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Correlations between the age structure in early-type galaxies and their properties

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Abstract. We present the results on our investigation of the age structure in early-type galaxies, based on optical/near-infrared photometry. First results have shown that the age structure in early-type galaxies is not as uniform as previously thought. The conclusion can only be that the formation of these galaxies is not exclussively based on a single scenario, e.g. monolithic collapse, or hierarchical merging. In our galaxy survey we compare the age structure of galaxies in different galaxy environment, of different mass and with different integral light properties, using the globular cluster systems as stellar probes. Depending on the size of the globular cluster sample we derive a cumulative age distribution and compare it to simulated systems with a known age structure. This allows us to detect globular cluster sub-populations with an age difference of several Gyr. So far we have found two galaxies, members of small groups of galaxies, which contain a significant population of intermediate age globular clusters in the inner region of the galaxy.

Keywords. galaxies: formation, galaxies: evolution, galaxies: star clusters, galaxies: elliptical and lenticular, cD

1. Introduction

Early-type galaxies are the largest concentrations of stars in the Universe and their formation and evolution is therefore of great interest. Recent studies (e.g. SAURON, see Davies *et al.* 2001) have shown that the class of early-type galaxies is not as uniform as previously thought and any formation scenario must hence not only explain the similarities between early-type galaxies but also the differences. Alternatively we may learn that different formation scenarios are at work in those galaxies. Finding correlations between the age structure in early-type galaxies and various galaxy parameters will help to answer the question about how these galaxies form.

2. Method

In order to find correlations between the age structure of early-type galaxies and various galaxy paramters, such as mass or galaxy environmant requires the investigation of a larger galaxy sample. In addition we have to ensure that all significant stellar populations within a galaxy are included in our data set. Therefore we apply a photometric method of age determination (Figure 1, left) in combination with Monte-Carlo simulations. For a given galaxy, represented by its globular cluster system, we derive the cumulative age distribution and compare it to the one of simulated systems with a given age structure. Via a reduced χ^2 test we find the age and relative size of the best fitting model system and will eventually use both parameters to quantify the age structure in the observed galaxy. To investigate the influence of galaxy parameters on the galaxies formation and evolution we introduce the *Methuselah* parameter Mth, derived with:

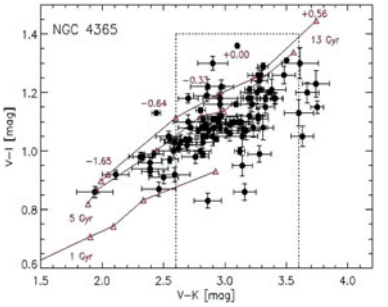

Figure 1. Color-color diagram for NGC 4365 globular clusters. The isochrones (solid lines) are taken from the Bruzual & Charlot (2003) SSP models and refer to a 1, 5 and 13 Gyr isochrone. The dashed box marks the color selection as described in Hempel & Kissler-Patig (2004).

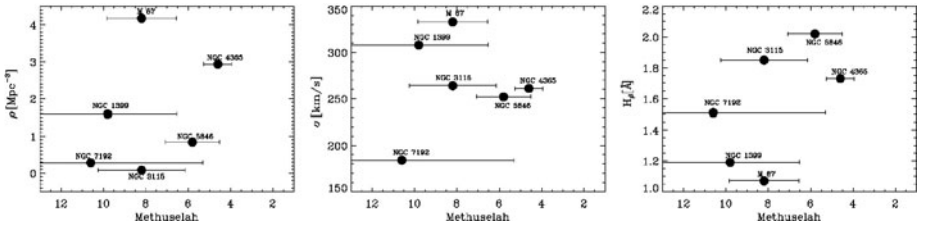

Figure 2. The *Methuselah* parameter as a function of immediate galaxy environment (left, velocity disperion (center), and H_β-index (right).

Mth=age$_1$*fraction$_1$+age$_2$*fraction$_2$. The indices correspond to two possible age populations in the globular cluster system. A low Mth value will therefore represent a mixed age population, with Mth decreasing with an increasing intermediate/young age population.

3. Results

So far our galaxy sample contains 11 early-type galaxies, for six of them the globular cluster sample is sufficiently large to apply the method of age determination (Hempel & Kissler-Patig 2004). The various galaxies differ in several parameters, e.g. size, environment and integrated light. Based on the photometric age estimates we derive the lowest Methuselah values for NGC 4365 and NGC 5846, the two galaxies in intermediate galaxy density environment to be 4.6 and 5.8, respectively. We note that both galaxies have previously be found to contain a significant fraction of intermediate age globular clusters. Considering the low number of galaxies in out sample at this point, the fact that we can not find any strong correlations between age structure and galaxie mass or spectral index is not suprising. To establish correlations which can be quantified by statistical tests will require a larger galaxy sample. We also keep in mind that so far observations do not extend beyond 1-1.5 effective radii. Given that early-type galaxies show a radial color gradient it is necessary to apply our analysis to photometric wide-field surveys.

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