Tales from the Vault: Orbital Periods for Seven CVs Longward of the Gap

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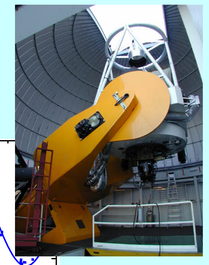
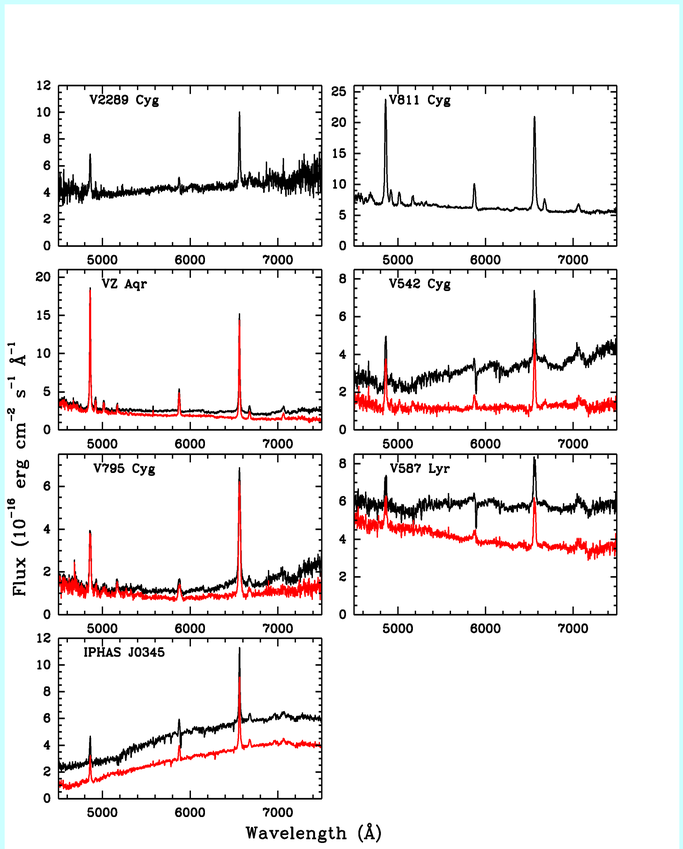
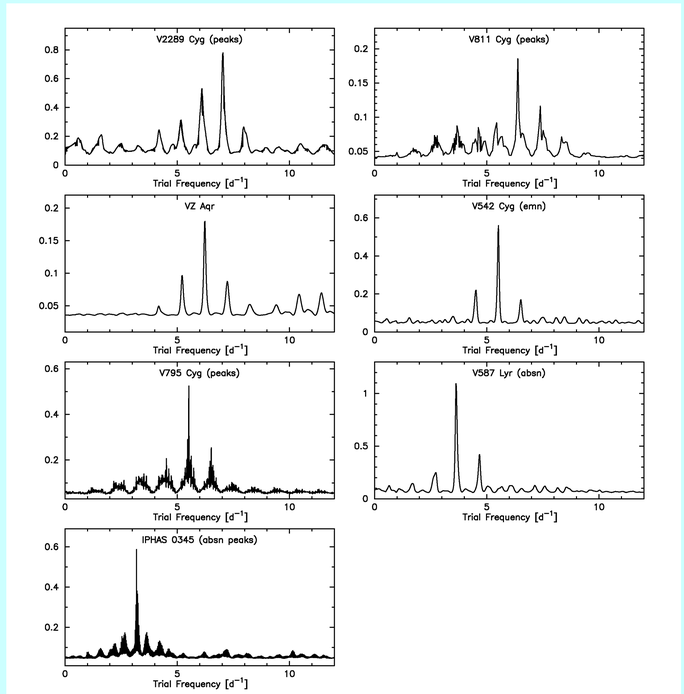


Abstract: We report new orbital periods for seven cataclysmic binaries; the stars and their periods are V2289 Cyg = Cyg2 (0.142 d); V811 Cyg (0.156 d); VZ Aqr (0.161 d); V542 Cyg (0.181 d); V795 Cyg (0.181 d, nearly identical to V542 Cyg); V587 Lyr = Tk5 (0.274 d); and IPHAS J0345+53 (0.314 d). All are catalogued as dwarf novae save for IPHAS J0345+53, the variability type of which is as yet unkonwn. The mean spectra of VZ Aqr, V795 Cyg, V587 Lyr, and IPHAS 0345 show the donor-star contribution, and in IPHAS 0345 and V587 Lyr the donor's velocity curve is measurable. V542 Cyg also shows a late-type contribution, but its radial velocity remains essentially constant. This system may be a heirarchical triple, or it may be that the late-type component is a chance superposition.



Mean spectra of the stars. Where two traces are shown, the black trace shows the average low-state spectrum (outburst spectra have been excluded), and the red trace shows the same data after subtraction of a scaled late-type spectrum. The subtraction was optimized to cancel the late-type features as well as possible.



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In some cases, only one choice of cycle count is allowed, so the period is uniquely determined. In others, the long-term alias remains uncertain, but the daily cycle count (and hence the gross period) is unambiguous in all cases.

Some Details:

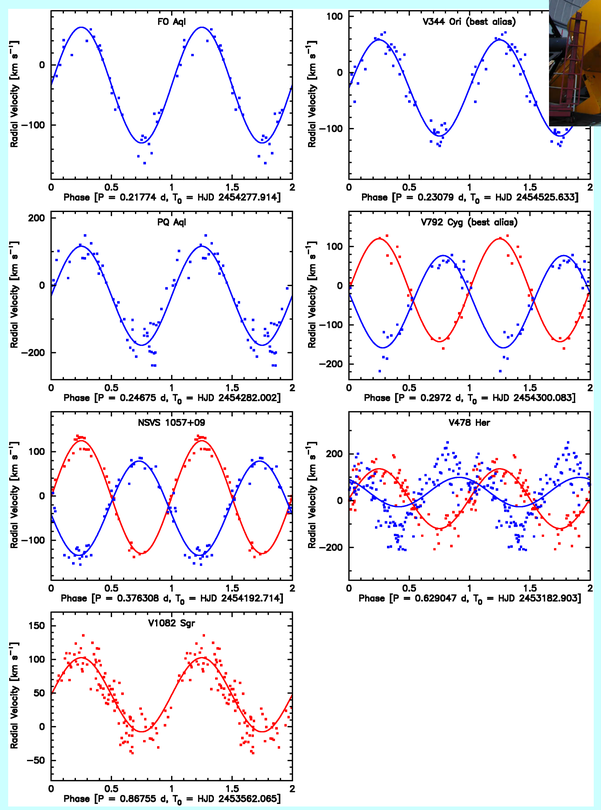
Most of these stars have been classified as dwarf novae. We observed them because they were little-studied, yet tractable. Most of our observations are from the 2.4m Hiltner telescope (pictured above right) at MDM Observatory on Kitt Peak. For V1082 Sgr we mostly used the MDM 1.3m McGraw-Hill telescope. All the observations are spectroscopic, and date from 2004 to 2008.

We observed over a wide range of hour angle to suppress daily cycle count ambiguities in the period analysis. All of these targets were observed on more than one observing run.

The spectra (left) mostly show typical CV emission lines, as well as the secondary star's spectrum. The figures show the results of subtracting scaled spectral type standards (estimated using "chi-by-eye").

We measured emission-line (Hα) velocities by convolving the line profile with an antisymmetric function, and taking the zero of the convolution to be the line center. The absorption-line velocities are from cross-correlations of line-rich spectral regions against late-type radial velocity standard stars. In the shorter-period objects, the absorption velocities were unmeasurable or not useful, while in the longest-period object V1082 Sgr, only the absorption velocities showed the period.

The periodograms plotted above were generated by fitting sinusoids at a dense grid of trial frequencies covering the entire range of plausible periods. The quantity plotted is the inverse mean-square residual vs. trial frequency. The highest peaks correspond to the adopted periods. Alias frequencies also show up in the searches, as explained in the figure caption.



Radial velocities folded on the adopted binary periods. Emission line velocities (H-alpha in all cases) are shown in blue, and red shows absorption-line velocities of the secondary star. The best-fitting sinusoids are plotted. Two cycles are plotted (with the data repeated) for continuity.

Discussion:

The five shortest-period objects – FO Aql, V344 Ori, PQ Aql, and V792 Cyg – appear to be typical dwarf novae, with periods above the so-called "gap" at roughly 2-3 hours. The other objects, V478 Her and V1082 Sgr, are more unusual.

At 15 hours, V478 Her's period is atypically long for a CV, yet the secondary does not dominate the light as might be expected at such a long period (compare its spectral decomposition to that of the shorter-period NSVS 1057+09). The Hα emission velocity shows a complicated modulation on the orbital period (see figure above). We estimate a distance of order 3 kpc (by combining the secondary star's spectral contribution and the Roche lobe size dictated by the orbital period). This puts V478 Her well over 1 kpc from the Galactic plane (at b = 29.7°).

The period of V1082 Sgr is still longer at 20.82 hr. Most of our observations show the star in high state, in which it sports a rich spectrum of high-excitation lines -- HeII 4686 becomes stronger than Hβ. However, some of our spectra (see the figure) show it in a low state in which most of the continuum is from the secondary star; in this state, all the emission lines except Hα disappear, and Hα becomes much weaker and narrower than in the high state. This is reminiscent of the low states seen in VY Scl-type novalikes. V1082 Sgr is evidently not an ordinary dwarf nova.