

# On the explanation of the Sandage effect

M. Catelan

*Instituto Astronômico e Geofísico, Universidade de São Paulo, São Paulo, Brazil*

There are two problems with the Lee et al. (1990, LDZ; Lee 1990, 1991) scenario for the Sandage effect (Sandage 1990 and references therein) which may still warrant further detailed analyses: 1) on the basis of standard tracks, RR Lyrae stars in OoII, M15-like globular clusters can only be well-evolved objects from the blue ZAHB for *unrealistically low helium abundance ( $Y$ ) values*; 2) in comparison with the models by Sweigart (1987, SW87), the evolutionary tracks of Lee & Demarque (1990, employed by LDZ) tend to overestimate the effect of evolution away from the ZAHB for the RR Lyrae stars, despite the similar assumptions involved in the calculations of the two sets of models. (See Catelan 1992a, C92A.) It is indeed possible to conclude that the claims by LDZ that the Sandage effect has been explained arise not only from the inclusion of the final 5-10% of HB evolution in their case, but also from the fact that their tracks do not agree very well with those of SW87, for both high and low  $Z$  [as an example,  $\Delta \log P(T_{\text{eff}})$ (M15 - NGC 2808/6864) increases by  $\simeq 10$ -30% due to the former effect, and by  $\simeq 25$ -45% due to the latter – see Catelan 1992b for details]. At any rate, if the RR Lyrae variables in OoII clusters are well-evolved objects from the blue ZAHB, an alternative way to obtain HB tracks with the necessary morphological characteristics (evolution predominantly redward for low metallicities) is urged, for  $Y_{\text{MS}} \simeq 0.20$  (or equivalently  $Y_{\text{HB}} \simeq 0.21 - 0.22$ ) – as presently required – is a value that seems both *cosmologically too low* (Olive et al. 1990), and unjustified in terms of independent observational and/or theoretical evidence (C92A). I suggest that a “mimicking effect” may be operating, in which HB stars do not have abnormally low  $Y$ , but instead enhanced core-mass values (with respect to the standard ones):  $\Delta M_c \approx +0.02 M_{\odot}$ . Several advantages are inherent to this scenario, such as a natural explanation of the results by Walker (1992) concerning the distance modulus to the LMC, and an increase in evolutionary RR Lyrae masses (“ $\alpha$ -enhanced” evolutionary values are lower than the latest double-mode ones – see C92A).

## References:

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