High Resolution Optical Spectroscopy of the Classical Nova V5668 Sgr 2015

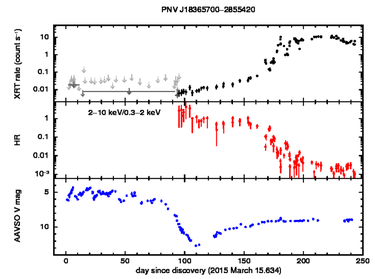
R. M. Wagner[1,2], C. E. Woodward[3], S. Starrfield[4], I. Ilyn[5], K. G. Strassmeier[5], K. L. Page[6], J. P. Osborne[6], and A. P. Beardmore[6]

[1]Large Binocular Telescope Observatory, [2]The Ohio State University, [3]University of Minnesota, [4]Arizona State University, [5]Leibniz-Institute for Astrophysics, Potsdam, [6]University of Leicester

Introduction

V5668 Sgr (N Sgr 2013 No. 2; PNV J18365700-2855420) was discovered by J. Seach (IAUC 9275) on 2015 Mar 15.634 UT (t_0 = JD 2,457,097.134). A low resolution spectrum obtained by Powles (IAUC 9275) showed a Hβ emission line and an emerging Fe II emission line spectrum suggesting that the new object was a Fe II-type classical nova. The nova reached 5th magnitude in mid-March.

The V-band (lower) and Swift XRT (upper) light curves are shown below. After a slow decline for the first 80 days the brightness fell 7 mag as the result of dust formation (ATEL 7643, 7748, 7862, 7986) reaching a minimum on day 110. The light curve has since recovered back up to 9th mag at the end of the observations.



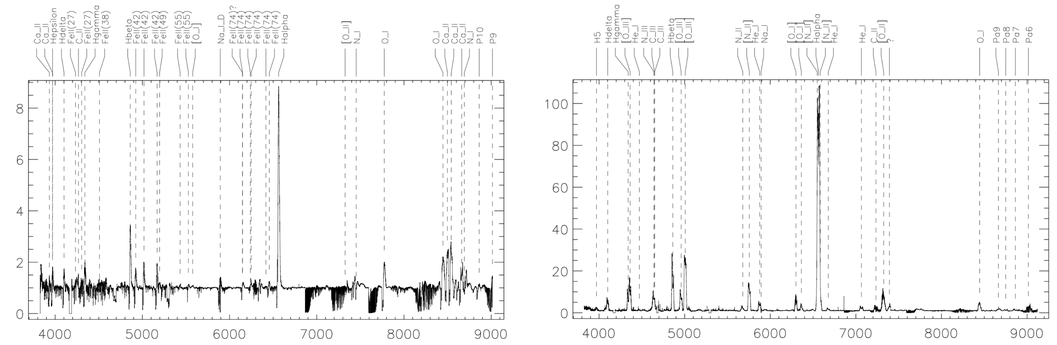
Observations

We obtained high resolution optical spectroscopy with the Potsdam Echelle Polarimetric and Spectroscopic Instrument (PEPSI; Strassmeier et al. 2015, AN 336, No. 4 324) built for the 2 × 8.4 m Large Binocular Telescope (LBT). PEPSI is the highest resolution spectrometer available on any 8-10 m class telescope (see figure lower right).

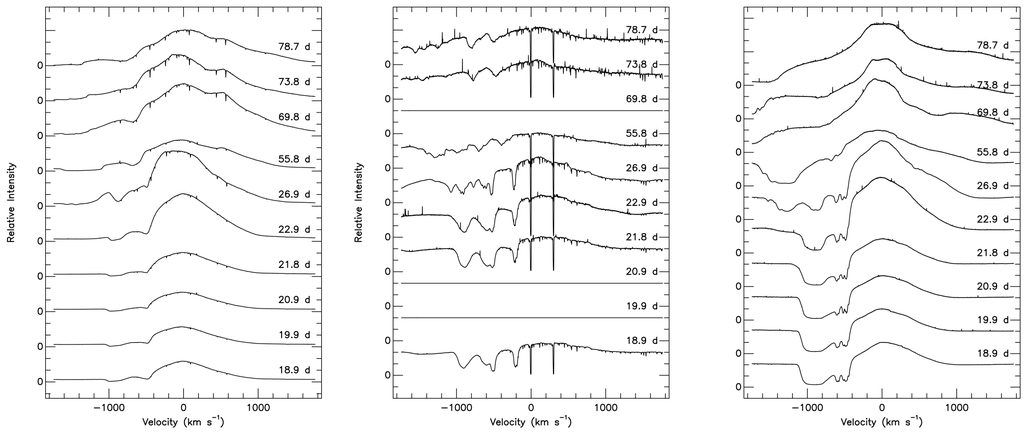
The spectra cover all or part of the 3830 to 9065 Å region in three exposures at spectral resolutions of 43,000, 120,000 or 270,000. Six cross dispersers cover six wavelength settings where two are observed simultaneously. PEPSI is still undergoing science commissioning and a reduction pipeline is in development. PEPSI can also be fed by a 350 m fiber running between the 1.8 m Vatican Advanced Technology Telescope (VATT) and LBT.

V5668 Sgr was observed on 23 epochs between 2015 Apr 3 (day 18.9) and Sep 27 UT (day 195.5). The nova was observed on 5 epochs with the LBT and 270K mode. Spectra were obtained on 17 epochs with the VATT and 120K mode. One spectrum (2015 Sep 27) was obtained with the LBT in 120 K mode.

Results

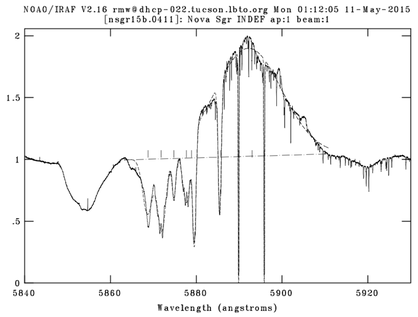


Left: Normalized spectrum obtained on 2015 Apr 3 UT (day 18.9) at a resolution of 270K during the Fe-II phase. The principal spectral features are indicated. The spectrum is dominated by emission lines with P Cyg-type line profiles including Hα, Hβ, Hγ, and Hδ; several multiplets of Fe II, Ca II, and Na I D. The interstellar Na I and K I lines are sharp and prominent. Right: Normalized spectrum obtained on 2015 Sep 27 UT (day 195.5) at a resolution of 120K during the early nebular phase. The spectrum is dominated by permitted emission lines of H, He I, C II, C III, N III, and O I and forbidden emission lines of [N II], [O I], [O II], and [O III].



Selected normalized line profiles during the Fe-II phase. Left: Evolution of the Hα line profile between days 18.9 and 78.7. There are two principal absorption line components at -490 and -895 km/s that show variations on day time scales but are absent by day 55.8. Middle: Na I D line profiles. Three epochs are unavailable. The variations in the absorption components are more evident. The interstellar Na I D lines are sharp and well-resolved at high spectral resolution. Right: O I 7774 Å line profiles. The line profiles are qualitatively similar to the Na I D line profiles. The absorption is nearly saturated initially but fractures into many smaller components within ~10 days. In all three figures, the shape of the line profiles suggests non-spherical outflows.

In an effort to constrain the interstellar extinction component in the direction of V5668 Sgr, we performed Gaussian de-convolution of the Na I D and K I line profiles. For example, the de-convolution of the Na I D line profile observed on 2015 Apr 11 UT is shown at right. Averaged over the available spectra, we find the following mean equivalent widths: W_λ(Na I D2) = 0.39 ± 0.06 Å and W_λ(K I 7699 Å) = 0.032 ± 0.002 Å. Using the calibration of Munari and Zwitter (1997, A&A, 318, 269) these values correlate with E(B-V) = 0.18 and 0.12 mag respectively. We note that the NED extinction calculator gives a maximum of A_V = 0.656 mag (E(B-V) = 0.21 mag) in this direction.



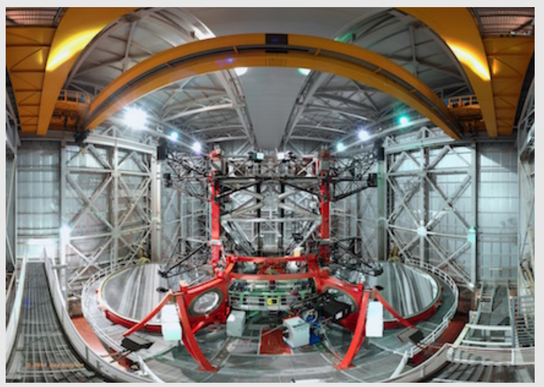
Conclusions

1. We obtained high resolution optical spectroscopy on 23 epochs using the LBT and VATT with PEPSI covering the 3830-9065 Å region at resolutions of 120,000 and 270,000.
2. Spectra between days 18 and 79 showed the continued evolution of a Fe II-type classical nova with significant changes in the strength of both emission and absorption line components.
3. The shape of the line profiles suggests that the ejection was non-spherical.
4. A spectrum obtained after the dust formation interval showed that the spectrum of V5668 Sgr was passing between the auroral and nebular phases.
5. Measurements of the equivalent width of the interstellar Na I D and K I absorption lines compared with the calibration with E(B-V) by Munari and Zwitter gives an estimate of E(B-V) = 0.12 (K I) to 0.18 (Na I D) mag.

Acknowledgments

SS acknowledges support from NSF and NASA grants to Arizona State University. CEW acknowledges support from NASA grants to the University of Minnesota.

The LBT is an international collaboration among institutions in the United States, Italy and Germany. LBT Corporation partners are: The University of Arizona on behalf of the Arizona Board of Regents; Istituto Nazionale di Astrofisica, Italy; LBT Beteiligungsgesellschaft, Germany, representing the Max-Planck Society, The Leibniz Institute for Astrophysics Potsdam, and Heidelberg University; The Ohio State University, and The Research Corporation, on behalf of The University of Notre Dame, University of Minnesota, and University of Virginia.



2 × 8.4 m Large Binocular Telescope with the PEPSI Permanent Focal Units (large white boxes mounted to the structure bottom and left and right of center).