Geometric Optics application - short guide

Introduction

GeometricOptics is a collection of packages related to optical system's design as illustrated in the book "Geometric Optics" by Antonio Romano, Roberto Cavaliere.
The whole application is composed of a main package called GeometricOptics and additional packages, combined with different chapters of the book.
Here is a full list of packages (in alphabetical order):

- BakerSchmidtCameraCP (Baker-Schmidt camera with conic primary)
- BakerSchmidtCameraSM (Baker-Schmidt camera with spherical mirrors)
- BuchroederCamera (Buchroeder Camera)
- CassegrainCombination (Cassegrain combinations)
- Fraunhofer (Fraunhofer's doublet)
- HoughtonCamera (Houghton Camera)
- HoughtonCassegrain (Houghton-Cassegrain)
- HoughtonCassegrainC (Houghton-Cassegrain with corrector at the prime focus)
- KlevtsovTelescope (Klevtsov Combination)
- MaksutovCamera (Maksutov Camera)
- MaksutovCassegrain (Maksutov-Cassegrain Telescope)
- SchmidtCamera (Schmidt Camera)
- SchmidtCassegrainCAfter (Schmidt-Cassegrain Telescope with a corrector after the Cassegrain combination)
- SchmidtCassegrainCBefore (Schmidt-Cassegrain Telescope with a corrector in front of the Cassegrain combination)
- SchmidtCassegrainCBeforeSM (Schmidt-Cassegrain Telescope with a corrector after Cassegrain combination and spherical mirrors)
- Triplet (Triplet)
- WrightCamera (Wright Camera)

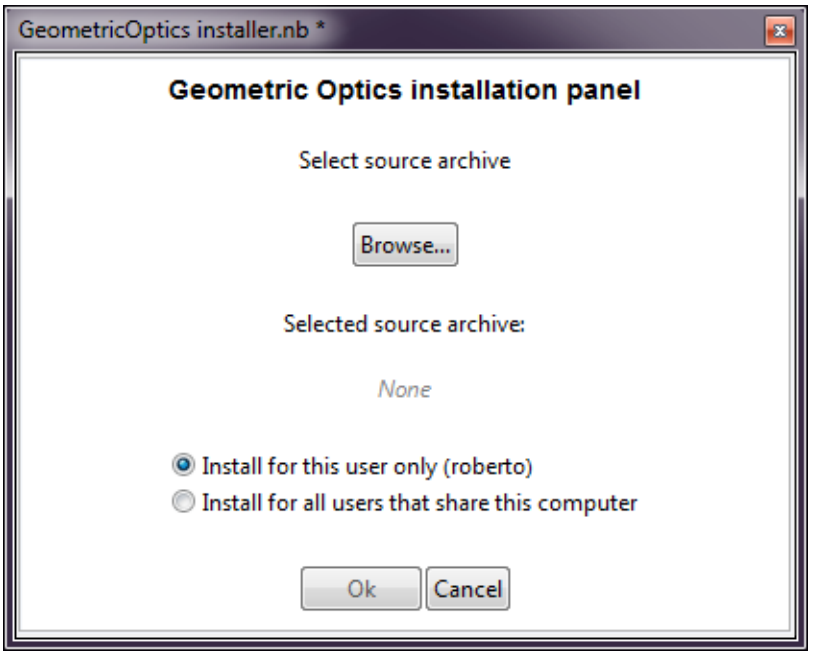
The main package defines the function TotalAberrations, an auxilliary function called by all packages, which can also be used as stand alone function to calculate aberrations. See examples provided in the notebook TotalAberration in \GeometricOptics\TotalAberrations

Installation

To run the application you need *Mathematica* 11 (or later) installed on your computer (it should also work on *Mathematica* 10.x as well).

The package has an installer notebook. Open the file “GeometricOptics installer.nb”.
In order to install the package you need to keep the zipped archive as downloaded.

Open *Mathematica* and then open the installer. It shows a dialog window like the following



First, using the “Browse...” button do select the zipped archive from where you want to installa the application. Note that if you already have some packages installed, this process will not cancel the existing folders. It only adds new packages.

When you have selected the archive, you have to define where you want to install the application. There are two possiblity:

- **Install for this user only** if you want the application be available only the for current logged user
- **Install for all users that share this computer**, to make the application available to all users.

  In the first case the installation folder is given by the variable $UserBaseDirectory and the full path will be

```
FileNameJoin[{$UserBaseDirectory, "Applications", "GeometricOptics"}]
```

```
C:\Users\roberto\AppData\Roaming\Mathematica\Applications\GeometricOptics
```

  To check the content of that folder run the command

```
SystemOpen[FileNameJoin[{$UserBaseDirectory, "Applications"}]]
```

  In the second case, the installation folder will start from $BaseDirectory and will be

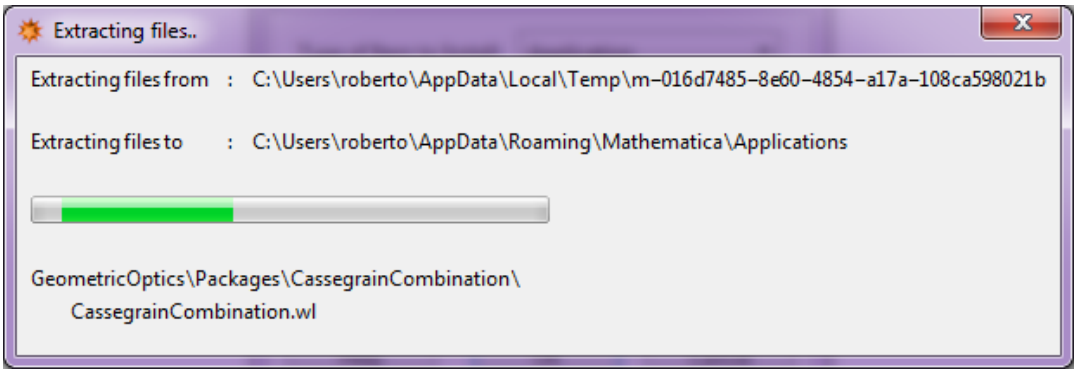
```
FileNameJoin[{$BaseDirectory, "Applications", "GeometricOptics"}]
```

```
C:\ProgramData\Mathematica\Applications\GeometricOptics
```

  To check the content of that folder run the command

```
SystemOpen[FileNameJoin[{$BaseDirectory, "Applications"}]]
```

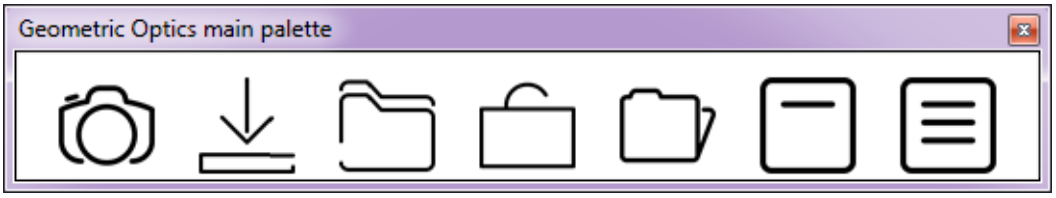
  When you have done all needed selections, click “OK” and an installation progress window will appear, like the following



  wait until it ends and then the software is fully installed and ready to be used.

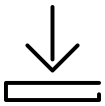
How to use the main package functionalities

Once you have installed the package, to check that the installation is completed and successfully, restart *Mathematica* and into the menu "Palettes" you should see an item named "Geometric Optics main palette". Click on it and it opens the palette like the following



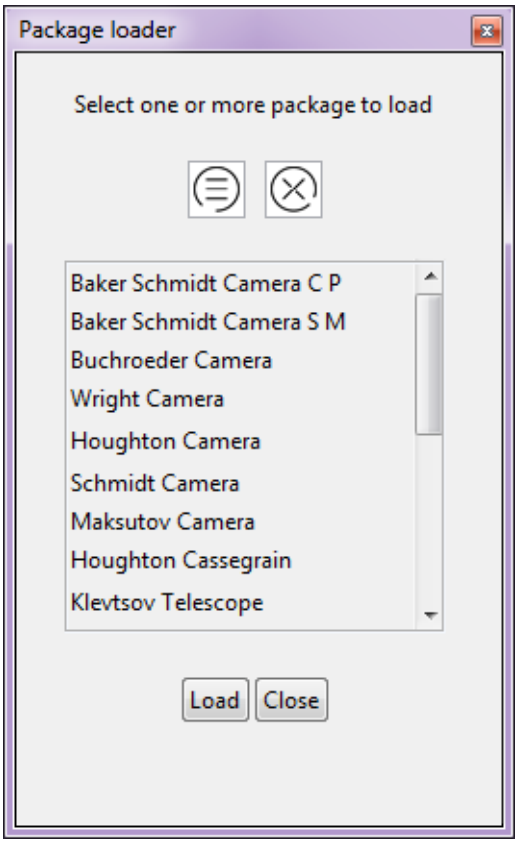
Here is a brief description of each function

This button loads the main GeometricOptics package and all packages installed. Use it to start a working session with all GeometricOptics functions



This button let's you to select one or more packages to load. If you already loaded the main package with the  button you don't need to use this one.

Is opens a dialog window like the following



The two icons have the following meaning

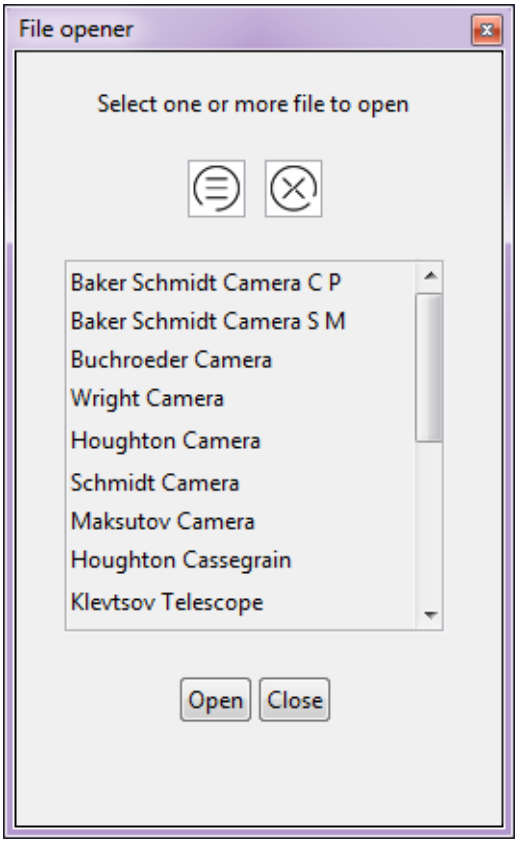
This first button let's you to select all available package from the list. If you want to manually select the packages to load, hit the CTRL key while clicking

on items in the list. It's recommended to load one package at time, however multiple packages can run at the same time.

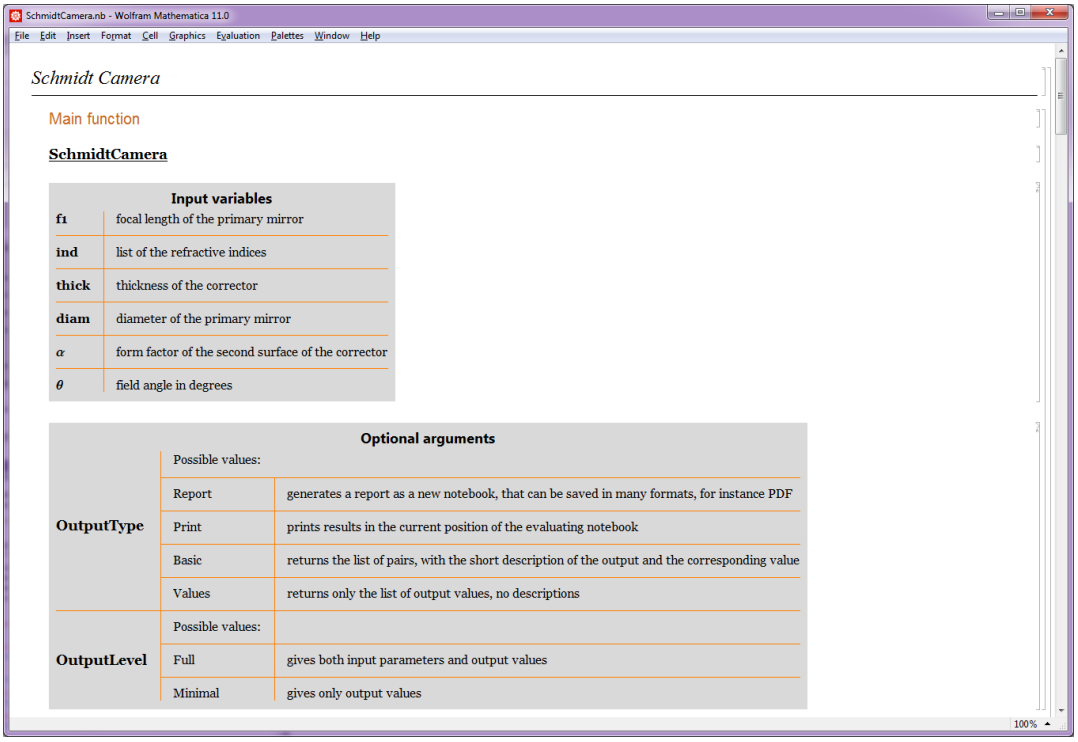
This other button clear all selected items.

Once you have selected the package(s) you want to do load, click "Load" and the dialog box will disappear. Now, you are ready to use the functions defined in the package you have loaded. If you don't know how to use them, you can use the default notebook that comes with each package. To open such notebook use the third button in the main palette

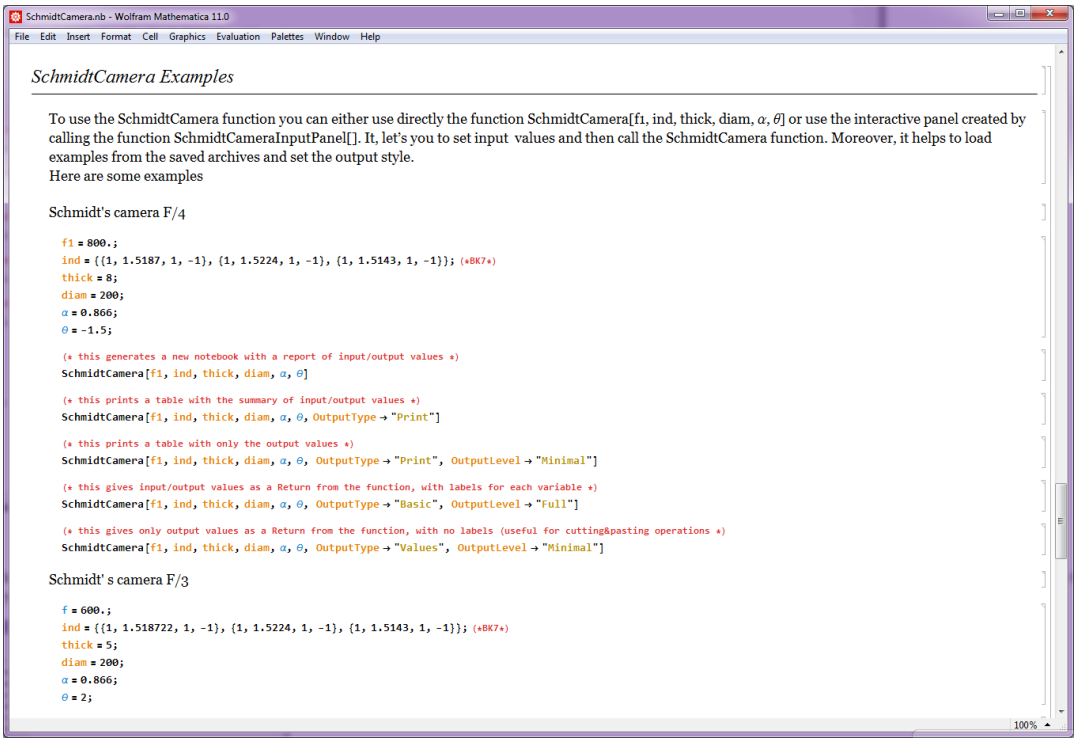
This button opens a dialog window very similar to the previous one



This time, you have to select one or more items from the list and then clicking "Open" it opens the notebooks related to selected packages. For examples, if you choose the first item "Baker Schmidt Camera CP" it opens the notebook like the following

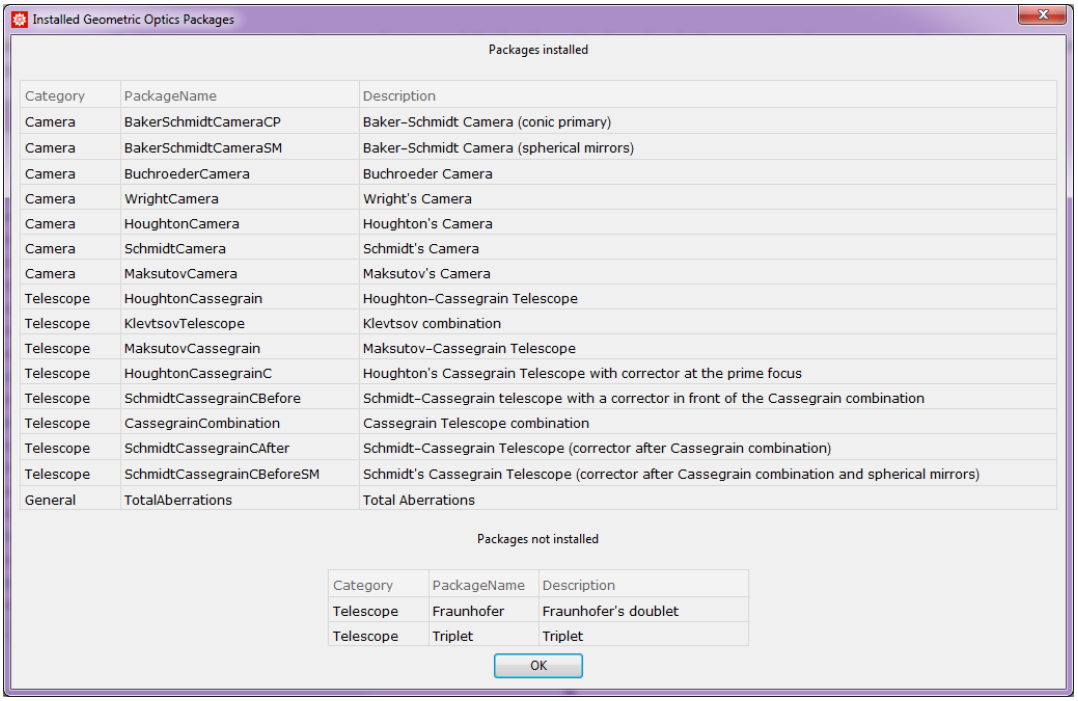


If you scroll down the noteook, you will find some examples of how to use the function BakerSchmidtCameraCP, as shown in the following image



This button is useful to check which packages are installed in your computer. Because chapters of the book can be downloaded separately, the corresponding packages are available separately too. So, use this button from the main

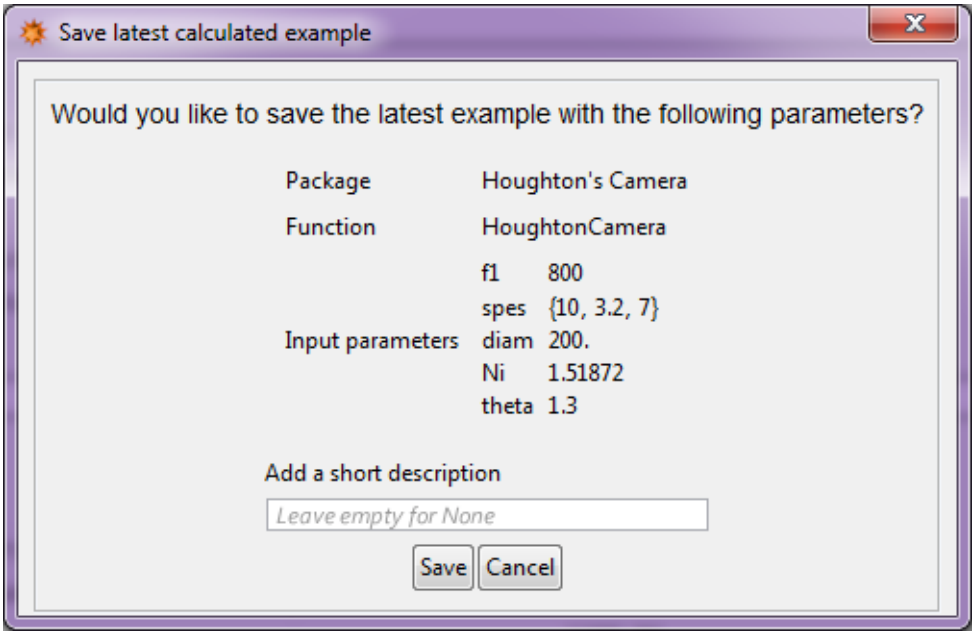
palette to know which packages you have already installed. Here is an example where the packages “Fraunhofer” and “Triplet” from the chapter 9 of the book “Geometric Optics” are not installed.



This button open the main folder where GeometricOptics is installed. Is useful if you want to check your files or installed packages.

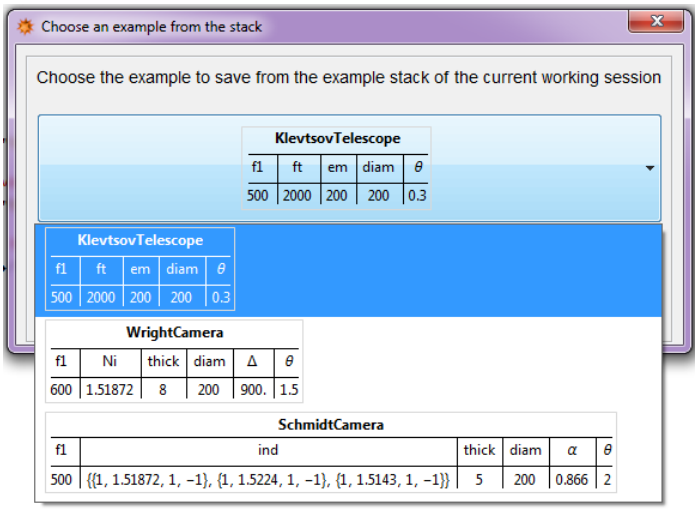
Finally, there are two additional buttons, useful to save examples from working session. When you run a function from a package, you may find interesting a special combination of input parameters getting a good optical system design. So you may want to save the input parameters set. These two buttons allow you to do that.

This button allows to save the input arguments of the latest computed example. Suppose you have computed a Houghton Camera examples and you want to save it. Click this button and it appears something like the following



Choose a short description to add and the click Save button. The example will be saved in the list of examples for the Houghton's Camera package.

This last button open a different dialog window that let's you to choice which example to save, from the list of all examples in the current session. The following image shows an example of three examples available in the current session that can be saved.



Note that examples saved using this buttons are permanently saved into a file so to be available across *Mathematica* sessions. Currently there is no a function to manage saved examples, if you want to remove examples from a package you can either delete the file Examples.m in the folder \GeometricOptics\Packages\[package_name]\Examples\ or edit it and

remove only those examples you want to cancel.

How to use the single package's functionalities

Each package has its own function, that allows the design of an optical system. All packages share the same structure, tha means they define a main function (named like the package) doing calculations related to the specific optical system it addresses. Then they define a GUI function having the same package name with the suffix "InputPanel". This function allows to use a small user interface to insert parameters for the specific package. Here is an example for the package WrightCamera.

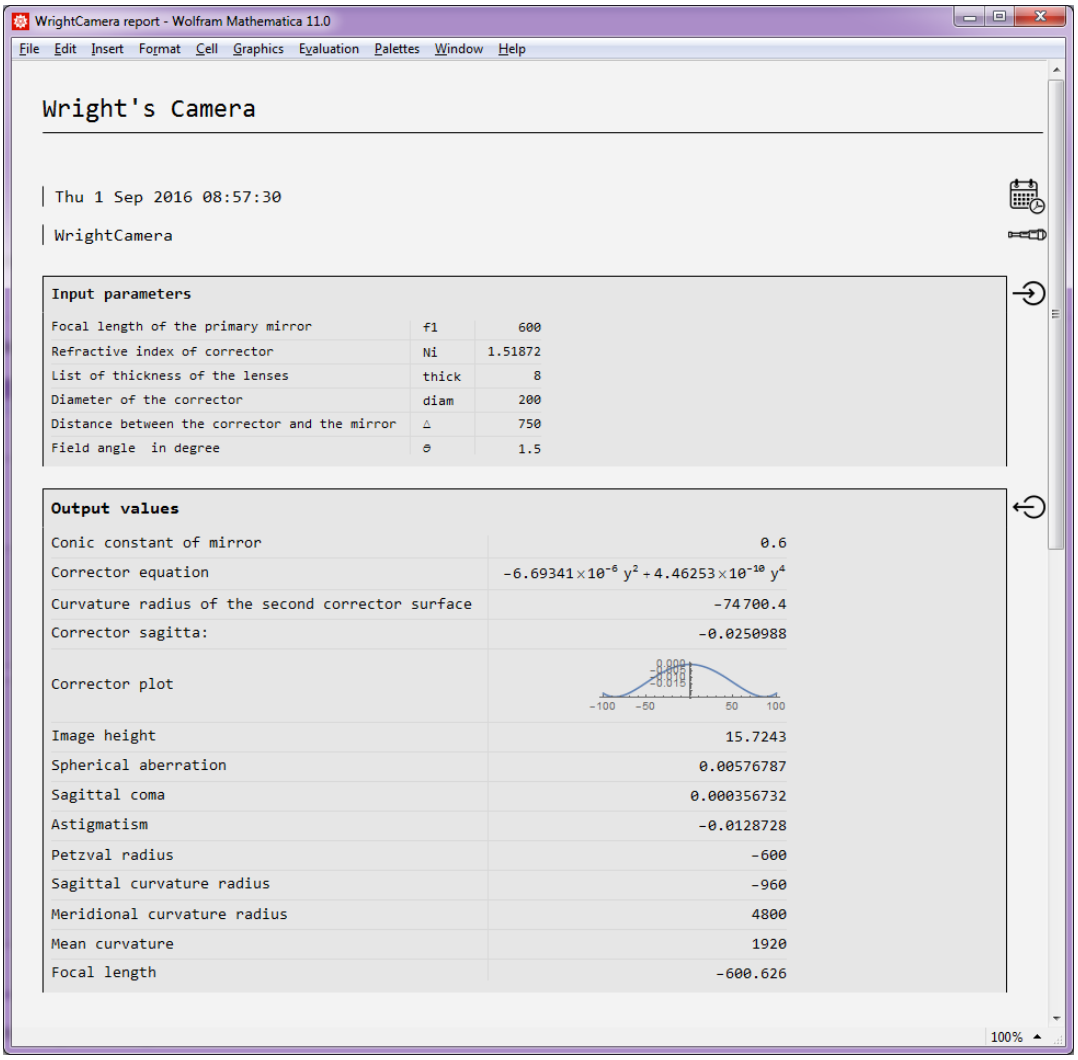
Here are the input parameters

```
f = 600;
Ni = 1.518722;(*BK7*)
thick = 8;
diam = 200;
Δ = 750;
θ = 1.5;
```

and here is the call to the package's main function named WrightCamera

```
WrightCamera[f, Ni, thick, diam, Δ, θ]
```

Evaluating the above function, generates a new notebook in the form of a report, with input and outputs of the calculation, as shown in the image



Each package's function accepts two additional parameters, as optional arguments:

OutputType, can be one of the following values:

- "Report" generates a report as a new notebook, that can be saved in many formats, for instance PDF
- "Print" prints results in the current position of the evaluating notebook
- "Basic" returns the list of pairs, with the short description of the output and the corresponding value
- "Values" returns only the list of output values, no descriptions

OutputLevel, can be one of the following values:

- "Full" gives both input parameters and output values
- "Minimal" gives only output values

The following are examples of WrightCamera with the above options

```
(* this prints a table with the summary of input/output values *)
WrightCamera[f, Ni, thick, diam, Δ, Θ, OutputType → "Print"]
```

Wright's Camera

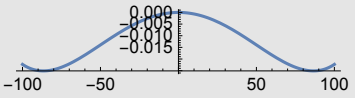
Thu 1 Sep 2016 08:58:28

WrightCamera

Input parameters

Focal length of the primary mirror	f1	600
Refractive index of corrector	Ni	1.51872
List of thickness of the lenses	thick	8
Diameter of the corrector	diam	200
Distance between the corrector and the mirror	Δ	750
Field angle in degree	Θ	1.5

Output values

Conic constant of mirror	0.6
Corrector equation	$-6.69341 \times 10^{-6}\, y^2 + 4.46253 \times 10^{-10}\, y^4$
Curvature radius of the second corrector surface	−74700.4
Corrector sagitta:	−0.0250988
Corrector plot	
Image height	15.7243
Spherical aberration	0.00576787
Sagittal coma	0.000356732
Astigmatism	−0.0128728
Petzval radius	−600
Sagittal curvature radius	−960
Meridional curvature radius	4800
Mean curvature	1920
Focal length	−600.626

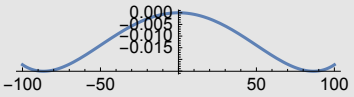

```
(* this prints a table with only the output values *)
WrightCamera[f, Ni, thick, diam, Δ, Θ,
 OutputType → "Print", OutputLevel → "Minimal"]
```

Wright's Camera

Thu 1 Sep 2016 08:58:34

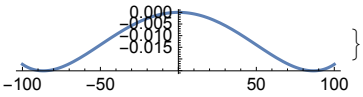
WrightCamera

Output values

Conic constant of mirror	0.6
Corrector equation	$-6.69341 \times 10^{-6}\, y^2 + 4.46253 \times 10^{-10}\, y^4$
Curvature radius of the second corrector surface	−74700.4
Corrector sagitta:	−0.0250988
Corrector plot	
Image height	15.7243
Spherical aberration	0.00576787
Sagittal coma	0.000356732
Astigmatism	−0.0128728
Petzval radius	−600
Sagittal curvature radius	−960
Meridional curvature radius	4800
Mean curvature	1920
Focal length	−600.626


```
(* this gives input/output values as a Return from the function,
with labels for each variable *)
WrightCamera[f, Ni, thick, diam, Δ, Θ, OutputType → "Basic", OutputLevel → "Full"]
```

```
{{Input parameters,
  {{f1, 600}, {Ni, 1.51872}, {thick, 8}, {diam, 200}, {Δ, 750}, {Θ, 1.5}}},
 {Output values, {{Conic constant of mirror, 0.6},
   {Corrector equation, -6.69341 × 10^-6 y^2 + 4.46253 × 10^-10 y^4},
   {Curvature radius of the second corrector surface, -74700.4},
   {Corrector sagitta:, -0.0250988}, {Corrector plot,
```

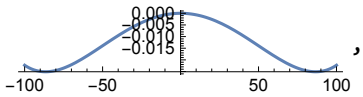



```
   },
   {Image height, 15.7243}, {Spherical aberration, 0.00576787},
   {Sagittal coma, 0.000356732}, {Astigmatism, -0.0128728}, {Petzval radius, -600},
   {Sagittal curvature radius, -960}, {Meridional curvature radius, 4800},
   {Mean curvature, 1920}, {Focal length, -600.626}}}}
```

```
(* this gives only output values as a Return from the function,
with no labels (useful for cutting&pasting operations *)
WrightCamera[f, Ni, thick, diam, Δ, Θ,
 OutputType → "Values", OutputLevel → "Minimal"]
```

$$\{0.6,\ -6.69341\times 10^{-6}\,y^2+4.46253\times 10^{-10}\,y^4,\ -74\,700.4,$$

$$-0.0250988,$$



$$,\ 15.7243,\ 0.00576787,$$

$$0.000356732,\ -0.0128728,\ -600,\ -960,\ 4800,\ 1920,\ -600.626\}$$

Troubleshooting and support

The whole software has been widely tested with many examples. However, it might happen that in some cases an error could arise. As a first attempt, save your work then close the *Mathematica* kernel (menu Evaluation→Quit Kernel→Local) and then load the package once again and run the same example. Sometimes, the problem could be due to an overlapping of variables value. Indeed, all packages use the same variable referring to theoretical parameters, so if you run many examples in the same working sessions and if they came from different packages, it could be that an old value of a parameter influences the current output.
If the problem still arise and you think it's something due to a wrong behavior of the source code, please contact us at

geometricopticsbook@gmail.com

Please, attach a notebook with all details of the problem.