On the Oosterhoff Classification of the Unusual, Metal-Rich Globular Clusters NGC 6388 and NGC 6441

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Abstract. We discuss the Oosterhoff classification of the unusual, metal-rich globular clusters NGC 6388 and NGC 6441, on the basis of new evolutionary models computed for a range of metallicities. Our results confirm the difficulty in unambiguously classifying these clusters into either Oosterhoff group, and also question the view that RR Lyrae stars (RRL) in Oosterhoff type II (OoII) globular clusters can all be evolved from a position on the blue zero-age horizontal branch (ZAHB).

1. Introduction

NGC 6388 and NGC 6441 are unusual in several respects, including the following. (i) In spite of being metal-rich ([Fe/H] \(\sim\) −0.55 dex), they contain prominent extensions to their red HBs—including both RRL and extended blue tails (Rich et al. 1997). (ii) As pointed out by Sweigart & Catelan (1998), the normally “horizontal” part of these clusters’ HBs is actually strongly tilted, with a \(\Delta V \sim 0.5\) mag from the lower part of the red HB to the tip of the blue HB—which cannot be accounted for by canonical stellar evolution models. (iii) The mean periods of the RRL in both clusters are extremely long for their metallicity—longer, in fact, even than in metal-poor, OoII globular clusters, thus apparently breaking down the traditional Oosterhoff classification scheme and posing yet another serious challenge to the models (Pritzl et al. 2000, 2001, 2002).

2. On the Oosterhoff Classification of NGC 6388 and NGC 6441

Such peculiarities notwithstanding, it has recently been suggested (Clement et al. 2001), on the basis of the RRL’s position on the \(P - A_V\) plane—i.e.,
reportedly coincident with the “line” occupied by “normal” RRL stars in OoII globular clusters (Clement & Rowe 2000)—that these globulars should be classified as OoII, with the RRL evolved away from a position on the blue ZAHB. This suggestion raises some fundamental questions, including the following:

(i) Do blue HB stars spend enough time within the instability strip as they evolve redward to the asymptotic giant branch (AGB) to produce the observed number of RRL in OoII globular clusters?

(ii) Does the predicted period-$T_{\text{eff}}$ relation for a given OoII cluster depend on the stellar distribution along the blue HB?

(iii) Is the period-$T_{\text{eff}}$ relation independent of metallicity?

To answer these questions, we have computed new evolutionary tracks and HB simulations for OoII globular clusters. Our main results (see Pritzl et al. 2002 for a more thorough discussion) can be summarized as follows:

(i) According to the models, blue HB stars do not spend enough time within the instability strip as they evolve redward to the AGB to produce the observed number of RRL in OoII globulars. This confirms the well-known arguments of Renzini & Fusi Pecci (1988) and Rood & Crocker (1989), which unfortunately have been almost entirely neglected in the literature since the mid-90’s.

(ii) The predicted period-$T_{\text{eff}}$ relation for a given cluster depends somewhat on the stellar distribution along the blue HB, leading to the presence of intrinsic scatter in the period-$T_{\text{eff}}$ plane and to longer mean period shifts for OoII clusters with bluer HBs. This has to be taken into account, when attempting to classify individual stars into an Oosterhoff type. On the other hand, only stars within a relatively narrow range of ZAHB colors, $(B - V)_0 > 0$, have a significant chance of becoming redward-evolving RRL.

(iii) The predicted period-$T_{\text{eff}}$ relation for redward-evolving RRL is a weak function of metallicity for OoII metallicities, but not for the metallicities of NGC 6388 and NGC 6441.

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