Spectroscopy Techniques

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I have an SBIG DSS7 spectrometer that I use with an SBIG 402 camera. The combination is used with the C11 operating at f10. The telescope is on an AstroPhysics mount, controlled by TheSky. The DSS7 has five different slit widths, with the finest yielding about 10 A or so resolution, with a scale of about 5.5A per pixel. I have used this combination a number of times, taking spectra of stars and nebula. I use my own software to control the spectrometer itself, which has three operating modes:

- Slit. For giving an image of the slit, so that you know where it is on the image field (i.e., is the object image on the slit?)
- Direction. This yields a fair quality sky image through the system and shows you the position in the field of where the various objects (stars, comet) are. The problem is to place the object on the slit by moving the telescope. My software allows me to superimpose an outline of the slit onto the direction image to make this easier.
- Spectrum. This mode takes a spectrum of whatever is on the slit.

Here are some examples of these images. First, an image of the slit. Actually, you can see that there are actually five slits of increasing width. The smallest, central one gives the highest resolution, while the others can give more sensitivity.


Second, here is a "direction" image, i.e., the field image where the telescope is pointed. In this case, this is a 10 sec. image of Comet Swan with the slit outline superimposed. I have already moved the scope to center the comet nucleus. The "width" of the slit is about 15 a-s for my system. You can see other stars in the field. The one to the right of the central slit will cause a slight error in the spectrum.

Here is a 120 sec. spectrum (after dark subtraction). It is easy to see the sky background lines from light pollution (and from atmospheric glow).
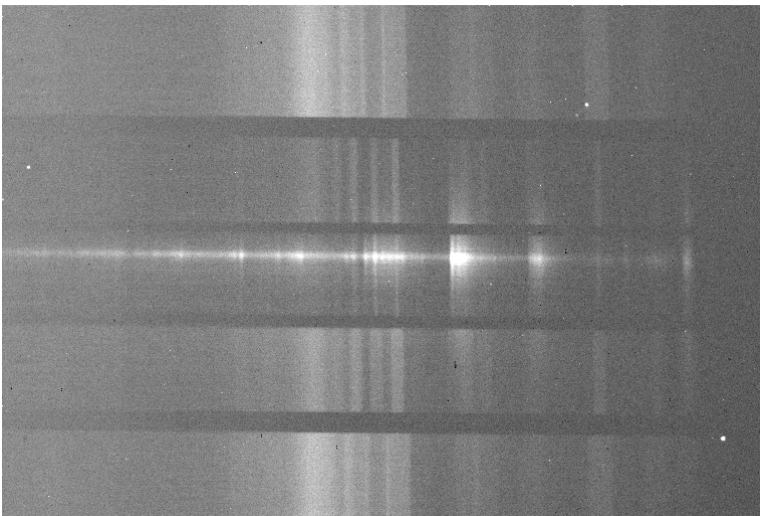
Finally, here is a spectrum of a small battery powered fluorescent lamp used for wavelength calibration (red is to the left, blue to the right).
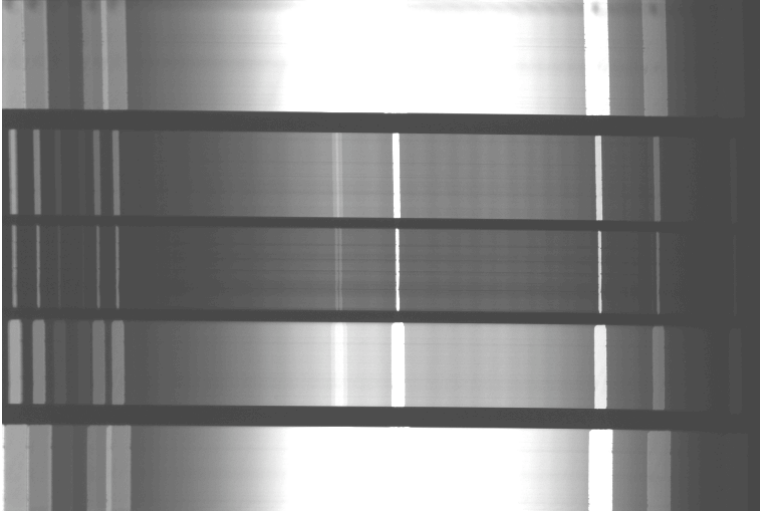
I use Maxim for taking the various images. During image taking, the scope is simply running (i.e., tracking) open loop, as I do not have a separate guide scope. I use an AP1200 or AP900 mount, with only about 3a-s P-P periodic error. However, errors in the mounting alignment, periodic error, shifts of optics (mirror flop), and even refractive changes in object position all conspire to move the object off the slit. This limits the length of exposures. However, with careful work (and use of software to track the comet and correct for refraction), I can do exposures of over 5 minutes with less than one slit width error (about 15a-s in the sky) even within 12 deg of the horizon.

Once I have the science (object) spectrum, I use Maxim to correct flats and darks, to remove background light pollution or other effects, and to prepare a digital graph of the spectrum. I then import this file into Excel. Meanwhile, I have taken a comparison spectrum to calibrate the wavelength scale, usually using a small fluorescent light. Using calibration lines from the comparison spectrum, my spreadsheet applies the wavelength scale to the science data, and graphs the results.

Various calibration steps are needed to make the spectra more useful:
Dark. Dark current in the CCD camera is often significant, so standard dark calibration is needed
Flat. Usually, brightness error due to optical defects and dust are not important; however, in some cases standard flat calibrations are needed.
Sky Background. Often the light pollution will generate both general background light and particular emission lines that must be removed. If the object spectrum only uses a small portion of its slit, then the rest of the slit spectrum can be used as the background source and subtracted, yielding the corrected spectrum. I usually use Maxim pixel math for this. If, on the other hand, the object is quite extended, then one needs to move the object away from the slit (using the telescope move) and making an exposure without the object. If the exposure times are not equal, additional correction is needed. One needs to be careful not to have bright stars giving spectra that contaminate the background

exposure.

Instrumental Response. For best results, one needs to adjust for the wavelength response of the system. Usually this is done by taking a spectrum of an object for which a known, absolute spectrum is available (usually a standard reference star). One then takes the ratio of the observed and absolute spectrum and uses this to correct the observed spectrum.