THE DA+dMe Binary WD 0334-6400

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Abstract

Multi-wavelength observations of the star WD 0334-6400 (or Ret 1 in *A Catalog and Atlas of Cataclysmic Variables: Living Edition*) show it to be a DA+dMe binary. Our analysis of the far-ultraviolet continuum and spectral lines reveal that $T_{eff} = 36500$ K; log $g = 7.7$; and the photosphere contains C, N, Si, P, and S. C/H $= 2 \times 10^{-6}$. The dMe star is seen as a flux excess in near-infrared photometry and appears to show occasional flaring of about one magnitude as seen in the Harvard plates. There is no evidence of periodic variability in the spectroscopic or photometric data.

Introduction

WD 0334-6400 was classified as a subdwarf O-type star with Balmer-line and Ca II H- and K-line emission in the Rodgers *et al.* catalog of high-latitude, early-type stars (1993). The catalog designation is P831-57 with R.A. = 3h34m34.23s, Decl. = -60o00'56.1", and V = 14.2. The emission line intensity and velocity was know to vary on a timescale of hours, but no well-defined period was detected. It was suspected that the emission lines arose from an accretion disk associated with the companion in orbit around the subdwarf O star. The subdwarf O absorption spectrum appeared constant, with lines of Fe III and H II detected, and an equivalent width of of H-delta of 1.10 ± 0.07 nm, implying an effective temperature of $>$ 21000 K.

In *A Catalog and Atlas of Cataclysmic Variables: Living Edition* by Downes and Shara (2005), WD 0334-6400 is provisionally listed as a nova-like variable. As a result of this designation, WD 0334-6400 was included in the *FUSE Survey of High-Declination Nova and Nova-like Cataclysmic Variables* during Cycle 4. We report the results of the FUSE observation and associated optical photometry of WD 0334-6400.

Observations

WD 0334-6400 was observed by FUSE on 2003 November 3 using the large aperture (LWRS). The observation spanned three exposures of 3955 s each for a total of 11865 s. The dataset is identified by the number D9131401000 in the MAST. Each exposure has been processed using a modified version of CalFUSE v3.0.7 that provides an option to convolve the extracted spectrum with B_3-spline function. This modification reduces the noise in the spectrum, while preserving the spectral resolution. A 0.01 Åbin size is used to facilitate the alignment and addition of each channel into into a summed spectrum. Figure 2 shows the summed spectrum of the seven spectral channels. The LiF 1B channel is excluded because of the presence of the worm. This instrumental artifact is described in Sahnow *et al.* (2000).

We obtained the original optical spectra of WD 0334-6400 (P83I-57) from William Roberts at the Australian National University. The observations are from 1993 October 11–14 and 1993 November 16 using the Mount Stromlo 1.9 m telescope and the Photon Counting Array (PCA). The spectra are reduced using standard IRAF reduction software and the summed spectrum is shown in Figure 1.

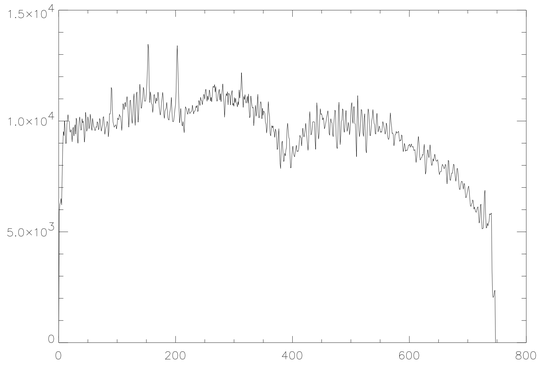

FIGURE 1: Optical spectrum of WD 0334-6400 from Roberts.

Spectral Analysis

We used TLUSTY200 to produce synthetic spectra of hot a DA white dwarf atmosphere in order to estimate the physical parameters of the star. We find a temperature of 36500 ± 250 K and a log of the surface gravity of 7.7 ± 0.1 as shown in Figure 2. Strong lines of carbon, nitrogen, silicon, and sulfur are also present (see Table 1).

Some of the absorption lines are due to interstellar absorption from which we estimate a column density of 3×10^{16} atoms-cm^{-2}. Fits to the C II and N I lines are consistent with a solar abundance ratio.

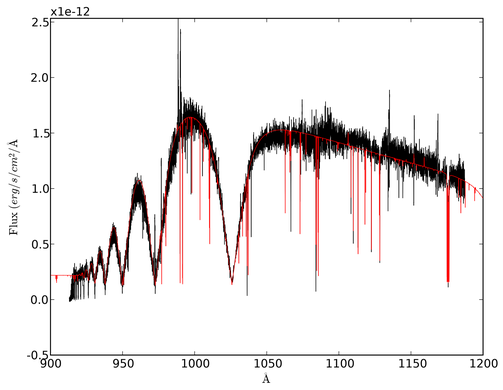

FIGURE 2: FUSE spectrum of the WD 0334-6440 with the best fitted model in red. The spectral lines are identified in Table 1.

Abundances

Table 1 is a list of photospheric absorptions lines that have been identified in the summed FUSE spectrum.

A comparison of the widths and central wavelengths of the strongest photospheric lines (e.g. the C III multiplet at ≈ 1175 Å) shows no variation of the central wavelength in the individual exposures. This constrains any radial velocity variations due to the orbital motion to less than 12 km/s over a period of 4 hours.

Table 1. Atmospheric Abundances

Ion	Number[a]
C III	-5.7 ± 0.1
N III	-6.0 ± 0.2
Si III	-7.5 ± 0.3
Si IV	-7.5 ± 0.3
S IV	-7.5 ± 0.3

[a] Quoted errors on 1σ statistical uncertainty.

Photometry

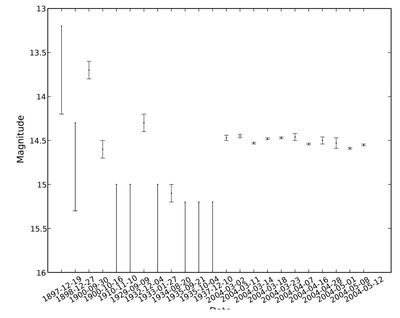

FIGURE 3: Photometry of WD 0334-6400 during the past 100 years. The observations between 1897 and 1937 are estimated magnitudes from the Harvard plate stacks. The 2004 observations are from B band CCD photometry. Note the ≈1 magnitude variation in 1900 (between September 30 and October 16) indicating the star is variable.

In an attempt to identify the orbital period of WD 0334-6400, B-band photometry was done on eleven nights during February through May of 2004. The observations are shown in Figure 3. No periodic variation is seen down to a level of 0.1 magnitudes. More data is needed to test whether there is variability at less than the 0.1 magnitude level.

A search of the Harvard plate stacks was also made, resulting in 12 observations of WD 0334-6400 during the period 1897 December 19 and 1937 December 10. Eight of the twelve observations are upper limits indicating the brightness was fainter than about 15 magnitude. The other four observations vary between 13.7 and 15.1 magnitudes with an estimated error of 0.1 magnitudes. The B-band photometry shows variability at the level of 0.1 magnitudes. While the archival observations are too sparse for a meaningful time series analysis, they do show that the star can vary by about 1 magnitude over a span of two weeks. We attribute this variability to flaring by the red dwarf companion.

Conclusions

A FUSE observation of WD 0334-6400 (Ret 1) does not confirm its tentatively classification as a nova-like variable. Instead, we reclassify this star as a DA+dMe binary. We attribute the variable emission lines to that active and flaring red dwarf companion star.

The strong photospheric absorption lines of the white dwarf in the far ultraviolet are probably due to accretion of the companion stars wind.

There is no evidence of periodic variability in the spectroscopic or photometric data.

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References

Downes, R.A., Webbink, R.F., Shara, M.M., Ritter, H., Kolb, U., Duerbeck, H.W. 2001, PASP, 113, 764.
Rodgers, A.W., Roberts, W.H., Walker, I. 1993, AJ, 106, 591.
Sahnow, D.J. *et al.* 2000, ApJL, 538, 7.

Table 1:

Figure 5:

Figure 6:

Figure 7: