Examples of Spectra

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Updated Nov. 6, 2006 (Swann)
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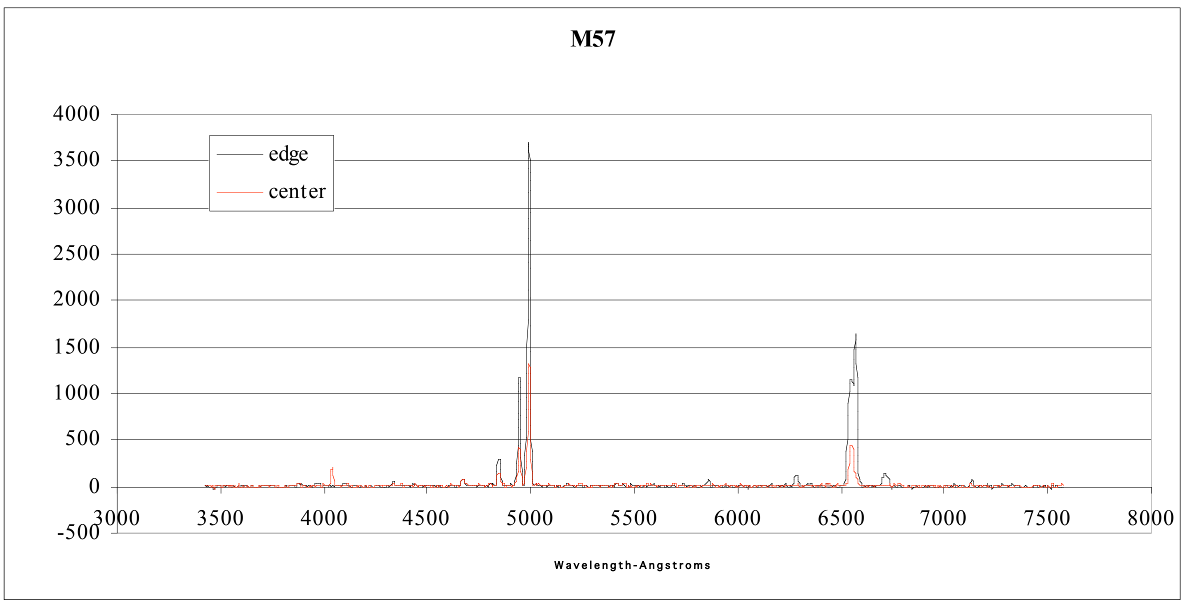
Stars

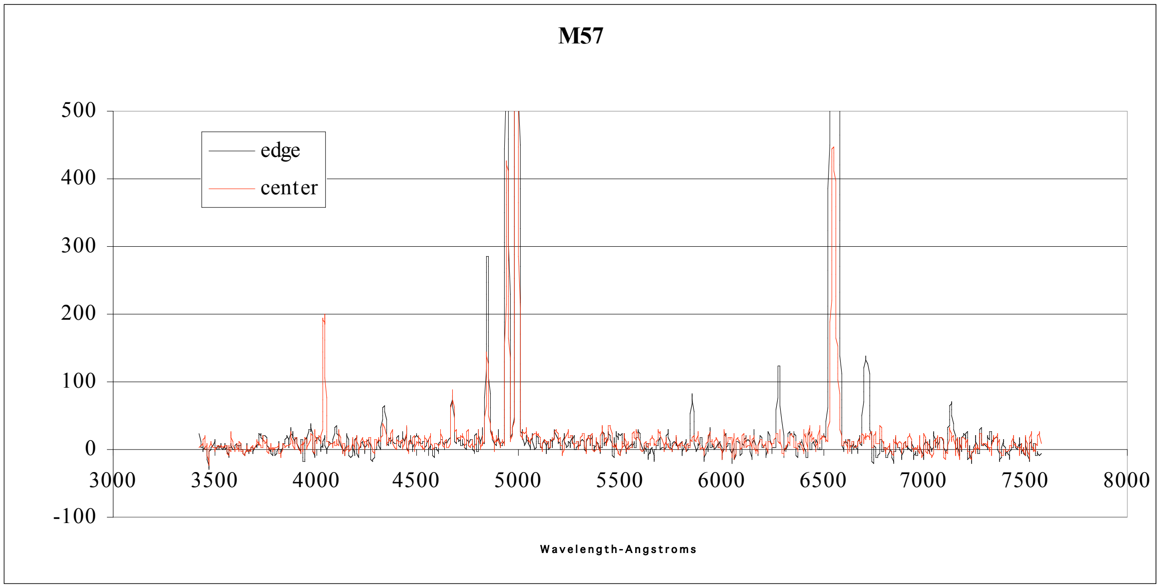
One can, of course, take spectra of stars. One can easily see the general variation across wavelength of the different classes of stars, and many detailed features of the spectra. However, this spectrometer is not nearly of sufficient resolution to do stellar Doppler shifts or similar work. One should also note that an 8th mag. star has all its light spread out continuously over the spectrum. In contrast, an 8th mag. nebula concentrates its light in a few sharp lines (see below), so it is often easier to get a spectrum of the nebula. Of course, a nebula that is so big that little of its light can get through the slit will also be a difficult target!

Planetary Nebula

Good old M57 is a good target. Here is an example. In this case, I compare the spectrum from primarily the edge (ring) and the region in the middle of the ring. Clearly the intensity of the lines tends to be lower in the middle of the ring as compared to the edge of the ring.



However, if we expand the scale, we see that some lines on the edge of the ring are simply not present in the center of the ring, including lines at about 4300, 5800, 6300, and 6700. The spike at 4100 in the center of the ring is an artifact of one of the images.



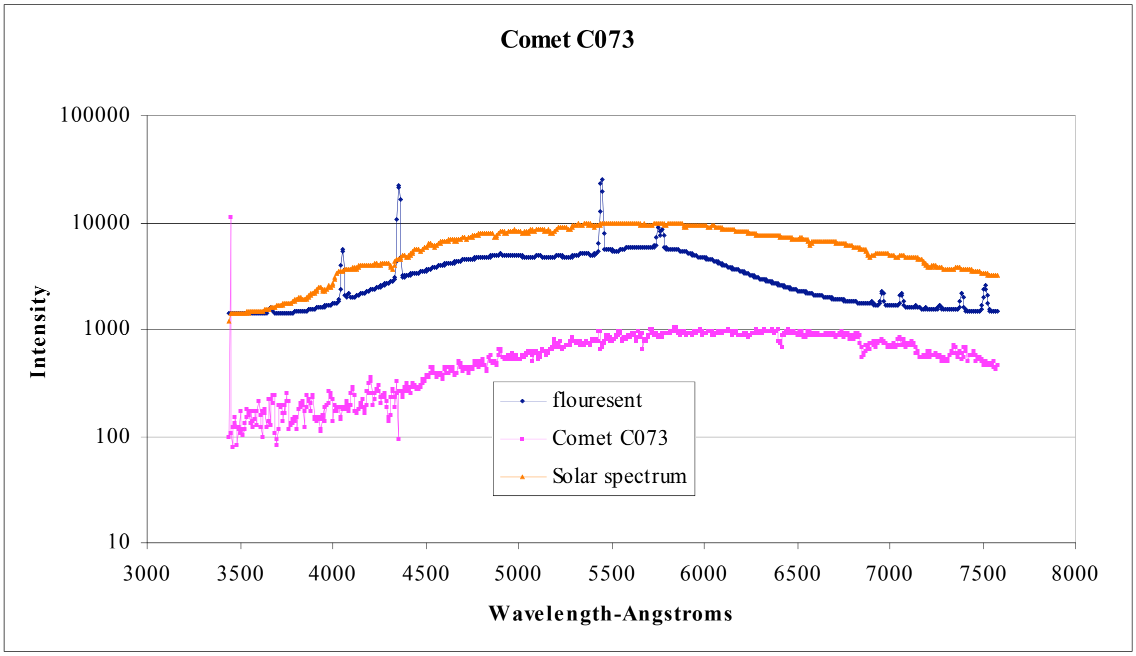
One can go to a variety of texts to identify the lines in the spectra: go to it!

Comet C073

In March 2006, comet C073 was in view. This was a reasonably bright comet, though low in the sky. There were two big problems in getting the spectrum. First, the comet was low, so the refractive changes in position limited the exposure times on the nucleus to about 30 sec. To fix this, I developed software to control the telescope to correct for this movement (and also the comet's movement itself which was relatively fast). The second "problem" was that the spectrum was featureless! I worked hard to discover the problem; however, concluded that this comet has very little chemical activity. I did obtain a spectrum that showed very similar to the solar spectrum, but with some extra strength in the red. It turns out that a few comets do have this behavior, but it certainly made for a boring spectrum (and many doubts that I was doing all this correctly!).

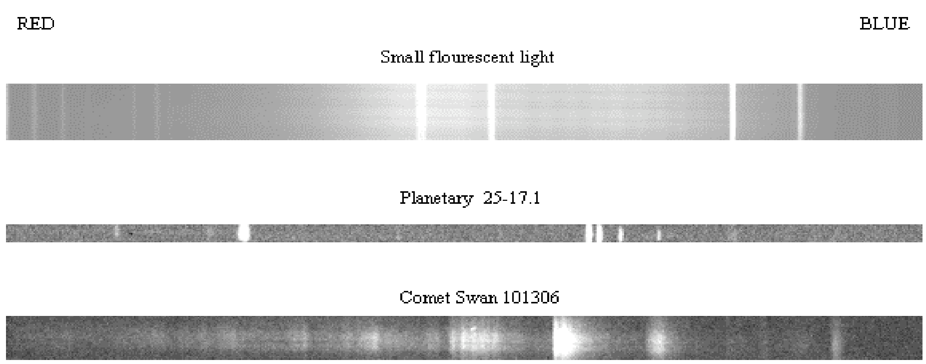
First image is of the raw spectrum of C073 (dark corrected, sky background removed, reversed left/right to put shorter wavelengths at the left). Because of the lack of notable spectral features, I compared it to a solar spectrum. Note that obtaining a solar spectrum is itself a tricky business--does one use the blue sky? A cloud? Center on the sun itself? If you are comparing to the comet, you don't want to introduce wavelength dependent filters or devices in the process.

The general curve of C073 follows the sun spectrum, but you can see that there is a slight deficiency of blue (at the left end) of the C073 spectrum as compared to the solar spectrum. That is, relative to the solar spectrum, the C073 has more red in it. This is real, and presumably results from the more effective scattering of red vs. red light by the comet gasses and dust. I performed a variety of tests, including ratios of various types. There is no clear sign of chemical band or line structure in the spectrum. The slight, wide dip at 7200 A is from atmospheric oxygen, and shows in both the solar and C073 spectrum.

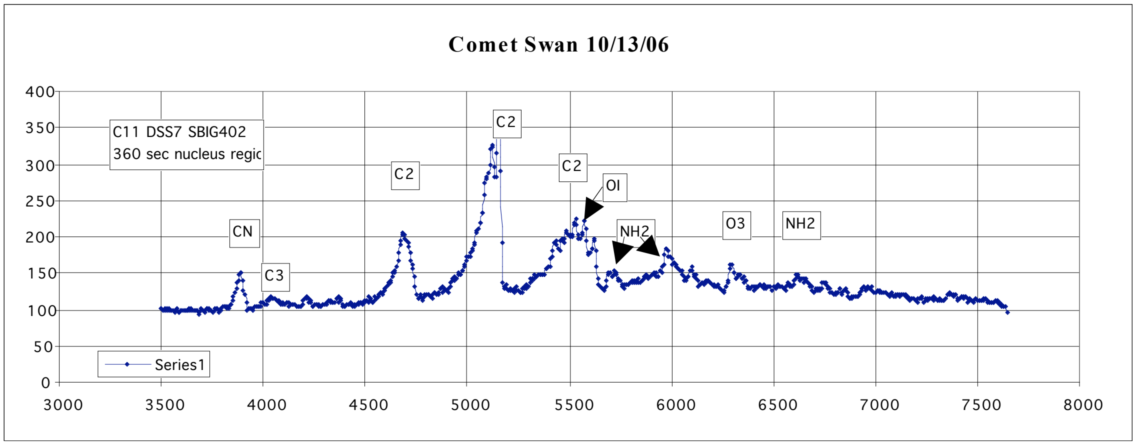


Comet Swan

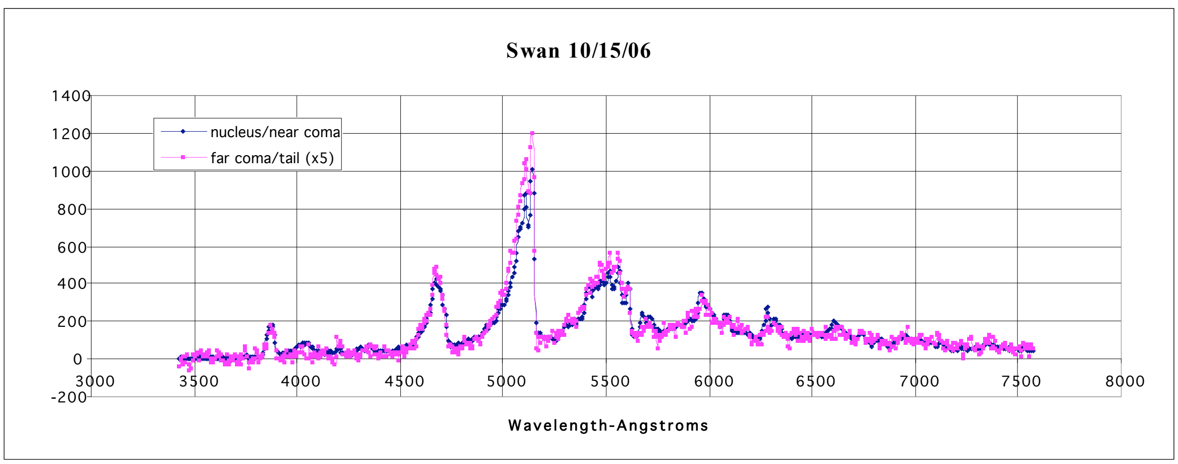
In October 2006 came Comet Swan. Again low in the sky, but reasonably bright. But this time, I could easily get about 120 sec exposures even without special guiding. Not only that, but the spectrum had obvious lines and bands (as expected!).



With a little work, I obtained the spectrum shown on Oct. 13, and assigned chemical sources to the lines, based on data from the book "Comets" (by Wilkening) and from Christian Buel's wonderful web site.



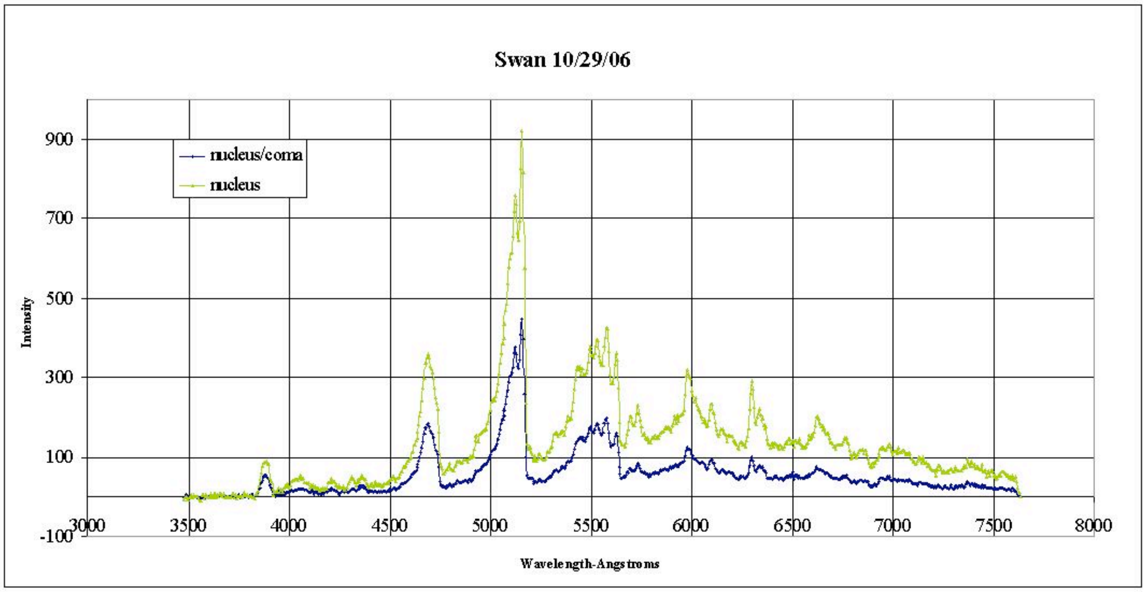
On Oct. 15, I had another try as shown, in which I took the nucleus and nearby coma, and then the farther coma and nearby tail. I compared the two in this graph (I adjusted the amplitude of the coma/tail to match the nucleus. There do seem to be some differences in the relative strengths of the lines. In addition, the C3 hump at about 4050 appears in the nucleus region, but appears to be absent farther away. However, because of limited data quality in this region, additional measurements would need to be taken to verify this.



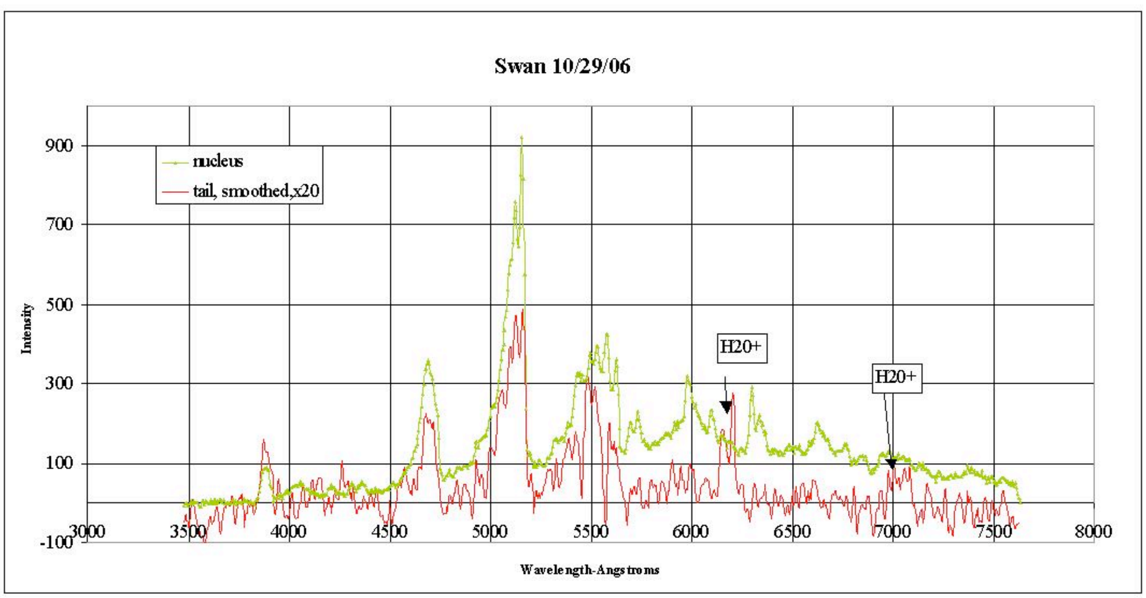
A comparison of Oct. 13 and 15 show no significant difference except possibly in the area between 4000-4500 Ang.; however, the data quality in that region is not good enough to be sure of the results.

On Oct. 29, I had another try at Comet Swan. There was a reported outburst in the days just prior to this run (which was delayed by weather). The waxing moon was beginning to be a problem, though it was in the East while the comet was in the West.

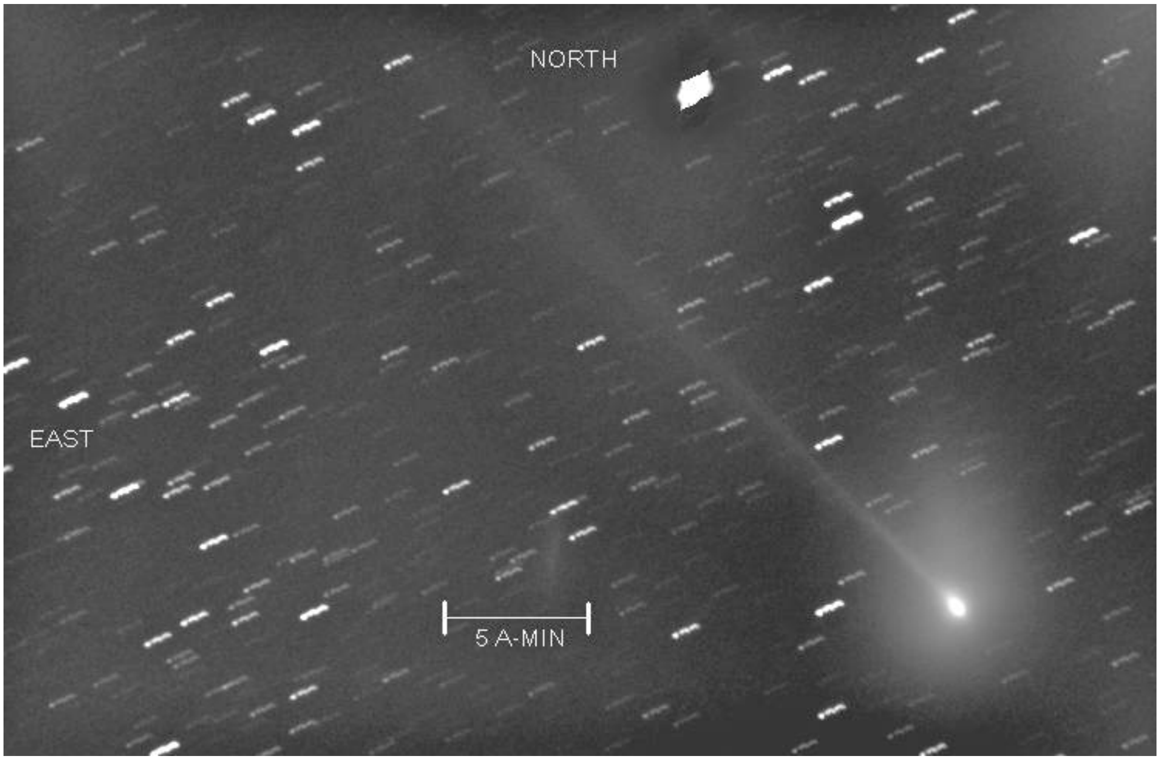
In the nucleus and coma regions, the results were similar to the curves above. However, there were a variety of apparent minor differences in the relative strengths of some of the lines, especially the NH2 lines. In addition, the continuous spectrum underlying the curve appears to have changed; however, I did not take good stellar spectra (as references), nor could I be sure that I was not seeing variations in different parts of the coma.



More interesting was that I was able to obtain what seem to be definitive observations of the tail. I set the slit at approximately 5-7 a-min to the NE of the nucleus so that it was essentially outside the coma, and lying across the tail. By carefully removing the background, I obtained the following curve using 10 minute exposures. The curve for the nucleus is reproduced again, while the tail spectrum is shown smoothed on adjacent data points (due to noisy data) and multiplied by x20 to show on the same scale. While the data are noisy, H2O+ emissions are clearly identifiable in the tail that are not measurable in the comet nucleus or coma. Comparison to the nucleus and coma curves show that several other emissions and the continuum present in the coma/nucleus are very small or not present in the tail.

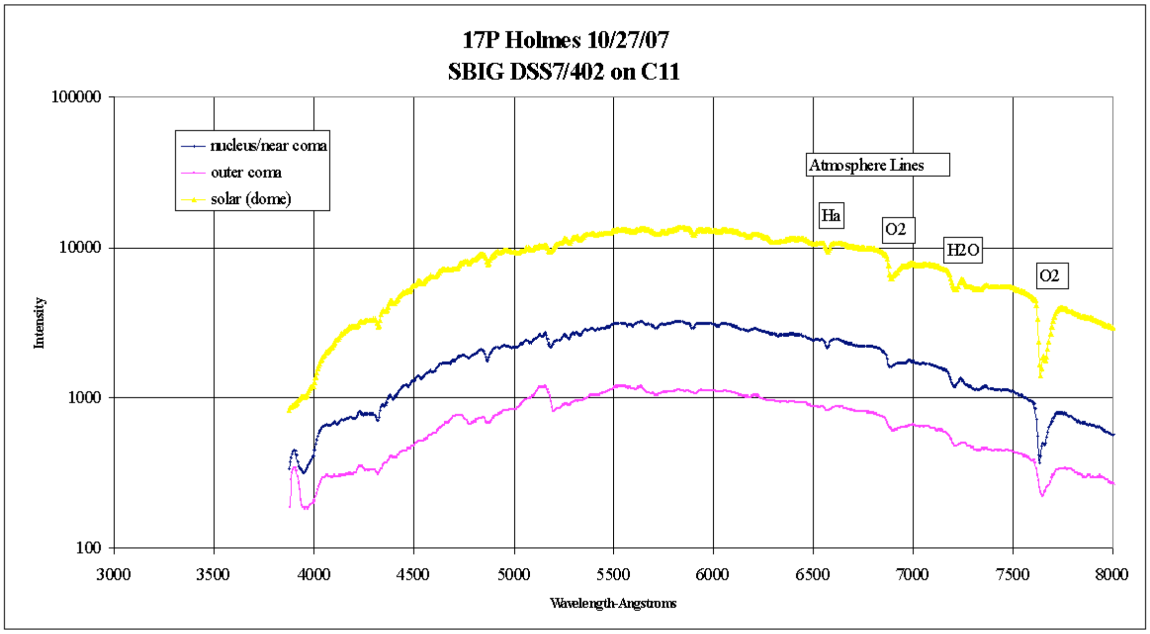


Finally, also on Oct. 29, even with the moonlight, I took a reasonable image of the comet, as shown below. This was about 30 images, each 30 sec, using an AP 6inch f12 SuperPlanetary operating at f4 (Maxfield reducer) and an SBIG 402 camera. Processing was in MaximDL.



Comet 17P Holmes

ON about Oct. 25, 2007, this faint (mag 8) comet brightened to an estimated Mag. 2 in less than 12 hours. Weather prevented observation at our observatory until Oct. 27 when the following spectra were taken. The equipment is a C11 at f/10, DSS7 and 402 camera. The brightness made data taking very easy, with good spectra taken in under a minute. The data shown were from 200 second exposure of the comet. The raw data are shown in the following graph, which shows the spectrum in the inner core including nucleus, outer core, and a reference solar spectrum (taken next day as a reflection off a nearby fiberglass dome). Virtually all the larger features in the Holmes spectrum are solar or earth features. Clearly, the major portion of the light from the comet is simple solar reflection, presumably by dust.



I then subtracted the "dome" solar spectrum, with the amount of subtraction chosen to make the average result close to zero amplitude. I then identified a series of features present in this comet, as were in Comet Swann. Some additional features (identified as "Small Difference in Big Atmospheric Absorption Lines" appear related to the atmospheric lines; however, the features appear to strong for that explanation alone. IN any case, the various features are only about 5% or so of the original spectrum brightness, ie, this comet is showing mostly dust but with weak spectral lines added.