THE ASTROPHYSICAL JOURNAL, 264:560–562, 1983 January 15

WY SAGITTAE (NOVA 1783): SPECTROSCOPIC CONFIRMATION OF WEAVER'S CANDIDATE AND DISCOVERY OF DEEP ECLIPSES

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Received 1982 June 3; accepted 1982 July 12

ABSTRACT

Weaver's faint blue variable candidate "N" for Nova WY Sagittae (1783) is found to have a typical cataclysmic variable spectrum: strong Balmer, He I, and He II emission lines superposed on a continuum. Coupled with the star's rapid optical flickering and excellent positional agreement with D'Agelet's nova (1783), the spectrum removes any doubt that WY Sge has been recovered.

Deep eclipses ($\gtrsim 2$ mag) of WY Sge have been observed. The binary has an orbital period of $(1.0756 \pm 0.0002)/N$ days, where $1 \leqslant N < 9$.

Subject headings: stars: eclipsing binaries — stars: individual — stars: novae

I. INTRODUCTION

In late July 1783, the French astronomer D'Agelet discovered a nova at $m_v \approx 5.4$ in Sagitta (see Gould 1866 for details of D'Agelet's observations). With the exception of the recently recovered Nova CK Vulpeculae (1670) (Shara and Moffat 1982), WY Sge (1783) is the oldest nova with an accurately known position ($\pm$ a few arc seconds, from D'Agelet's mural quadrant observations). On the basis of its relative blueness, apparent magnitude, lack of proper motion, irregular brightness fluctuations, and position, Weaver (1951) was able tentatively to identify WY Sge with a 19th magnitude star 6″ from the reported position of D'Agelet's nova. A finding chart for WY Sge (labeled *N*) was also provided by Weaver (1951). Warner's (1971) high-speed photometry supported Weaver's candidate star by showing it to have systematic light variations with amplitudes 0.1–0.2 mag on time scales of minutes. We are unaware of any other modern observations of WY Sge, which has now been within spectrographic range of large telescopes for over a decade.

II. SPECTROPHOTOMETRY

To settle firmly the question of the identity of D'Agelet's nova and to check on the properties of a nova two centuries after eruption, we obtained spectra of WY Sge with the Multiple Mirror Telescope (MMT) spectrograph + Reticon on 1981 October 4. With the 300 lines mm^{-1} grating we obtained 18 spectra, each of 5 minutes duration and covering the wavelength range 3800–6800 Å with 2–3 Å resolution. The star and sky were observed alternately and simultaneously in twin $2'' \times 3''$ diaphragms separated by $\sim 20''$. After dividing out the flat field source, normalizing to relative flux from spectrophotometric standard observations, adding all 18 (individually rather noisy) spectra, and convolving with the standard MMT Gaussian smoothing filter, we obtained the average spectrum of WY Sge shown in Figure 1.

The observed prominent Balmer, He I, He II, and C III + N III emission lines, superposed on a continuum, form the characteristic signature of a cataclysmic variable. Weaver's (1951) tentative identification of Nova WY Sge (1783) is completely confirmed.

The strong 4428 Å interstellar absorption feature is supportive of Weaver's 3 kpc estimate for the nova's distance in the following way. With central depth of $\sim 16\%$, this feature gives $E_{B-V} \approx 1.6$ mag according to the calibration of Sneden *et al.* (1978), although λ4428 is not very well correlated with dust grains that cause the visual extinction. Taking $E_{B-V} \approx 0.6$ mag kpc^{-1} in the galactic disk (Spitzer 1978) yields a rough distance of 2.7 kpc. We note that the λ4428 feature in WY Sge has a FWHM of ~ 40 Å, significantly larger than typically found (~ 20 Å) in other stars (Herbig 1975).

No radial velocity variations of Hβ or He II λ4686 larger than the 2–3 Å spectrum resolution were observed during the $\sim 2\frac{1}{2}$ hr of observations. The strong He I lines observed, particularly the triplet λ5876 and the singlet λ4921, may be indicative of a high He/H

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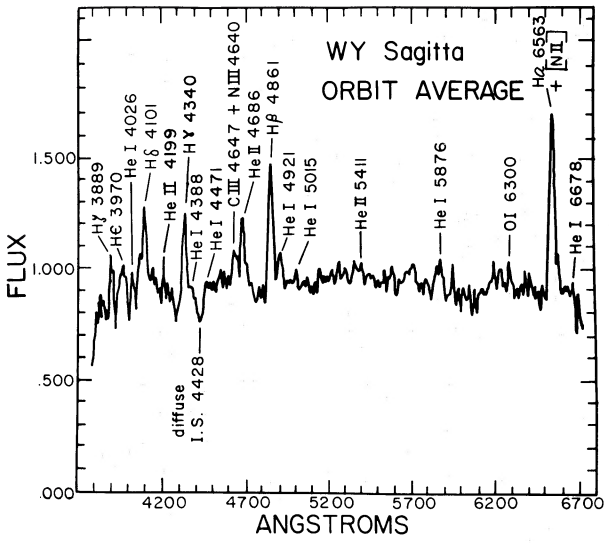

FIG. 1

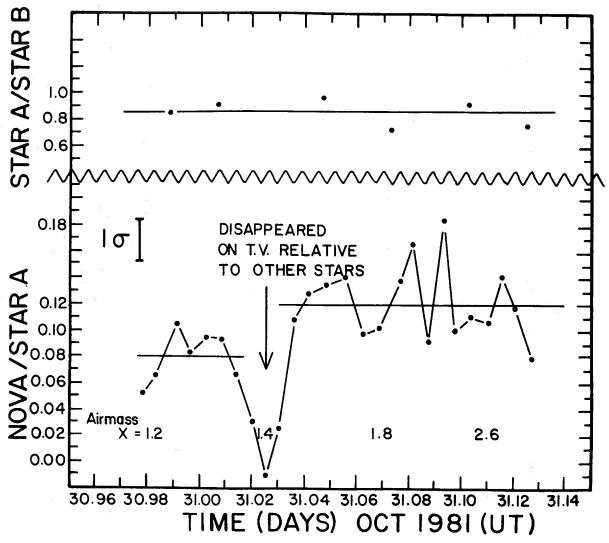

FIG. 2

FIG. 1.—The sum of 18 five minute spectra of WY Sge, taken with the Multiple Mirror Telescope spectrograph + Reticon on 1981 October 4. The prominent emission lines of H I, He I, He II, and C III + N III, characteristic of old novae, confirm Weaver's (1951) candidate for WY Sge.

FIG. 2.—The photoelectric light curve of WY Sge on 1981 October 30/31, obtained with the Mont Mégantic 1.6 m telescope. Star A is an $m_{pg} = 16.5$ A3–A5 star identified in Weaver's (1951) finding chart; star B is ~ 40″ east of star A.

ratio (Williams and Ferguson 1982) in the accretion disk of WY Sge. Alternatively, the He I lines may be formed in a region of higher temperature than the Balmer lines, somewhat closer to the accreting white dwarf star.

III. PHOTOELECTRIC PHOTOMETRY

WY Sge was observed to dim and become invisible on the MMT guide TV system on the nights of 1981 October 3/4 and 4/5. The eclipses were completed in ~ 20 minutes. The estimated centers of the eclipses occurred at October 04.138 ± 0.004 and October 05.210 ± 0.004 Universal Time. The binary orbital period is therefore $(1.072 \pm 0.008)/N$ days, where the length of our October 4/5 observations constrain the integer N to $1 \leqslant N < 9$.

On the night of 1982 October 30/31 A. F. J. M. obtained differential photoelectric photometry of WY Sge with the Mont Mégantic 1.6 m telescope and a single-channel S-11 (blue sensitive) photomultiplier tube. No filter was used. Star A (marked as such on Weaver's 1951 finder chart) and a clearly visible star (we call B) 40″ east of A were used to obtain the light curve shown in Figure 2. Stars A and B remained constant in brightness throughout the observations.

The earlier MMT TV observations are confirmed by the Mégantic photometry. WY Sge appears fainter before eclipse than after, and the eclipse lasts ~ 20 minutes. During eclipse the old nova becomes fainter than $m_B \sim 21$. The shape of the eclipse suggests that it is grazing, or that the eclipsed object is comparable to the size of the system's nondegenerate star.

The faintness of WY Sge limits us to a Mégantic eclipse timing of October 31.025 ± 0.002 UT. This and the earlier, inexact timings are sufficient to allow an improved estimate, $P = (1.0756 \pm 0.0002)/N$ days, but not to determine uniquely the period P of the old nova. High-speed photometry with the MMT to determine P and to verify Warner's (1971) observations of short-time scale quasi periodicities are planned for the near future.

IV. CONCLUSIONS

Weaver's (1951) candidate for Nova WY Sagittae (1783) has been spectroscopically confirmed. The old nova undergoes deep eclipses ($\geqslant 2$ mag), and the binary orbital period is $(1.0756 \pm 0.0002)/N$ days, where $1 \leqslant N < 9$.

Ron Webbink first pointed out the importance of WY Sge to us and encouraged us to obtain spectra of it. Thanks are also due to the organizers, and particularly to John Faulkner, of the 1981 Santa Cruz Summer School on Cataclysmic Variables, where this investigation was conceived.

We are grateful to the director of the Steward Observatory for observing time on the Multiple Mirror Telescope. M. M. S. acknowledges financial support from the National Science Foundation through grant AST 79-21073 to Arizona State University. A. F. J. M. acknowledges financial support from the Natural Sciences and Engineering Research Council of Canada.

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