

# The Pulsation Period of the Hot Hydrogen-Deficient Star MV Sagittarii

John R. Percy

Rong Fu

Department of Astronomy and Astrophysics, University of Toronto, Toronto, ON, M5S 3H4, Canada; [john.percy@utoronto.ca](mailto:john.percy@utoronto.ca)

Received January 20, 2012; revised April 30, 2012; accepted April 30, 2012

**Abstract** MV Sgr is a hot, hydrogen-deficient star which has undergone R CrB fadings. We have used self-correlation analysis and Fourier analysis of CCD V-band photometry in the AAVSO International Database to identify a period of 8.0 days in this star; the amplitude is about 0.03 magnitude. The variability is most likely due to pulsation.

## 1. Introduction

Hydrogen-deficient stars (Clayton 1996; Werner and Rauch 2008) are a rare but very diverse (Jeffery 2008a) group of objects, in advanced and unusual stages of evolution. In this paper, we are concerned with hydrogen-deficient stars which can undergo the R CrB phenomenon—unpredictable fadings, followed by slow return to maximum brightness. Most of the approximately fifty such stars in our galaxy are cool—“classical” R CrB stars—but a few hot members of the group have been discovered.

There are two proposed mechanisms for producing “classical” R CrB stars: the merger of a helium white dwarf and a carbon-oxygen white dwarf, and a final helium shell flash (Iben *et al.* 1996; Saio and Jeffery 2002). Observational evidence seems to favor the former mechanism, though a few R CrB stars may be produced by the latter mechanism (Clayton 2011). The hot hydrogen-deficient stars do not necessarily arise from the same mechanism(s) as the cool ones, and may in fact have diverse evolutionary histories (De Marco *et al.* 2002).

Many R CrB stars are also pulsating variables, and the pulsation may be partly responsible for the mass loss that leads to the fadings. Pulsating hot hydrogen-deficient variable stars have been classified as PV Tel stars, but Jeffery (2008b) argues that this classification should be replaced by three new classes, based on the pulsation period and mode in the star.

MV Sgr (AAVSO 1838–21, HV 4168,  $V \sim 13.35$ ) was discovered to be an R CrB star in 1928 by Miss Ida Woods (Hoffleit 1959), and has been studied by various techniques since then (De Marco *et al.* 2002). Its atmospheric properties are  $T_{eff} = 16,000 \pm 500$  K and  $\log g = 2.48 \pm 0.30$ , and pulsations had not been found in MV Sgr as of 2008 (Jeffery 2008b).

Since observations of this star have been made by AAVSO observers, one of

the purposes of this paper is to provide feedback to the observers, showing the kind of science that can be done with their observations. An additional purpose is to demonstrate how undergraduate students (such as co-author Fu) can carry out useful research with archival variable star data.

## 2. Data, analysis, and results

Visual and CCD V-band data were taken from the American Association of Variable Star Observers International Database (AID; Henden 2012). There were a total of 2,315 visual observations, and 138 CCD V-band observations. The former were made by 33 different observers; the latter were made by G. Di Scala, M. Simonsen, J. Temprano, and D. Wells.

The most numerous V-band observations were in the season JD 2455644–2455852. Self-correlation analysis (Percy and Mohammed 2004) of these showed a clear period of about 8.0 days, with a full amplitude of about 0.03 magnitude, and at least eight repeating minima, indicating coherent variability (Figure 1). Self-correlation analysis of the whole V-band dataset showed a period of  $8.0 \pm 0.1$  days, with a similar amplitude. The mean error of the observations, as determined from the intercept on the vertical axis, is 0.03 magnitude. Self-correlation analysis of the visual data did not show a detectable signal, which is probably due to the small amplitude and the much higher noise level.

The analysis was repeated with Fourier analysis, using the PERIOD04 software (Lenz and Breger 2005). For the V-band data, in the season JD 2455644–2455852, and in the whole dataset, the highest peaks were at frequencies of 0.128 cycle/day (period 7.8 days) and 0.122 cycle/day (period 8.2 days), respectively; the latter spectrum is shown in Figure 2. In each case, the highest peak was only slightly higher than the next-highest peak. It did, however, agree with the period found from self-correlation analysis. For the visual data, the highest peak was at a frequency of 0.204 cycle/day (period 4.9 days), but this was only slightly higher than the noise level, and may not be significant, especially considering the small amplitude and the much higher noise level in the visual data.

## 3. Discussion and conclusions

MV Sgr displays a period of 8.0 days, which we assume to be due to pulsation. The signal is not strong, but it is quite clear in the self-correlation diagram, and is consistent with the results of the Fourier analysis. This enables us to place the star in Jeffery's (2008b) PV Tel I sub-class.

MV Sgr was not known to be pulsating (Saio and Jeffery 1988; Jeffery 2008b). We now have one more piece of useful information about this star. Also, the discovery of pulsation provides further support for the possible connection between pulsation and the R CrB phenomenon in hydrogen-deficient stars.

#### 4. Acknowledgements

We thank the AAVSO observers and staff for making and archiving the visual and CCD observations used in this study, and the referee Geoff Clayton for his useful suggestions. This study was supported by the Ontario Work-Study Program.

#### References

- Clayton, G. C. 1996, *Publ. Astron. Soc. Pacific*, **108**, 225.  
Clayton, G. C. 2011, in *Asymmetric Planetary Nebulae V*, eds. A. A. Zijlstra, F. Lykou, I. McDonald, and E. Lagadec, Jodrell Bank Centre for Astrophysics, Manchester, UK, 157.  
De Marco, O., Clayton, G. C., Herwig, F., Pollacco, D. L., Clark, J. S., and Kilkenny, D. 2002, *Astron. J.*, **123**, 3387.  
Henden, A.A., 2012, Observations from the AAVSO International Database, private communication.  
Hoffleit, D. 1959, *Astron. J.*, **64**, 241.  
Iben, I., Jr., Tutukov, A. V., and Yungelson, L. R. 1996, *Astrophys. J.*, **456**, 750.  
Jeffery, C. S. 2008a, in *Hydrogen-Deficient Stars*, eds. K. Werner, and T. Rauch, ASP Conf. Ser. 391, Astron. Soc. Pacific, San Francisco, 3.  
Jeffery, C. S. 2008b, *Inf. Bull. Var. Stars*, No. 5817, 1.  
Lenz, P., and Breger, M. 2005, *Commun. Astroseismology*, **146**, 53.  
Percy, J. R., and Mohammed, F. 2004, *J. Amer. Assoc. Var. Star Obs.*, **32**, 9.  
Saio, H., and Jeffery, C. S. 1988, *Astrophys. J.*, **328**, 714.  
Saio, H., and Jeffery, C. S. 2002, *Mon. Not. Roy. Astron. Soc.*, **333**, 121.  
Werner, K., and Rauch, T., eds. 2008, *Hydrogen-Deficient Stars*, ASP Conf. Ser. 391, Astron. Soc. Pacific, San Francisco.

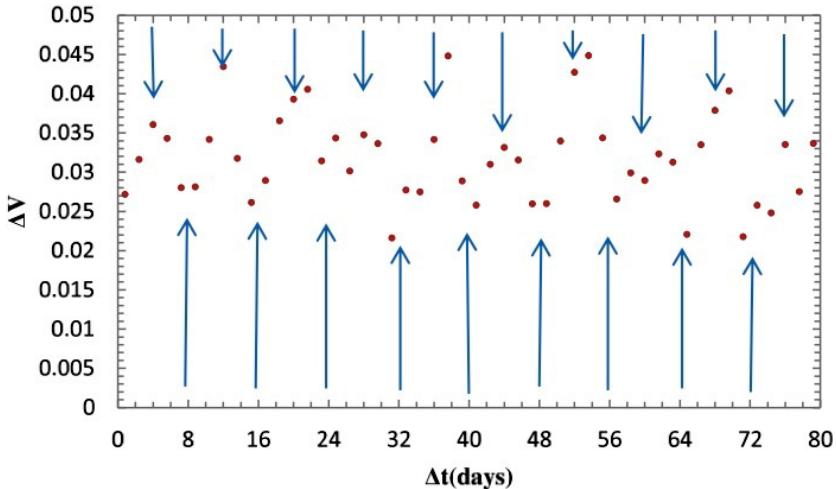


Figure 1. Self-correlation diagram for CCD V-band observations of MV Sgr during the season JD 2455644–2455852 when the observations are most numerous. There are repeating minima at multiples of 8.0 days: 8, 16, 24 (weak), 32, 40, 48, 56, 64... days, and maxima at 4, 12, 20, 28 (weak), 36, 44, 52... indicating coherent variability. These minima and maxima are marked. The minima (including at  $\Delta t = 0$ ), do not extend below 0.025 because this is the average error of the observations. The minima and maxima die out at large  $\Delta t$  because of the scarcity of  $\Delta$  magnitudes with these  $\Delta t$  values.

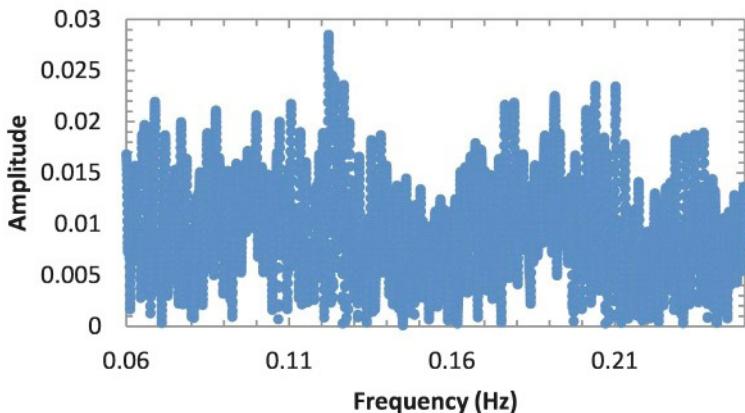


Figure 2. Fourier spectrum for CCD V-band observations of MV Sgr. The highest peak is at a frequency corresponding to a period of 8.0 days.