Spectroscopic Data Reduction

Types of frames:
- bias
- flat (dome or sky)
- arc lamp (e.g. CuAr, HeNeAr)
- object (science target, standard star)

Spectroscopic Reduction Flow Chart:

2D Processing:

process bias frames
- subtract overscan, trim
- combine to make master bias

process flat-field frames
- subtract overscan, trim, subtract bias
- combine to make master flat
- response
  - fit a somewhat high order polynomial to each line of your master flat, then divide each line by this fit. This produces a normalized master flat with values near unity and only pixel-to-pixel variation corrections left in it. The overall response curve of the instrument has been removed.
- illumination (optional)
  - if you have sky flats, you can use them to produce a correction for your data. The illumination correction uses exposures of a uniformly illuminated slit to determine the throughput of the slit along its length.

object frames
- subtract overscan, trim, subtract bias, divide normalized master flat

extract the spectra

- this is often done interactively
  - define an aperture for the target
  - define two background aperture and fit the background
  - fit the trace
    - the spectral dispersion does not run exactly along a CCD row, so find the line containing the aperture in each column and describe with a fit
- extract spectra for arc lamps using aperture from corresponding target

check/inspect extracted spectra

- e.g. look for cosmic rays, reject from 2D image, re-extract

1D Processing:

derive and apply wavelength solution

- Before beginning the wavelength calibration, download a line atlas and identify the lines. This is usually not an easy task! Observatories have line identification charts, sometimes separated into strong and weak lines.
- Identify the lines in the first arc lamp spectrum. Fit a polynomial to the wavelength-pixel relation to get a wavelength solution.
- once you have identified the lines in the first arc spectrum, automatic algorithms can usually do a good job finding the lines in the rest of the arcs.
- add information about wavelength solution to headers
- apply wavelength solution to data

correct for telluric absorption

- use the spectrum of a featureless star to derive a template for the discrete atmospheric absorption bands.
- shift and scale the template to remove absorption from science targets and standard stars
- do this before flux calibration so that the absorption bands do not affect the determination of the sensitivity

derive and apply flux calibration

- depending on the software you use, this step can require extensive calibration data, for example of extinction as a function of airmass at different telescope sites.
- before starting, make sure airmass is recorded, e.g. in the header
- take a standard star observation and break it into small bins (40-80 Å wide). Tabulate the observed counts and nominal flux (or AB magnitude). This is where you might use calibration tables to account for extinction.
- use the table above to create a coarsely sampled sensitivity function → this function effectively converts from instrumental to physical units