protected:Nn \@@_draw_arrows:nn
  {\group_begin:
   \int_zero_new:N \l_@@_first_arrow_int
   \int_set:Nn \l_@@_first_arrow_int {#1}
   \int_zero_new:N \l_@@_last_arrow_int
   \int_set:Nn \l_@@_last_arrow_int {#2}
```

We begin a loop over the arrows we have to draw. The variable \l_@@_arrow_int (local in the environment {WithArrows}) will be used as index for the loop.

```
   \int_set:Nn \l_@@_arrow_int \l_@@_first_arrow_int
   \int_until_do:nNnn \l_@@_arrow_int > \l_@@_last_arrow_int
     {
```

We extract from the property list of the current arrow the fields “initial” and “final” and we store these values in `\l_@@_initial_int` and `\l_@@_final_int`. However, we have to do a conversion because the components of a property list are token lists.

```
      \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str _\int_use:N\l_@@_arrow_int _prop}
                    {initial} \l_tmpa_tl
      \int_set:Nn \l_@@_initial_int {\l_tmpa_tl}
      \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str _\int_use:N\l_@@_arrow_int _prop}
                    {final} \l_tmpa_tl
      \int_set:Nn \l_@@_final_int {\l_tmpa_tl}
```

If the arrow ends after the last line of the environment, we raise an error (we recall that, after the construction of the `\halign`, `\g_@@_line_int` is the total number of lines of the environment). However, if the option `group` or the option `groups` is in force, we don’t raise an error because the error has already been raised in `\@@_draw_arrows:`.

```
      \int_compare:nNnTF \l_@@_final_int > \g_@@_line_int
         {\int_compare:nNnT \l_@@_pos_arrows_int < 6
               {\@@_error:n {Too~few~lines~for~an~arrow}}}
         \@@_draw_arrows_i:
      \int_incr:N \l_@@_arrow_int
     }
   \group_end:
   }
```

The macro `\@@_draw_arrows_i:` is only for the lisibility of the code. The first `\group_begin:` is for the options of the arrows (but we remind that the options `ll`, `rr`, `rl`, `lr`, `i` and `jump` have already been extracted and are not present in the field `options` of the property list of the arrow).

```
\cs_new:Nn \@@_draw_arrows_i:
     {\group_begin:
      \int_set:Nn \l_@@_level_int 3
```

We process the options of the current arrow. The second argument of `\keys_set:nn` must be expanded exactly three times. An x-expansion is not possible because there can be tokens like `\bfseries` in the option `font` of the option `tikz`. This expansion is a bit tricky.

```
      \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str
                        _\int_use:N\l_@@_arrow_int _prop} {options} \l_tmpa_tl
      \exp_args:NNo \exp_args:No
          \@@_keys_set: {\l_tmpa_tl,tikz={xshift = \l_@@_xoffset_dim}}
```

We retrieve the value of the field `position` of the current arrow. If the arrow has no option of position, the value of this field is -1. If the arrow has a option of position, you modify the current value of `\l_@@_pos_arrows_int` to reflect this value.

```
      \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str _\int_use:N\l_@@_arrow_int _prop}
         {position} \l_tmpa_tl
      \int_set:Nn \l_tmpa_int \l_tmpa_tl
      \int_compare:nNnF \l_tmpa_int = {-1}
         {\int_set_eq:NN \l_@@_pos_arrows_int \l_tmpa_int}
```

We create two booleans to indicate the position of the initial node and final node of the arrow in cases of options `rr`, `rl`, `lr` or `ll`:

```
      \bool_set_false:N \l_@@_initial_r_bool
      \bool_set_false:N \l_@@_final_r_bool
      \int_case:nn \l_@@_pos_arrows_int
             {0 {\bool_set_true:N \l_@@_initial_r_bool
                 \bool_set_true:N \l_@@_final_r_bool}
              2 {\bool_set_true:N \l_@@_initial_r_bool}
              3 {\bool_set_true:N \l_@@_final_r_bool}}
```

option	rr	ll	rl	lr	v	i	group	groups
`\l_@@_pos_arrows_int`	0	1	2	3	4	5	6	7

The option `v` can be used only in `\Arrow` in `CodeAfter` (see below).

In case of option `i` at a local or global level (`\l_@@_pos_arrows_int` = 5), we have to compute the x-value of the arrow (which is vertical). The computed x-value is stored in `\l_@@_x_dim` (the same variable used when the option `group` or the option `groups` is used).

```
    \int_compare:nNnT \l_@@_pos_arrows_int = 5
         { \dim_set:Nn \l_@@_x_dim {-\c_max_dim}
           \@@_update_x_value:nn \l_@@_initial_int \l_@@_final_int }
```

`\l_@@_initial_tl` contains the name of the Tikz node from which the arrow starts (in normal cases... because with the option `i`, `group` and `groups`, the point will perhaps have another x-value — but always the same y-value). Idem for `\l_@@_final_tl`.

```
    \tl_set:Nx \l_@@_initial_tl
            {\int_use:N\l_@@_initial_int-\bool_if:NTF\l_@@_initial_r_bool rl .south}
    \tl_set:Nx \l_@@_final_tl
            {\int_use:N\l_@@_final_int-\bool_if:NTF\l_@@_final_r_bool rl .north}
```

We use "`.south`" and "`.north`" because we want a small gap between two consecutive arrows (and the Tikz nodes created have the shape of small vertical segments: use option `shownodes` to visualize the nodes).

The label of the arrow will is stored in `\l_tmpa_tl`.

```
    \prop_get:cnN {g_@@_arrow_\l_@@_prefix_str _\int_use:N\l_@@_arrow_int _prop}
                  {label}
                  \l_tmpa_tl
```

We have to compute the coordinates of the extremities of the arrow. We retrieve the coordinates in `\g_tmpa_tl` and `\g_tmpb_tl`. This extraction of the coordinates is necessary because we must give coordinates and not nodes (even anchored) to `\@@_draw_arrow:nnn` to have the `xshift` correct.

```
    \int_compare:nNnTF \l_@@_pos_arrows_int < 5
       {\begin{tikzpicture} [@@_standard]
            \tikz@scan@one@point\pgfutil@firstofone(\l_@@_initial_tl)
            \tl_gset:Nx \g_tmpa_tl {\dim_use:N\pgf@x,\dim_use:N\pgf@y}
            \tikz@scan@one@point\pgfutil@firstofone(\l_@@_final_tl)
            \tl_gset:Nx \g_tmpb_tl {\dim_use:N\pgf@x,\dim_use:N\pgf@y}
        \end{tikzpicture}
}
```

If we use option `i` or `group` or `groups`, we use the abscissa specially computed in `\l_@@_x_dim`.

```
       {\begin{tikzpicture} [@@_standard]
            \tikz@scan@one@point\pgfutil@firstofone (\l_@@_initial_tl)
            \tl_gset:Nx \g_tmpa_tl {\dim_use:N \l_@@_x_dim , \dim_use:N \pgf@y}
            \tikz@scan@one@point\pgfutil@firstofone (\l_@@_final_tl)
            \tl_gset:Nx \g_tmpb_tl {\dim_use:N \l_@@_x_dim , \dim_use:N \pgf@y}
        \end{tikzpicture}}
```

Eventually, we can draw the arrow with the code in `\l_@@_tikz_code_tl`. We recall that the value by default for this token list is : "`\draw (#1) to node {#3} (#2) ;`". This value can be modified with the option `TikzCode`. We use the variant `\@@_draw_arrow:nno` of the macro `\@@_draw_arrow:nnn` because of the characters *underscore* in the name `\l_tmpa_tl` : if the user uses the Tikz library `babel`, the third argument of the command `\@@_draw_arrow:nno` will be rescanned because this third argument will be in the argument of a command `node` of an instruction `\draw` of Tikz... and we will have an error because of the characters *underscore*.[27]

```
    \@@_draw_arrow:nno {\g_tmpa_tl} {\g_tmpb_tl} {\l_tmpa_tl}
```

We close the TeX group opened for the options given to `\Arrow[...]` (local level of the options).

```
    \group_end: }
```

[27] There were other solutions: use another name without *underscore* (like `\ltmpatl`) or use the package underscore (with this package, the characters *underscore* will be rescanned without errors, even in text mode).

The function `@@_tmpa:nnn` will draw the arrow. It's merely an environment `{tikzpicture}`. However, the Tikz instruction in this environment must be inserted from `\l_@@_tikz_code_tl` with the markers `#1`, `#2` and `#3`. That's why we create a function `\@@_def_function_tmpa:n` which will create the function `\@@_tmpa:nnn`.

```
\cs_new_protected:Nn \@@_def_function_tmpa:n
    {\cs_set:Nn \@@_tmpa:nnn
          {\begin{tikzpicture}[@@_standard,every~path/.style = {WithArrows/arrow}]
              #1
           \end{tikzpicture}}}
```

When we draw the arrow (with `\@@_draw_arrow:nnn`), we first create the function `\@@_tmpa:nnn` and, then, we use the function `\@@_tmpa:nnn` :

```
\cs_new_protected:Nn \@@_draw_arrow:nnn
           {
```

If the option `wrap-lines` is used, we have to use a special version of `\l_@@_tikz_code_tl` (which corresponds to the option `TikzCode`).

```
            \bool_if:nT {\l_@@_wrap_lines_bool && \l_@@_in_DispWithArrows_bool}
               { \tl_set_eq:NN \l_@@_tikz_code_tl \c_@@_tikz_code_wrap_lines_tl }
```

Now, the main lines of this function `\@@_draw_arrow:nnn`.

```
            \exp_args:No \@@_def_function_tmpa:n \l_@@_tikz_code_tl
            \@@_tmpa:nnn {#1} {#2} {#3} }
\cs_generate_variant:Nn \@@_draw_arrow:nnn {nno}
```

If the option `wrap-lines` is used, we have to use a special version of `\l_@@_tikz_code_tl` (which corresponds to the option `TikzCode`).

```
\tl_set:Nn \c_@@_tikz_code_wrap_lines_tl
                 {
```

First, we draw the arrow without the label.

```
                   \draw (#1) to node (@@_label) {} (#2) ;
```

We retrieve in `\pgf@x` the abscissa of the left-side of the label we will put.

```
                   \tikz@parse@node \pgfutil@firstofone (@@_label.west)
```

We compute in `\l_tmpa_dim` the maximal width possible for the label. `0.3333 em` is the default value of `inner sep` in the nodes of Tikz. Maybe we should put the exact Tikz parameter. Here is the use of `\g_@@_right_x_dim` which has been computed previously with the v-nodes.

```
                   \dim_set:Nn \l_tmpa_dim {\g_@@_right_x_dim - \pgf@x - 0.3333 em}
```

We retrieve in `\g_tmpa_tl` the current value of the Tikz parameter "`text width`".[28]

```
                   \path \pgfextra {\tl_gset:Nx \g_tmpa_tl \tikz@text@width} ;
```

Maybe the current value of the parameter "`text width`" is shorter than `\l_tmpa_dim`. In this case, we must use "`text width`" (we update `\l_tmpa_dim`).

```
                   \tl_if_empty:NF \g_tmpa_tl
                      {\dim_set:Nn \l_tmpb_dim \g_tmpa_tl
                       \dim_compare:nNnT \l_tmpb_dim < \l_tmpa_dim
                           {\dim_set_eq:NN \l_tmpa_dim \l_tmpb_dim}}
```

Now, we can put the label with the right value for "`text width`".

```
                   \dim_compare:nNnT \l_tmpa_dim > \c_zero_dim
                      {\path (@@_label.west)
                        node [anchor = west, text~width = \dim_use:N \l_tmpa_dim]
                        {#3} ; } }
```

[28] In fact, it's not the current value of "`text width`": it's the value of "`text width`" set in the option `tikz` provided by witharrows. These options are given to Tikz in a "`every path`". That's why we have to retrieve it in a path.

The command \@@_update_x_value:nn will analyze the lines between #1 and #2 in order to modify \l_@@_x_dim in consequence. More precisely, \l_@@_x_dim is increased if a line longer than the current value of \l_@@_x_dim is found. \@@_update_x_value:nn is used in \@@_draw_arrows: (for options group and groups) and in \@@_draw_arrows:nn (for option i).

```
\cs_new_protected:Nn \@@_update_x_value:nn
    {\int_step_inline:nnnn {#1} 1 {#2}
        {\begin{tikzpicture} [@@_standard]
         \tikz@scan@one@point\pgfutil@firstofone (##1-l)
         \dim_gset:Nn \g_tmpa_dim {\dim_max:nn \l_@@_x_dim \pgf@x}
         \end{tikzpicture}
         \dim_set_eq:NN \l_@@_x_dim \g_tmpa_dim } }
```

The command \WithArrowsLastEnv is not used by the package witharrows. It's only a facility given to the final user. It gives the number of the last environment {WithArrows} at level 0 (to the sens of the nested environments). This macro is fully expandable and, thus, can be used directly in the name of a Tikz node.

```
\cs_new:Npn \WithArrowsLastEnv {\int_use:N \g_@@_last_env_int}
```

9.12 The command Arrow in CodeAfter

The option CodeAfter is an option of the environment {WithArrows} (this option is only available at the environment level). In the option CodeAfter, one can use the command Arrow but it's a special version of the command Arrow. For this special version (internally called \@@_Arrow_code_after), we define a special set of keys called WithArrows/CodeAfter.

```
\keys_define:nn {WithArrows/CodeAfter}
     {tikz     .code:n            = \tikzset {WithArrows/arrow/.append~style = {#1}} ,
      tikz     .value_required:n  = true,
      rr       .value_forbidden:n = true,
      rr       .code:n            = \@@_analyze_option_position:n 0 ,
      ll       .value_forbidden:n = true,
      ll       .code:n            = \@@_analyze_option_position:n 1 ,
      rl       .value_forbidden:n = true,
      rl       .code:n            = \@@_analyze_option_position:n 2 ,
      lr       .value_forbidden:n = true,
      lr       .code:n            = \@@_analyze_option_position:n 3 ,
      v        .value_forbidden:n = true,
      v        .code:n            = \@@_analyze_option_position:n 4 ,
      TikzCode .tl_set:N          = \l_@@_tikz_code_tl,
      TikzCode .value_required:n  = true,
      xoffset  .dim_set:N         = \l_@@_xoffset_dim,
      xoffset  .value_required:n  = true}
```

```
\NewDocumentCommand \@@_Arrow_code_after {O{} mmm O{}}
     {\int_set:Nn \l_@@_pos_arrows_int 1
      \int_set:Nn \l_@@_previous_pos_arrows_int {-1}
      \group_begin:
```

Even if \Arrow in CodeAfter has its own set of options (WithArrows/CodeAfter), we set the level of the options to 3 (as with the classical command \Arrow) because of the error messages.

```
        \int_set:Nn \l_@@_level_int 3
        \keys_set:nn {WithArrows/CodeAfter}
                     {#1,#5,tikz={xshift = \l_@@_xoffset_dim}}
        \bool_set_false:N \l_@@_initial_r_bool
        \bool_set_false:N \l_@@_final_r_bool
        \int_case:nn \l_@@_pos_arrows_int
               {0 {\bool_set_true:N \l_@@_initial_r_bool
                   \bool_set_true:N \l_@@_final_r_bool}
                2 {\bool_set_true:N \l_@@_initial_r_bool}
                3 {\bool_set_true:N \l_@@_final_r_bool}}
```

We test wether the two Tikz nodes (#2-l) and (#3-l) really exist. If not, the arrow won't be drawn.

```
          \cs_if_free:cTF {pgf@sh@ns@wa-\l_@@_prefix_str-#2-l}
            {\msg_error:nnx {witharrows} {Wrong~line~specification~in~Arrow} {#2}}
            {\cs_if_free:cTF {pgf@sh@ns@wa-\l_@@_prefix_str-#3-l}
               {\msg_error:nnx {witharrows} {Wrong~line~specification~in~Arrow} {#3}}
               {\int_compare:nNnTF \l_@@_pos_arrows_int = 4
                   {\begin{tikzpicture} [@@_standard]
                       \tikz@scan@one@point\pgfutil@firstofone(#2-l.south)
                       \dim_set_eq:NN \l_tmpa_dim \pgf@x
                       \dim_set_eq:NN \l_tmpb_dim \pgf@y
                       \tikz@scan@one@point\pgfutil@firstofone(#3-l.north)
                       \dim_set:Nn \l_tmpa_dim {\dim_max:nn \l_tmpa_dim \pgf@x}
                       \tl_gset:Nx \g_tmpa_tl
                                   {\dim_use:N \l_tmpa_dim , \dim_use:N \l_tmpb_dim}
                       \tl_gset:Nx \g_tmpb_tl
                                   {\dim_use:N \l_tmpa_dim , \dim_use:N \pgf@y}
                    \end{tikzpicture} }
                   {\begin{tikzpicture} [@@_standard]
                       \tikz@scan@one@point\pgfutil@firstofone
                                   (#2-\bool_if:NTF\l_@@_initial_r_bool rl .south)
                       \tl_gset:Nx \g_tmpa_tl {\dim_use:N \pgf@x , \dim_use:N \pgf@y}
                       \tikz@scan@one@point\pgfutil@firstofone
                                   (#3-\bool_if:NTF\l_@@_final_r_bool rl .north)
                       \tl_gset:Nx \g_tmpb_tl {\dim_use:N \pgf@x , \dim_use:N \pgf@y}
                    \end{tikzpicture}}
                \@@_draw_arrow:nnn {\g_tmpa_tl} {\g_tmpb_tl} {#4} }}
     \group_end:
     }
```

9.13 MultiArrow

The command \@@_MultiArrow:nn will be linked to \MultiArrow when the CodeAfter is executed.

```
\cs_new_protected:Nn \@@_MultiArrow:nn
    {
```

The user of the command \MultiArrow (in CodeAfter) will be able to specify the list of lines with the same syntax as the loop \foreach of pgffor. That's why we construct a "clist" of expl3 from the specification of list given by the user. The construction of the "clist" must be global in order to exit the \foreach and that's why we construct the list in \g_tmpa_clist.

```
     \foreach \x in {#1} {\cs_if_free:cTF {pgf@sh@ns@wa-\l_@@_prefix_str-\x-l}
                           {\msg_error:nnx {witharrows}
                                           {Wrong~line~specification~in~MultiArrow}
                                           {\x}}
                           {\clist_gput_right:Nx \g_tmpa_clist {\x}}}
```

We sort the list \g_tmpa_clist because we want to extract the minimum and the maximum.

```
     \int_compare:nNnTF {\clist_count:N \g_tmpa_clist} < 2
       {\@@_error:n {Too~small~specification~for~MultiArrow}}
       {\clist_sort:Nn \g_tmpa_clist
                     {\int_compare:nNnTF {##1} > {##2}
                            {\sort_return_swapped:}
                            {\sort_return_same:}}
```

We extract the minimum in \l_tmpa_tl (it must be an integer but we store it in a token list of expl3).

```
        \clist_pop:NN \g_tmpa_clist \l_tmpa_tl
```

We extract the maximum in \l_tmpb_tl. The remaining list (in \g_tmpa_clist) will be sorted in decreasing order but never mind...

```
        \clist_reverse:N \g_tmpa_clist
        \clist_pop:NN \g_tmpa_clist \l_tmpb_tl
```

We draw the teeth of the rak (except the first one and the last one) with the auxiliary function `\@@_MultiArrow_i:n`. This auxiliary fonction is necessary to expand the specification of the list in the `\foreach` loop. The first and the last teeth of the rak can't be drawn the same way as the others (think, for example, to the case of the option "`rounded corners`" is used).

```
        \exp_args:Nx \@@_MultiArrow_i:n {\g_tmpa_clist}
```

Now, we draw the rest of the structure.

```
        \begin{tikzpicture}[@@_standard,every~path/.style={WithArrows/arrow}]
          \draw [<->] ([xshift = \l_@@_xoffset_dim]\l_tmpa_tl-r.south)
                       -- ++(5mm,0)
                       -- node (@@_label) {}
                          ([xshift = \l_@@_xoffset_dim+5mm]\l_tmpb_tl-r.south)
                       -- ([xshift = \l_@@_xoffset_dim]\l_tmpb_tl-r.south)  ;
          \tikz@parse@node \pgfutil@firstofone (@@_label.west)
          \dim_set:Nn \l_tmpa_dim {20 cm}
          \path \pgfextra {\tl_gset:Nx \g_tmpa_tl \tikz@text@width} ;
          \tl_if_empty:NF \g_tmpa_tl {\dim_set:Nn \l_tmpa_dim \g_tmpa_tl}
          \bool_if:nT {\l_@@_wrap_lines_bool && \l_@@_in_DispWithArrows_bool}
                  {\dim_set:Nn \l_tmpb_dim {\g_@@_right_x_dim - \pgf@x - 0.3333 em}
                   \dim_compare:nNnT \l_tmpb_dim < \l_tmpa_dim
                           {\dim_set_eq:NN \l_tmpa_dim \l_tmpb_dim}}
          \path (@@_label.west)
           node [anchor = west, text~width = \dim_use:N \l_tmpa_dim] {#2} ;
        \end{tikzpicture} } }

\cs_new_protected:Nn \@@_MultiArrow_i:n
     {\begin{tikzpicture}[@@_standard,every~path/.style={WithArrows/arrow}]
        \foreach \k in {#1}
           {\draw[<-] ([xshift = \l_@@_xoffset_dim]\k-r.south) -- ++(5mm,0) ;} ;
      \end{tikzpicture}}
```

9.14 The error messages of the package

```
\msg_new:nnn {witharrows}
             {AllowLineWithoutAmpersand}
             {The~option~"AllowLineWithoutAmpersand"~is~deprecated~because~lines~
              without~ampersands~are~now~always~allowed.~The~option~
              "AllowLineWithoutAmpersand"~will~probably~be~deleted~in~a~future~version.~
              However,~you~can~go~on~for~this~time.}
\msg_new:nnn {witharrows}
             {Option~unknown}
             {The~option~"\tl_use:N\l_keys_key_tl"~is~unknown~or~
              meaningless~in~the~context.~If~you~go~on,~it~will~be~ignored.}
\msg_new:nnn {witharrows}
             {Third~column~in~an~environment~{WithArrows}}
             {By~default,~an~environment~\{WithArrows\}~can~only~have~two~columns.~
              Maybe~you~have~forgotten~a~\str_use:N \c_backslash_str
              \str_use:N \c_backslash_str.~If~you~really~want~more~than~two~columns,~
              you~should~use~the~option~"MoreColumns"~at~a~global~level~or~for~
              an~environment.~However,~you~can~go~one~for~this~time.}
\msg_new:nnn {witharrows}
             {Third~column~in~an~environment~{DispWithArrows}}
             {An~environment~\{DispWithArrows\}~or~\{DispWithArrows*\}~can~only~
              have~two~columns.~If~you~go~on,~you~may~have~an~incorrect~output.}
\msg_new:nnn {witharrows}
             {The~option~"jump"~must~be~non~negative}
             {You~can't~use~a~strictly~negative~value~for~the~option~"jump"~of~command~
              \token_to_str:N\Arrow.~ You~can~create~an~arrow~going~backwards~with~
              the~option~"<-"~of~Tikz.}
\msg_new:nnn {witharrows}
```

```
             {Too~few~lines~for~an~arrow}
             {An~arrow~specified~in~line~\int_use:N \l_@@_initial_int\ can't~be~drawn~
              because~it~arrives~after~the~last~line~of~the~environment~(remind~that~
              the~command~\token_to_str:N\Arrow\ must~be~in~the~*start*~line~
              of~the~arrow).~If~you~go~on,~this~arrow~will~be~ignored.}
\msg_new:nnn {witharrows}
             {{WithArrows}~used~outside~math~mode}
             {The~environment~\{WithArrows\}~should~be~used~only~in~math~mode.~
              Nevertheless,~you~can~go~on.}
\msg_new:nnn {witharrows}
             {{DispWithArrows}~used~in~math~mode}
             {The~environment~\{DispWithArrows\}~should~be~used~only~outside~math~mode.~
              If~you~go~on,~you~will~have~other~errors.}
\msg_new:nnn {witharrows}
             {Two~options~are~incompatible}
             {You~try~to~use~the~option~"\tl_use:N\l_keys_key_tl"~but~
             this~option~is~incompatible~or~redundant~with~the~option~"
             \int_case:nn\l_@@_previous_pos_arrows_int
                 {0 {rr}
                  1 {ll}
                  2 {rl}
                  3 {lr}
                  4 {v}
                  5 {i}
                  6 {group}
                  7 {groups}}"~
             set~in~the~same~
             \int_case:nn\l_@@_level_int
                  {1 {command~\token_to_str:N\WithArrowsOptions}
                   2 {declaration~of~options~of~the~environment~
                      \{\@currenvir\}}
                   3 {command~\token_to_str:N\Arrow}}.~
             If~you~go~on,~I~will~use~the~option~"\tl_use:N\l_keys_key_tl".}
\msg_new:nnn {witharrows}
             {Option~will~be~ignored}
             {The~option~"\tl_use:N\l_keys_key_tl"~can't~be~used~here.~
              If~you~go~on,~it~will~be~ignored.}
\msg_new:nnn {witharrows}
             {Arrow~in~first~column}
             {You~should~not~use~the~command~\token_to_str:N\Arrow\
              \tl_if_eq:NNF \l_@@_CommandName_tl \l_tmpa_tl
                    {(renamed~in~\str_use:N \c_backslash_str
                     \tl_use:N \l_@@_CommandName_tl)~}
              ~in~the~first~column~but~only~in~the~second~column.\\
              However~you~can~go~on~for~this~time.}
\msg_new:nnn {witharrows}
             {Wrong~line~specification~in~Arrow}
             {The~specification~of~line~"#1"~you~use~in~\token_to_str:N\Arrow\
              ~doesn't~exist.\\
              If~you~go~on,~the~arrow~will~be~ignored.}
\msg_new:nnn {witharrows}
             {Wrong~line~specification~in~MultiArrow}
             {The~specification~of~line~"#1"~doesn't~exist.\\
              If~you~go~on,~it~will~be~ignored~for~\token_to_str:N \MultiArrow.}
\msg_new:nnn {witharrows}
             {Too~small~specification~for~MultiArrow}
             {The~specification~of~lines~you~gave~to~\token_to_str:N \MultiArrow\
              is~too~small:~we~need~at~least~two~lines.~If~you~go~on,~the~
              command~\token_to_str:N\MultiArrow\ ~will~be~ignored.}
\msg_new:nnn {witharrows}
```

```
             {tag*~without~amsmath}
             {We~can't~use~\token_to_str:N\tag*~because~you~haven't~loaded~amsmath~
              (or~mathtools).~If~you~go~on,~the~command~\token_to_str:N\tag\
              will~be~used~instead.}
\msg_new:nnn {witharrows}
             {Command~not~allowed~in~{DispWithArrows}}
             {The~command~\token_to_str:N #1
              is~not~allowed~in~the~first~column~of~\{DispWithArrows\}~but~
              only~in~the~second~column.~If~you~go~on,~this~command~will~be~ignored.}
\msg_new:nnn {witharrows}
             {Command~not~allowed~in~{WithArrows}}
             {The~command~\token_to_str:N #1
              is~not~allowed~in~\{WithArrows\}~but~is~allowed~in~the~second~
              column~of~\{DispWithArrows\}~If~you~go~on,~this~command~will~be~ignored.}
\msg_new:nnn {witharrows}
             {Multiple~tags}
             {You~can't~use~twice~the~command~\token_to_str:N\tag\
              in~a~line~of~the~environment~\{\@currenvir\}.~If~you~go~on,~the~tag~
              '#1'~will~be~used.}
\msg_new:nnn {witharrows}
             {Multiple~labels}
             {Normally,~we~can't~use~the~command~\token_to_str:N\label\
              twice~in~a~line~of~the~environment~\{\@currenvir\}.~
              However,~you~can~go~on.~
              \bool_if:NT \c_@@_showlabels_loaded_bool
                  {However,~only~the~last~label~will~be~shown~by~showlabels.~}
              If~you~don't~want~to~see~this~message~again,~you~can~use~the~option~
              "AllowMultipleLabels"~at~the~global~or~environment~level.}
\msg_new:nnn {witharrows}
             {Multiple~labels~with~cleveref}
             {Since~you~use~cleveref,~you~can't~use~the~command~\token_to_str:N\label\
              twice~in~a~line~of~the~environment~\{\@currenvir\}.~
              If~you~go~on,~you~may~have~undefined~references.}
```

9.15 Environment {CasesWithArrows}

```
\coffin_new:N \l_@@_halign_coffin
\NewDocumentEnvironment {CasesWithArrows} {m O{}}
         {\hbox_set:Nn \l_tmpa_box {$\left\{\vcenter to 1cm {} \right.$}
          \dim_zero_new:N \l_@@_delim_wd_dim
          \dim_set:Nn \l_@@_delim_wd_dim {\box_wd:N \l_tmpa_box}
          \box_clear_new:N \l_@@_left_part_box
          \hbox_set:Nn \l_@@_left_part_box
                       {$\bool_if:NT \l_@@_displaystyle_bool \displaystyle #1 {}$}
          \bool_if:nT \c_@@_mathtools_loaded_bool
                 {\MH_if_boolean:nT {show_only_refs}
                    {\MT_showonlyrefs_false:
                      \MH_set_boolean_T:n {show_only_refs}
                      \clist_set:Nn \l_@@_tags_clist {all}}}
           \bool_if:NT \c_@@_amsmath_loaded_bool \intertext@
           \if_mode_math:
               \@@_error:n {{DispWithArrows}~used~in~math~mode}
           \fi:
           \bool_set_true:N \l_@@_in_DispWithArrows_bool
           %
           \_@@_pre_environment:n {#2}
           \nointerlineskip
           \hbox_to_wd:nn {0.6\linewidth} {}
           $$
           \spread@equation
           \vcoffin_set:Nnw \l_@@_halign_coffin \displaywidth
              \bool_if:NTF \l_@@_fleqn_bool
           {\tabskip = \c_zero_skip}
           {\tabskip = 0 pt plus 1000 pt minus 1000 pt}
    \bool_if:NTF \c_@@_amsmath_loaded_bool
       {\cs_set_eq:NN \@@_old_label \ltx@label}
       {\cs_set_eq:NN \@@_old_label \label}
    \halign to \displaywidth \bgroup
      \int_gincr:N \g_@@_line_int
      \cs_set_eq:cN \l_@@_CommandName_tl \@@_Arrow_first_column:
      \bool_set_true:N \l_@@_in_first_column_bool
      \strut
      \bool_if:NT \l_@@_fleqn_bool
            {\skip_horizontal:n \l_@@_mathindent_dim}
      \hfil
      \skip_horizontal:n {\box_wd:N \l_@@_left_part_box + \l_@@_delim_wd_dim}
      $\bool_if:NT \l_@@_displaystyle_bool \displaystyle {##}$
      \tabskip = \c_zero_skip
     &
      \clist_if_in:NVT \l_@@_tags_clist \g_@@_line_int
          {\clist_set:Nn \l_@@_tags_clist {all}}
      \cs_set:Npn \notag {\clist_clear:N \l_@@_tags_clist}
      $\bool_if:NT \l_@@_displaystyle_bool \displaystyle {{}##}$
      \tabskip = 0 pt plus 1000 pt minus 1000 pt
      \tikz [remember~picture,overlay]
           \node [@@_node_style,
                  name = wa-\l_@@_prefix_str-\int_use:N\g_@@_line_int-l,
                  alias = {\tl_if_empty:NF \l_@@_name_tl
                            {\l_@@_name_tl-\int_use:N\g_@@_line_int-l}} ] {} ;
      \hfil
      \tikz [remember~picture,overlay]
           \node [@@_node_style,
                  name = wa-\l_@@_prefix_str-\int_use:N\g_@@_line_int-r,
                  alias = {\tl_if_empty:NF \l_@@_name_tl
                            {\l_@@_name_tl-\int_use:N\g_@@_line_int-r}} ] {} ;
      \bool_if:NT \l_@@_shownodenames_bool
           {\hbox_overlap_right:n {\small wa-\l_@@_prefix_str
                                            -\int_use:N\g_@@_line_int}}
     & ##
      \tabskip = \c_zero_skip
     && \@@_error:n {Third~column~in~an~environment~{DispWithArrows}}
        \if_false: ## \fi:
      \cr}
{\clist_if_in:NnT {last} \l_@@_tags_clist
         {\clist_set:Nn \l_@@_tags_clist {all}}
    \\
    \egroup
    \unskip\unpenalty\unskip\unpenalty
    \box_set_to_last:N \l_tmpa_box
    \nointerlineskip
    \box_use:N \l_tmpa_box
    \dim_gzero_new:N \g_@@_alignment_dim
    \dim_gset:Nn \g_@@_alignment_dim {\box_wd:N \l_tmpa_box}
    \box_clear_new:N \l_@@_new_box
    \hbox_set:Nn \l_@@_new_box {\hbox_unpack_clear:N \l_tmpa_box}
    \dim_compare:nNnT {\box_wd:N \l_@@_new_box} < \g_@@_alignment_dim
         {\dim_gset:Nn \g_@@_alignment_dim {\box_wd:N \l_@@_new_box}}
 \vcoffin_set_end:
 \hbox_to_wd:nn \displaywidth
   {
    \bool_if:NTF \l_@@_fleqn_bool
          {\skip_horizontal:n \l_@@_mathindent_dim}
          {\hfil}
    \hbox_to_wd:nn \g_@@_alignment_dim
         { \box_use_drop:N \l_@@_left_part_box
```

```
                     \dim_set:Nn \l_tmpa_dim {   \box_ht:N \l_@@_halign_coffin
                                               + \box_dp:N \l_@@_halign_coffin}
                     $\left\{ \vcenter to \l_tmpa_dim {\vfil} \right.$}
              \hfil}
           \coffin_typeset:Nnnnn
                        \l_@@_halign_coffin {l} {vc} {-\displaywidth} \c_zero_dim
           $$
           \_@@_post_environment:
           \bool_if:nT \c_@@_mathtools_loaded_bool
                    {\MH_if_boolean:nT {show_only_refs}
                          \MT_showonlyrefs_true:}
           \ignorespacesafterend
           }
```

9.16 The command WithArrowsNewStyle

A new key defined with `\WithArrowsNewStyle` will not be available at the local level (`\l_@@_level_int` = 3).

```
\NewDocumentCommand \WithArrowsNewStyle {mm}
   { \keys_if_exist:nnTF {WithArrows/General} {#1}
       {\@@_error:nn {Key~already~defined} {#1}}
       {\keys_define:nn {WithArrows/General}
            {#1 .code:n = {\int_compare:nNnTF \l_@@_level_int < 3
                              {\keys_set:nn {WithArrows/General} {#2}}
                              {\@@_error:n {Option~unknown}}}}
```

We set the options in a TeX group in order to detect if some keys in `#2` are unknown. If a key is unknown, an error will be raised. However, the key will, even so, be stored in the definition of key `#1`. When the key `#1` will be used, the error will be raised again.

```
        \group_begin:
           \WithArrowsOptions{#2}
        \group_end:} }
```

```
\msg_new:nnn {witharrows}
             {Key~already~defined}
             {The~key~'#1'~is~already~defined.~If~you~go~on,~
              your~instruction~\token_to_str:N\WithArrowsNewStyle\ will~be~ignored.}
```

10 History

10.1 Changes between versions 1.0 and 1.1

Option for the command `\\` and option `interline`

Compatibility with `\usetikzlibrary{babel}`

Possibility of nested environments `{WithArrows}`

Better error messages

Creation of a DTX file

10.2 Changes between versions 1.1 and 1.2

The package witharrows can now be loaded without having loaded previously tikz and the libraries `arrow.meta` and `bending` (this extension and these libraries are loaded silently by witharrows).

New option `groups` (with a *s*)

Better error messages

10.3 Changes between versions 1.2 and 1.3

New options `ygap` and `ystart` for fine tuning.

Minor bugs.

10.4 Changes between versions 1.3 and 1.4

The package footnote is no longer loaded by default. Instead, two options `footnote` and `footnotehyper` have been added. In particular, witharrows becomes compatible with beamer.

10.5 Changes between versions 1.4 and 1.5

The Tikz code used to draw the arrows can be changed with the option `TikzCode`.
Two new options `CodeBefore` and `CodeAfter` have been added at the environment level.
A special version of `\Arrow` is available in `CodeAfter` in order to draw arrows in nested environments.
A command `\MultiArrow` is available in `CodeAfter` to draw arrows of other shapes.

10.6 Changes between versions 1.5 and 1.6

The code has been improved to be faster and the Tikz library `calc` is no longer required.
A new option `name` is available for the environments `{WithArrows}`.

10.6.1 Changes between 1.6 and 1.6.1

Correction of a bug that leads to incompatibility with `\usetikzlibrary{babel}`.

10.7 Changes between 1.6.1 and 1.7

New environments `{DispWithArrows}` and `{DispWithArrows*}`.

10.8 Changes between 1.7 and 1.8

The numbers and tags of the environment `{DispWithArrows}` are now compatible with all the major LaTeX packages concerning references (autonum, cleveref, fancyref, hyperref, prettyref, refstyle, typedref and varioref) and with the options `showonlyrefs` and `showmanualtags` of mathtools.

10.9 Changes between 1.8 and 1.9

New option `wrap-lines` for the environments `{DispWithArrows}` and `{DispWithArrows*}`.

10.10 Changes between 1.9 and 1.10

If the option `wrap-lines` is used, the option "`text width`" of Tikz is still active: if the value given to "`text width`" is lower than the width computed by `wrap-lines`, this value is used to wrap the lines.
The option `wrap-lines` is now fully compatible with the class option `leqno`.
Correction of a bug: `\nointerlineskip` and `\makebox[.6\linewidth]{}` should be inserted in `{DispWithArrows}` only in vertical mode.

10.11 Changes between 1.10 and 1.11

New commands `\WithArrowsNewStyle` and `\WithArrowsRightX`.

10.12 Changes between 1.11 and 1.12

New command `\tagnextline`.
New option `tagged-lines`.
An option of position (`ll`, `lr`, `rl`, `rr` or `i`) is now allowed at the local level even if the option `group` or the option `groups` is used at the global or environment level.
Compatibility of `{DispWithArrows}` with `\qedhere` of amsthm.
Compatibility with the packages refcheck, showlabels and listlbls.
The option `\AllowLineWithoutAmpersand` is deprecated because lines without ampersands are now always allowed.