

pst-diffraction

Diffraction patterns for diffraction from circular, rectangular and triangular apertures;
v.2.04a

Manuel Luque

Herbert Voß

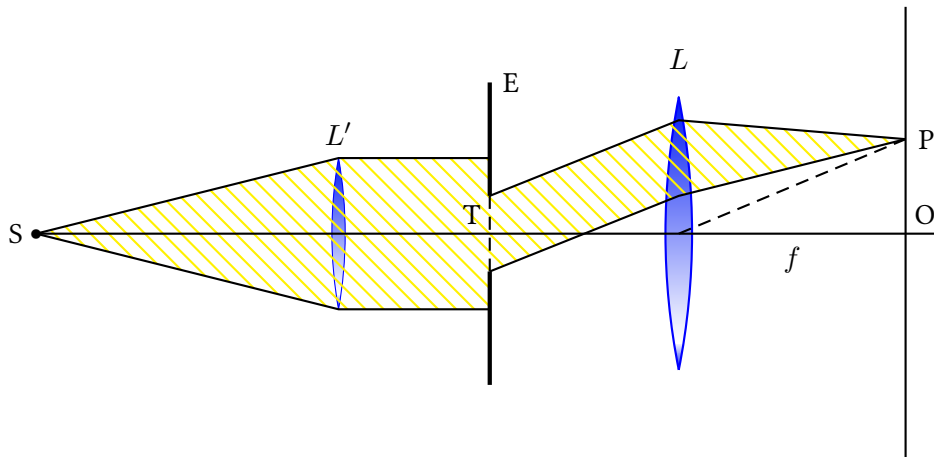
June 29, 2024

Contents

1	Optical setup	2
2	The color	2
3	Diffraction from a rectangular aperture	3
4	Diffraction from two rectangular apertures	5
5	Diffraction from a circular aperture	6
6	Diffraction from two circular apertures	6
7	Diffraction from a triangular aperture	8
8	List of all optional arguments for <code>pst-diff</code>	10
	References	10

Thanks to: Julien Cubizolles, Doris Wagner, Timothy Van Zandt, Keno Wehr, Michael Zedler.

1 Optical setup



Monochromatic light rays diverging from the focal point S of a positive lens L' emerge parallel to the axis and strike the aperture stop E with the aperture T . The light bends behind the aperture, this bending is called diffraction: Every point in the opening acts as if it was a point source (Huygens's principle) and the light waves of all those points overlap and produce an interference pattern (diffraction pattern) on a screen. When the screen is very far away, the observed patterns are called Fraunhofer diffraction patterns. In this case one can assume that the rays from the aperture striking the same point P on the screen are parallel.

In practice one wants to realize a short distance between the aperture stop and the screen. Hence one sets up a converging lens L after the opening and installs the screen into the focal plane (containing the points P and O) of this lens. Parallel rays incident on the lens are then focused at a point P in the focal plane.

With the following PSTricks-commands we can draw the diffraction patterns for different geometric forms of apertures. It is understood that only monochromatic light is used. The aperture stops can have rectangular, circular or triangular openings.

The options available are the dimensions of the aperture under consideration and of the particular optical setting, e.g. the radius in case of an circular opening. Moreover one can choose the wavelength of the light (the associated color will be given automatically by the package).

There are three commands, for rectangular, circular and triangular openings respectively:

```
\psdiffractionRectangle [Options]
\psdiffractionCircular [Options]
\psdiffractionTriangle [Options]
```

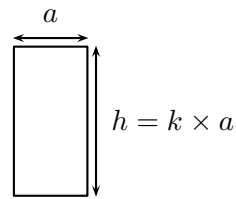
2 The color

The desired color is defined by specifying the associated wavelength λ (in nanometers). Red for instance one gets by the option `lambda=632` because red light has the wavelength $\lambda_{\text{rot}} = 632 \text{ nm}$.

The conversion of the wavelength into the associated RGB-value is done by PostScript. The code is similar to the code of a FORTRAN program which can be found here:

<http://www.midnightkite.com/color.html>

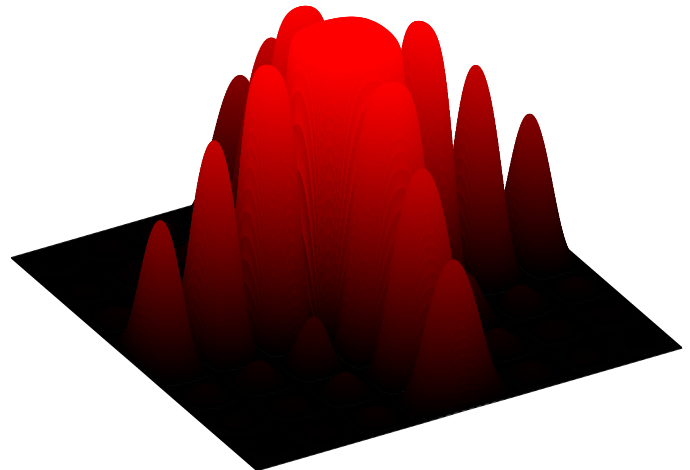
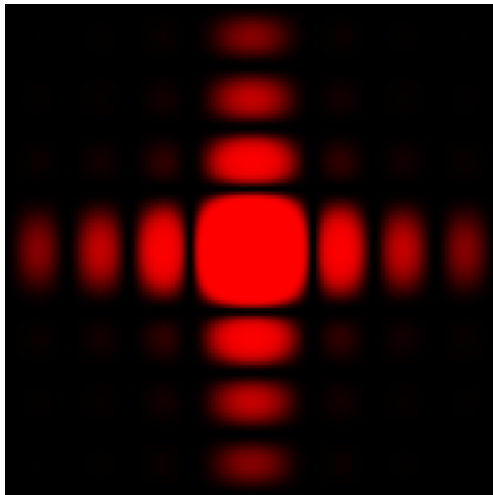
3 Diffraction from a rectangular aperture



The width of the rectangle with the area $h = k \times a$ is defined by the letter a , the height by k . The focal length is specified by f , the desired resolution in pixels [pixel]. With the option `contrast` one can improve the visibility of the minor secondary maxima more. We get a black and white picture if we use the option `colorMode=0`, the option `colorMode=1` provides the associated negative pattern. The options `colorMode=2` and `colorMode=3` render color pictures in the CMYK and RGB color model respectively.

By default the settings are as follows:

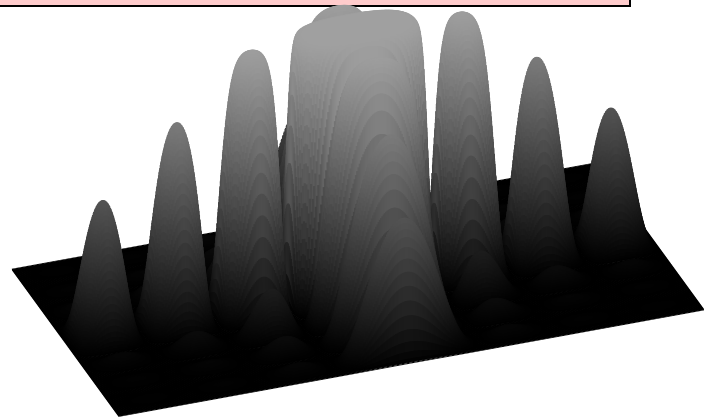
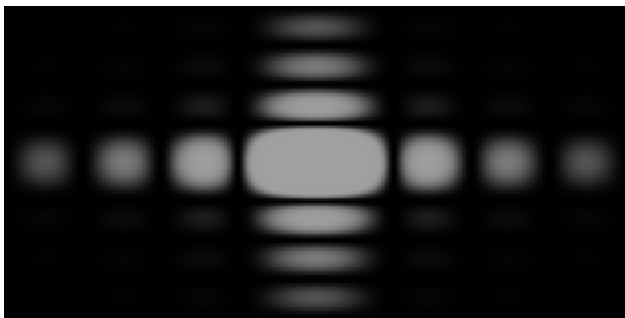
`a=0.2e-3 in m;` `k=1;` `f=5 in m;`
`lambda=650 in nm;` `pixel=0.5;` `contrast=38, greatest value;`
`colorMode=3;` `IIID=false.`



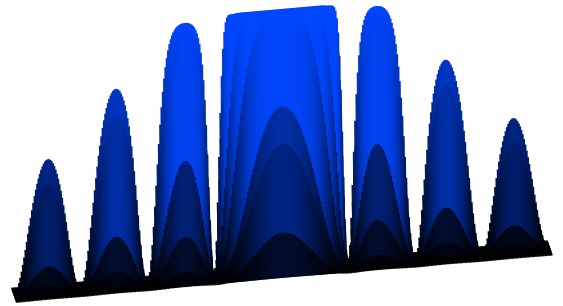
```
\begin{pspicture}(-3.5,-3.5)(3.5,3.5)
\psdiffractionRectangle[f=2.5]
\end{pspicture}
\hfill
\begin{pspicture}(-1.5,-2.5)(3.5,3.5)
\psdiffractionRectangle[IIID,Alpha=30,f=2.5]
\end{pspicture}
```



```
\begin{pspicture}(-2,-4)(2,4)
\psdiffractionRectangle[a=0.5e-3,k=0.5,f=4,pixel=0.5,colorMode=0]
\end{pspicture}
\hfill
\begin{pspicture}(0,-3)(4,4)
\psdiffractionRectangle[IIID,a=0.5e-3,k=0.5,f=4,pixel=0.5,colorMode=0]
\end{pspicture}
```



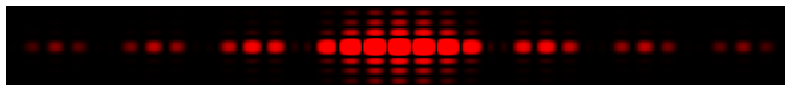
```
\begin{pspicture}(-2.5,-2.5)(3.5,3)
\psdiffractionRectangle[a=0.5e-3,k=2,f=10,lambda=515,colorMode=1]
\end{pspicture}
\hfill
\begin{pspicture}(-1.5,-2)(3.5,3)
\psdiffractionRectangle[IIID,Alpha=20,a=0.5e-3,k=2,f=10,lambda=515,colorMode=1]
\end{pspicture}
```



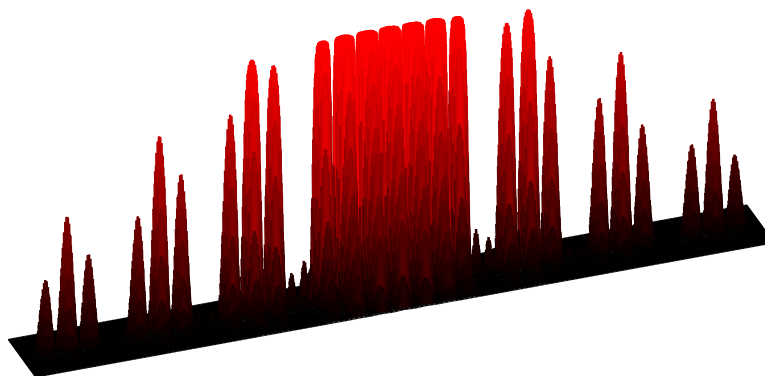
```
\begin{pspicture}(-3.5,-1)(3.5,1)
\psdiffractionRectangle[a=0.5e-3,k=20,f=10,pixel=0.5,lambda=450]
\end{pspicture}
\hfill
\begin{pspicture}(-3.5,-1)(3.5,4)
\psdiffractionRectangle[IIID,Alpha=10,a=0.5e-3,k=20,f=10,pixel=0.5,lambda=450]
\end{pspicture}
```

4 Diffraction from two rectangular apertures¹

It is also possible to render the diffraction pattern of two congruent rectangles (placed parallel such that their base is located on the x -axis) by using the option `twoSlit`. By default this option is deactivated. The distance of the two rectangles is specified by the option `s`. The default for `s` is $12e^{-3}$ m.



```
\begin{pspicture}(-4,-1)(4,1)
\psdiffractionRectangle[a=0.5e-3,k=10,f=10,pixel=0.5,lambda=650,twoSlit,s=2e-3]
\end{pspicture}
```

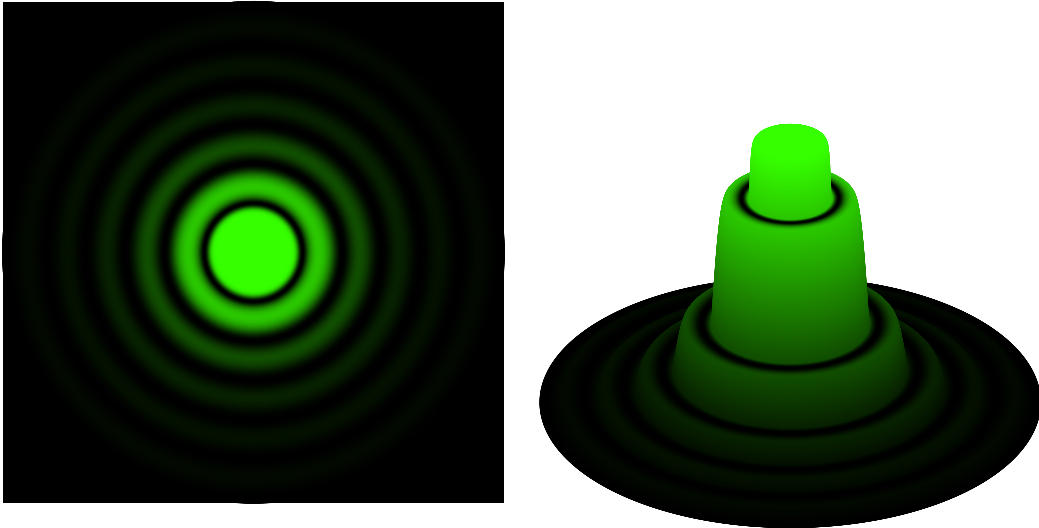


```
\begin{pspicture}(-2,-1)(4,4)
\psdiffractionRectangle[IIID,Alpha=20,a=0.5e-3,k=10,f=10,pixel=0.5,lambda=650,twoSlit,s=2e-3]
\end{pspicture}
```

¹ This simulation was provided by Julien Cubizolles.

5 Diffraction from a circular aperture

The radius of the circular opening can be chosen via the letter r , e.g. $r=1e-3$. The default is $r = 1$ mm. In the first quadrant PSTricks displays the graph of the intensity distribution (the maximum in the center will be cropped if its height exceeds the margin of the environment `pspicture*`).

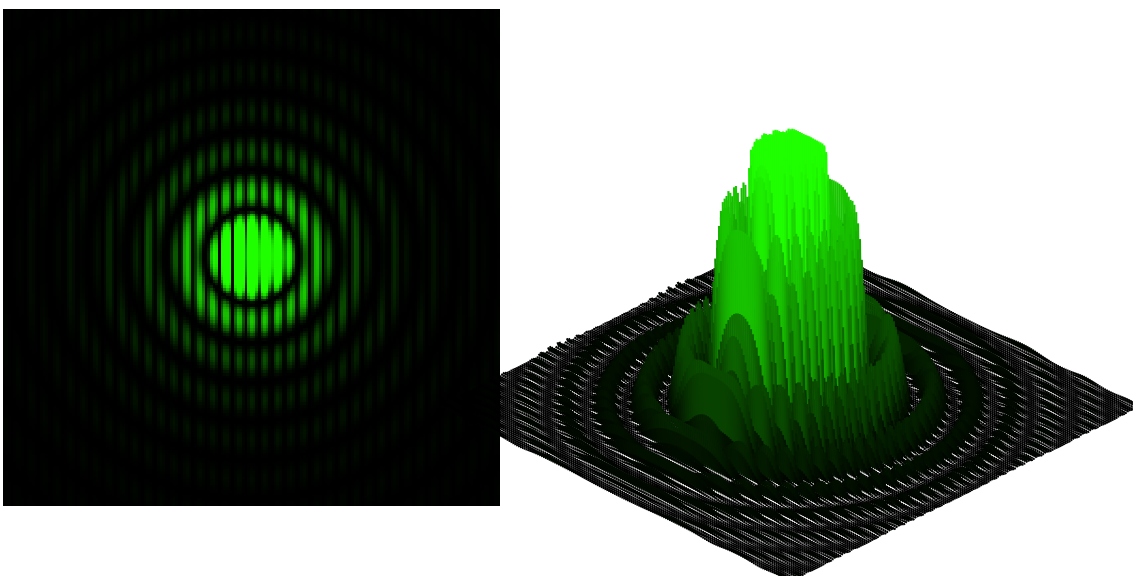


```
\begin{pspicture}(-3.5,-3.5)(3.5,3.5)
\psdiffractioCircular[r=0.5e-3,f=10,pixel=0.5,lambda=520]
\end{pspicture}
%
\begin{pspicture}(-3.5,-1.5)(3.5,3.5)
\psdiffractioCircular[IIID,r=0.5e-3,f=10,pixel=0.5,lambda=520]
\end{pspicture}
```

6 Diffraction from two circular apertures

Only the case of equal radii is provided, this common radius can be defined like in the previous section via $r=...$. Furthermore one has to give the half distance of the circles measured from their centers by $d=...$, e.g. $d=3e-3$. Also the option `twoHo1e` has to be used.

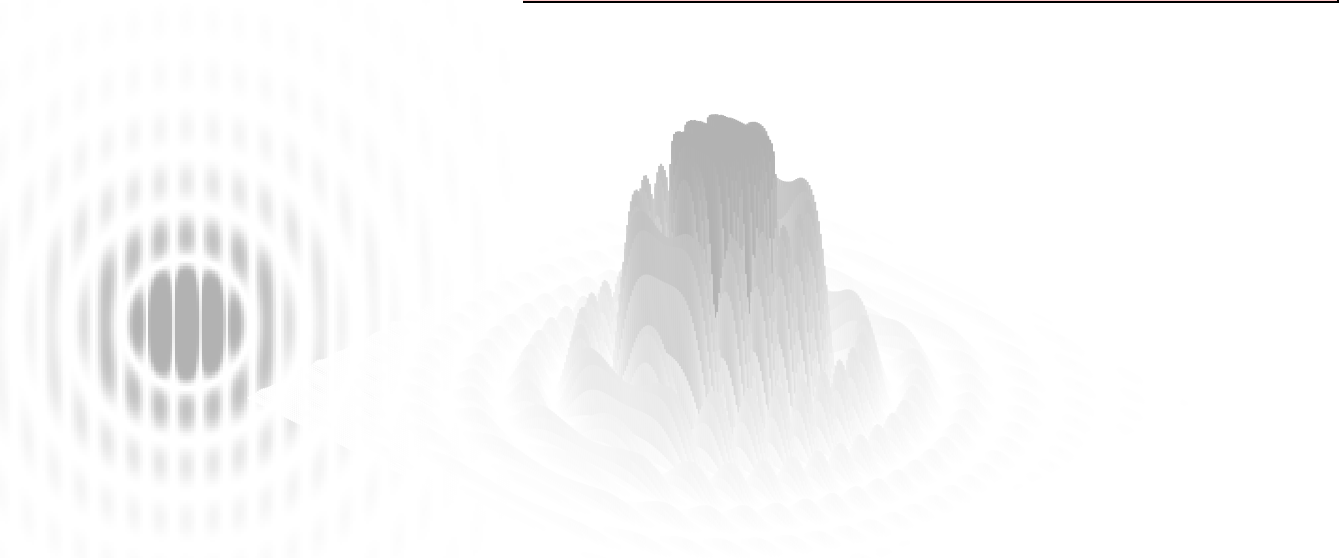
The rendering process could take some time in this case...



```

\begin{pspicture}(-3,-3.5)(3.5,3.5)
\psdiffractionCircular[r=0.5e-3,f=10,d=3e-3,lambda=515,twoHole]
\end{pspicture}
%
\begin{pspicture}(-3.5,-1.5)(3.5,3.5)
\psdiffractionCircular[IIID,r=0.5e-3,f=10,d=3e-3,lambda=515,twoHole]
\end{pspicture}

```



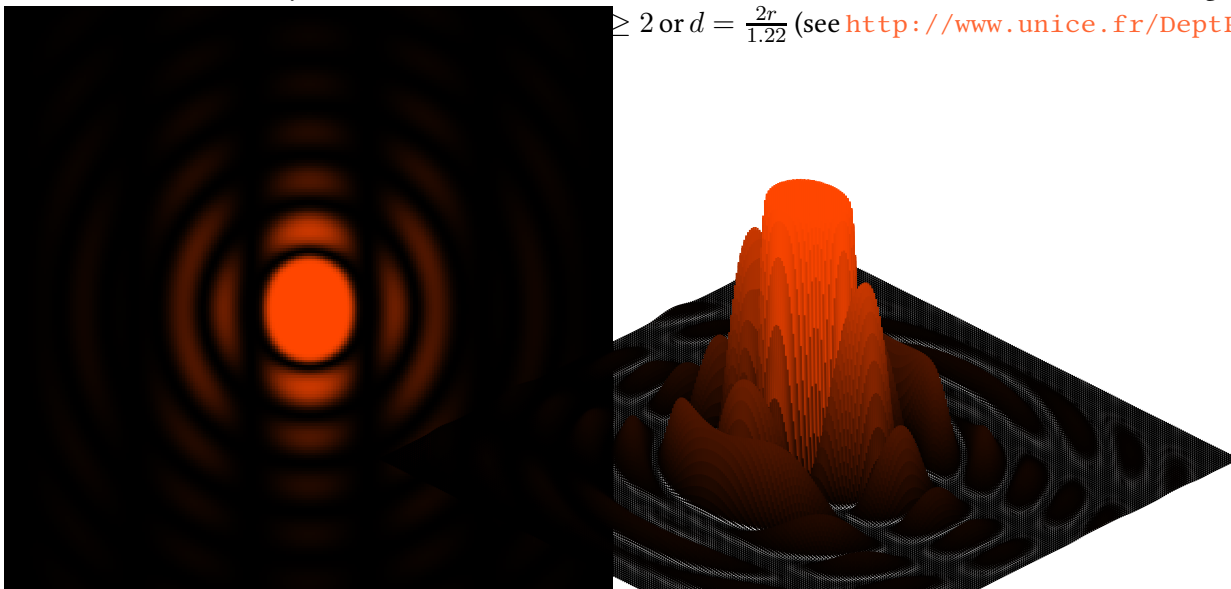
```

\begin{pspicture}(-3.5,-3)(3.5,4)
\psdiffractionCircular[r=0.5e-3,f=10,d=2e-3,lambda=700,twoHole,colorMode=0]
\end{pspicture}
%
\begin{pspicture}(-3.5,-2)(3.5,3.5)
\psdiffractionCircular[IIID,r=0.5e-3,f=10,d=2e-3,lambda=700,twoHole,colorMode=0]
\end{pspicture}

```

Not in every case bands occur in the central circle. The number N of those inner bands is given by $N = 2.44 \frac{d}{\lambda}$.

≥ 2 or $d = \frac{2r}{1.22}$ (see <http://www.unice.fr/DeptPhys/optique/diff/trou>)



```

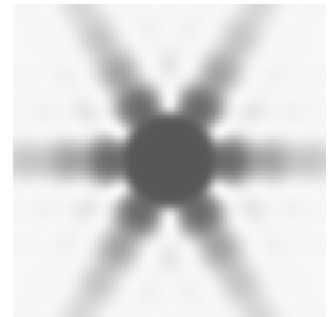
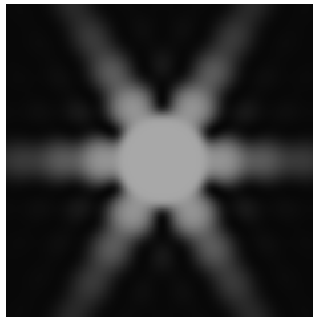
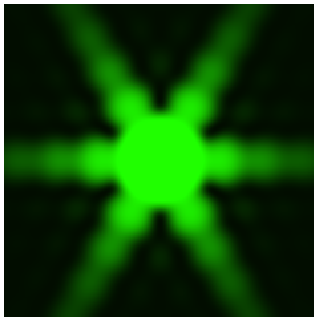
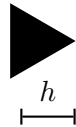
\begin{pspicture}(-3,-3.5)(3,3.5)
\psdiffractionCircular[r=0.5e-3,f=10,d=4.1e-4,lambda=632,twoHole]
\end{pspicture}
%

```

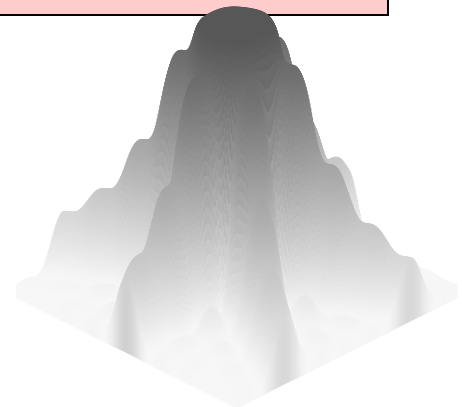
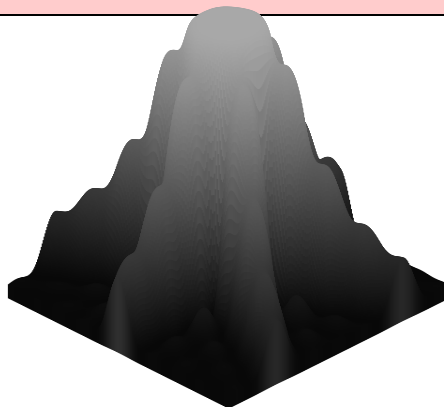
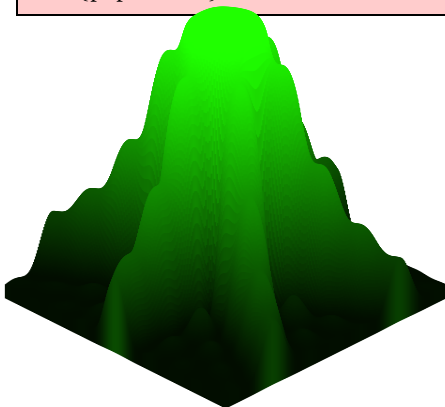
```
\begin{pspicture}(-3.5,-1.5)(3.5,3)
\psdiffractioCircular[IIID,r=0.5e-3,f=10,d=4.1e-4,lambda=632,twoHole]
\end{pspicture}
```

7 Diffraction from a triangular aperture

Only the case of an equilateral triangle is provided, whose height h has to be defined as an option. As is generally known, h can be computed from the length s of its side by $h = \frac{\sqrt{3}}{2}s$. A black and white picture can be obtained by using the option `colorMode=0`.



```
\begin{pspicture}(-3,-3)(3,2.5)
\psdiffractioTriangle[f=10,h=1e-3,lambda=515,contrast=38]
\end{pspicture}
\quad
\begin{pspicture}(-3,-3)(3,2.5)
\psdiffractioTriangle[f=10,h=1e-3,colorMode=1,contrast=38,lambda=515]
\end{pspicture}
\quad
\begin{pspicture}(-3,-3)(3,2.5)
\psdiffractioTriangle[f=10,h=1e-3,colorMode=0,contrast=38,lambda=515]
\end{pspicture}
```




```
\begin{pspicture}(-3,-2)(3,3.5)
\psdiffractionTriangle[IIID,f=10,h=1e-3,lambda=515,contrast=38]
\end{pspicture}
\quad
\begin{pspicture}(-3,-2)(3,3.5)
\psdiffractionTriangle[IIID,f=10,h=1e-3,colorMode=1,contrast=38,lambda=515]
\end{pspicture}
\quad
\begin{pspicture}(-3,-2)(3,3.5)
\psdiffractionTriangle[IIID,f=10,h=1e-3,colorMode=0,contrast=38,lambda=515]
\end{pspicture}
```

8 List of all optional arguments for `pst-diff`

`pst-diff` is the short form for the keywords in the package `pst-diffraction`.

Key	Type	Default
<code>a</code>	ordinary	[none]
<code>k</code>	ordinary	[none]
<code>r</code>	ordinary	[none]
<code>d</code>	ordinary	[none]
<code>h</code>	ordinary	[none]
<code>scale</code>	ordinary	[none]
<code>s</code>	ordinary	[none]
<code>lambda</code>	ordinary	[none]
<code>f</code>	ordinary	[none]
<code>gamma</code>	ordinary	[none]
<code>pixel</code>	ordinary	[none]
<code>colorMode</code>	ordinary	[none]
<code>contrast</code>	ordinary	[none]
<code>showFunc</code>	boolean	true
<code>IIID</code>	boolean	true
<code>twoHole</code>	boolean	true
<code>twoSlit</code>	boolean	true

References

- [1] H. Bouasse and Z. Carrière. *Diffraction*. Paris: Delagrave, 1923, p. 480.
- [2] Michel Goosens et al. *The L^AT_EX Graphics Companion*. 2nd ed. Reading, Mass.: Addison-Wesley Publishing Company, 2007.
- [3] Nikolai G. Kollock. *PostScript richtig eingesetzt: vom Konzept zum praktischen Einsatz*. Vaterstetten: IWT, 1989.
- [4] Manuel Luque. *Augustin Fresnel*.
<http://melusine.eu.org/syracuse/mluque/fresnel/augustin/fresnel.html>, 2004.
- [5] George O. Reynolds et al. *The New Physical Optics Notebook Tutorials in Fourier Optics*. Society of Photo Optical, 1989. ISBN: 0819401307. URL:
<http://www.langtoninfo.co.uk/de/showitem.asp?isbn=0819401307%7D>.
- [6] Herbert Voß. “Die mathematischen Funktionen von Postscript”. In: *Die T_EXnische Komödie* 1/02 (Mar. 2002), pp. 40–47.
- [7] Herbert Voß. *PSTricks – Grafik für T_EX und L^AT_EX*. 4. Heidelberg/Hamburg: DANTE – Lehmanns, 2007.
- [8] Herbert Voß. *L^AT_EX Referenz*. 1. Heidelberg/Hamburg: DANTE – Lehmanns, 2007.
- [9] Herbert Voss. *PSTricks Support for pdf*. <http://PSTricks.de/pdf/pdfoutput.phtml>, 2002.
- [10] Michael Wiedmann and Peter Karp. *References for T_EX and Friends*.
<http://www.miwie.org/tex-refs/>, 2003.
- [11] Timothy Van Zandt. *PSTricks - PostScript macros for Generic TeX*.
<http://www.tug.org/application/PSTricks>, 1993.

Index

- a, 3
- CMYK, 3
- colorMode, 3, 8
- contrast, 3
- d, 6
- Environment
 - pspicture*, 6
- f, 3
- h, 8
- IIID, 3
- k, 3
- Keyword
 - a, 3
 - colorMode, 3, 8
 - contrast, 3
 - d, 6
 - f, 3
 - h, 8
 - IIID, 3
 - k, 3
 - lambda, 2, 3
 - pixel, 3
 - r, 6
 - twoHole, 6
 - twoSlit, 5
- lambda, 2, 3
- Macro
 - \psdiffractionCircular, 2
 - \psdiffractionRectangle, 2
 - \psdiffractionTriangle, 2
- Package
 - pst-diffraction, 10
- Package option
 - pst-diff, 10
- pixel, 3
- \psdiffractionCircular, 2
- \psdiffractionRectangle, 2
- \psdiffractionTriangle, 2
- pspicture*, 6
- pst-diff, 10
- pst-diffraction, 10
- r, 6
- RGB, 3
- twoHole, 6
- twoSlit, 5