A common colour-magnitude relation from giant elliptical galaxies to globular clusters?

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Abstract. We discuss the existence of a common colour-magnitude relation (CMR) of metal-poor globular clusters and early-type galaxies, i.e. giant ellipticals, normal ellipticals and lenticulars, dwarf ellipticals and lenticulars, and dwarf spheroidals. Such CMR would cover a range of $\sim 14$ mag, extending from the brightest galaxies, down to the globular clusters on the fainter side.

Resumen. Se investiga sobre la existencia de una única relación color-magnitud trazada por cúmulos globulares pobres en metales y por galaxias de tipo temprano, i.e. elípticas gigantes, elípticas y lenticulares normales, elípticas y lenticulares enanas, y enanas esferoidales. Tal relación cubriría un rango de $\sim 14$ mag, y se extendería desde las galaxias más brillantes hasta los cúmulos globulares en el extremo débil.

1. Introduction

The fact that early-type galaxies in clusters and groups define a tight sequence in the colour-magnitude diagram (CMD) in the sense that bright ellipticals are redder than fainter ones, has been known for a long time (e.g. Baum 1959). Spectroscopic studies of giant ellipticals (e.g. Kuntschner 2000) and dwarf galaxies (e.g. Mieske et al. 2007) have shown that this colour-magnitude relation (CMR) mainly reflects metallicity effects: the more luminous (i.e. massive) galaxies are more capable to retain their metal content than low-mass ones thanks to their deeper potential wells (e.g. Rakos et al. 2001, and references therein).

Studies of extragalactic globular cluster (GC) systems observed with HST have revealed that in some galaxies, the more luminous blue (i.e. metal-poor) GCs are redder than fainter ones, showing what seems to be a CMR. This relation has been called blue tilt and its origin and existence are still under discussion (Strader & Smith 2008, and references therein).
2. The “blue tilt” of globular clusters in NGC 4486

From ACS-HST observations, the existence of a CMR among metal-poor GCs of different GCs systems has been reported (Harris et al. 2006, Strader et al. 2006, Mieske et al. 2006). Despite this trend has been interpreted as a mass-metallicity relation, it has also been suggested that the origin of the blue tilt might be related to photometric errors: blue GCs might be more extended systems and, as a consequence, marginally resolved by ACS-HST (Kundu 2008). Forte et al. (2007) have detected through ground-based observations, a notable tilt of the colours of the blue GCs associated with NGC 4486 (M87) in the Virgo cluster. They found a linear relation that corresponds to a 0.06 mag \((C - T_1)\) colour increase per magnitude. This finding is against the hypothesis of the blue tilt arising from photometric errors. Recently, Romanowsky et al. (2008) have arrived at a similar conclusion.

3. The colour-magnitude relation in the Antlia cluster

Smith Castelli et al. (2008) have found a tight CMR in the Antlia cluster. Considering new members identified through GEMINI-GMOS spectroscopy, this relation spans \(\sim 10\) mag in brightness, from giant elliptical to dwarf galaxies, with no apparent change of slope (Smith Castelli 2008, Smith Castelli et al. in preparation). This slope is consistent with those found in other clusters like Virgo and Fornax, and is also similar to that found by Forte et al. (2007) for the blue tilt of NGC 4486 GCs. When all these stellar systems are shifted to the Antlia distance, they seem to follow a common CMR from blue GCs to giant ellipticals as it can be seen in Fig. 1 (Smith Castelli et al. in preparation). The equation of the Antlia CMR fit is \(T_{10} = 39.2(\pm 1.6) - 14.1(\pm 0.9) \ast (C - T_1)\). Considering \((m - M) = 32.73\) for Antlia (Dirsch et al. 2003) and \((m - M) = 31.0\) for NGC 4486 (Forte et al. 2007), the equation of the ‘blue tilt’ of NGC 4486 shifted to the Antlia distance reads \(T_{10} = 43.2 - 16.7 \ast (C - T_1)\).

4. The “blue tilt” in other globular cluster systems

We have found no evidence of a blue tilt in the GC system of NGC 1399, the central galaxy of the Fornax cluster, but a unimodal colour distribution for the brightest GCs (Dirsch et al. 2003, Forte et al. 2007). Similarly, Bassino et al. (2008) detected no blue tilt in the blue GCs around the two dominant galaxies of the Antlia cluster, NGC 3258 and NGC 3268 (but see Harris et al. 2006); both GC systems present unimodal colour distributions for the most luminous clusters. However, the blue tilt has been observed in some normal elliptical and S0 galaxies (Mieske et al. 2006, Spitler et al. 2006). The fact that this feature is present in some galaxies and not in others might be pointing to an environmental effect regarding the formation of the GCs, that is not clearly understood yet.
5. Concluding remarks and future perspectives

There is a uniform CMR for early-type galaxies in nearby clusters (Sandage 1972, Bower, Lucey & Ellis 1992, Smith Castelli et al. 2008, Misgeld et al. 2008, De Rijcke et al. 2008). The blue tilt of the NGC 4486 GC system appears to extend this relation to very faint magnitudes. However, this effect is not seen if we consider the GC system of NGC 1399 in Fornax and the brightest galaxies in Antlia.

Assuming that the CMR of early-type galaxies corresponds to a mass-metallicity relation, it sets a limit for the highest metallicity that a member galaxy of a cluster can reach for a given mass. The colour (metallicity?) range covered by early-type galaxies in Antlia is similar to the one corresponding to all NGC 4486 GCs.

A common and well defined CMR among giant and dwarf elliptical galaxies is surprising given that their chemical histories are supposed to be different. Moreover it would be if such a relation extends towards the GCs regime. We have no explanation for such extended universal trend at the moment. On one hand, the fact that the 'blue tilt' is seen in some galaxies and not in others, is pointing to an environmental effect. On the other hand, the universality of the CMR of early-type galaxies lead several authors to suggest that its build up is independent of the local environment (e.g. Smith Castelli et al. 2008). If blue GCs follow this universal trend, is it a consequence of the environment in which they are now immersed or due to their primordial formation conditions?

We plan to further extend this investigation before arriving at sensible conclusions. The existence of a common CMR between early-type galaxies and blue GCs would represent a new challenge to our understanding of the formation and evolution of stellar systems in the Universe.

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Figure 1. Colour-Magnitude diagram of early-type galaxies in the Antlia cluster, and NGC 4486 globular clusters (red points) shifted to the Antlia distance. As a reference, the dashed line is the fit to the blue tilt of NGC 4486 globulars found by Forte et al. (2007).

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