Secular Variation of the Mode Amplitude-Ratio of the Double-Mode RR Lyrae Star NSVS 5222076, Part 2

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Abstract We present results from our ongoing investigation of the double-mode RR Lyrae (RRd) star, NSVS 5222076, and specifically of the long-term temporal variation of the amplitude-ratio, A0/A1, of the star's fundamental and first-overtone pulsation modes. Our earlier paper on this subject (Hurdis and Krajci 2010) described a seemingly monotonic decrease of the amplitude-ratio in the *V* band, from 1.93 in 2005 to 1.76 in 2008 to 1.48 in 2009. After further observation of the star during the 2010 and 2011 observing seasons, we report that the *V*-band amplitude-ratio continued to decrease to 1.40 in 2010, but then increased to 1.82 in 2011. This suggests that, rather than decreasing monotonically toward a switch of dominant pulsation mode, A_0/A_1 may be varying in an oscillatory manner.

1. Introduction

The current paper is a continuation of our investigation of NSVS 5222076 (Hurdis and Krajci 2010), and in particular of the long-term temporal variation of the star's mode amplitude-ratio, A_0/A_1. Our equipment and methods remained the same as in the earlier study and the reader is referred to that paper for those details.

The earlier paper described a rapid, and seemingly monotonic, decrease of the amplitude-ratio in the *V* band, from 1.93 in 2005 to 1.76 in 2008 to 1.48 in 2009, and raised the possibility that NSVS 5222076 could be on the verge of switching its dominant pulsation mode from the fundamental to the first-overtone. It was noted that precedents for mode switching had been observed in the globular cluster M3, where four stars (V79, V166, V200, and V251) had been observed to switch their dominant pulsation modes (Corwin *et al.* 1999, Clementini *et al.* 2004, Clement and Thompson 2007). Among these, V79 has been the most changeable. Goranskij *et al.* (2010) have recently chronicled the history of its observed switches from fundamental mode pulsator to mixed-mode pulsator with dominant first-overtone, then returning to fundamental mode pulsation but with a Blazhko period of 65.4 days. V79 having revealed this menu of possible options for RR Lyrae behavior, it would seem important

for observers to continue to monitor the variation of the mode amplitude-ratio of NSVS 5222076, a field star located well out of the Galactic plane in Bootes, and unimpeded by the crowded star field of a globular cluster.

In 2010 and 2011, all observations were made with the Wright28 telescope, under the aegis of the AAVSO robotic telescope network (AAVSOnet). In 2010, 919 *V*-band images and 913 *I*-band images were taken on ten nights, between JD 2455272 and JD 2455367. In 2011, 892 *V*-band images and 886 *I*-band images were taken on twelve nights, between JD 2455600 and JD 2455666.

As in the earlier study, two software packages were used to perform period analysis of the photometric data extracted from the images. These were PERANSO version 2.20 (Vanmunster 2005), and PERIOD04 (Lenz and Breger 2005). The mode amplitudes were derived from PERIOD04 by least-squares fit of the computed Fourier frequencies to the measured light curves.

2. Results

Among the five individual data sets from the five years that the star has been observed, the computed pulsation periods for NSVS 5222076 vary slightly, but in a random manner, i.e., not in a manner clearly attributable to coherent period change. These random variations may be related to the Blazhko-like modulations reported in our earlier paper (Hurdis and Krajci 2010), which may overwhelm the detection of any long-term period changes. Moreover, we find no correlation between these small year-to-year variations in computed period and the corresponding variations in amplitude-ratio reported below. Our observations are all available in the AAVSO International Database for researchers to apply other statistical methods. The means of the five yearly values computed for the fundamental and first-overtone periods were P0 = 0.49405 ± 0.00005 day and P1 = 0.36684 ± 0.00011 day.

The 2010 and 2011 amplitude-ratio results were as follows. In the *V* band, A_0/A_1 decreased from 1.48 ± 0.01 in 2009 to 1.40 ± 0.02 in 2010, but then increased to 1.82 ± 0.02 in 2011. These results are graphically illustrated in Figure 1, where the upper half of the figure shows (for all five years that the star has been observed) the number and distribution of the time-series observations, while the lower half shows the time variation of A_0/A_1. We note that the 2005 observation time-series and amplitude-ratio results are those of Oaster *et al.* (2006). In the *I* band, A_0/A_1 decreased from 1.52 ± 0.03 in 2009 to 1.38 ± 0.03 in 2010, but then increased to 1.81 ± 0.03 in 2011. These results are illustrated in Figure 2.

In conclusion, two additional years of observation of NSVS 5222076 have revealed that the seemingly monotonic decrease of A_0/A_1 has ended in both wavelength bands, and that in 2011 it increased. This suggests the variation of A_0/A_1 with time may actually be oscillatory. We note that no observations of the star exist between those of 2005 (Oaster *et al.* 2006) and those in 2008

(Hurdis 2009), so it is unknown how A_0/A_1 may have varied during that interval. Continued observation of NSVS 5222076 will be needed to clarify the interesting behavior of its mode amplitude-ratio.

3. Acknowledgements

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References

Clement, C. M., and Thompson, M. 2007, *J. Amer. Assoc. Var. Star Obs.*, **35**, 336.

Clementini, G., Corwin, T. M., Carney, B. W., and Sumerel, A. N. 2004, *Astron. J.*, **127**, 938.

Corwin, T. M., Carney, B. W., and Allen, D. M. 1999, *Astron. J.*, **117**, 1332.

Goranskij, V., Clement, C. M., and Thompson, M. 2010, in *Variable Stars, the Galactic Halo and Galaxy Formation*, eds. C. Sterken, N. Samus, and L. Szabados, Sternberg Astronomical Institute, Moscow, 115.

Hurdis, D. A. 2009, *J. Amer. Assoc. Var. Star Obs.*, **37**, 28.

Hurdis, D. A., and Krajci, T. 2010, *J. Amer. Assoc. Var. Star Obs.*, **38**, 1.

Lenz, P., and Breger, M. 2005, *Commun. Asteroseismology*, **146**, 53.

Oaster, L., Smith, H. A., and Kinemuchi, K. 2006, *Publ. Astron. Soc. Pacific*, **118**, 405.

Vanmunster, T. 2005, PERANSO period analysis software, www.peranso.com.

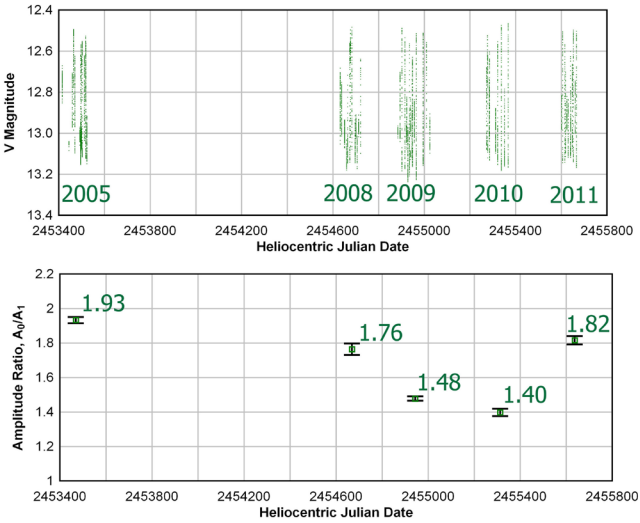

Figure 1. Secular variation of mode amplitude-ratio, A_0/A_1, for *V* band. Upper plot: combined data sets: Oaster *et al.* 2005, Hurdis 2008, Hurdis and Krajci 2009, 2010, and 2011, *V* filter. Lower plot: Time variation of amplitude ratio, A_0/A_1, *V* filter.

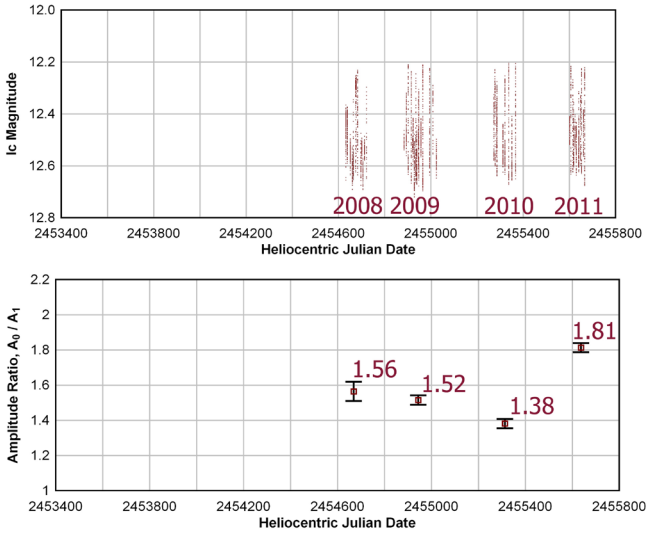

Figure 2. Secular variation of mode amplitude-ratio, A_0/A_1, for *I* band. Upper plot: combined data sets: Hurdis 2008, Hurdis and Krajci 2009, 2010, and 2011, *I* filter. Lower plot: Time variation of amplitude ratio, A_0/A_1, *I* filter.