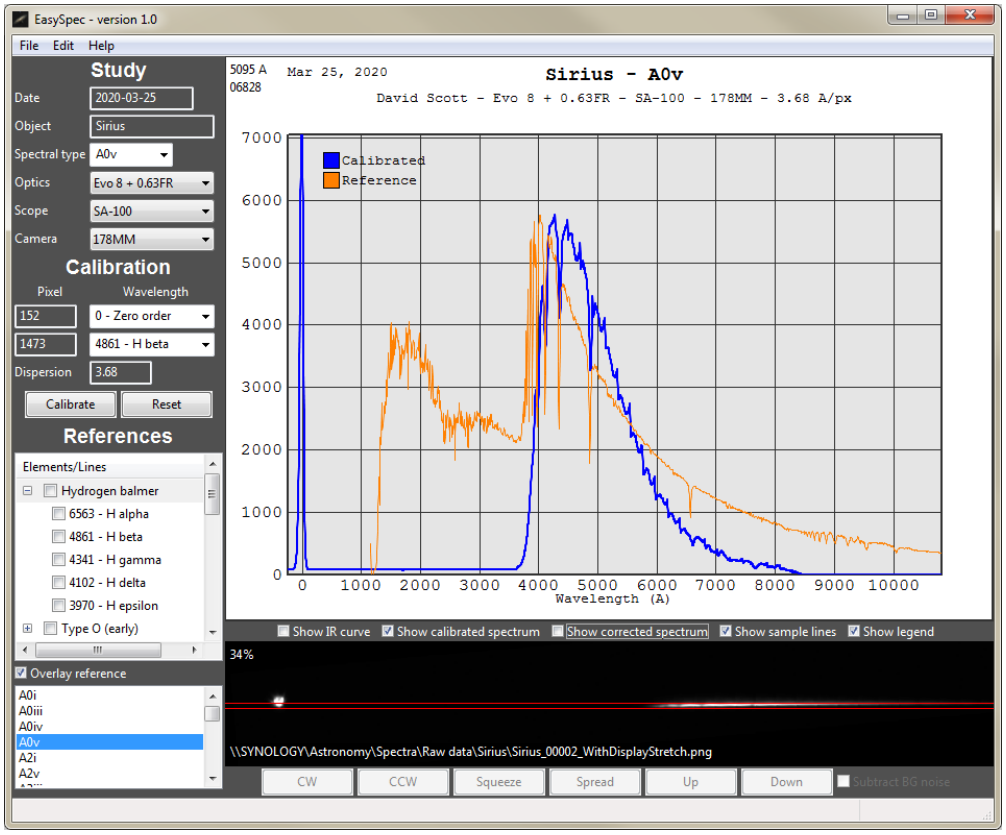
EasySpec

Version 1.8

Introduction

EasySpec (**ES**) was created in to make analysis as astronomy spectra fun and easy, hence the name. There are several programs already available, but as a beginner, I found them to be either too sophisticated or too simple but with a less than satisfying user interface. My goal was to automate basic functions and really streamline the process of going from a raw spectra to a possible identification. I also wanted to make it



easy to document, save and share your findings. I think **ES** does all this nicely.

Cloudy Nights member: descott12
November 11, 2023

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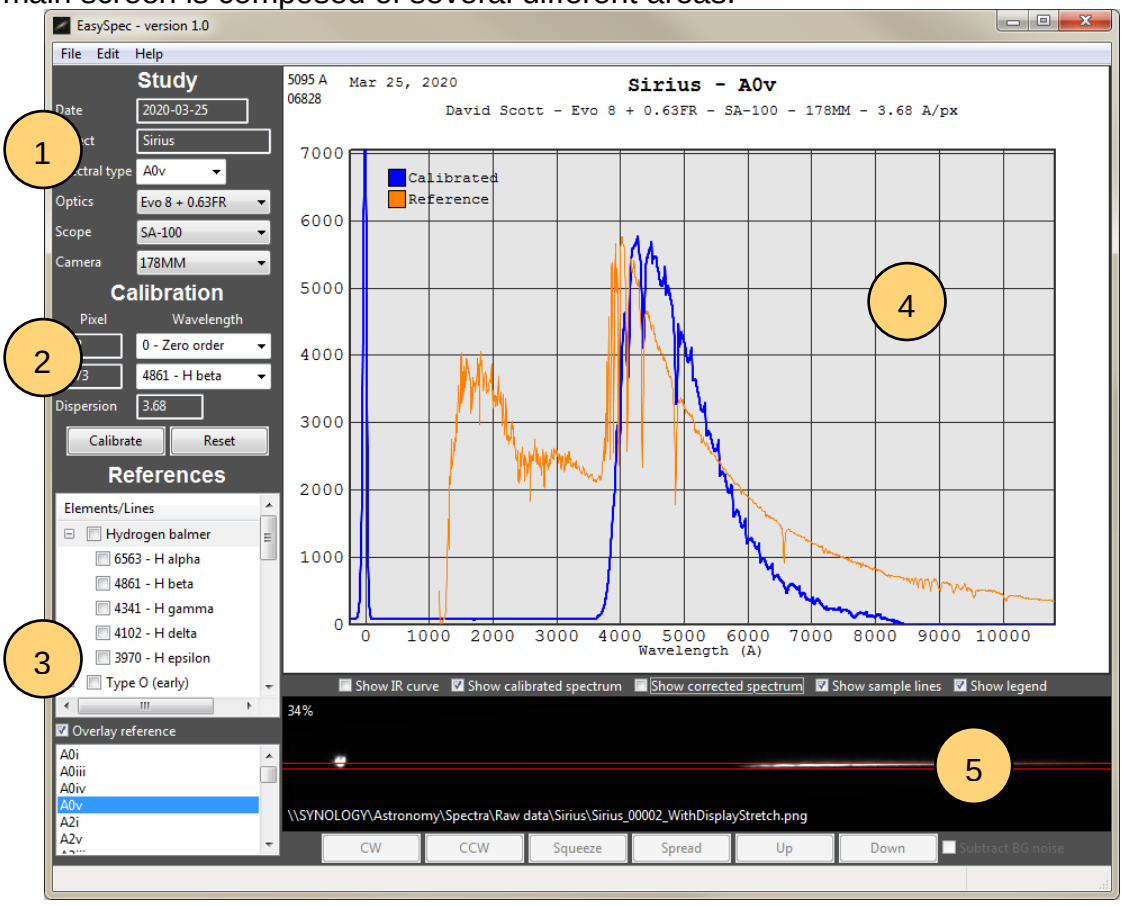
Installation

There is no installation required. Simply drag and drop the **ES** folder to a convenient place (such as your Desktop) and run the `EasySpec.exe` program file. You may wish to create a shortcut to this file in your Task Bar for easy access.

The application is a Windows program and it has been tested on Windows 7 and 10. In addition to the program file, there is a configuration file, `EasySpec.ini`, that may contain various settings. You should not need to edit this file directly but its contents are described in the **Appendix**.

The main screen

The main screen is composed of several different areas:



The Study Area

1. This is where you can specify the name of your object of interest as well as the equipment that you used to capture the spectrum (optics, camera and spectroscope). The **Date** field will be automatically pulled from the raw spectrum image file when it is loaded but you can override the date if needed. The choices for the optics, scope and camera are configured in **Preferences**. There is a **Notes** field that can be used to

display a short annotation about the exposure, etc. It is displayed just above the **Graph** area.

The Calibration Area
2. This is where you specify the wavelengths of your calibration points and calibrate your spectrum.

The Reference Area
3. This is where you can overlay a reference spectrum from the Pickle library and/or various wavelengths of interest. For example, you could overlay an A0v spectrum and one or more of the Balmer lines.

The Graph Area
4. This is where your processed spectrum will be displayed. It can display one or more of the following: your raw spectrum, the calibrated spectrum, a spectrum corrected for your instrument response, the instrument response itself, as well as a legend, a

reference spectrum and any number of reference lines. Some of these choices can be selected by checking the appropriate checkboxes below the graph. The graph can be panned around by left-clicking and dragging the mouse and you can zoom in or out with the mouse wheel or by pressing the **+** and **-** keys, respectively. Double-clicking will automatically set the zoom to 100% and center the graph.

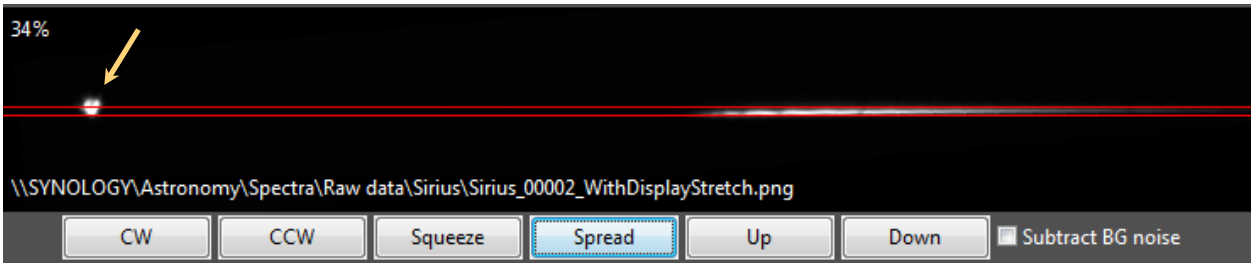
The Raw Spectrum Area
5. This is where the raw spectrum data file is displayed. Controls in this area allow you to rotate the image and to specify a narrow band area to sample the spectrum.

Loading a raw spectrum

To load a spectrum, simply drag and drop the raw image file onto the **Raw Spectrum Area**. The date of the spectrum file will be used to fill in the date in **The Study Area**. If this date is not correct, you can edit the date directly by typing in the field or by double-clicking in the field to bring up a calendar date picker.

Images should be captured in a lossless format in order to maintain the most information. This includes lossless png and FITS files. In addition, you can load a SER movie file (currently only 16-bit monochrome files are supported).

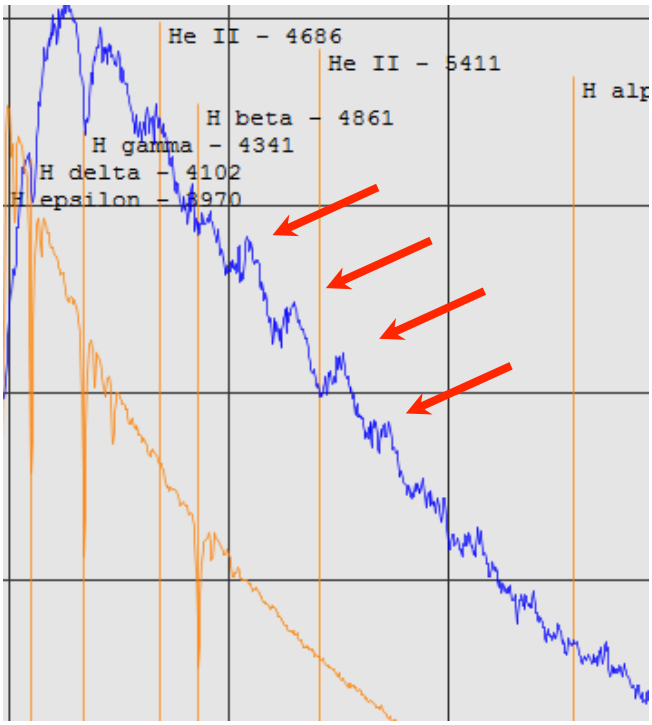
Raw spectra files should be captured so that the first order spot is on the left (gold arrow) The spectrum can be panned around by left-clicking and dragging the mouse. The spectrum can be zoomed by rolling the mouse wheel or by pressing the **+** and **-** keys, respectively. Double-clicking will automatically set the zoom to 100% and center the image.



Once you get the spectrum centered and zoomed appropriately, you can rotate it clockwise or counter clockwise as needed by pressing the **CW** and **CCW** buttons, respectively. The image will rotate 1 degree or 10 degrees if you hold the **Shift** key when pressing the buttons.

The sampling area is identified by the two parallel red lines. You can move the sampling area up or down by pressing the **Up** and **Down** buttons, respectively. The image will move 1 pixel or 10 pixels if you hold down the **Shift** key when pressing the buttons. In addition you can move the sample area to a specific point by **Shift** left-clicking on any spot in the image. When the spectrum image window has the mouse focus, you can also use the up and down arrow keys to move up or down by 1 pixel. You can adjust the height of the sampling area by pressing the **Squeeze** and **Spread** buttons. The sampling area will change by 1 pixel or 10 pixels if you hold down the **Shift** key when pressing the buttons.

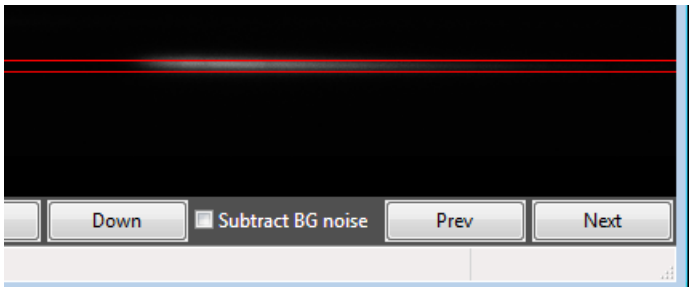
Note: It is best to capture your spectra with the spectrum as close to horizontal as possible. This is because any rotation can and will introduce some artifacts such as jagged spikes (as shown below - red arrows) that can substantially alter your results. A rotation of a degree or two is not bad but anything larger should be avoided if possible.



Check the **Subtract BG noise** checkbox to automatically remove any background noise detected in the sampling area. This may or may not improve the resulting spectrum (depending on your data).

You can display or hide the sample area lines by checking the **Show sample lines** checkbox as needed.

As you move or otherwise alter the sampling area, the spectrum will be displayed and updated in **The Graph Area**.



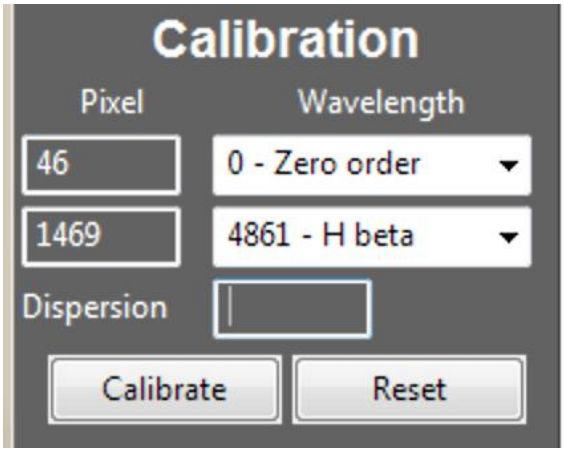
If you have loaded a SER data file, then the **Prev** and **Next** buttons in the lower-right corner will be enabled. These allow you to step through each frame in the file in order to find the best frame. When the spectrum image viewer has the mouse focus, you can use the left and right arrow keys to change the current frame.

Calibration

Once you have loaded a raw spectrum and defined your sample area, it is time to calibrate the spectrum. Calibration can be done in two ways:

Two point calibration

Right click on a point in **The Graph Area** and choose **Add as first calibration point**. The pixel value of this point is placed into the first wavelength field in **The Calibration Area**. Choose the wavelength that is associated with this point. Right click on a second point in **The Graph Area** and choose **Add as second calibration point**. The pixel value of this point is placed into the second wavelength field in **The Calibration Area**. Choose the wavelength that is associated with this second point.

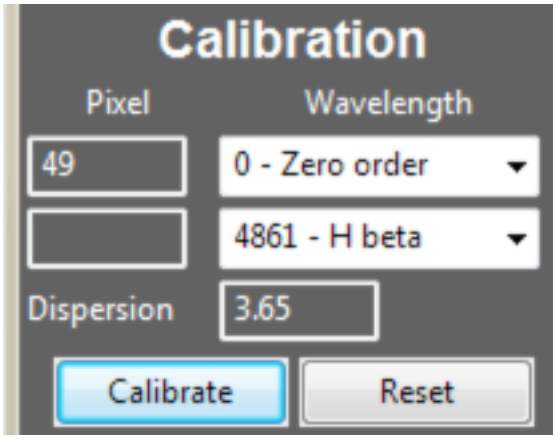


You can choose any identifiable wavelengths but it is customary to use the zero order peak and one of the H Balmer absorptions, if visible. Note: the choices for wavelengths to choose from in the lists can be configured. Click **here** for more information.

Once you have defined both points, press the **Calibrate** button. The **Dispersion** will be calculated and displayed and your calibrated curve will be displayed in **The Graph Area**.

One point calibration

If you already know the dispersion of your system, you can use a one point calibration. Right click on a point in **The Graph Area** and choose **Add as first calibration point**. The pixel value of this point is placed into the first wavelength field in **The Calibration Area**. You can choose any identifiable wavelengths but it is usually easiest to use the zero order peak. Enter your **Dispersion**, press the **Calibrate** button and your calibrated curve will be displayed in **The Graph Area.**



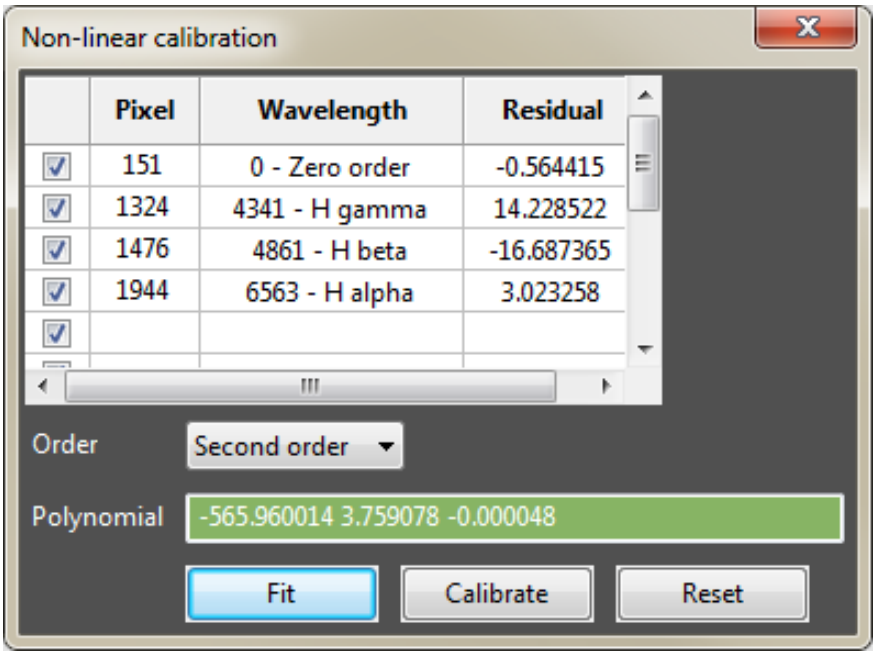
You can undo the calibration and start over by pressing the **Reset** button. Also, if you didn't click exactly on the right spot when adding your calibration points and your calibrated curve isn't matching your reference lines (see below) perfectly, you can tweak the calibration by editing the pixel values in **The Calibration Area** and then press

Calibrate again. For example, in the example above, I could change the 49 to 48 or 50 and then press **Calibrate**.

Non-linear calibration

EasySpec can also calibrate non-linear data files that result from systems such as the Alpy 600 or even the SA-100 when used in conjunction with a prism. In these cases, a simple linear relationship between horizontal pixels and the wavelength does ***not*** exist.

To start a non-linear calibration, press the **Calibrate** button while holding the **Shift** key down. The **Non-linear calibration** window will open. On the spectrum graph, right click on a identifiable features and choose **Add calibration point**. Repeat this for multiple pixel values and the pixel values will start filling down in the **Pixel** column. For each pixel value, click in the **Wavelength** cell and choose a wavelength from this list or enter a value.



Once you have your pixel wavelengths defined, choose an order from the **Order** list and press **Fit**. A polynomial will be generated to fit the data and the errors for each point will be displayed in the **Residual** column. The actual coefficients of the polynomial will be displayed as well. Press the **Calibrate** button and display some reference lines on the spectrum to see how well the fit is.

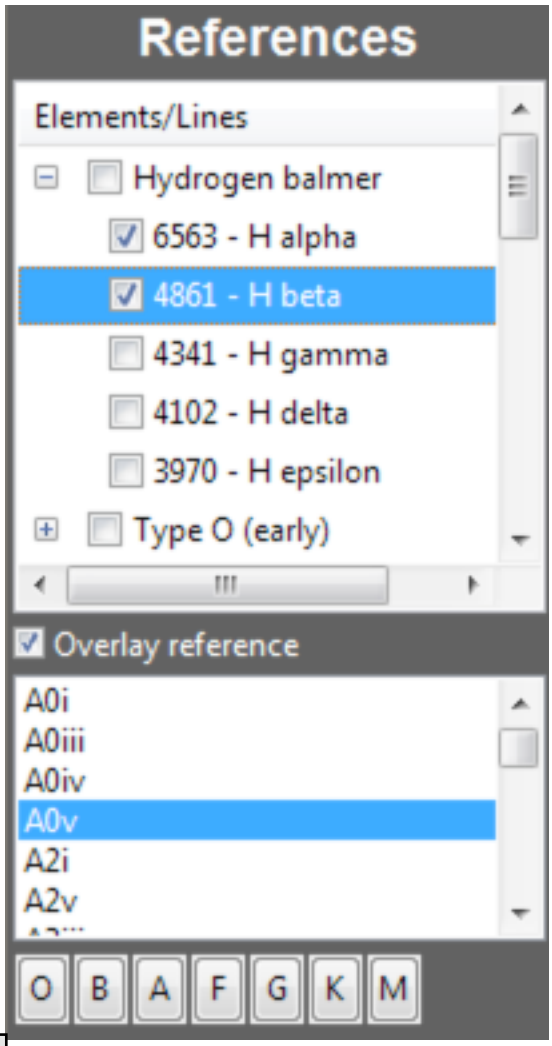
If the residuals are too high or the fit on the graph is not good, you can add more data points or change the **Order.** After making a change, you can press **Fit** and **Calibrate** again to see how it looks. Press the **Reset** button to clear the calibration and start from scratch. Note that higher order polynomials can generally fit more complicated data but you will need more data points. As a rule you need at least one more data point than the order. So a second order polynomial needs at least 3 points. In reality adding more points will help get a better fit.

Once your calibration looks good, just close the window by pressing the **X** button in the upper-right corner. The polynomial will be remembered and will be re-displayed in the **Non-linear calibration** window the next time you open it. If you happen to be working

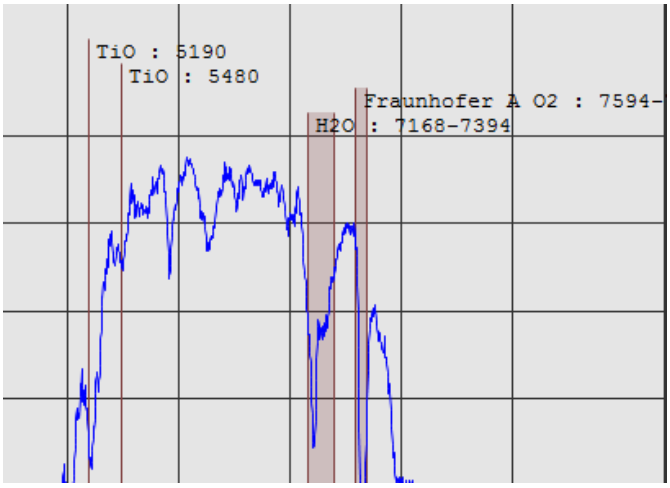
with the same data file, you don't have to re-select points and fit the data. You can simply press **Calibrate** to calibrate the spectrum. If the data file is different, then you will need to redo the calibration process.

References

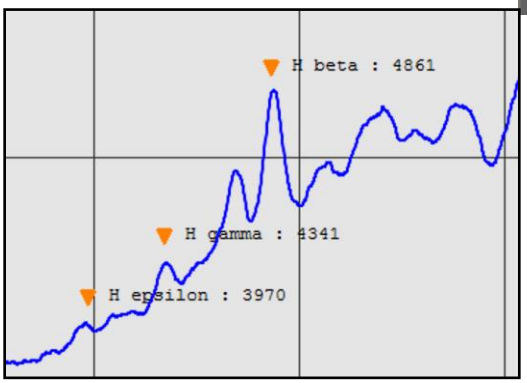
Once you have calibrated your spectrum, you can overlay reference spectra and/or reference lines. Reference lines are arranged in groups such as *Hydrogen Balmer* or *Type O*. You can select an entire group or select only certain lines with a group.



Most reference lines are a single wavelength, but some (like the Telluric absorptions) are actually a broader band or range of wavelengths.



Note that you can configure the groups and individual lines that are in this list (see



Appendix).

At the bottom of the reference line list, there is a group called "`User defined`" and this section can be populated with any number of reference lines that are of interest but are not currently in the built-in reference line library. See **Preferences** for instructions on adding reference lines.

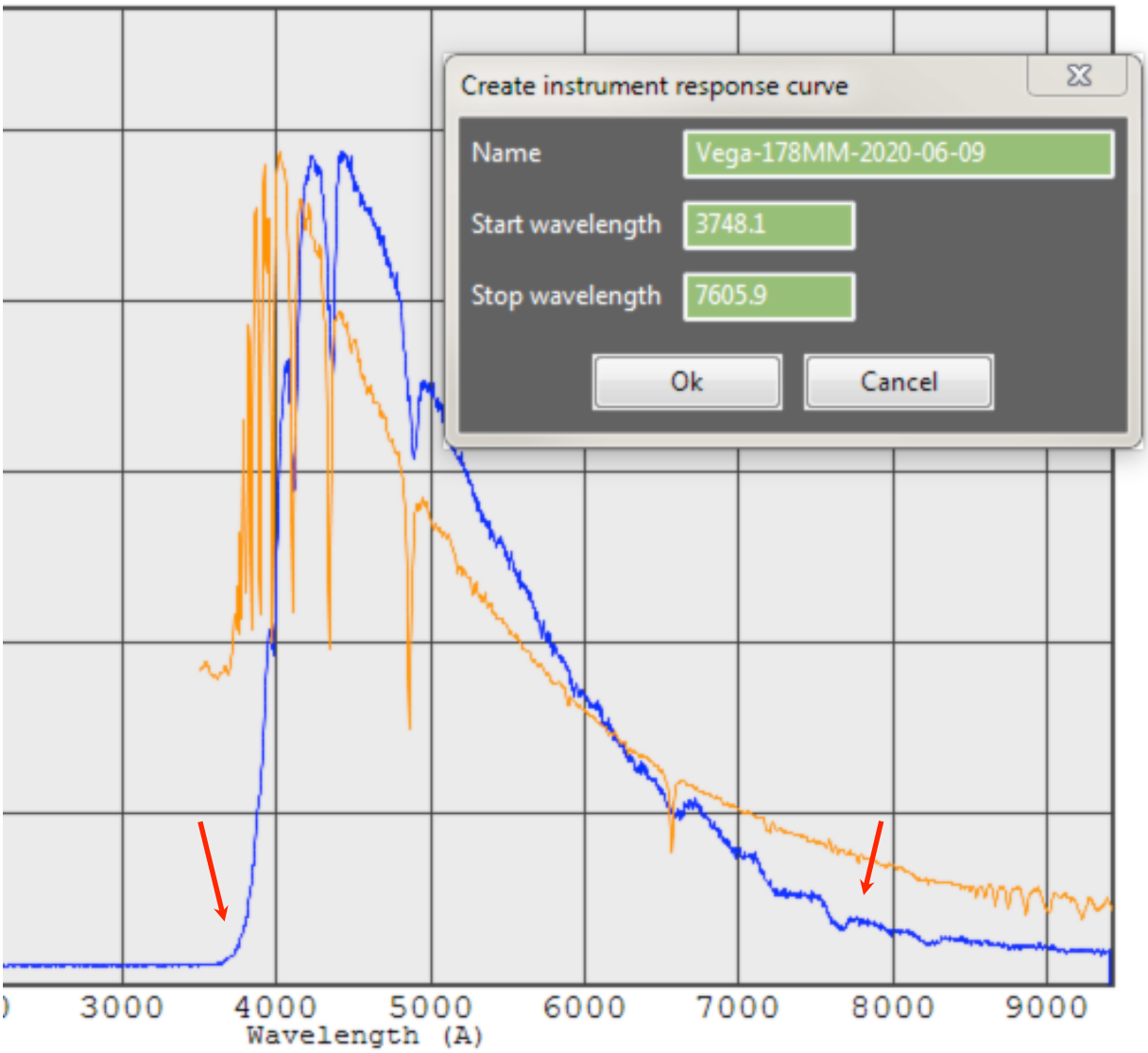
Reference wavelengths can be displayed as above with a vertical line. You can also mark them with a small triangular symbol as shown to the right. The actual data and the shape of the curve determine which looks better. This option can be selected on the **Appearance** tab in **Preferences**.

You can also display an entire reference spectrum from the Pickle library by checking the **Overlay reference** checkbox and selecting a spectrum. By pressing the up or down arrow keys, you can display each reference until you find the best match.

To jump to the start of a main spectral type category, just press the appropriate **OBAFGKM** button.

Instrument Response Curves

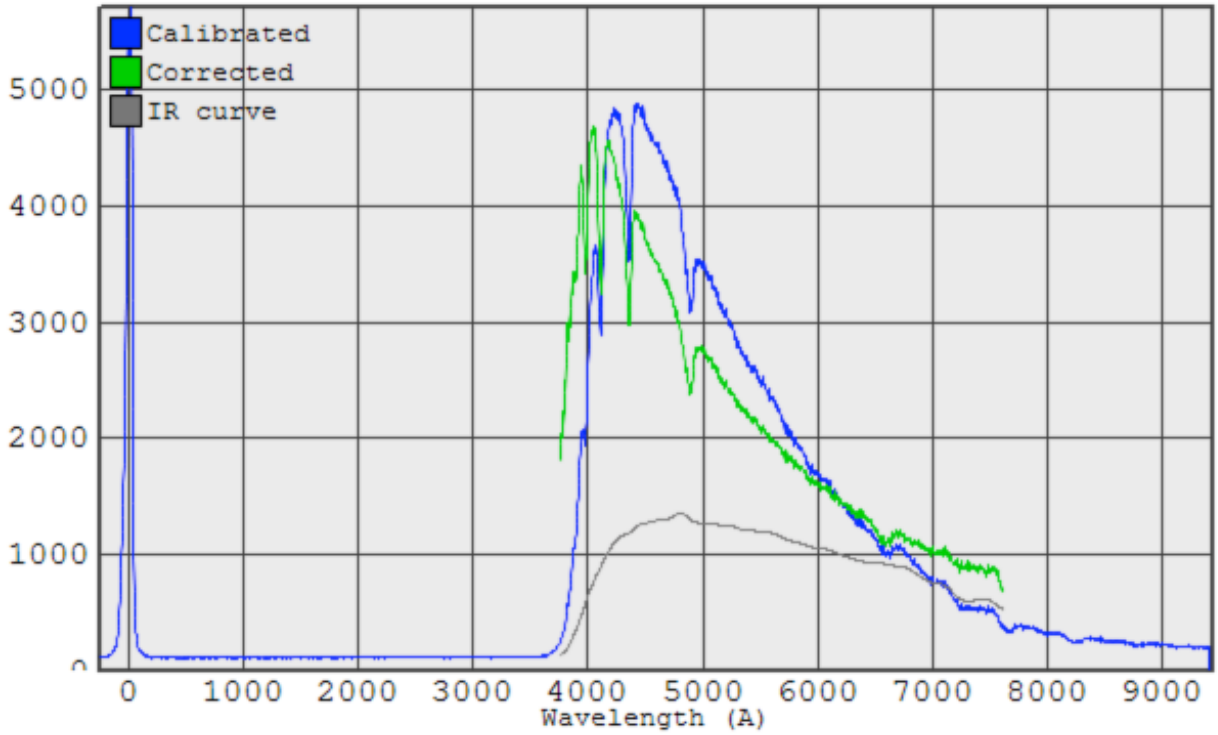
To create an instrument response (IR) curve, load and calibrate a spectrum. Then overlay a corresponding reference spectrum. Choose **Tools ▶ Instrument response ▶ Create** from the main menu. A popup window will appear. Give your IR curve a name. It is good idea to include information like the name of the source object, the spectral type, the camera, and/or the date. Now you will select points on the graph to specify a range of wavelengths to include in the IR curve. This is important as your sensor likely does



not have the same sensitivity to a wide range of wavelengths as the reference. So we want to limit it in order to make a useful IR curve. Basically, only include areas on the curve that show a meaningful response above the baseline. The example shows two red arrows that specify a start and stop wavelength. Right click on a spot and choose **Set start/stop wavelength for IR response curve** from the popup menu. Do this twice,

once for the start and once for the stop wavelength. You can reselect points if you are not happy with your choices. Press **Ok** to continue and our IR curve will be saved. You will be prompted to apply it now. You can press **Yes** to apply it now or **No** and load it later.

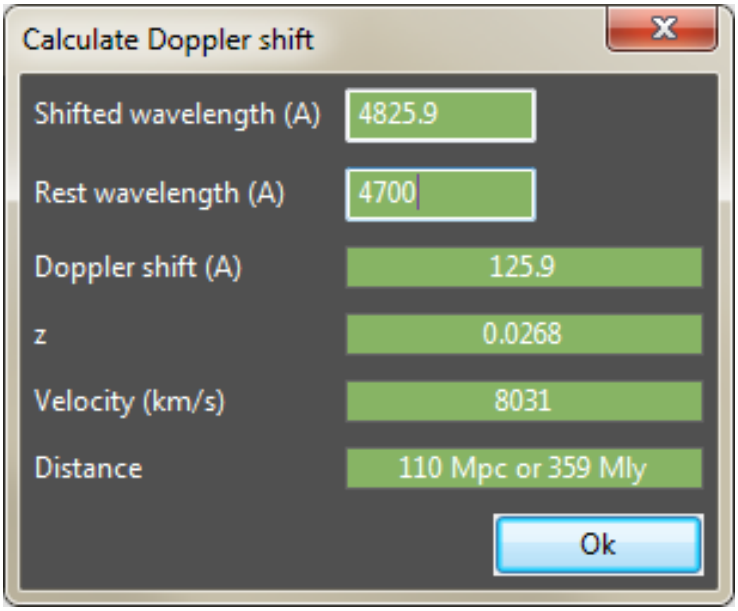
To load and apply an IR curve, choose **Tools ▶ Instrument response ▶ Load** from the main menu. A list will appear and you can choose a curve. Be sure to apply a curve



that was created for the current sensor/optics. This is a good reason why it is important to include that information in the curve's name when you create them. Depending on how you have your display checkboxes checked, you could see a calibrated curve, a corrected curve and possibly the IR curve. The IR curve does not use the Intensity values for the Y-axis as the other curves do. In reality the IR curve is really just a ratio and it is normalized so 1000 on the Y-axis equals a ratio of 1.0. The corrected curve is simply the calibrated curve ***divided*** by the IR curve. So the curves will be equal when the IR curve is 1000 (ratio of 1.0), the corrected curve will be below the calibrated curve when the IR curve > 1000 and the corrected curve will be above the calibrated curve when the IR curve < 1000.

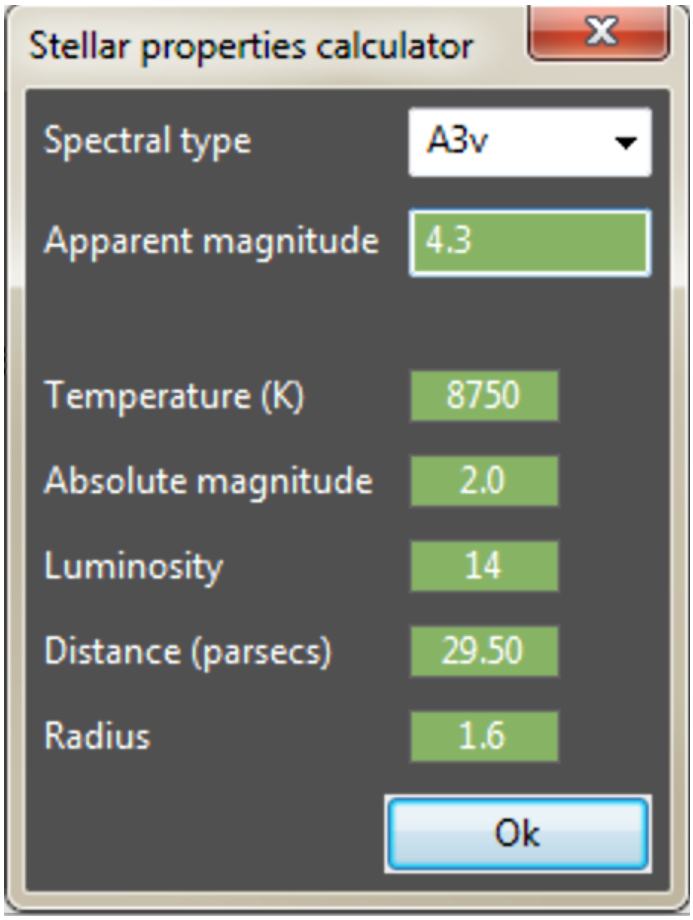
Calculating Doppler shifts

To calculate a Doppler shift, load and calibrate a spectrum. Choose **Tools ▶ Calculate Doppler shift** from the main menu. A popup window will appear. Identify a feature that appears to be shifted. Enter the **shifted** wavelength and the corresponding **rest** wavelength. Alternately, you can **right** click on the calibrated spectrum and choose **Set the shifted wavelength**... or **Set the rest wavelength**... and these values will be auto-filled. The Doppler shift, the z value, the velocity and the distance will be calculated.



Stellar properties calculator

Choose **Tools ▶ Stellar properties calculator** from the main menu. The calculator window will appear. You can select a spectral type and enter an apparent magnitude and this tool will calculate the temperature, absolute magnitude, luminosity, distance and radius. Note that the calculations are only approximations but they should be relatively accurate.



Miscellaneous

Saving your data

You can save your spectrum data to a .dat file format by choosing **File ▶ Save** from the main menu. You will be prompted for a folder to save the data into. The text in the **Object** field (in **The Study Area**) is used to name the file so you must enter an object name first. The raw and calibrated data will be saved. For example:

```
c:\my folder\vega_raw.dat
c:\my folder\vega_calibrated.dat
```

Screen capture

You can capture your current screen (both the graph and the raw spectrum) by choosing **Edit ▶ Screen capture** from the main menu. The image will be saved into the Windows clipboard and you can then paste into another application and save it as a file.

Smooth curve

You can smooth the raw spectrum graph (if not calibrated yet) or the calibrated spectrum graph by choosing **Edit ▶ Smooth curve** from the main menu. Note: to un-smooth the curve, simply re-calibrate the curve.

Flatten curves

You can smooth the calibrated spectrum graphs and a reference spectrum (if displayed) by choosing **Edit ▶ Flatten curves** from the main menu. This will attempt to normalize the baseline and produce a “flat” curve so it easier to compare absorptions and emissions. Note: to un-flatten the curve, simply re-calibrate the curve.

Online reference

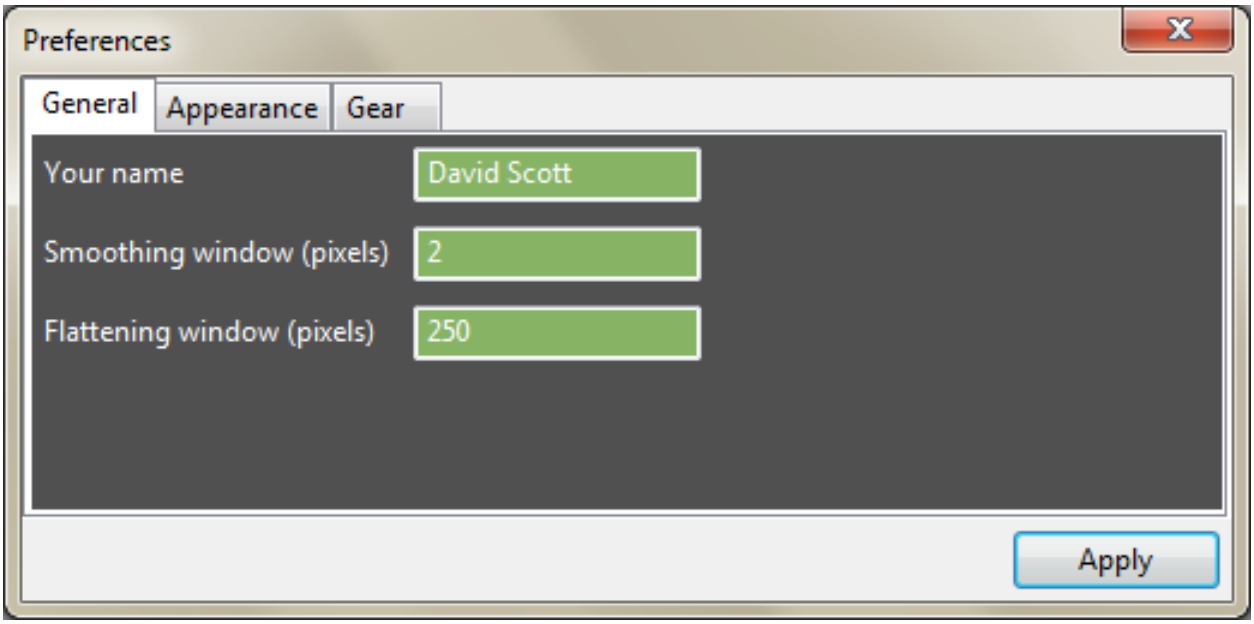
You can automatically open a online spectral types reference by choosing **Help ▶ Online reference f**rom the main menu. By default, this goes to very helpful Wikipedia page but the URL can be configured in the configuration file (see **Appendix**).

Preferences

Choose **File ▶ Preferences** from the main menu to specify the choices you have the lists for you gear, set colors, and some other the settings. There are a few tabs.

General

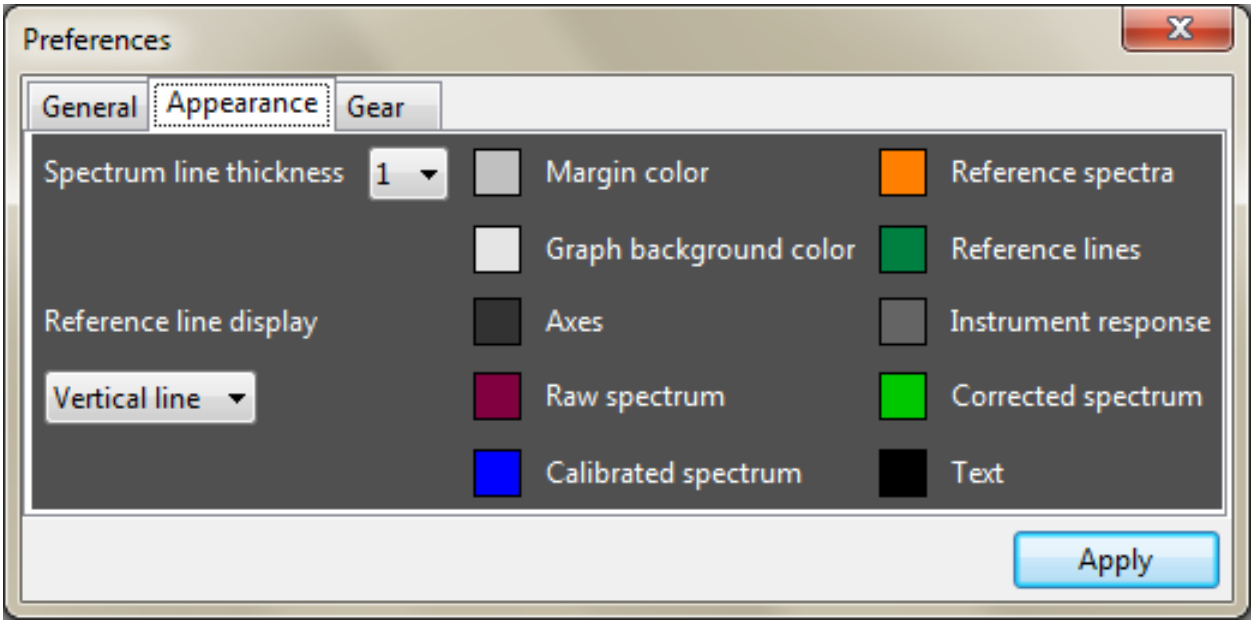
The **General** tab allows you to specify your name as it will appear on the graph and when you take screenshots.
The size of the data windows used when smoothing and flattening your curves can also be set. A large window is more aggressive and can remove wanted detail but a small window may not have enough effect to work well. For smoothing, you should use a small window (around 2 or 5, for example). For flattening you need to use a much larger window (such as 200 or so). You may need to experiment to find values that work well with your data. Press **Apply** to save your changes. You do not need to close the



Preferences window for your changes to have an effect.

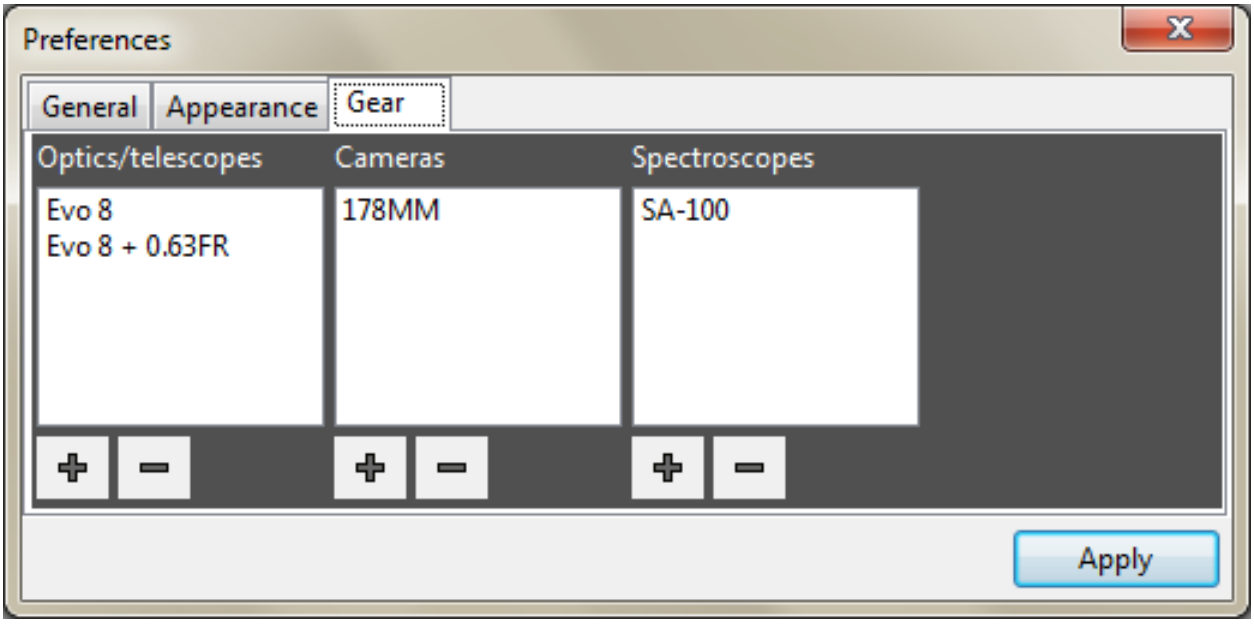
Appearance

The **Appearance** tab allow you choose colors for the various parts of the graph, the line width (for the raw and calibrated spectrum only) and you can choose how to annotate wavelengths of interest (with either a vertical line or an arrow symbol). Press **Apply** to save your changes. You do not need to close the **Preferences** window for your changes to have an effect.



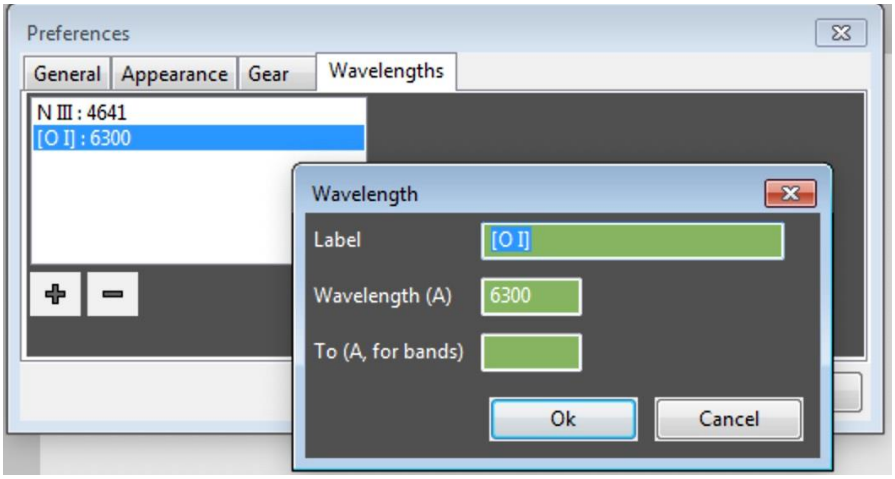
Gear

The **Gear** tab allows you to specify your **Optics**, **Cameras** and **Spectroscopes**. For each, press the **+** and **-** buttons to add and remove choices, respectively. Double-click on a choice to edit it. Press **Apply** to save your changes. You will not need to close the **Preferences** window and restart the program before your changes will take effect.



Wavelengths

The **Wavelengths** tab allows you to specify user-defined reference lines that can be overlaid over your calibrated spectra. Press the **+** and **-** button to add and remove reference lines. Double-click on an entry to edit it. Press **Apply** to save your changes. You will not need to close the **Preferences** window and restart the program before your changes will take effect.



To add or edit an entry, enter a text **Label** and a **wavelength**. If the reference line is actual a wider band, the also enter a wavelength in the **To** field.

Appendices

Troubleshooting

Q: Why do a get an error message about a dll file missing when trying to start the application?
A: As with all Windows programs, this program requires various helper .dll files. The necessary ones should be included in the installation folder. However, if you receive a message when trying to start the application about a dll file that is missing, please let me know and I will fix the omission.

Q: Why does my calibrated curve not appear when I press **Calibrate**?
A: Make sure the **Show calibrated spectrum** checkbox is checked. See **The Graph Area**.

The configuration file

`EasySpec.ini` is the configuration file that lives in the same folder as the program file. It is a standard Windows .ini file with [SECTIONS] in square brackets and individual NAME=VALUE settings in each section. Comments lines begin with a semicolon symbol.

```
[GENERAL]
; The last used choices for your equipment are saved here
defaultOptics=Evo 8 + 0.63FR
defaultCamera=178MM
defaultScope=SA-100
; the last calculated dispersion is saved here
dispersion=3.65

; this is a scale factor used to make the IR curve viewable on
; the graphs. This means that a IR curve value of 1.0 is graphed
; as 1000 on the intensity scale
IRCurveScaleFactor=1000

; your name as configured in the Preferences
yourName=David Scott
; the web page used by Help > Online Reference
ReferenceURL=https://en.wikipedia.org/wiki/Stellar_classification

; professionally recorded spectra capture data over a much wider
; wavelength range and the spectra for O and B stars can have
; a much higher intensity in UV wavelengths which are typically
; below what an amateur setup can measure. This setting allows
; us to clip of parts of the spectrum below this value.
referenceSpectrumLowerCutoff=3500
```

```
; The data window size used when smoothing curves.
smoothingWindowSize=10

; the data window size used when flattening curves.
flatteningWindowSize=50


[DISPLAY]
; the various colors are save here. The format is:
;    r g b alpha
; the alpha value is currently ignored
marginColor=255 255 255 255
graphBackgroundColor=229 229 229 255
axisColor=50 50 50 255
rawSpectrumColor=128 0 64 255
calibratedSpectrumColor=0 0 255 255
referenceSpectrumColor=255 128 0 255
referenceLineColor=255 128 0 255
instrumentResponseColor=100 100 100 255
textColor=0 0 0 255
correctedSpectrumColor=0 200 0 255
; the line width - currently only used for the RAW spectrum
spectrumLineWidth=1
```

The `Wavelengths.xml` file

This file determines what reference lines and groups are displayed in the **The Reference Area**. It is stored in the **`Resources`** folder inside the main installation folder. It is a standard xml file and it can be edited as needed but please only use Notepad as other editors can over-complicate the file and make it unusable. The format is as follows:

```
<wavelengths>

<group name="Hydrogen balmer">
      <wavelength name="H alpha" value="6563" calibrate="yes"/>
      <wavelength name="H beta" value="4861" calibrate="yes"/>
</group>

<group name="Type O (early)">
      <wavelength name="He I" value="4471" />
      <wavelength name="He II" value="4686" />
      <wavelength name="He II" value="5411" />
</group>

<group name="Type G">
      <wavelength name="H" value="3968" />
      <wavelength name="K" value="3934" />
      <wavelength name="Ca I" value="4227"/>
      <wavelength name="G band" value="4300" to="4313" />
```

```
</group>
</wavelengths>
```

You can have any number of `<group>` tags and each `<group>` can have one or more `<wavelengths>` inside it. The values are in Angstroms. The `calibrate="yes"` attribute specifies that this entry should also be used in the wavelength lists in **The Calibration Area**.

Most `<wavelength>` entries have a name and a value for the wavelength. You can also define a band of wavelengths as in the "G band" entry above. In these cases, you provide a value and a second wavelength with the "`to`" tag.

Version history

Version 1.0
Initial release

Version 1.1
1. Bug fix - The colors would sometimes make the graph lines partially transparent.
2. Bug fix - Reference spectrum F2iv was incorrectly labeled as F02iv.
3. Bug fix - The spectral type edit control was ignored so the user couldn't manually enter a spectral class.

Version 1.2
1. Updated wavelengths.xml to include carbon stars.
2. Can now display reference bands, not just lines.
3. Updated Wavelengths.xml to display the G band as a band and added the Telluric absorption bands.

Version 1.3
1. Updated wavelengths.xml to include Fe II class novas, S-class stars, more WR emissions and SN Type 1a.
2. Reference lines can now be identified with vertical lines or arrow symbols.
3. Added the Notes field.
4. Can now load an external .dat file as a reference curve.
5. Subtract background noise was not subtracting the correct value.
6. Bug fix - calibration failed if the first calibration point was not the zero order peak.

Version 1.4
1. Added the Stellar Properties Calculator
2. Bug fix - The tool tip for Dispersion was attached to the first pixel entry field.
3. Added the ability to do non-linear calibration

Version 1.5
1. Added the ability to define user-defined reference lines.

Version 1.6

1. Any wavelength value can be entered now when doing a non-linear calibration. Before, the user had to pick from a list of predefined wavelengths.
2. The spectral types list was not sorted properly.

Version 1.7
1. Changes to the Smoothing preference are automatically reflected in the display graph.
2. The App would crash if a user-defined wavelength label was too long or if it contained a double quote character.
3. Fixed incorrect log file message about not being able to open the Wavelngths.xml file.

Version 1.8
1. Added support for loading SER video files.
2. Added support for 16-bit monochrome FITS files