# PSTricks

## pst-spirograph

**v.0.41**

A PSTricks package for drawing spirograph curves

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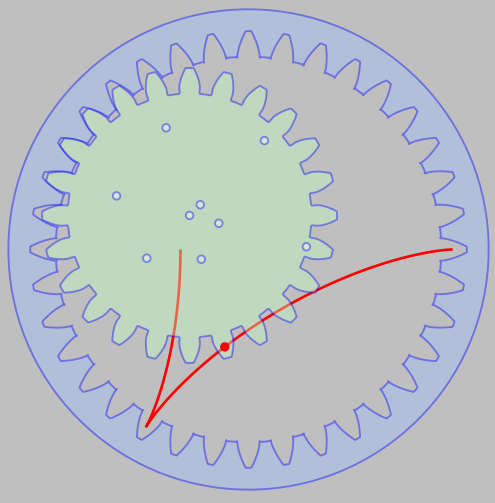

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# Contents



Thanks for feedback and contributions to:
Uwe Ziegenhagen;

# 1 Introduction

pst-spirograph is a package to simulate the operation of a spirograph. A spirograph is a geometric drawing toy that produces mathematical roulette curves that are technically known as hypotrochoids and epitrochoids. The mathematician Bruno Abakanowicz invented the spirograph between 1881 and 1900.[1] It was used to calculate an area delimited by curves. A hypotrochoid is generated by a fixed point on a circle rolling inside a fixed circle.[2] It consists of a small toothed wheel rotating inside or outside a ring gear. The weighing tile wheel has nine drilled holes numbered from 0–8, through these small holes the tip of a pen or pencil can be put. This causes the small wheel to rotate one or more laps around the crown and draws a hypocycloid.

The wheel can also turn off a first fixed gear, it is thus possible to draw epicycloids . The command is written as

```
\psSpirograph [Options] (x,y)
```

and can optionally be followed by the coordinates of the point where you wish to place the Spirograph: `\psSpirograph [Options] (x,y)` which by default is centered at the origin. The optional parameters, including default values are indicated as following:

1. `Z1=20`: number of teeth of the wheel 1, the crown;
2. `Z2=10`: number of teeth of the wheel 2;
3. `m=0.5`: relative size of the gear;
4. `ap=20`: pressure angle in degrees, it must be reduced if the number of teeth crown is large (if the path of the teeth will be incorrect), e.g. take `Z1=120`;
5. `holenumber=0`: active hole number;
6. `polarangle=0`: polar angle in degrees to position the center of the inner/outer gear; of the small wheel. It is a useful parameter for an animation, then it is the starting angle..
7. `thetamax=360`: the end value for the rotation of the second inside/outside gear;

There are two Boolean values for the organisation of the two circles:

- `circles`: to draw circles of contact (default is `false`.
- `inner`: the gear rotates inside of the crown (`true` — default) or outside (`false`).

In the drawing, the color selection wheel and the line of the curve is made with the following setting:

1. `color1={[rgb]{0.625 0.75 1}}`;
2. `color2={[rgb]{0.75 1 0.75}}`;
3. `curvecolor=red` ;
4. `curvewidth=1pt`: linewidth of the hypocycloid;
5. `circlescolor=red` .

The origin of the spirograph can be set by the coordinates $(x, y)$. If the they are missing, $(0, 0)$ is assumed. By default, the wheels are not filled with color. The color inside the wheels must be set by the option `fillStyle=solid` .

1 http://en.wikipedia.org/wiki/Spirograph
2 http://mathworld.wolfram.com/Spirograph.html

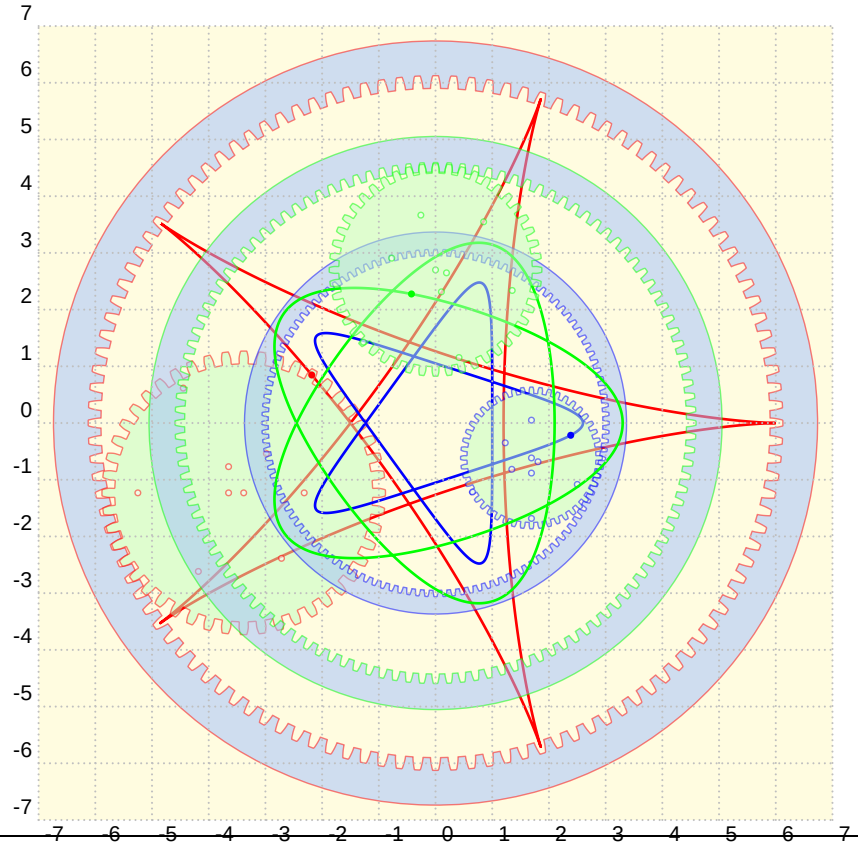
The choice of color and line thickness contour of the wheels is made with usual PSTricks options: `linecolor` and `linewidth`. The transparency of the small wheel is adjusted with the `opacity` option of PSTricks.

The last parameter is the angle `thetamax=360`, which represents the rotation in degrees the center of the small wheel around the ring, so it is a parameter to adjust, depending on the planned route of the hypocycloid.

# 2 Parameter

## 2.1 Relative size

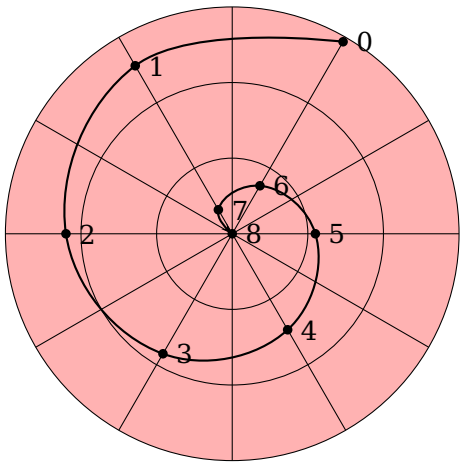
The relative size of the two gears can be set by the optional argument `m`, which can take every possible value.

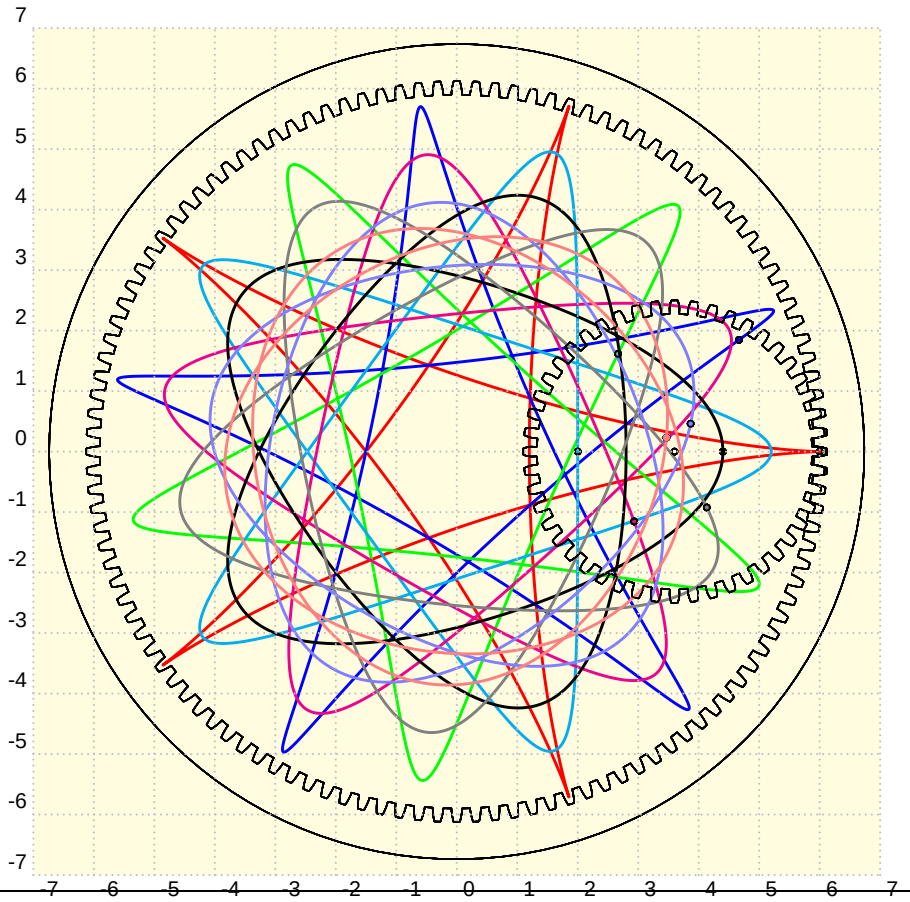



```
\psset{unit=0.75}
\begin{pspicture}[showgrid=top,opacity=0.5](-7,-7)(7,7)
\psframe*[linecolor=yellow!30](-7,-7)(7,7)
\psset{thetamax=720,Z1=120,Z2=48,ap=10,linewidth=0.025,fillstyle=solid}
\psSpirograph[m=0.1,polarangle=200,holenumber=0,linecolor=red]
\psSpirograph[m=0.05,polarangle=340,holenumber=3,curvecolor=blue,linecolor=blue]
\psSpirograph[m=0.075,polarangle=90,holenumber=6,curvecolor=green,linecolor=green]
\end{pspicture}
```

## 2.2 Pencil position

The holes (`holenumber`) for the pencil are ordered from outside into the center of the gear with different polar coordinates (radius and angle) . They are numbered from 0 to 8 and the position cannot be changed. Every given number greater than 8 will be reset internally to 8.

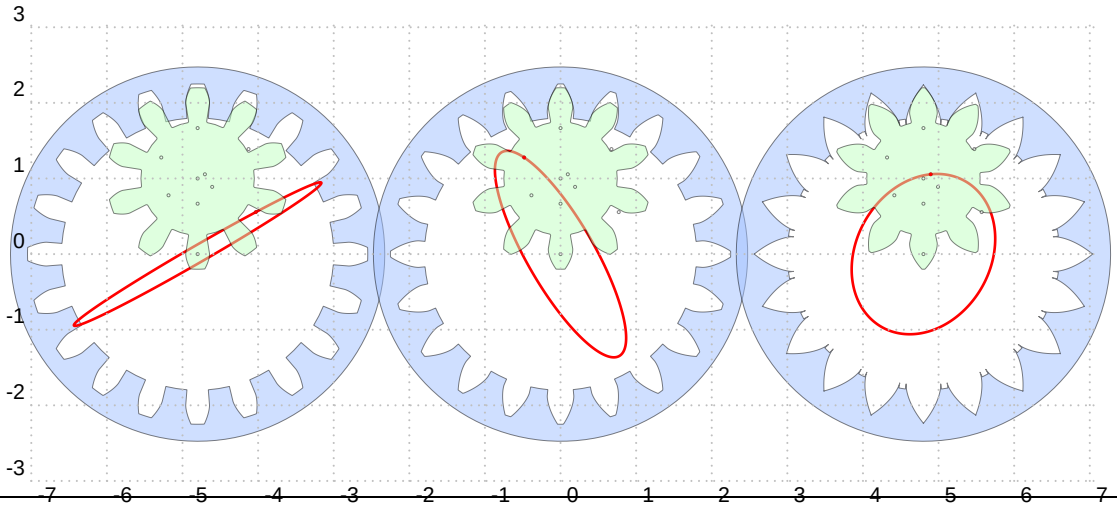





```
\psset{unit=0.8cm}
\begin{pspicture}[showgrid=top,opacity=0.5](-7,-7)(7,7)
\psframe*[linecolor=yellow!30](-7,-7)(7,7)
\psset{thetamax=720,Z1=120,Z2=48,m=0.1,ap=10,linewidth=0.025,curvewidth=1.1pt}
\psSpirograph[holenumber=0]
\psSpirograph[holenumber=1,curvecolor=blue] \psSpirograph[holenumber=2,curvecolor=green]
\psSpirograph[holenumber=3,curvecolor=cyan] \psSpirograph[holenumber=4,curvecolor=magenta]
\psSpirograph[holenumber=6,curvecolor=black] \psSpirograph[holenumber=5,curvecolor=black!50]
\psSpirograph[holenumber=7,curvecolor=blue!50]\psSpirograph[holenumber=8,curvecolor=red!50]
\end{pspicture}
```

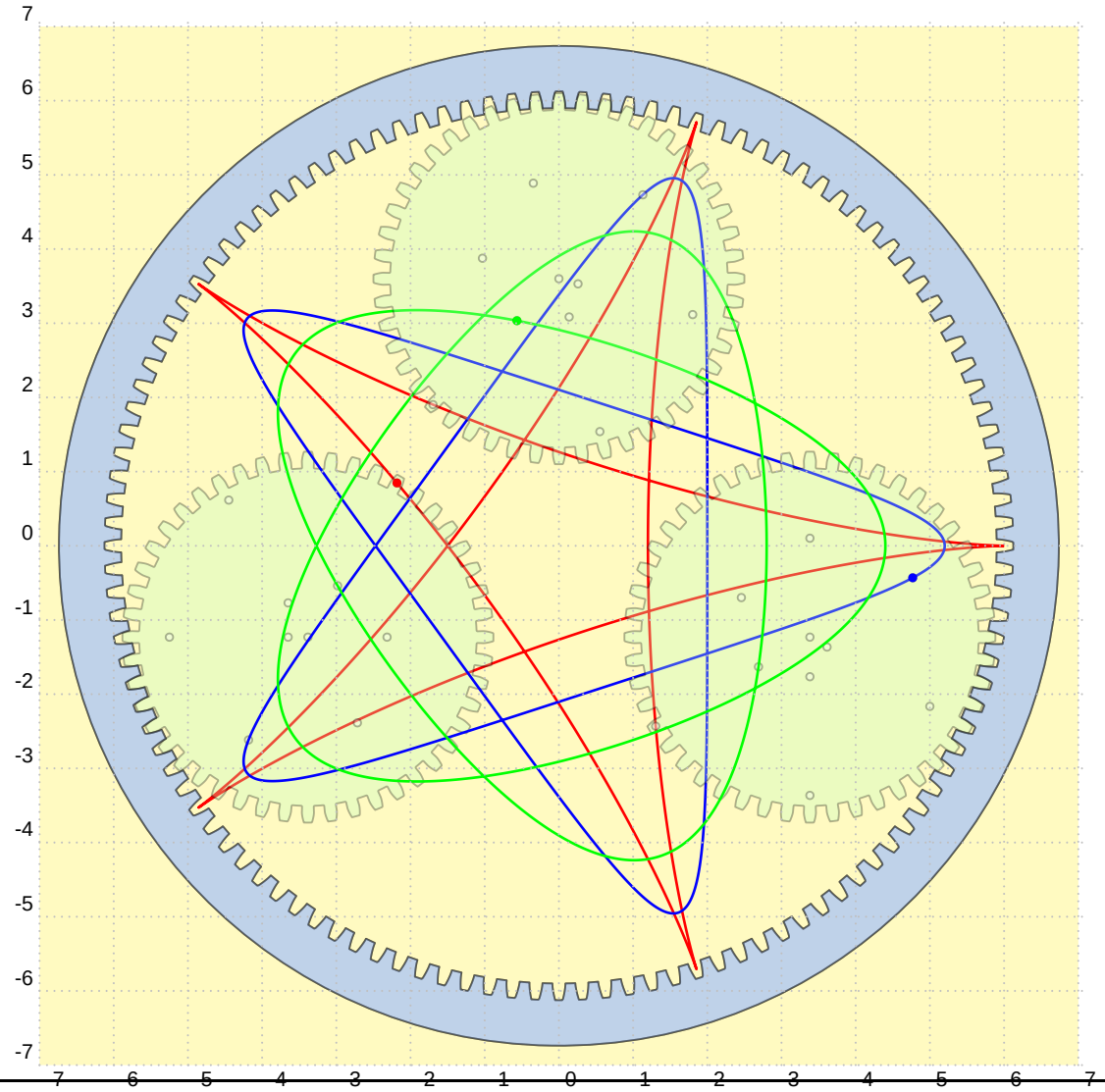
## 2.3 Pressure Angle

This value defines the look of a “teeth”. Values greater than 30 make no real sense.

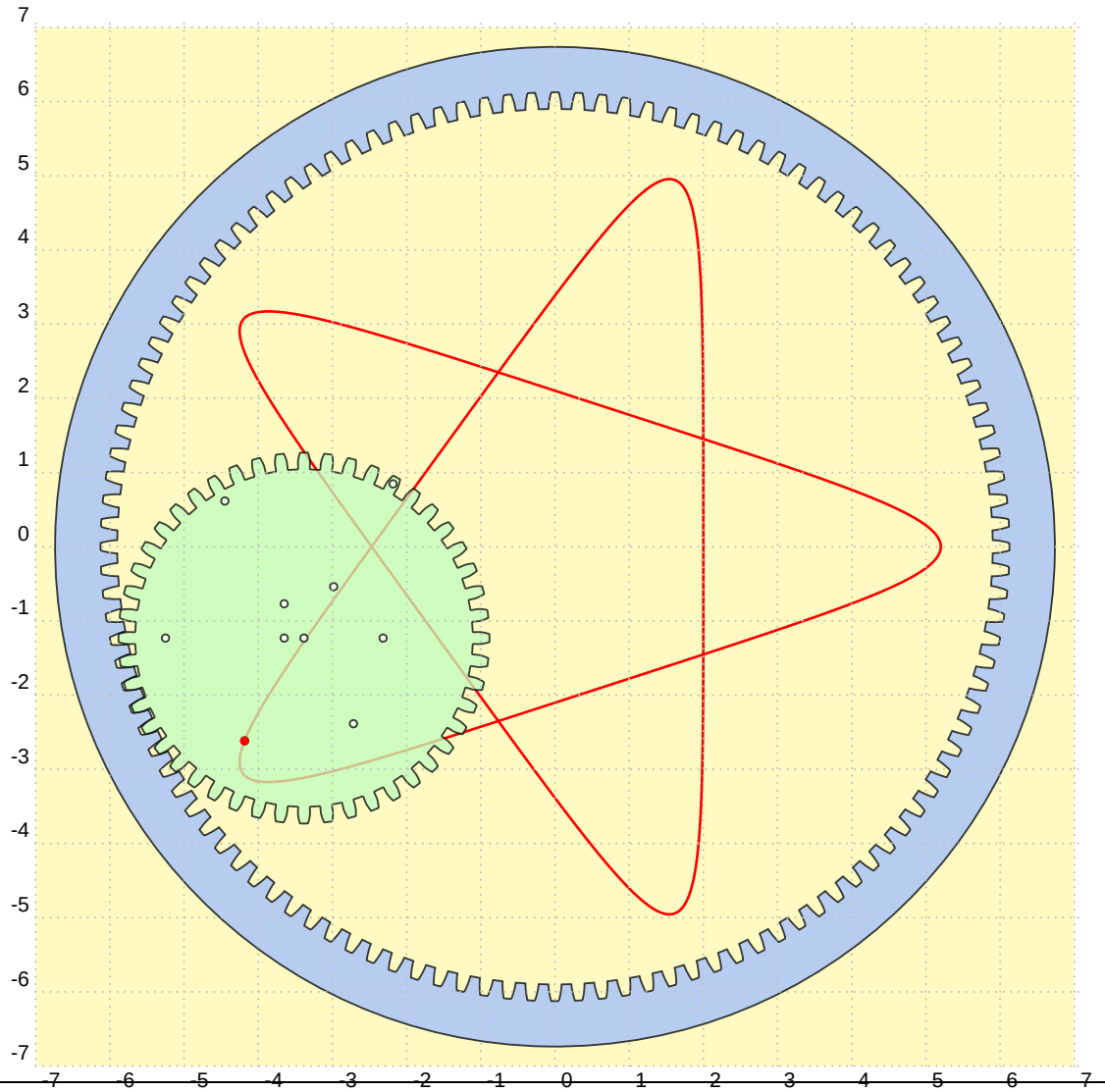



```
\begin{pspicture}[showgrid=top,opacity=0.5](-7,-3)(7,3)
\psset{unit=0.4,linewidth=0.025,fillstyle=solid,polarangle=90}
\psSpirograph[ap=0](-12,0)
\psSpirograph[ap=20, holenumber=4](0,0)
\psSpirograph[ap=30, holenumber=8](12,0)
\end{pspicture}
```

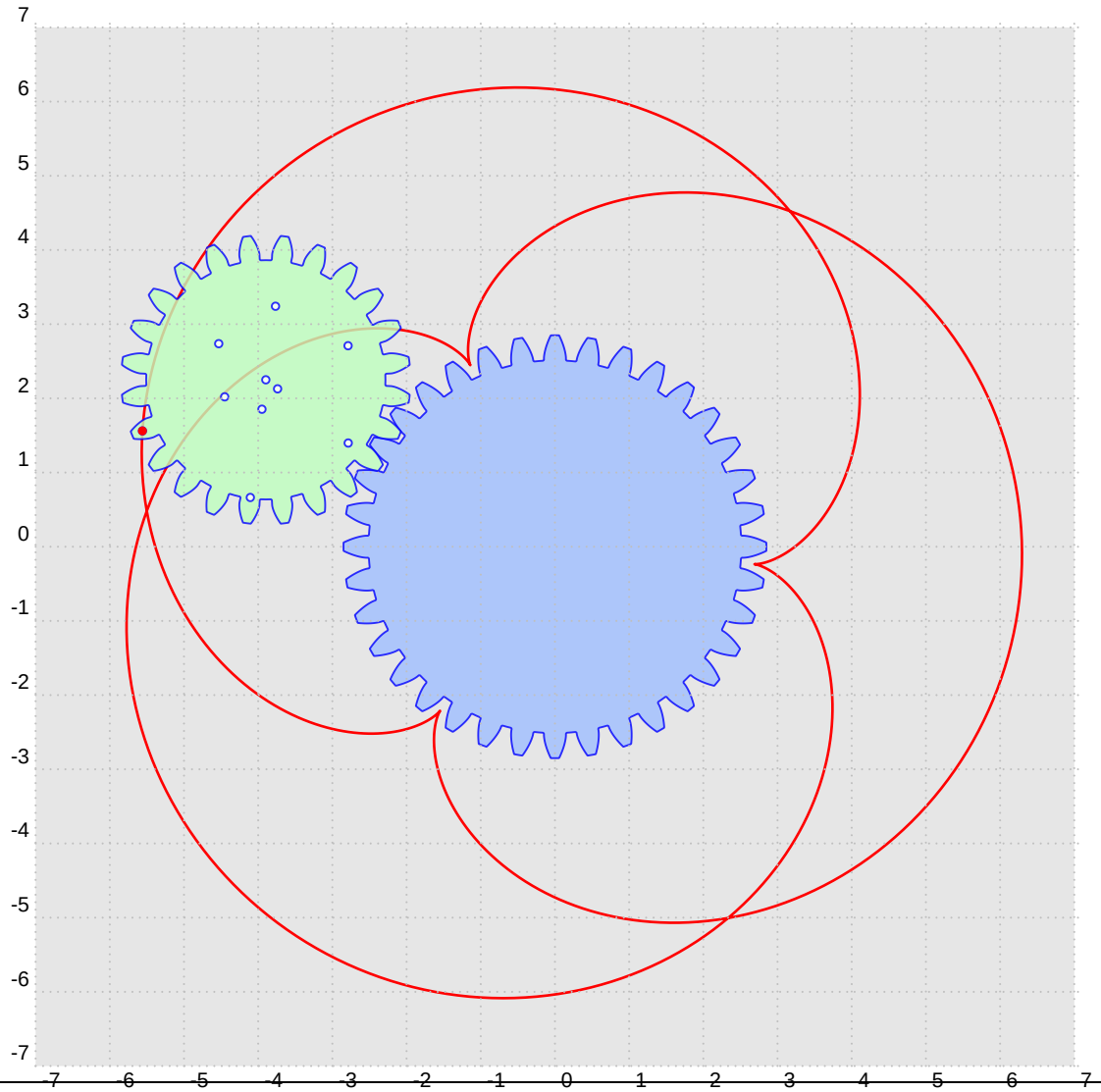
# 3 Examples



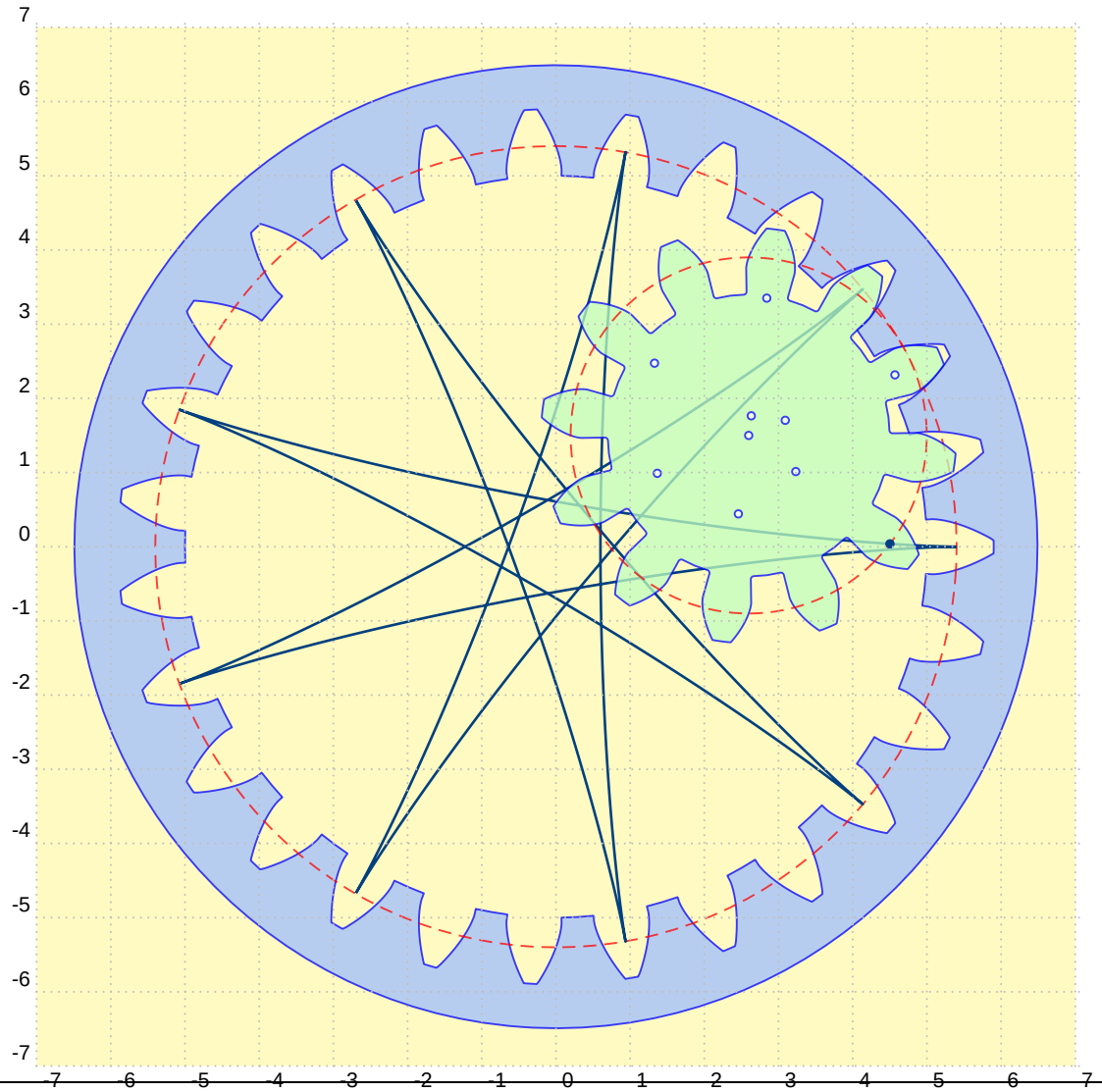

```
\begin{pspicture}[showgrid=top](-7,-7)(7,7)
\psframe*[linecolor=yellow!30](-7,-7)(7,7)
\psSpirograph[thetamax=720,Z1=120,Z2=48,m=0.1,ap=10,linewidth=0.025,
   fillstyle=solid,polarangle=200,holenumber=0,opacity=0.3]
\psSpirograph[thetamax=720,Z1=120,Z2=48,m=0.1,ap=10,linewidth=0.025,
   fillstyle=solid,polarangle=340,holenumber=3,opacity=0.3,curvecolor=blue]
\psSpirograph[thetamax=720,Z1=120,Z2=48,m=0.1,ap=10,linewidth=0.025,
   fillstyle=solid,polarangle=90,holenumber=6,opacity=0.3,curvecolor=green]
\end{pspicture}
```



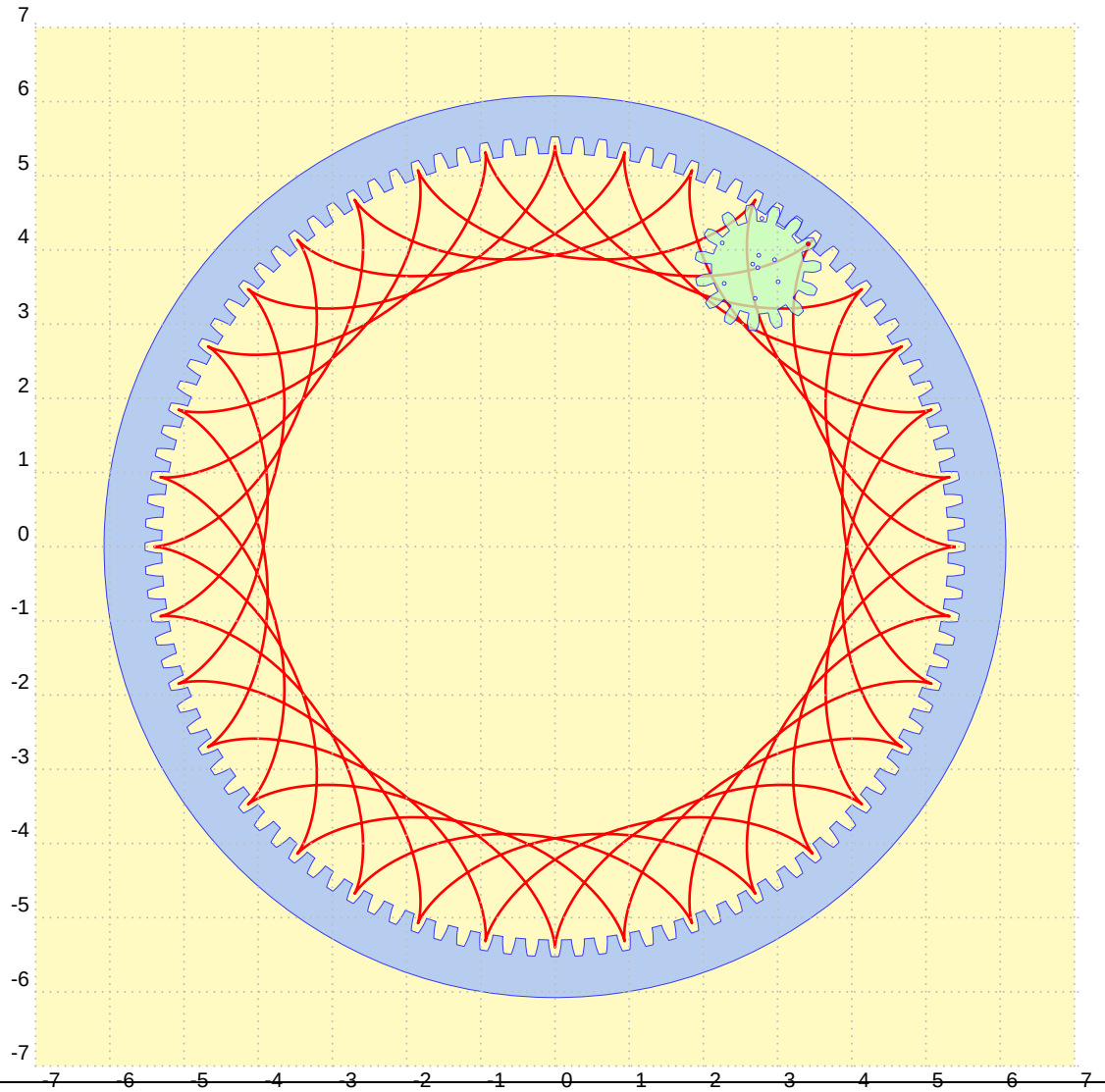

```
\begin{pspicture}[showgrid=top](-7,-7)(7,7)
\psframe*[linecolor=yellow!30](-7,-7)(7,7)
\psSpirograph[thetamax=720,Z1=120,Z2=48,m=0.1,ap=10,linewidth=0.025,
          fillstyle=solid,polarangle=200,holenumber=3,opacity=0.75]
\end{pspicture}
```



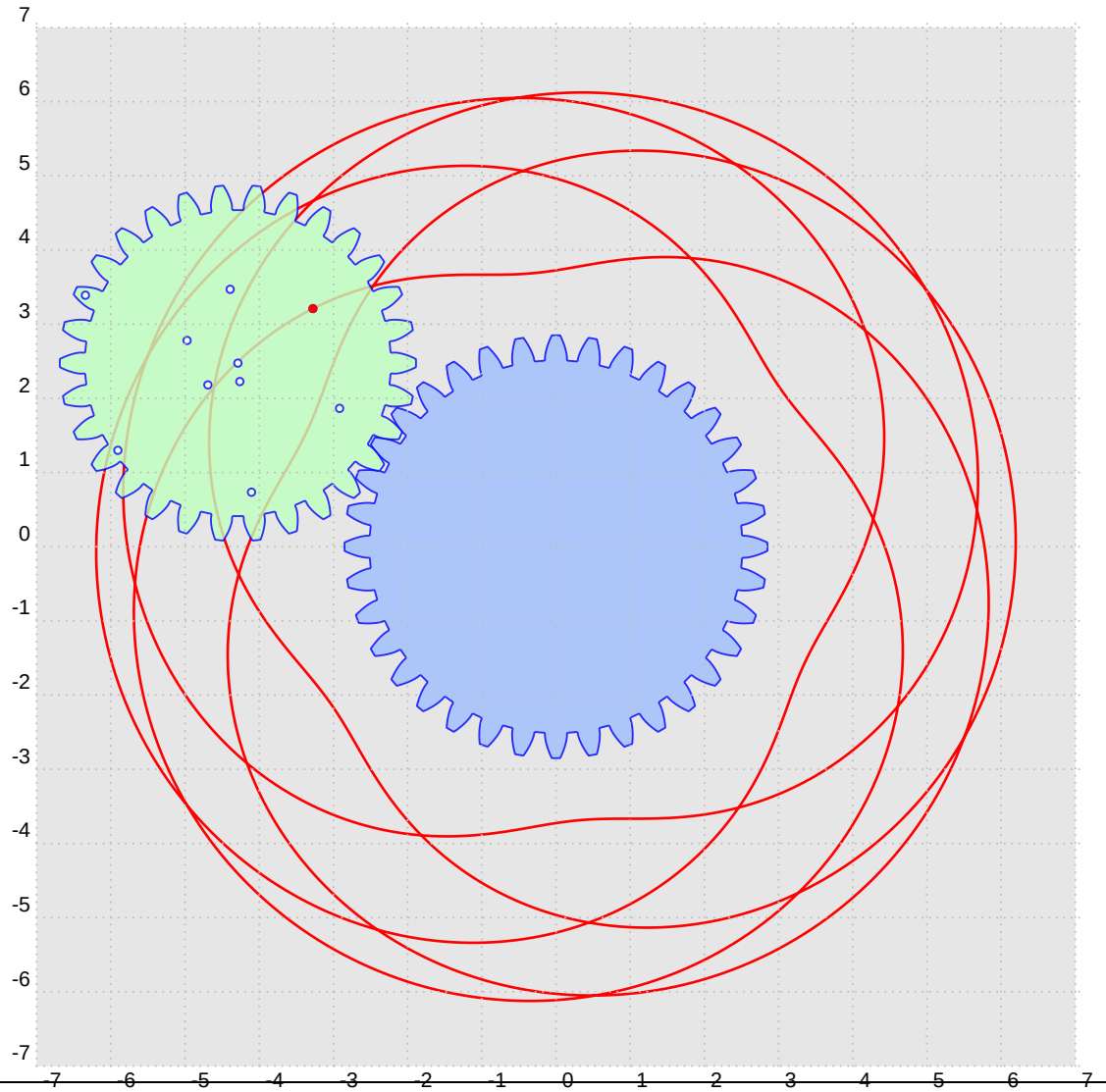

```
\begin{pspicture}[showgrid=top](-7,-7)(7,7)
\psframe*[linecolor=gray!20](-7,-7)(7,7)
\psSpirograph[thetamax=720,Z1=36,Z2=24,m=0.15,linewidth=0.025,ap=20,inner=false,
  fillstyle=solid,polarangle=150,linecolor=blue,holenumber=0,opacity=0.8]
\end{pspicture}
```




```
\begin{pspicture}[showgrid=top](-7,-7)(7,7)
\psframe*[linecolor=yellow!30](-7,-7)(7,7)
\psSpirograph[thetamax=1440,Z1=27,Z2=12,m=0.4,linewidth=0.025,
  curvecolor={[rgb]{0 0.25 0.5}},circles,fillstyle=solid,polarangle=30,
  linecolor=blue,holenumber=0,opacity=0.75]
\end{pspicture}
```



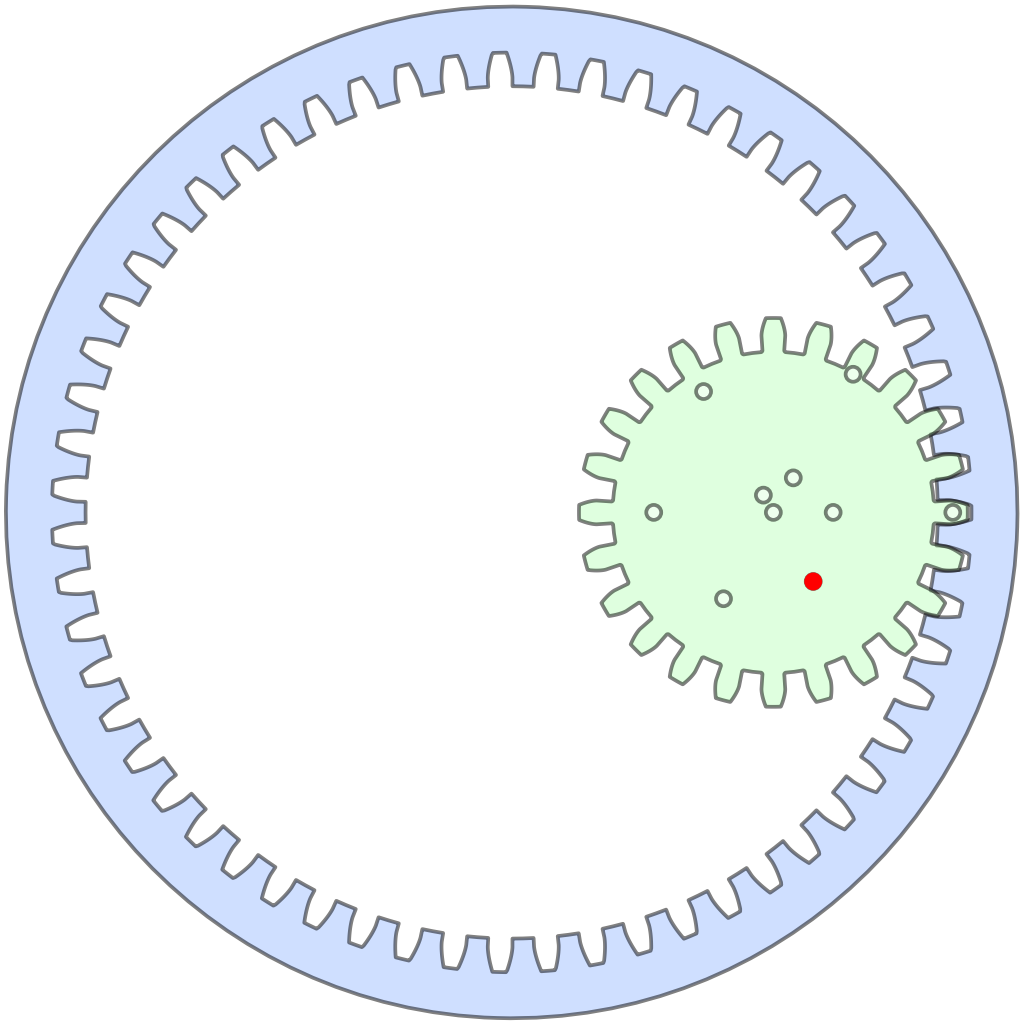

```
\begin{pspicture}[showgrid=top](-7,-7)(7,7)
\psframe*[linecolor=yellow!30](-7,-7)(7,7)
\psset{unit=0.5}
\psSpirograph[thetamax=-1800,Z1=108,Z2=15,m=0.2,linewidth=0.025,ap=10,
  fillstyle=solid,polarangle=54,linecolor=blue,holenumber=0,opacity=0.75]
\end{pspicture}
```




```
\begin{pspicture}[showgrid=top](-7,-7)(7,7)
\psframe*[linecolor=gray!20](-7,-7)(7,7)
\psSpirograph[thetamax=1800,Z1=36,Z2=30,m=0.15,linewidth=0.025,ap=20,inner=false,
  fillstyle=solid,polarangle=150,linecolor=blue,holenumber=4,opacity=0.8]
\end{pspicture}
```

# 4 Animations

With package `animate` one can easily create animations. You get a better result with `\multiframe{360}{iA=0+4}{...}` but that increases the file size of the PDF.



```
\begin{animateinline}[
  width=0.9\linewidth,
  begin={\begin{pspicture}(-3.5,-3.5)(3.5,3.5)},
  end={\end{pspicture}},
  palindrome,controls,
% autoplay
]{5}
\multiframe{100}{iA=0+8}{%
  \psSpirograph[thetamax=\iA,Z1=59,Z2=24,m=0.1,ap=10,curvewidth=1.1pt,
    linewidth=0.025,fillstyle=solid,polarangle=\iA,holenumber=5,opacity=0.5](0,0)}
\end{animateinline}
```

There are some more examples in the documention directory of the package.

## 5 List of all optional arguments for `pst-spirograph`

| Key | Type | Default |
|---|---|---|
| Z1 | ordinary | 20 |
| Z2 | ordinary | 10 |
| m | ordinary | 0.5 |
| ap | ordinary | 20 |
| polarangle | ordinary | 0 |
| holenumber | ordinary | 1 |
| thetamax | ordinary | 360 |
| color1 | ordinary | [rgb]{0.625 0.75 1} |
| color2 | ordinary | [rgb]{0.75 1 0.75} |
| circlescolor | ordinary | red |
| curvecolor | ordinary | red |
| curvewidth | ordinary | 1pt |
| inner | boolean | true |
| circles | boolean | true |

## References


[1] Victor Eijkhout. *TEX by Topic – A TEXnician Reference*. DANTE – lehmanns media, Heidelberg/Berlin, 1 edition, 2014.

[2] Denis Girou. Présentation de PSTricks. *Cahier GUTenberg*, 16:21–70, April 1994.

[3] Michel Goosens, Frank Mittelbach, Sebastian Rahtz, Dennis Roegel, and Herbert Voß. *The LATEX Graphics Companion*. Addison-Wesley Publishing Company, Boston, Mass., second edition, 2007.

[4] Nikolai G. Kollock. *PostScript richtig eingesetzt: vom Konzept zum praktischen Einsatz*. IWT, Vaterstetten, 1989.

[5] Herbert Voß. *LATEX Referenz*. DANTE – lehmanns media, Heidelberg/Hamburg, 2. edition, 2010.

[6] Herbert Voß. *PSTricks – Grafik für TEX und LATEX*. DANTE – lehmanns media, Heidelberg/Berlin, 6 edition, 2010.

[7] Herbert Voß. *LATEX Quick Reference*. UIT, Cambridge/UK, 1. edition, 2011.

[8] Herbert Voß. *PSTricks – Graphics for LATEX*. UIT, Cambridge/UK, 1. edition, 2011.

[9] Timothy Van Zandt. *multido.tex - a loop macro, that supports fixed-point addition*. CTAN:/macros/generic/multido.tex, 1997.

[10] Timothy Van Zandt and Denis Girou. Inside PSTricks. *TUGboat*, 15:239–246, September 1994.

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