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NOVA SCORPII 2011 = PNV J16551100-3838120 = V1312 Sco

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Introduction

On June 1, 2011, AAVSO sent out Special Notice 240 advising that a possible nova had been discovered by John Seach (Chatsworth Island, NSW, Australia) at RA 16 55 11 Dec -38 38 12 J2000, later named in Alert Notice 442 as NOVA SCORPII 2011 = PNV J16551100-3838120 and finally designated as V1312 Sco [note that my own working designation for the object was sn240].

That evening (June 1) and on a number of subsequent nights, I was able to observe the object for up to 3.5 hours from my observatories in Maryland, even though it only reached 11deg above the southern horizon (AirMass=5). Observations included time series using a C11 f6.3 and ST7e camera with J-C Red filter started on June 2, and spectroscopy using an 18in f3.5 Newtonian with DSS7 spectrometer and ST402 camera.

It was obvious on the first night that the object was real (i.e., not an observational error) and the strong Ha line in the first spectrum showed that it was an apparent nova. On the first night I was able to take a reasonably good spectrum, which in fact was the first one of this object. While continuing spectrometry, the following night I also began photometric observations. I continued both kinds of observations on every clear night through June and July 2011, ceasing only when the object had faded below workable intensity.

Photometry Time Series Results

Time series photometry was conducted in Red because of the low altitude of the object, as well as early results showing that there appears to be extensive reddening of the object spectrum. Exposures were 60 sec, and approximately 150 were made each night. Differential photometry was performed, and the resulting data analyzed using Excel and Peranso. The Peranso period analysis results were graphed using Excel. AAVSO provided a finder chart with V-magnitude markings for nearby field stars. I chose star designated 103 as my comp star. Comparisons of 103 with 81 over the following two months showed no apparent variation in either.

Because of the low altitude, I made no attempt to perform absolute photometry. Because very few of the 20+ nights were clear, a major challenge was to clean the data while rejecting noisy images (usually due to clouds) without introducing bias into the measurements. At the minimum, I rejected any image in which star 81 (the brightest) varied by more than 0.05mag from either the preceding or following image. While this eliminated most noisy data, I also chose in some cases to reject additional data when it looked questionable. Until the nova faded past the end of July, I was able to use the data for trends and for fast and slow period analysis as described below. After the end of July, I was only able to use the data to determine the average brightness during part of a data set (to track the continuing fading trend of the nova).

Because of the extreme low altitude of V1312 from my location in Maryland, USA (11deg and lower), I conducted several analyses of the data to help determine data quality and limitations. For example, Fig 1 shows the instrumental magnitude of nearby Star080 throughout the night for a selection of the data sets. Each data set is plotted on a time scale centered on the transit time of V1312. Thus, as the nova rose, transited, then set, one would see the effect of extinction. To simplify the plot, data sets containing very noisy data were not plotted. This figure shows that there were seven data sets (out of 20) that followed very similar fairly smooth curves, indicating rather clear nights, with DatSet15 showing the least attenuation throughout the session. Other data sets, even when relatively smooth, showed much larger slopes, indicating distant cloud formations of varying complexity. I have also noted the airmass at each 0.02day relative to the transit.

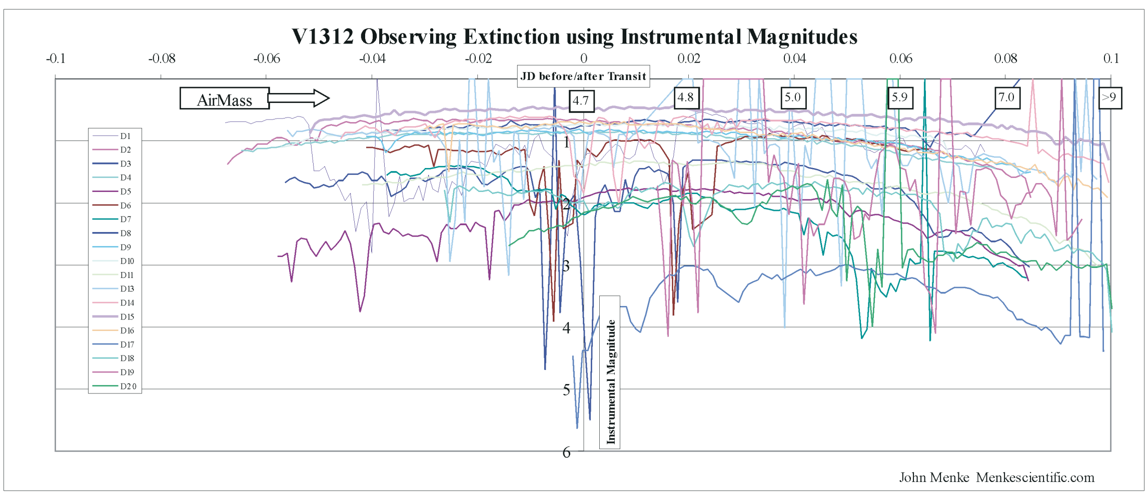

Figure 1. Selection of Data Sets showing Magnitude through the Night

Fig 2 shows for DataSet15 (the least attenuated) a plot of instrumental magnitude vs airmass. This graph shows that on this night, at transit the stars were dimmed approximately 0.75 mag (in Red) compared to Airmass=1. Using this information with Fig 1, one sees that even other less clear but not cloudy nights, the attenuation ranged up to about 1 mag. On cloudy nights, the attenuation fluctuated from 1-3 mag.

Fig 3 shows the cleaned trend data, with the magnitude (Red filter) relative to star 103. The X-axis shows the Julian Day –2450000. The object begins with an actual magnitude of about 10 and drops in stages during the flowing two months. One additional data point taken as a byproduct of the spectrometer measurements described below indicates that the nova was about 0.05mag fainter on the day previous to the first data point in Fig 1. Inspection of each group of data points shows that on about JD5753, the range of values during a given night appears to increase. This is a real effect, and not the result of noise in the data as the nova became fainter.

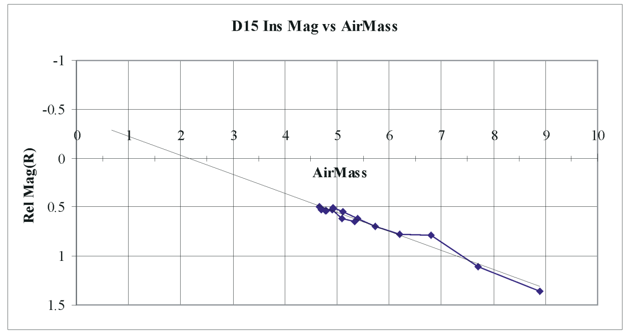

Figure 2 Ins Mag vs Air Mass

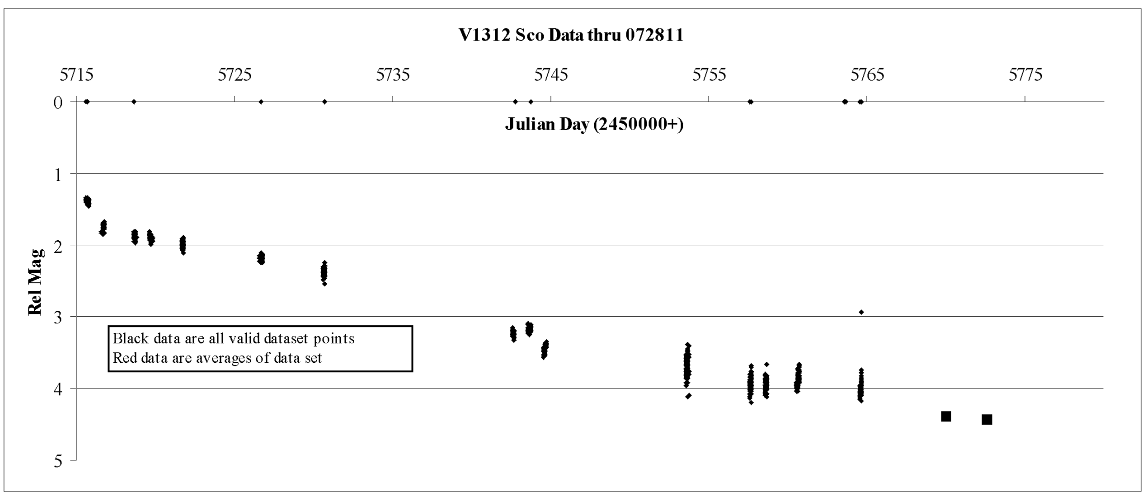

Figure 3 V1312 Sco Brightness Trend

Fast Periodicities. Visual inspection of the data within many data sets gave the impression that there were periodicities in the data in the range of about 15min (about 0.01 day); however, there was always substantial apparent noise in the period signal. I used Peranso, a Fourier analysis program, to search for periodicities, but have plotted the Peranso results in Excel where the results could be easily smoothed and presented more clearly. As the number of data sets grew, and although the strength of the apparent periodic signals shown in Peranso waxed and waned, the periodicities in the 15-30 minute period range continued to be present throughout the observing season. The amplitude of the fast periods appears to be about 0.05-0.1mag.

Fig 4 shows the results of the period analysis showing the presence of signals at the 0.01day (14.4 minute) period, and strong indications of others in the range of 0.01-0.02. At periods much shorter than 0.005, the signals become overwhelmed by the artifacts from the 1.3 minute (0.0009day) cadence of the data acquisition. It should be noted that signals in this range of periods, though variable in strength, consistently appear both when the whole data set is analyzed, or when most subsets of the data are analyzed. It is also clear that the fast period signals only occur when measuring the nova, and not when measuring another pair of comp stars.

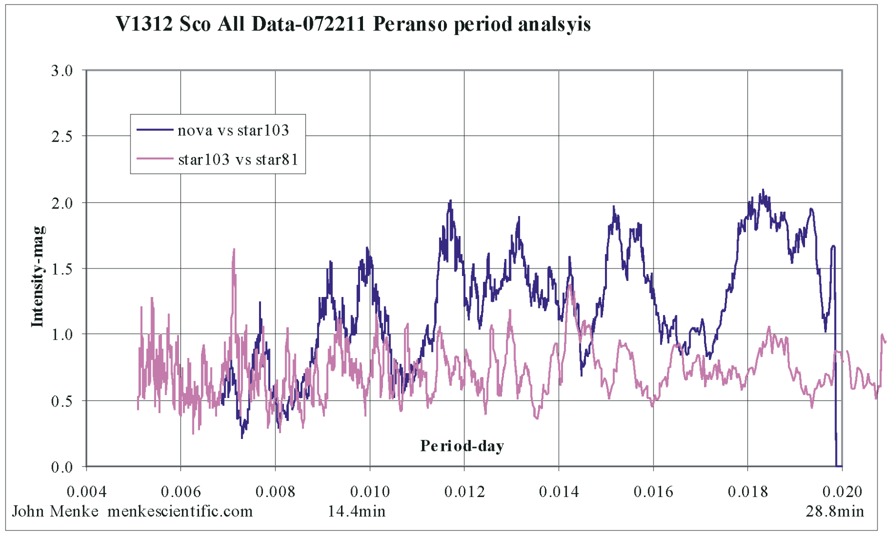

Figure 4 Fast Period Analysis

Is there a periodic signal that is coherent through the set of data (e.g., indicating a pulsating or rotating object)? Evidently not: while signals in the range of .009-.015day) appear to be present in most data sets, combining the data sets does not improve the relative signal level of these periods in the Peranso results. Presumably this indicates that the signal is not coherent, but is more likely fluctuations or flickering occurring with an average periodicity in this range.

Slow Periodicities. Fig 5 shows the cleaned data but with each data set offset to make its mean value close to 0mag. The data sets are numbered, with the legend showing the date (MMDDYY) of the beginning of each data set. It can be seen that the trend of the data each night would be sometimes up, or down, or level, or even concave up or down. Analysis showed that these variations were not the result of extinction. Assuming that there was a periodic signal present, several different graphical analyses indicated a plausible period of about 0.35 day. Peranso period analyses verified the presence of a 0.35day signal, though as with the faster signals, it varied in strength. The amplitude appears to be about 0.1mag. The Peranso analysis also showed strong signals at sub-multiples of 1day (0.5, 0.33, 0.25day, etc). While the apparent 0.35day period does stand out, it's close proximity to the 1/3 day harmonic means that with such short observing durations, it is very hard to make a clear measurement of the signal.

Using the entire set of cleaned data up through July 21, I used Peranso to analyze the periodicity of the data as shown below. While analyzing for both fast and slow signals, I compared the results using the nova vs star 103, and the results of using star103 vs star81. The results were taken from Peranso and graphed in Excel both to provide a uniform presentation and to allow custom averaging of the period data.

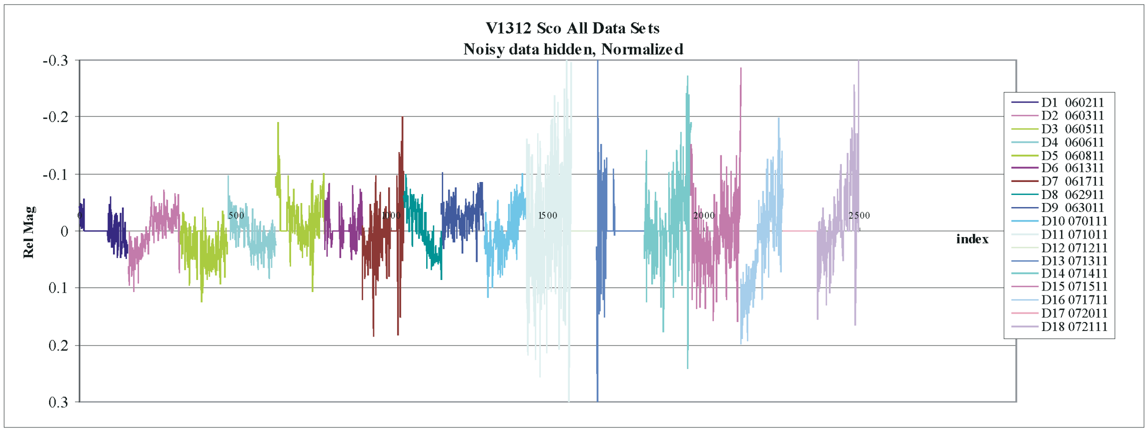

Figure 5 Adjusted Data Set

Fig 6 shows the results of the "slow" period analysis. The 0.5, 0.33, 0.25 day signals (artifacts) are present as is the 0.35 day (8.4hr) signal. As with the fast period signal, other signals appear to be present, the data are noisy, but the 0.35day signal shows only in the nova data, and is present when different (reasonably large) data subsets are analyzed or when different analysis methods are used.

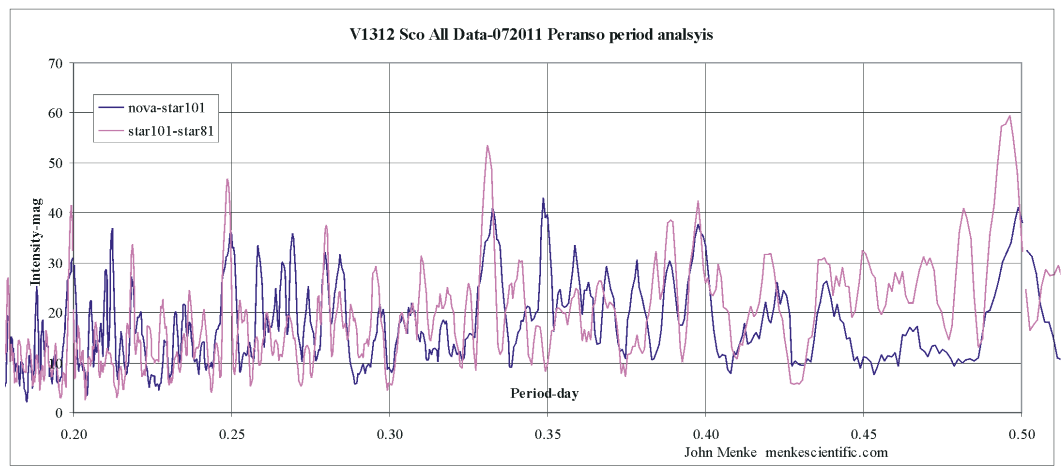

Figure 6 Slow Period Analysis

Spectral Results

Spectra were taken using the DSS7 100u slit giving an instrument resolution of approximately 50A. However, even with the object low on the horizon, the relatively small (25u FWHM) image size at the slit and the system control of the target position yielded a typical resolution (as measured by the width of emission lines) of about 25A. The slit is oriented E-W, so differential refraction errors affecting the overall slope of the spectrum were sometimes substantial. However, the extensive reddening of the spectrum whether from the low elevation and/or possible interstellar reddening reduces the adverse effects. In any case, the consequence is that the quality of the spectrum is very much reduced in the blue.

Spectral images were each 120sec, and approximately 12-20 images were taken from each nights run for analysis. Wavelength calibration was done using the Ha and Hb lines in the data. Instrumental calibration was done using a class B9 reference star about 30a-min from the target, with a spectrum of this star taken early in each observing session. The resulting spectrum was ratioed with a B8 spectrum from the Vspec software library to determine the instrumental calibration and to cancel the atmospheric lines.

Fig 7 shows the spectral results for all the runs, while Fig 8 shows just the first and last spectrum taken in the series. To show the progression of the nova, each spectrum has been adjusted to approximately the same intensity at 6000A. High levels of noise in the data in the blue is obvious. There appear to be regular changes in the slope of the red regions as the event progressed; however, due to the differential refraction and low altitude, it is difficult to say whether this is real.

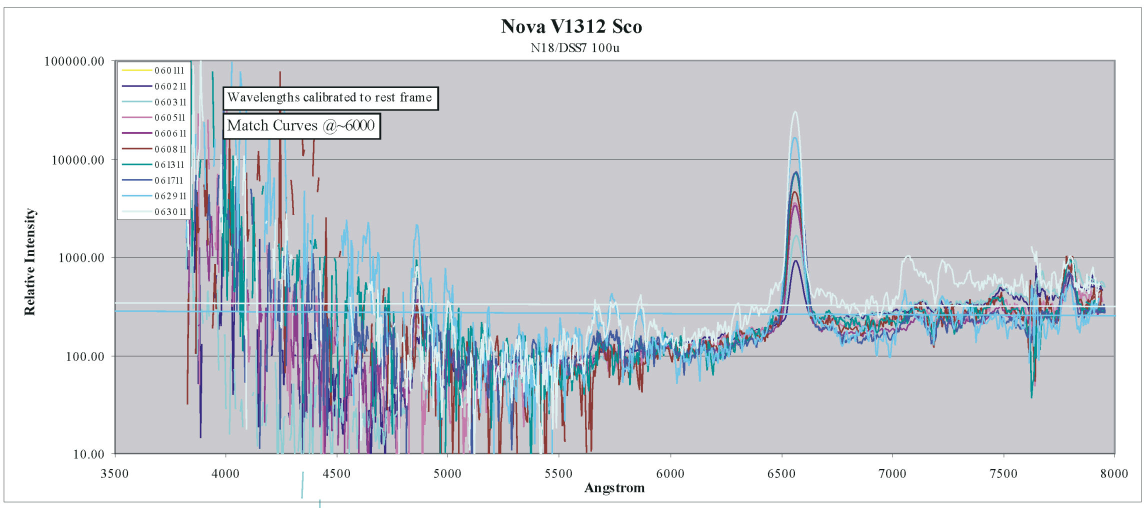

Figure 7 All Spectra

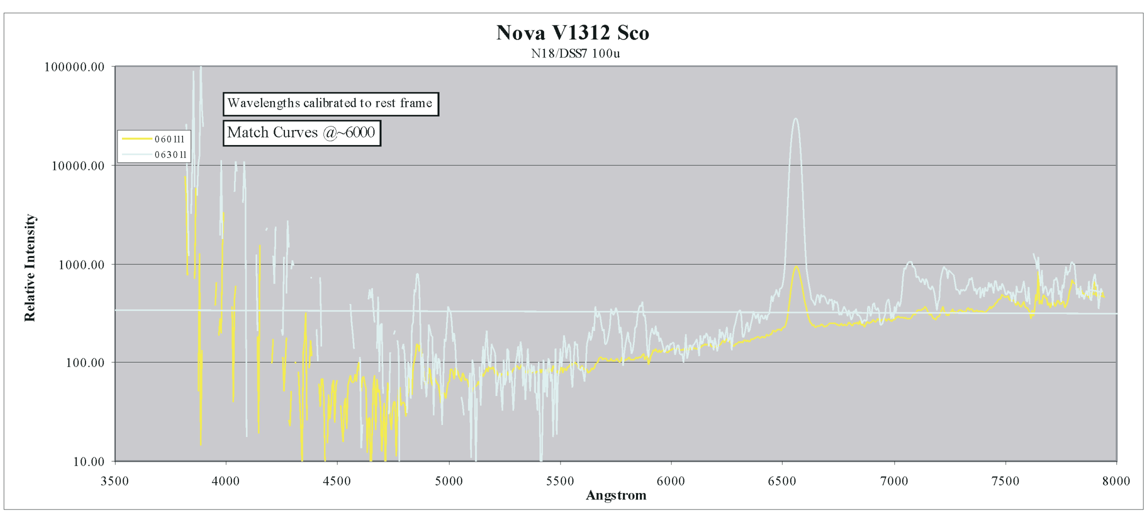

Figure 8 First and Last Spectrum

The strength of the various emission lines obviously evolved during the event, superimposed on the general intensity decline of the nova. Because of the low altitude and limited observing window, it was not feasible to obtain reference star spectra interspersed with target spectra during each night. However, two different methods of tracking line intensity with time were performed:

- Measuring the ratio of the line intensity (including its own background) to the spectrum intensity at 6000A (a measure of the continuum intensity). The continuum at 6000A may, of course, vary differently from the continuum "under" each emission line. This result is shown in Fig 9.
- Measuring the ratio of the line intensity minus its own background to its own background/continuum (this required fitting a Gaussian to each line in the spectrum). This result is shown in Fig. 10

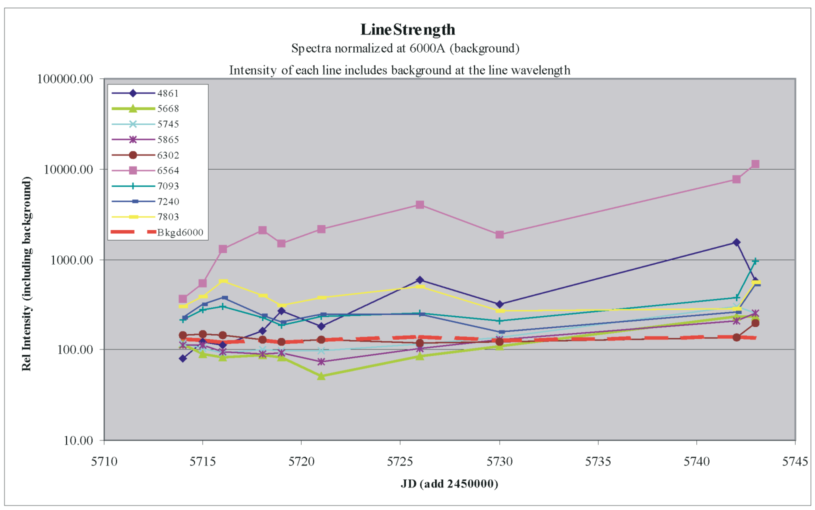

Figure 9. Line strength vs time vs 6000A value

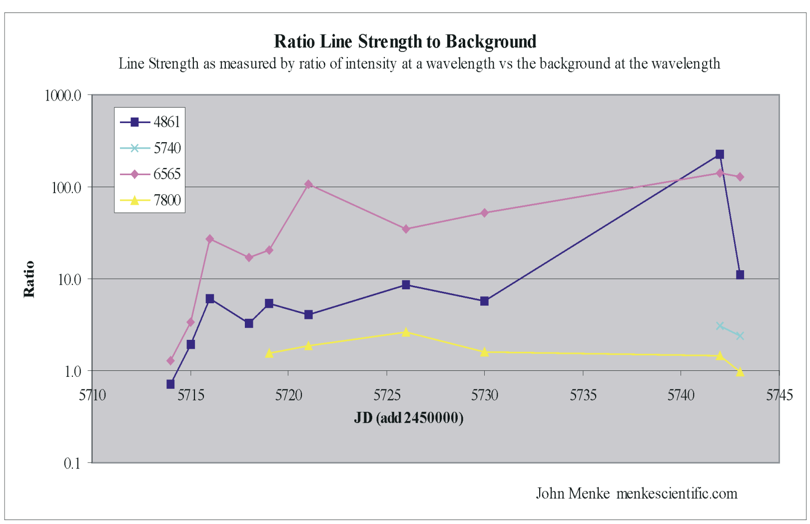

Figure 10. Line Strength vs time vs local background (see text)

The Ha at 6565 is of course the dominant line, with Hb at 4861 second. Both increase rapidly in strength in the first three sessions (June 1-3), and much less rapidly after that. The group of lines near 5000A do not show at all until June 17, after which they rapidly increase. The emission line at 7805A shows a relatively constant strength throughout. The last spectrum (June 30) shows a sudden and interesting appearance of structure beginning at about 7050; however, bad weather and declining brightness of the nova prevented followup spectra.