Silent - Spectrograph sImulation & EmulatioN Tool

Manual

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Contents

1 Introduction

This program is opensource and written with extensive use of the Qt library[1] for GUI applications with C++. Hence, it comes without warrenty. However, the developer is thankfull for any usefull comments and bug reports[2].

Three types of spectragraphs are implemented yet: the classical one, the échelle and 3D spectrograph. These spectrographs are the most common ones in astronomical, medical, chemical and biological applications. The main goal is to hand-out a program to calculate in a fast manner, the most important spectral parameters of these spectrographs to determine the optical properties. This will support the optical designer in finding start values for the design/optimization with ray-tracing under the consideration of the scientific requirements the instrument has to be adapted for. Furthermore, the spectral format on the CCD is simulated and allows the identification of the position of the spectral regions (lines) of interest. This is especially important for échelle and 3D spectrographs were also the spatial distribution of the spectra/diffraction orders on the CCD has to be calculated. Last but not least, it allows the calculation of a full CCD image with specified (astronomical) sources, noise and efficiencies. These outputs can be used to test data-reduction pipelines before the instrument is physically build and will finally help to make a desicion between different designs.

2 Classical Spectrograph

When the program is started, the main window appears which shows the interface for échelle spectrographs. In the tool bar on top, select "Spec - Classical" to open the configuration editor for the classical spectrograph. This interface should be more or less self-explanatory. The blaze-efficiency corresponds to the maximum of the efficiency curve of the grating. The maximum appears at the blaze-wavelength which corresponds to the specified blaze-angle. Note that efficiency curves provided by most suppliers are limited to master gratings and in general used replicated gratings suffer from much less efficiencies.

For calculating the efficiency at the input slit, a gaussian intensity distribution is used. If "circular" slit is selected, the slit width corresponds to the diameter of this circular input aperture. When selecting "rectangular", the user can specify the slit length. If this is set to zero, the efficiency will be calculated for an "infinitely" long slit.

The efficiencies for the optical surfaces are interpolated with the use of available reflection data from Thorlabs[3]. These files can be replaced in the local folder by custom data, if necessary. Files are:

- protected_Ag.txt: For the silver coating with protection layer.
- protected_Al.txt: For the aluminium coating with protection layer.

[1] www.qt.io
[2] Write an e-mail to dsablowski@aip.de
[3] www.thorlabs.com

- protected_Au.txt: For the gold coating with protection layer.
- uprotected_Au.txt: For unprotected gold coating.
- UVEnhanced_Al.txt: For optimised reflection in the blue region of aluminium.
- vis_ar.txt: For antireflection coating of lenses in the visible.

As soon as the push button "Parameters" is hit, the program calculates relevant data and writes it to text-files. When finished, a window for plotting these data can be opened from the tool bar "Parameters - Classical". Choose the parameter you want to plot vs wavelength, hit the find value button and then the plot botton. The "Instrument Efficiency" is the result under consideration of all optical surfaces, input slit, CCD etc. but without earth's atmosphere. This is taken into account for the "Overall Efficiency". The window to plot these parameters can be opened multiple times, select "Parameters - Classical" in the menu bar again.

To calculate spectra either one-dimensional or as whole images, the following line lists are used (in current folder):

- absor_line.txt: For (Balmer) absorption lines.
- neon_line.txt: For neon emission line spectrum.
- thar_uves.txt: For Thorium-Argon emission line spectrum.

3 Échelle Spectraphs

The interface for échelle spectrographs is the main window which appears after program has started. It should be self-explanatory. For details about slit, surface efficiency and blaze-effciency, see Sect. 2.

For the X-disperser there are four methods implemented, the naive diffraction grating, dispersion prism (60°), volume-phase holographic grating and the volume-phase holographic grism. The diffraction grating is specified as common for ruled gratings. The prism is specified entirely by the use of the material. Sellmeier equation is used to calculate the dispersion. The VPH-Grating needs to be characterized by some parameters and the efficiency of it is calculated after Kogelnik's theory. Under "Tools - VPHG", there is a VPH grating tool to study the efficiency of VPHG. The VPH-Grism is considered in symmetric path, e.i, the center wavelength will pass through without deviation and both bratings have equal material and angles. The angle G in Fig. 1 is the "Grism angle" dislayed at bottom left in the window.

The plots at the right, showing averaged values for the efficiency, signal and signal-to-noise ratio. These values are averaged over the diffraction orders. The separation between orders in pixels and the overlap of orders in wavelength are also displayed.

The parameters are computed and stored to text files, when pressing the "Parameters" button. These values can be plotted with "Parameters - Echelle". The échellogram is computable and visualized in the same manner.

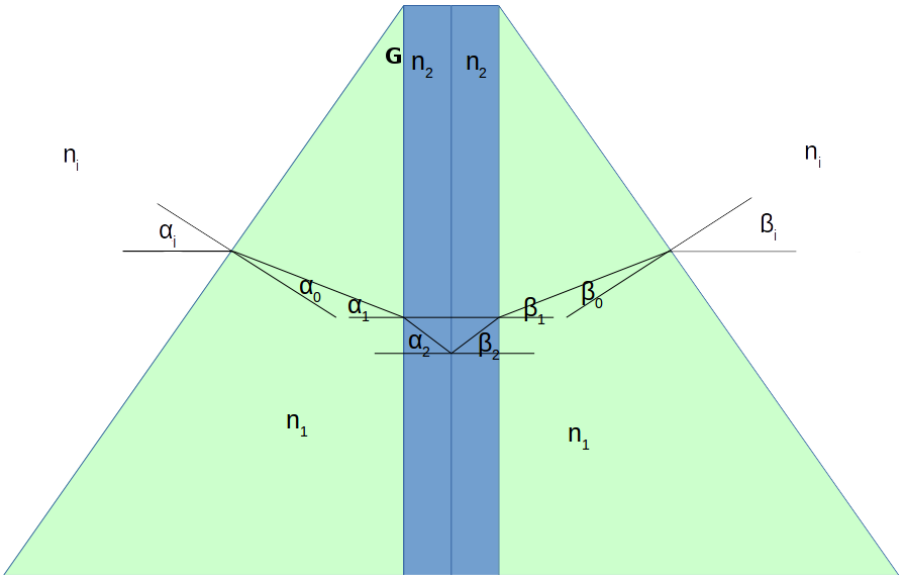

Figure 1: Light path in an symmetric Grism.

4 3D-Spectrograph

This type of spectrograph is currently implemented to support standard diffraction grating and VPH grating. Select "Spec - 3D" in the menu bar to open the configuration editor.

In principle this is a classical spectrograph layout assumed, but the user can specify the number of slitlets. These are equidistantly distributed over the CCD in y direction. For further information see Sect. 2.

5 Tools

Some additional tools are provided which can be selected in the menu bar.

5.1 VPHG

This tool calculates properties of volume phase holographic gratings after Kogelnik's theory. Within this approximation, the maximum semiampitude is limited for a given set of parameters. This value is displayed at bottom left in the window and the specified value has to be smaller. The performance is calculated for the specified center wavelength and wavelength range. There is also the possibility to simulate the behavior of the grating, when tuned, e.i., the grating for a specified angle of incidence (AOI) and angle of diffraction (AOD) is rotated for use in different wavelength ranges. The specified center wavelength is fixed and the user can set a tune wavelength.

5.2 Optical Fibres

This tool provides some basic behaviors of optical fibres. There are several different doping options available. The parameters will be plotted vs. wavelength. It has to be noted here that transmission and modal noise are not fully implemented at this time. This tool gives also a minium bend radius, which depends on the input f-ratio.

5.3 TSI

The telescope-spectrograph-interface tool is used to specify details of the connection between telescope and spectrograph. This connection takes the optical train from the telescope focus to the spectrograph main collimator into account. This tool is currently not fully implemented. Pressing the "Apply" button will generate a configuration file, which will be used for the spectrograph calculations. Click "Remove" to delete that file.