Far Ultraviolet Spectroscopy of Old Novae.
II. RR Pic, V533 Her, and DI Lac

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Abstract
The old novae V533 Her (Nova Her 1963), DI Lac (Nova Lac 1910), and RR Pic (Nova Pic 1891) are in (or near) their quiescent stage, following their nova explosions, and continue to accrete at a high rate in the aftermath of their explosions. They exhibit continua that are steeply rising into the FUV, as well as absorption lines and emission lines of uncertain origin. All three have Far Ultraviolet Spectroscopic Explorer (FUSE) spectra that offer not only higher spectral resolution but also wavelength coverage extending down to the Lyman Limit. For DI Lac, we have matched these FUSE spectra with existing archival International Ultraviolet Explorer spectral coverage to broaden the FUV wavelength coverage. We adopted the newly determined interstellar reddening corrections of Selvelli & Gilmozzi. The dereddened FUV spectra have been modeled with our grids of optically thick accretion disks and hot, NLTE white dwarf (WD) photospheres. The results of our modeling analysis indicate that the hot components in RR Pic and V533 Her are likely to be accretion disks with mass accretion rates of $10^{-8} M_\odot$ yr$^{-1}$ and $10^{-9} M_\odot$ yr$^{-1}$ respectively. However, the disk cannot produce the observed absorption lines. For the WD to be the source of the absorption lines in these two systems, it must be very hot, with a radius several times its expected size (because the WD in these systems is massive, it has a smaller radius). For DI Lac, we find the best fit to be a disk with $M = 10^{-10} M_\odot$ yr$^{-1}$ with a 30,000 K WD.

Key words: novae, cataclysmic variables – stars: individual (RR Pic, V533 Her, DI Lac)

1. Introduction
Cataclysmic variables (CVs) are compact binaries comprised of a Roche-lobe filling Sun-like star transferring gas to a white dwarf (WD) via an accretion disk (if the WD is non-magnetic) or via a magnetically channeled accretion column if the WD is magnetic. When a critical mass of hydrogen-rich gas accumulates on the WD, an explosive thermonuclear runaway is triggered identified as a classical nova.

Following the nova explosion, the stellar remnant enters a phase of non-explosive evolution during quiescence. This phase is not well-understood. Do these post-novae evolve into dwarf novae as their accretion rates drop? When does nuclear burning, and hence the soft X-ray production, stop following the nova explosion? The timescale for this to occur is predicted to be in the range of 1 to >10 years, possibly as long as 300 years, depending upon the mass of the WD and the amount of H left on the WD after the nova explosion, and is inversely dependent on the WD mass. What are the accretion rates of old novae as a function of time since the nova explosion? Is there enhanced mass transfer due to irradiation of the secondary donor star (causing the donor to bloat and/or by driving a wind off of the donor star) by the hot WD and/or hot accretion disk? Does the mass of the WD grow following a nova outburst?

An essential key to answering a number of these questions is in the far-ultraviolet wavelength domain where the Planckian peak in the energy distribution of a CV accretion disk or accreting WD occurs. Specifically, a reliable determination of the rate of accretion onto each post-nova WD and a comparison of the accretion rates of each system, at different times since their last eruption, could bear directly on the accretion related questions mentioned above.

The old novae RR Pic, V533 Her, and DI Lac have good quality far-ultraviolet spectra on the MAST archive obtained from the Far Ultraviolet Spectroscopic Explorer (FUSE), and International Ultraviolet Explorer (IUE). In addition, archival FUSE spectra enable our model fitting to extend down to the Lyman Limit, which provides additional insights and constraints on the nature of the hot emitting component. Moreover, RR Pic offers a number of advantages for a synthetic spectral analysis. RR Pic itself has an accurate trigonometric parallax and very good FUSE spectra. Our analysis utilizes the new Hubble FGS parallax distance of 400 pc, which removes one critical free parameter in our model fitting. The physical and orbital parameters from the literature for RR Pic, V533 Her and DI Lac are summarized in Table 1.

In Section 2, we present a log of the FUSE and IUE spectroscopic observations, and describe the spectral line features in the FUSE wavelength range. In Section 3, we present the results of a search for line and continuum variations as a function of orbital phase. In Section 4, we describe our synthetic spectral fitting codes, model grids, and fitting procedure. In Section 5, we present our model fitting results. Finally, in Section 6, we summarize our conclusions.

2. Far Ultraviolet Spectroscopic Observations
The observing log of far-ultraviolet spectroscopic observations of RR Pic, V533 Her, and DI Lac is presented in Table 2. All spectra were downloaded from the MAST archive. All of the FUSE spectra of the three systems were acquired through the LWRS aperture in TIME-TAG mode. Each exposure was made up of multiple subexposures. As pointed out by Godon et al. (2012), the FUSE reduction requires a
Table 1

Physical and Orbital Properties of Old Novae

| System Name | Nova Name | P_{orb} (hr) | i (degree) | d (pc) | V | E(B-V) | M_{bol} (M_\odot) | Speed Class |
|-------------|-----------|--------------|------------|--------|---|--------|-------------------|-------------|
| RR Pic      |           | 3.481        | 65         | 380-490 | 12.3 | 0.00    | 0.95              | Slow        |
| V533 Her    |           | 3.53         | 62         | 560-1250 | ...  | 0.03    | 0.95              | Slow        |
| DI Lac      |           | 13.6         | <18        | ...     | ...  | 0.26    | ...               | ...         |

Notes.

a Selvelli & Gilmozzi (2013).
b Vogt (1975).
c Schmidtobreick et al. (2008).
d Warner (1985).
e Haefner & Metz (1982).
f McQuillin et al. (2012).
g Rodriguez-Gil & Martinez-Pais (2002).
h Kraft (1964).
i Slavin et al. (1995).
j Gill & O’Brien (2000).

Table 2

Observation Log

| System Name | Telescope | Data ID | Obs. Date YYYY-MM-DD | Time hh:mm:ss | Exp.Time (s) |
|-------------|-----------|---------|----------------------|---------------|-------------|
| RR Pic      | FUSE      | D9131601001 | 2003 Oct 29 | 13:35:41 | 1792 |
|             | FUSE      | D9131601002 | 2003 Oct 29 | 14:40:16 | 3916 |
|             | FUSE      | D9131601003 | 2003 Oct 29 | 16:24:04 | 3733 |
|             | FUSE      | D9131601004 | 2003 Oct 29 | 18:07:39 | 4185 |
|             | IUE       | SWP05775   | 1979 Jul 11 | 23:15:54 | 1200 |
| DI Lac      | FUSE      | D9131301001 | 2003 Oct 20 | 09:38:42 | 2572 |
|             | FUSE      | D9131301002 | 2003 Oct 20 | 11:02:47 | 3473 |
|             | IUE       | SWP29325   | 1986 Sep 28 | 18:09:18 | 16799 |
| V533 Her    | FUSE      | D9131701001 | 2003 Jul 01 | 03:34:36 | 548  |
|             | FUSE      | D9131701002 | 2003 Jul 01 | 04:19:26 | 1390 |
|             | FUSE      | D9131701003 | 2003 Jul 01 | 05:15:22 | 496  |
|             | IUE       | SWP44805   | 1992 May 29 | 07:52:12 | 18000 |

The FUSE spectra for the three systems along with their respective line identifications are displayed for RR Pic in Figure 1, V533 Her in Figure 2, and DI Lac in Figure 3. The absorption line and emission line identifications for the FUSE (as well as for IUE) spectra of RR Pic, V533 Her, and DI Lac are comprehensively tabulated by Selvelli & Gilmozzi (2013).

In the FUSE wavelength range, RR Pic has a rich absorption line spectrum—as noted by Selvelli & Gilmozzi (2013), who tabulate equivalent widths (EW) and full widths at half-maximum (FWHM). Limiting our focus to the strongest absorption features (EW > 0.75 Å), they are Lyman Epsilon (938), Si VI (934 and 945), Lyman Delta (950), Si III (1012 and 1016), Si IV (1063, 1073), P V (1118), blended P V (1128.38) + Si IV (1128.3), and C III (1175).

For V533 Her, all of the emission lines in its FUSE spectrum are sharp and of geocoronal origin, with FWHM of a fraction of an Angstrom. However, V533 Her, like RR Pic, exhibits a rich absorption line spectrum. The strongest features (EW > 0.75 Å) are due to Si IV (1063), Si II (1108), P V (1118), Si IV (1123), P V (1128), Si IV (1128), and C III (1175). The strongest among these features are the P V lines. If the abundances derived from these P lines are suprasolar, then their overabundance points to explosive CNO burning, and hence are associated with the 1963 and earlier nova explosions of V533 Her (cf. Sion & Sparks 2014).

For DI Lac, unlike RR Pic and V533 Her, the FUSE spectrum does not clearly reveal strong absorption features. The spectrum is rather noisy and, like V533 Her, it is strongly affected by ISM molecular hydrogen absorption.

The IUE spectra of the three old novae are briefly displayed together on a log–log scale in Figure 4. The clear signature of wind outflow is seen in the IUE spectra of DI Lac and V533 Her spectra, with the C IV (1550) resonance doublet present, with P Cygni structure. The presence of this feature, with its blueshifted absorption, along with the blueshifts of other absorption features, points to a wind from the disk and/or boundary layer. We will come back to description of the IUE spectra of the three systems in the results section.

3. Phase Dependent FUV Line and Continuum Variations

In order to shed light on the origin of the absorption lines in the FUSE spectra of the three systems, we examined the subexposures that were obtained over each individual FUSE orbit. For RR Pic and V533 Her, there were four such exposures each, and two for DI Lac.
For RR Pic, each subexposure is essentially one orbit of the FUSE spacecraft. The average spacecraft orbital period is 90 minutes. The first exposure started on October 29 at 13:35:41, and the last exposure started on October 29 at 18:07:39 and lasted for approximately 4000 s. Hence, RR Pic was observed with FUSE for approximately 6 hr, compared with its orbital period of 3.481 hr.

The spectra obtained in orbits 1 and 3 are almost identical to each other and have a higher flux level than the spectra obtained in orbits 2 and 4, which are themselves almost identical to each other. We have co-added exposures 1 and 3 together, as well as 2 and 4. In Figure 5, we have overplotted the two resulting co-added spectra.

The absorption line features are slightly blueshifted for exposures 1 and 3, and slightly redshifted for exposures 2 and 4. This is consistent with the occulting material coming from the L1 stream over-shooting the disk, because during that phase, the WD is moving away from the observer, therefore explaining the redshift observed in exposures 2 and 4 with less flux (in a manner similar to the FUSE observations of EM Cyg, Godon et al. 2009). However, the material absorbing the flux does not change the depth of the lines, but rather reduces the overall flux (luminosity) of the spectrum. Thus, the absorption lines do not form from the material overshooting the disk. In view of this line behavior, the possibility remains that the absorptions are associated with the accreting WD itself. We note also that the IUE spectra of RR Pic exhibit the same drop of flux at the orbital phase when the emission lines are slightly redshifted compared to when the lines are slightly blueshifted. The IUE SWP spectrum of RR Pic that we retrieved from the archive was obtained when the flux was maximum, i.e., at the orbital phase where the emission lines are blueshifted.

The total exposure time for V533 Her is 1.145 hr, compared with its orbital period of 3.53 hr. Our search for variations in the line and continuum flux proved more difficult than expected, due to the more noisy subexposures.

For the fainter DI Lac, we have only two FUSE subexposures to examine. The total FUSE exposure time was 6045 s or 1.679 hr, compared with its orbital period of 13.6 hr. Hence, this amounts to a little over 12% of its orbit. From our
Figure 2. The FUSE spectrum of the old nova V533 Her, with line identification. This spectrum presents a multitude of ISM molecular hydrogen lines that have been marked, as well as ISM O I lines, with vertical tick marks at the top of each panel. Here too, the sharp emission lines are helio-coronal in origin. Some broad high-level ionization species absorption lines have been identified, with the source as marked on the figure.

Figure 3. The FUSE spectrum of the old nova DI Lac with line identifications. This spectrum is more noisy and it is strongly affected by ISM absorption lines (marked as in Figure 2), which literally slices the spectrum every 15 Å or so. Most of the spectrum in the shorter wavelengths (<1000 Å) is not reliable, as it is dominated by sharp airglow emission lines and noise. We shifted the upper panel upward to show where the “positive” flux is of the same order as the “negative” flux. Some absorption lines from the source have been marked where they could be expected, but are not clearly identified.
used TLUSTY Version 203 Hubeny 1988

\[ \log \text{WD stellar photospheres, with temperatures from 12,000 to} \]

\[ \text{cold component. The high accretion rate standard disk models} \]

\[ \text{The continuum slope of the three} \]

\[ \text{standard disk model. We adopt a projected standard stellar rotation rate} \]

\[ \text{examination of the two subexposures, there is little to suggest} \]

\[ \text{any variation in the continuum level and absorption lines} \]

\[ \text{during the FUSE observation.} \]

\[ 4. \text{Synthetic Spectral Analysis} \]

\[ \text{We adopted model accretion disks from the grid of solar} \]

\[ \text{composition, optically thick, steady state disk models (“the} \]

\[ \text{standard disk model”) of Wade & Hubney (1998). In these} \]

\[ \text{accretion disk models, the outermost disk radius,} \]

\[ \text{so that} \]

\[ \text{the FUSE and SWP FUV band pass. For the disk models, unless otherwise specified, we selected} \]

\[ \text{we obtain a distance of 427 pc, which is within the range of RR} \]

\[ \text{Because the absorption lines do not arise in the disk, (see} \]

\[ \text{5. Synthetic Spectral Fitting Results} \]

\[ 5.1. \text{RR Pic} \]

\[ \text{The} \]

\[ \text{for comparison. The slope of the continuum of the} \]

\[ \text{and strong} \]

\[ \text{absorption features, suggesting a hot photosphere and/or a hot} \]

\[ \text{accretion disk. Therefore, we only model the FUSE spectrum} \]

\[ \text{Rout} \]

\[ \text{chosen so that} \]

\[ \text{accretion disk model does not} \]

\[ \text{the FUSE flux is due to a hot WD, then we obtain a very high} \]

\[ \text{Such a model is shown in Figure 6. For} \]

\[ \text{a hot WD photosphere itself. However, unless the} \]

\[ \text{model fits to the FUSE spectrum, with} \]

\[ \text{CM}\]

\[ \text{the FUSE spectrum of RR Pic is consistent with} \]

\[ \text{or low mass accretion rate, giving} \]

\[ \text{the WD mass to} \]

\[ \text{the WD photosphere. If true,} \]

\[ \text{addition of a WD (with a non-inflated radius) to the disk disk model does not} \]

\[ \text{5.2. V533 Her} \]

\[ \text{The} \]

\[ \text{is displayed, as indicated, on log-log scale. For comparison, three standard} \]

\[ \text{The continuum slope of the three} \]

\[ \text{with a low mass accretion rate standard disk model (} \]

\[ \text{a relatively} \]

\[ \text{we have co-added the spectra from orbit 1 with that of orbit 3,} \]

\[ \text{when the source is least likely veiled by material flowing over} \]

\[ \text{the FUSE spectrum reveals a rising FUV continuum (toward shorter wavelengths)} \]

\[ \text{stronger UV absorption features, and a combination of both. The} \]

\[ \text{FUSE} \]

\[ \text{at} \]

\[ \text{or a hot} \]

\[ \text{and strong} \]

\[ \text{a hot component. If we assume that the} \]

\[ \text{a very high temperature WD, or a combination of both. The} \]

\[ \text{mean} \]

\[ \text{for comparison. The slope of the continuum of the} \]

\[ \text{The} \]

\[ \text{a higher temperature.} \]

\[ \text{and/or its hot accretion disk.} \]

\[ \text{such a hot component. If we assume that the} \]

\[ \text{the presence of a non-standard disk.} \]

\[ \text{However, the} \]

\[ \text{FUSE} \]

\[ \text{and strong} \]

\[ \text{model fits to the FUSE spectrum, with} \]

\[ \text{we obtain a distance of 427 pc, which is within the range of RR} \]

\[ \text{The} \]

\[ \text{accretion disk model does not} \]

\[ \text{When} \]

\[ \text{absorption features, suggesting a hot photosphere and/or a hot} \]

\[ \text{accretion disk. Therefore, we only model the} \]

\[ \text{accretion disk model. We adopt a projected standard stellar rotation rate} \]

\[ \text{examination of the two subexposures, there is little to suggest} \]

\[ \text{any variation in the continuum level and absorption lines} \]

\[ \text{the FUSE flux is due to a hot WD, then we obtain a very high} \]

\[ \text{Such a model is shown in Figure 6. For} \]

\[ \text{a non-inflated radius, the scale factor-derived distance is reduced to} \]

\[ \text{we obtain a distance of 427 pc, which is within the range of RR} \]

\[ \text{a hot WD photosphere itself. However, unless the} \]

\[ \text{addition of a WD (with a non-inflated radius) to the disk disk model does not} \]

\[ \text{Because the absorption lines do not arise in the disk, (see} \]

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\[ \text{5. Synthetic Spectral Fitting Results} \]

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\[ \text{accretion disk. Therefore, we only model the} \]

\[ \text{accretion disk model. We adopt a projected standard stellar rotation rate} \]

\[ \text{we have co-added the spectra from orbit 1 with that of orbit 3,} \]

\[ \text{the FUSE spectrum reveals a rising FUV continuum (toward shorter wavelengths)} \]

\[ \text{and strong} \]

\[ \text{accretion disk model, and could indicate the presence of a non-standard disk.} \]

\[ \text{However, the} \]

\[ \text{FUSE} \]

\[ \text{a very high temperature WD, or a combination of both. The} \]

\[ \text{we obtain a distance of 427 pc, which is within the range of RR} \]

\[ \text{a hot WD photosphere itself. However, unless the} \]

\[ \text{addition of a WD (with a non-inflated radius) to the disk disk model does not} \]

\[ \text{Because the absorption lines do not arise in the disk, (see} \]

\[ \text{addition of a WD (with a non-inflated radius) to the disk disk model does not} \]

\[ \text{addition of a WD (with a non-inflated radius) to the disk disk model does not} \]

\[ \text{Because the absorption lines do not arise in the disk, (see} \]

\[ \text{addition of a WD (with a non-inflated radius) to the disk disk model does not} \]
Figure 5. The FUSE Spectrum of RR Pic is made of four FUSE exposures. Exposures 1 and 3 are almost identical to each other; they have been co-added, and the resulting spectrum is shown in black. Exposures 2 and 4 both show the same significant decrease in flux, and they too are almost identical to each other. Exposures 2 and 4 have been co-added, and are shown in red.

Figure 6. The FUSE spectrum of RR Pic (in red) is modeled with a WD photosphere (solid black line). The WD model has a temperature of 80,000 K, with \( \log(g) = 7.0 \), corresponding to a radius of 0.033 \( R_\odot \), giving a distance of 518 pc. The high temperature is needed to fit the shortest wavelength region of the spectrum, and the large radius is derived from scaling the theoretical spectrum to the known distance. The known ISM absorption lines, the oxygen doublet emission region, geocoronal emission lines, and other artifacts have been omitted from the spectrum and are marked in blue.
Figure 7. Best fitting model disk (in black) for the *FUSE* spectrum of RR Pic (in red). The accretion disk model has an inclination of \(i = 60^\circ\), a WD mass \(M_{\text{wd}} = 1.03 \, M_\odot\) and a high accretion rate of \(10^{-8} \, M_\odot \, \text{yr}^{-1}\), giving a distance of 306 pc, a result that is within the range of RR Pic's parallax distance. The regions affected by the ISM and broad emission lines were masked before the fitting and are marked in blue. Note that the absorption lines of the source are not masked, as they were initially tentatively modeled with a hot WD model.

Figure 8. Best fitting WD solar abundance model for the *FUSE* spectrum of V533 Her. The WD temperature has been set to 40,000 K, with \(\log(g) = 8.6\), corresponding to a 1.0 \(M_\odot\) WD with a radius of 6000 km, and giving a distance of only 316 pc, or about 1/2 to 1/4 the accepted distance.
Although this could be due to a non-standard disk, the FUSE spectrum of V533 Her has a slope consistent with a hot FUV component at a temperature $40,000 \pm 5000$ K, the exact value depending on the assumed WD surface gravity $g_{\log}$. For a $1 M_\odot$ model, a hot WD fit yields a distance that is too short ($300-400$ pc), about 2–3 times smaller than the accepted value. Because the distance obtained from the model scales like the WD radius, a possible solution would be a hot WD with an inflated radius, two to four times larger than the expected $6000$ km.

Turning to accretion disk models, a disk around a $1 M_\odot$ WD with an accretion rate of $10^{-9} M_\odot$ yr$^{-1}$ and $i = 60^\circ$ produces a good continuum fit and a reasonable distance of 832 pc, but does not produce any absorption lines because of the large Keplerian velocity broadening effect at an angle of 60°.

Although this could be due to a non-standard disk, the FUSE spectrum of V533 Her has a slope consistent with a hot FUV component at a temperature $40,000 \pm 5000$ K, the exact value depending on the assumed WD surface gravity $g_{\log}$. For a $1 M_\odot$ model, a hot WD fit yields a distance that is too short ($300-400$ pc), about 2–3 times smaller than the accepted value. Because the distance obtained from the model scales like the WD radius, a possible solution would be a hot WD with an radius inflated to 2–3 times its value. In Figure 8, we present a solar abundances 40,000 K WD fit with $g_{\log} = 8.6$, corresponding to a $1 M_\odot$ WD with a radius of 6000 km, giving a distance of 316 pc.

Turning to accretion disk models, a disk around a $1 M_\odot$ WD with an accretion rate of $10^{-9} M_\odot$ yr$^{-1}$ and $i = 60^\circ$ produces a good continuum fit and a reasonable distance of 832 pc. This disk model is shown in Figure 9. Here too, the disk does not fit any of the absorption lines.

The disk+WD fit to the FUSE spectrum of V533 Her produces the best fit when each component contributes about half of the flux. This is achieved for $\dot{M} = 10^{-9.5} M_\odot$ yr$^{-1}$ and $T_{\text{wd}} = 60,000$ K, giving a distance of 640 pc and where the WD contributes 51% of the flux and the disk contributes the remaining 49%. This model is shown in Figure 10.

Note, however, that although the model disk fits match the FUSE slope better, disk models clearly do not fit any of the absorption features. This is important because a hot WD model does fit the absorption lines in the FUSE spectrum quite well. Nevertheless, we can virtually rule out the WD because it contributes too little FUV flux, unless it is very hot with an inflated radius two to four times larger than the expected 6000 km.

5.3. DI Lac

The distance we obtain from the model fit scales with the radius of the WD, which itself depends on the WD mass. Because both the WD mass and distance to the system are unknown, and the spectra are of a low quality, there is a degeneracy in the modeling. Therefore, we assume a standard WD mass of $M_{\text{wd}} = 0.8 M_\odot$, $g_{\log} = 8.4$, and an inclination of $18^\circ$ in the disk models.

The IUE spectrum of DI Lac presents a moderately shallow continuum slope, consistent with a component with a
temperature of about 20,000 K. A WD with $T = 20,000$ K gives an unrealistic distance of barely 40 pc (that would scale to less than 100 pc assuming a low WD mass), whereas the disk model agreeing with the slope has a mass accretion rate of $10^{-10} M_\odot \text{ yr}^{-1}$ and gives a distance of 140 pc (see Figure 4).

The FUSE spectrum of DI Lac is consistent with a component with a temperature of about 30–35,000 K. A 0.8 $M_\odot$ WD with a temperature of 35,000 K gives a distance of $\sim$110 pc. An accretion disk model best fit to the FUSE spectrum has a mass accretion rate of $10^{-10} M_\odot \text{ yr}^{-1}$ (giving a distance of 140 pc) to $3 \times 10^{-10} M_\odot \text{ yr}^{-1}$ (and a distance of 300 pc).

Because both the FUSE and IUE spectra of DI Lac are of fairly low quality, but give similar results that are consistent with each other, we decided to model the combined FUSE + IUE spectrum. The best fit model to the combined FUSE + IUE spectrum of DI Lac is a disk + WD model, where a 30,000 K WD helps fit the absorption lines in the FUSE range of the spectrum, whereas a disk with $M = 10^{-10} M_\odot \text{ yr}^{-1}$ provides the lower flux needed to fit the IUE range of the spectrum. The distance obtained from this model is $d = 175$ pc. This combination FUSE + IUE fit is displayed in Figure 11, showing the FUSE range, and in Figure 12, showing the IUE range. The dotted line is the contribution of the WD, and the dashed line is the flux of the model accretion disk.

6. Summary

It is apparent from our study of the hot components in the old novae addressed in this paper that the range of wavelengths extending down to the Lyman Limit by the FUSE spacecraft is essential to uncovering the nature of the hot component, be it a WD, or an accretion disk. The FUSE coverage reveals that, for RR Pic, the hot component is more likely represented by a bright accretion disk with the corresponding accretion rate of $10^{-8} M_\odot \text{ yr}^{-1}$. An accretion rate this high is supported by optical observations of the accretion rates of old novae (e.g., Warner 1995 and references therein). This best-fitting accretion disk solution has a WD of $\sim 1 M_\odot$, a disk inclination of $60^\circ$, and yielded a distance to RR Pic of 506 pc, which agrees well with the parallax distance. We find that a hot WD ($T \sim 70–80,000$ K) also fits the FUSE spectrum of RR Pic, but implies a WD radius inflated to about 20,000 km to agree with the observed distance.

Likewise for V533 Her, the FUSE spectra provide fitting solutions with an accretion disk around a 1 $M_\odot$ WD and a disk
inclination of 60°, yielding an accretion rate of $10^{-9} \ M_\odot \ yr^{-1}$ at a distance of 832 pc. However, as in the case of RR Pic, the strong absorption features are not reproduced by the accretion disk. Here too, we cannot rule out a hot WD with an inflated radius as the source of the FUV: a 40,000 K WD fits the FUSE spectrum and some of the absorption lines, assuming a WD
radius of $\sim$12,000–24,000 km. A combined WD+disk model also yields a reasonable fit, with a 60,000 K WD providing 51% of the flux and a $10^{-9.5} M_\odot \text{yr}^{-1}$ disk providing the remaining 49%, giving a distance of 640 pc.

For DI lac, we opt to combine the FUSE spectrum with the matching IUE spectrum, which together provide self-consistent results. We find that the best fit is obtained with a combined disk+WD model, where the WD has a temperature of 30,000 K. Our derived accretion rate of $10^{-10} M_\odot$ is lower by about an order of magnitude than both RR Pic and V533 Her. Although Nova Lac 1910 is considerably earlier than Nova Her 1963, Nova Pic 1925 is almost as old as Nova Lac 1910, but has an accretion rate two orders of magnitude higher.

The existing IUE spectra of RR Pic and V533 Her both exhibit a continuum slope much more shallow than that of the standard disk model (see Figure 4), in disagreement with the FUSE spectra revealing a hot component that can be matched with a hot accretion disk. This inconsistency could be an indication that the standard disk model does not apply here, thus precluding the use of the IUE spectra in our spectral analysis. Moreover, the following should be noted: the inconsistency in attributing the flux in the IUE range to a cool disk and the flux in the FUSE range to a high accretion rate disk, despite the flux matching up in the wavelength overlap region between FUSE and IUE, suggests that the two components contribute roughly equally at the overlapping wavelength region. Hence, the cool component must be cooler and the hot component must be hotter than would be yielded by fits to the two wavelength ranges, done separately.

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