Integrating under SEDs

This capability is useful for calculating line fluxes, flux ratios, and estimating fluxes through other instruments or photometric filters.

This worksheet walks you through calculating integrated fluxes underneath both the raw SED data and from a fitted model.

Note: replace `<path-to-iris>` with the full path to the directory in which the Iris demo material was downloaded. If you used Github to download the sources, `<path-to-iris>` will be `<path-to>/aas229iris` If you downloaded the data from the thumb drive, it'll be `<path-to>/iris`.

Calculating integrated fluxes under a set of star-forming galaxies

NOTE

This section uses a previously-fit **template library.** You will need to follow the **Template Fitting Worksheet** in `<path-to-iris>/worksheets/template_fitting/template_fitting_worksheet.pdf` to import the custom template library into your Iris installation to follow the entire thread.

However, you may skip the sections which use the fitted model to compute integrated fluxes without repercussion to the science thread.

Setup

Install Iris into a conda environment if you haven't already done so following the installation directions (http://bit.ly/iris-workshop-install).

Edit the fitted model in `<path-to-iris>/worksheets/integrate/modified-blackbodies.json` so that the user model files point to your HOME directory. This is near the end of the JSON file:

```
  "userModelList" : [ {
    "name" : "template.m1",
    "file" :
"<abs-path-to-home>/.vao/iris/analysis/custom_models/templates/modified-blackbo
dy",
    "function" : "None"
  }, {
    "name" : "template.m2",
    "file" :
"<abs-path-to-home>/.vao/iris/analysis/custom_models/templates/modified-blackbo
dy",
    "function" : "None"
  } ],
  "confidenceResults" : null
}
```

Launch Iris if it is not already open.

```
$ source activate iris-workshop
(iris-workshop) $ iris
```

1. Load `z1sf_kirkpatrick.dat` into Iris (**Load from File** → **Browse** for `<path-to-iris>/worksheets/integrate/z1sf_kirkpatrick.dat` and click "**Load as spectrum/SED**"). These data are a set of star-forming galaxies at redshift z~1, published in Kirkpatrick et al. (2012).

2. Open the **Iris Visualizer** from the desktop icon.

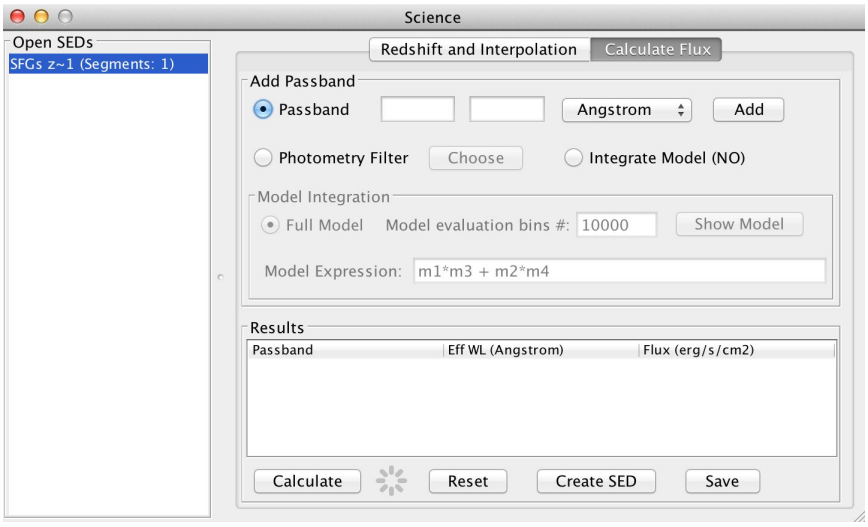
3. Open the **Fitting Tool** from the desktop icon.

4. From the Fitting Tool window, select **File** → **Load Json…**, and search for `<path-to-iris>/worksheets/integrate/modified-blackbodies.json`

5. In the Visualizer, click the “**Evaluate**” button at the bottom. This will plot the model on top of the data.

Integrate under the SED

1. Open the Science Tools from the "**Shift, Interpolate, Integrate**" icon on the desktop. Select the "**Calculate Flux**" tab.



2. By default, integration is performed under the SED data directly. "**Integrate Model (NO)**" should be shown and unselected.

3. Add passbands and photometric filters to integrate under the model with. Some suggestions:

   a. Calculate infrared flux: Click "**Passband**" and enter **8e3** and **1e7** in the two boxes for the integration range, and select **Angstroms** as the unit. (8*10^3 - 10^7 Angstroms = 8 - 1000 microns). Then click "**Add**." The resultant flux is shown in the **Results** table.

   b. Estimate the fluxes through the Herschel PACS, Spitzer MIPS, and WISE bands 3 and 4.

      Select "**Photometry Filter**." Search for the Herschel telescope and select all three PACS bands (click **Pacs.blue**, **hold down Shift**, then **select Pacs.red**), then search for Spitzer and add the MIPS bands (now **hold the Ctrl/Command button**, and **select** all three **MIPS bands**). Lastly, open the **WISE** folder and highlight **WISE.W3** and **WISE.W4**.

      Click "**Done**" at the bottom of the **Photometry Filter Selector**.

   You will notice that some points show  symbols. If you follow the example, this would be the WISE.4 band. This is because there are not enough points within the integration band to perform a calculation. **Integrating under a model** or an **interpolated** SED will help estimate fluxes for these points.

Integrate under the SED model

1. To integrate under the fitted model, click the radio button by "**Integrate Model (NO)**." This should then say "**Integrate Model (YES)**."

2. Click "**Calculate**" to recalculate the fluxes in the passbands under the model.

   You'll notice that the WISE band fluxes are estimated this time since the model covers this spectral

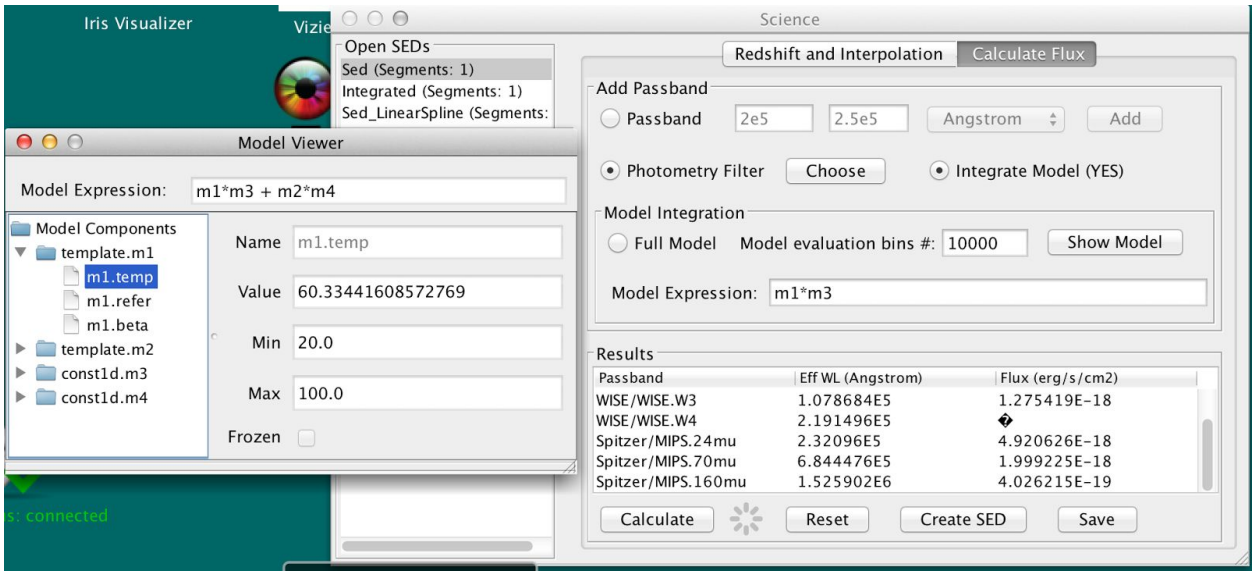
range.

3. You can integrate under an arbitrary combination of the fitting model components.

   For example, unselect the "**Full Model**" radio button. This allows you to edit the **Model Expression**. If you forget what the terms in the model are, click "**Show Model**", and a mini window of the model parameters is displayed.

   Let's integrate under the warmer dust component. Remove the cold dust component from the model expression, `m2*m4`, then click "**Calculate**" to recalculate the fluxes.

   [An image of this setup is shown on the next page.]



4. For any integration (under the model or not), you can save the results to a file (click the "**Save**" button in the bottom-right) or export them as another SED in the **Builder** for further analysis in Iris (click "**Create SED**").

Integrate under the interpolated SED

If you do not have a model for your SED, you can create an interpolated copy of the SED, then estimate the fluxes through the interpolated SED.

1. Switch to the **Redshift and Interpolation** tab.

2. Under the "**Interpolation**" panel, choose your interpolation options. For example:

    a. Use a **Linear Spline** as the **Method**

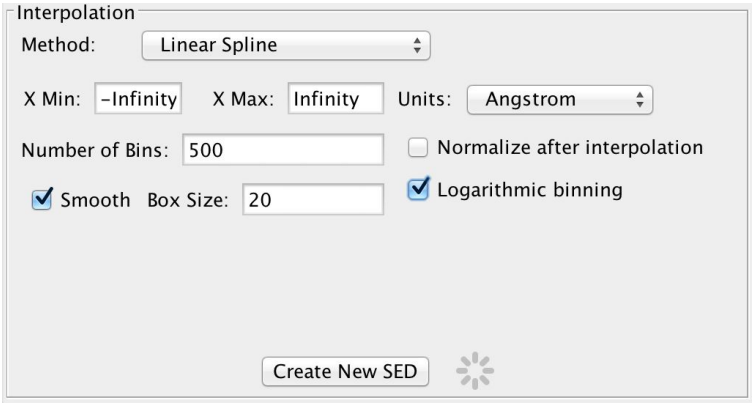
    b. Keep the spectral bounds **X Min and X Max** at **-Infinity** and **Infinity**. This will interpolate the SED on it's full spectral range.

    c. The **Number of Bins** is the total number of bins to use for interpolation. Change this to **500**. The interpolated SED will have 2000 points.

    d. **Smooth** the SED with a boxcar method, using a box size of **20**.

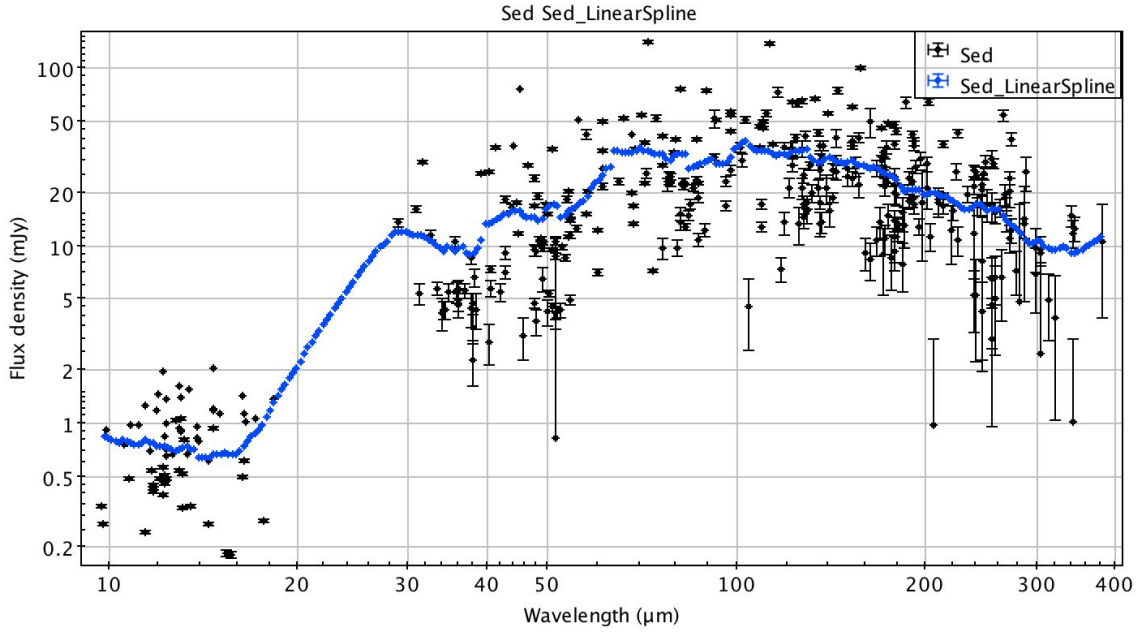
    e. Keep the binning **logarithmic** as the spectral range spans multiple decades.

    The Interpolation panel should look like



3. Click "**Create New SED**". This will add the interpolated SED to the **Builder** and **Visualizer**.

4. View the interpolated SED on top of the original one. In the **Visualizer**, go to **View** → **Coplot…** and highlight "**Sed**" and "**Sed_LinearSpline**", then click "**Plot Seds**".

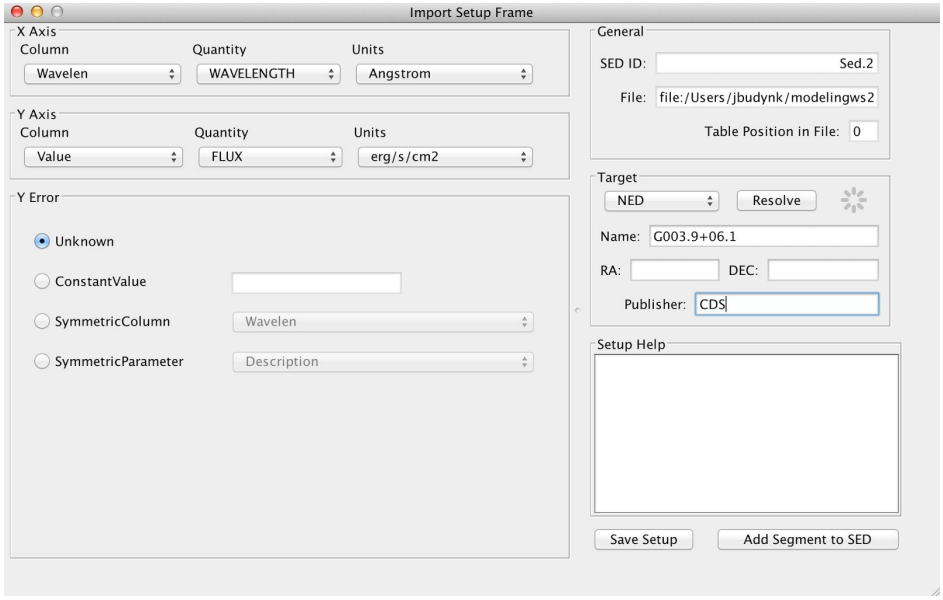


There's a bit of roughness at the top of the far infrared bump, which should be relatively smooth. Play around with the interpolation parameters to get a more proper shape if you'd like.

5. When you're happy with the interpolation, you can switch back into the **Calculate Flux** tab in the Science frame, add back your filters and passbands, and recalculate the integrated fluxes. All the bands, so long as they're within the spectral coverage of the aggregate SED, should have a value.

Calculating abundances and column densities

You can use the fitting and integration capabilities to measure the flux inside spectral lines. You can use the spectrum of G003.9+06.1, a planetary nebula, taken from the MASH catalog. The flux are arbitrary; choose erg/s/cm2 when loading in the file to make reading the calculated fluxes easier. The spectrum is located in `<path-to-iris>/worksheets/integrate/PHR1731-2216_6D220701HD.dat` As it is in a non-compliant format, you will need to provide the column mappings to the data with the **Import Setup frame**. Below is an image of what your importer should look like:



To do the calculated line fluxes, you will need to

1. Fit the data continuum
2. Fit the spectral lines

   For both steps 1 and 2, make sure you use the "**LeastSqaures**" statistic, as there are no uncertainties reported, making chi-squared statistics fail.

3. Calculate the flux under specific model components

   a. Add a user-defined **passband** spanning the spectral line of interest.

      Tip: to make defining the passband easier, switch the spectral units in the Visualizer to Angstroms, Hz, or eV (the spectral units provided in the science tool), hover the cursor over the start and end ranges, and write the values in the passband fields.

   b. Unselect "**Full Model**"
   c. Edit the model expression to contain only the continuum component
   d. Click "**Calculate**". Write down the flux.
   e. Edit the model expression to contain only the spectral line of interest
   f. Recalculate the flux and write it down.

4. Off to the side, subtract the continuum flux from the emission line flux, or subtract the absorption line flux from the continuum. This should give you the line flux estimate.