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On the mode switching of RRd stars in the globular cluster M3

J. M. Benkő

Konkoly Observatory of the Hungarian Academy of Sciences,
P. O. Box 67. H-1525 Budapest, Hungary e-mail: benko@konkoly.hu

Abstract. M3 is so far the only cluster in which RRd variable stars have been reported to switch from one dominant mode to another while remaining RRd variables. Investigating synthetic light curves sampled according to the published photometric data sets, we have concluded that the observational material is not sufficient to decide whether any mode switchings have happened or not. As it is demonstrated the previously published mode switchings were – most likely – artifacts of the bad sampling.

Key words. Stars: variables: RR Lyr – Globular clusters: individual: M3

Variations in the double-mode behaviour have been observed in a number of RRd variable stars (Jerzykiewicz et al. 1982, Jurcsik & Barlai 1990, Clement et al. 1993, 1997, Pardue et al, 1995). These variations concern initiation or cessation of the double-mode behaviour and changes in the length and amplitude ratios of the two periodicities. None of these studies reports a switch between dominant modes to have actually occurred in these stars. However, for five RRd stars (V68, V99, V166, V200, V251) of the known nine in the globular cluster M3 such a possible mode switch by different authors (Corwin et al. 1999; Benkő & Jurcsik 2000; Clementini et al. 2004) has been published.

It has to be stressed, that all possible switching was found within 1-2 years long time series. The question is whether they were real events or just artifacts of data distributions?

To decide the question the best available (longest, homogeneous) CCD data sets have been chosen as a reference light curve for each RRd star in M3. These data sets were analysed applying Fourier techniques by using the program package MUFRAN (Kolláth 1990). Using the found frequencies of the fundamental and first overtone modes, their harmonics and linear combinations in each data set, least square fit solutions were calculated in order to determine the amplitudes. The modal content of the pulsation is quantified by the amplitude ratio: Fourier amplitude of the first overtone mode divided by the amplitude of the fundamental mode.

The estimation of errors of amplitude ratios yields the key to justifying their possible changes. The systematic errors of amplitude ratios were tested by a simulation: synthetic time series were generated using the frequencies, amplitudes, phases of reference light curves with observational times of data sets where mode switching were published. Fourier parameters were determined in the same way as for the reference data in 1000

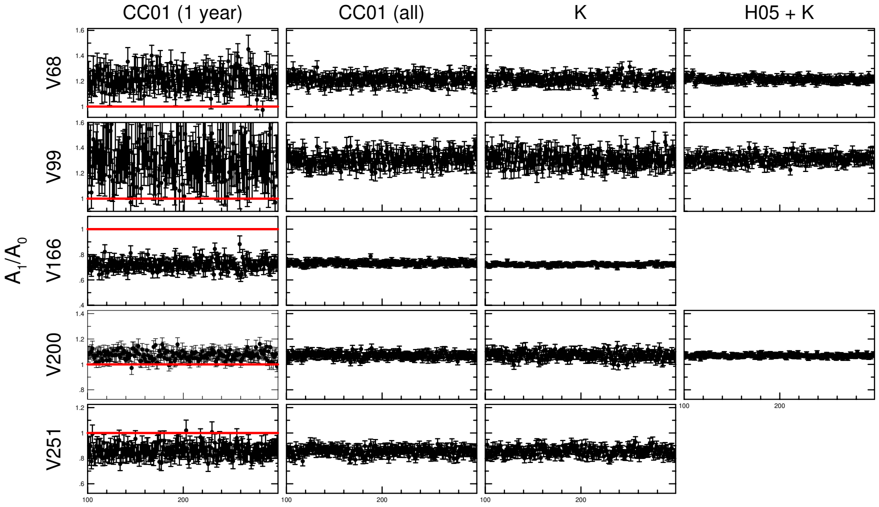

Fig. 1. Calculated amplitude ratios (A_1/A_0) of synthetic light curves versus iteration number n. Here n is defined by $T_0 = t_0 + n * 0.01$ days; t_0 and T_0 are the epoch of the beginning of the synthetic light curves and a given sampled one, respectively. The rms error of the fit is also marked for each point. Data distributions were taken from CC01 = Corwin & Carney (2001), H05 = Hartmann et al. (2005), K = CCD obs. at Konkoly in 1998-1999.

simulations/each data set/each star. The initial epoch of simulated light curves were shifted at each iteration steps with 0.01 days and white noise with variance corresponding to the observed data was also added. The mean results of these tests are given in Fig. 1.

1/ The real errors of the amplitude ratios could be an order of magnitude higher than their fitting errors. 2/ The same sampling rate yields strongly different accuracy of amplitude ratio from star by star. Therefore, improving of time coverage of data is reducing the systematic error but not equally. 3/ The amplitude ratios were severely affected by the value of the initial phase in those cases when only few nights of observations were involved even in high precision CCD observations.

These results suggest that the formerly published mode switching events were overinterpretations of bad sampled observations. This conclusion are also supported by the theoretical calculations of Buchler & Kolláth (2002) who showed that the mode-switching time scale is of the order of hundred years in the most dramatic case.

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