

## Double Mode Variables in M3

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**Abstract.** Using recent and earlier observations of M3 obtained at Konkoly Observatory, and all the other available photometry, the five known double mode RR Lyrae (RRd) stars have been analyzed. Long term amplitude and period changes of both modes have been followed.

We performed Fourier analyses of all the published (see Table III in Nemeč & Clement 1989; Clement & Goranskij 1999) and some recent and/or unpublished data (Bakos et al., Benkő et al., and Szeidl et al., all in preparation) for the RRd stars in M3. Attempts were made to transform the amplitudes of the different observations to consistent values, but small inconsistencies might have remained in the results. However, this inhomogeneity has negligible effect on the amplitude ratios. The periods of the modes were determined for each dataset separately. To evaluate the actual amplitudes, least squares solutions were calculated using also the harmonics and the linear combinations of the modes.

The results for individual RRd stars are:

**V68:** This star shows a strong double-mode behavior with moderately dominant first overtone pulsation. No definite amplitude ratio changes have been found. The frequency of the first overtone mode ( $\nu_1$ ) is slightly increasing, in accordance with the shape of the O–C diagram shown by Szeidl (1965). In contrast, the period of the fundamental mode does not seem to change.

**V79:** Our new CCD observations (Benkő et al.) confirm the double-mode nature discovered by Clement et al. (1997). The spectrum is dominated by  $\nu_1$  which could not be seen in the spectra before the 1990s. The period of the fundamental mode started to decrease drastically in the 1980s, and it is still decreasing! Using a different dataset in part, we have found practically the same fundamental mode periods as Clement & Goranskij (1999).

**V87:** The double-mode behavior of V87 is marginal. It is only possible to find  $\nu_0$  in the high quality, lengthy data series. The period of the overtone pulsation ( $P_1$ ) seems to be stable with  $dP_1/dt < 7 \cdot 10^{-11}$  [d/d].

**V99:** This star was revealed as an RRd by Corwin, Carney, & Allen (1999). The amplitude ratio changed just recently according to our new CCD observations (Benkő et al., in preparation). If further observations confirm the dominance of the fundamental mode, then the star would be the first example of a mode switch from the first overtone to the fundamental (see Fig. 1.). Observations from the 1920s also show the fundamental mode to have been dominant then, which, however, raises the possibility that there should be “random” changes occurring in the amplitude ratios instead of mode switching connected to stellar evolution.  $P_1$  is decreasing while no change is found for  $P_0$ .

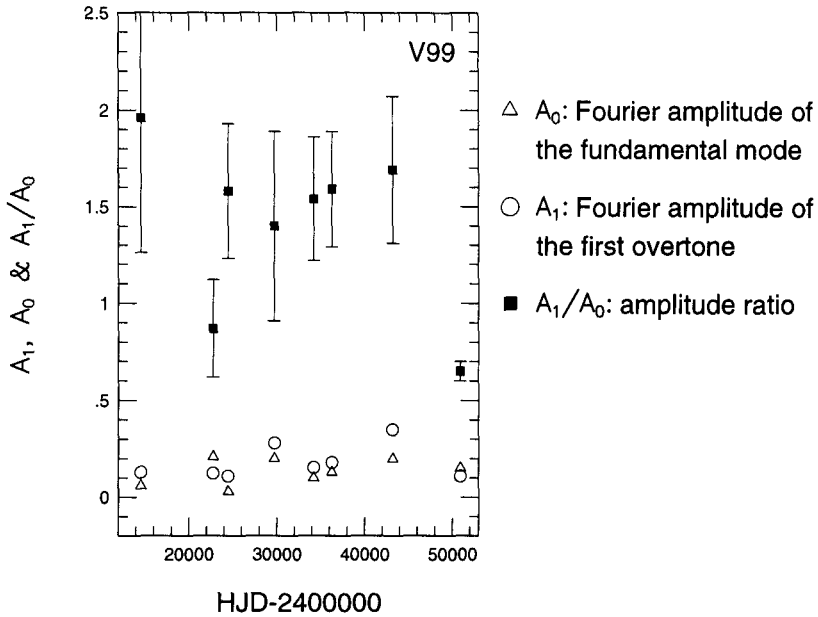


Figure 1. The amplitudes and amplitude ratios of V99 at different epochs are shown. The errors of the amplitude ratios were determined using a Monte Carlo method. See details in the text.

**V166:** The star is one of the few RRd stars where the fundamental mode dominates over the first overtone. The amplitude ratio is probably constant, and no evidence is found for period change as well.

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## References

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