Stellar Populations as Building Blocks of Galaxies
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The star formation history of dwarf galaxies: First results of the MAGPOP-ITP

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Abstract. The MAGPOP-ITP is a large observational project of the EU MAGPOP Network. In order to study the star formation history of dwarf galaxies, a total of 60 nights was allocated on the 4 large La Palma telescopes in the framework of an International Time Programme. The programme comprises continuum, Hα and near-infrared imaging and optical spectroscopy of quiescent and star-forming dwarfs in the field and in the Virgo Cluster. All galaxies in the sample are selected to have imaging in the UV (by GALEX) and in the optical (by SDSS), and many have additional data available in the GOLDMine database.

The aim of the programme is to study the star formation of dwarf galaxies in function of their environment and dwarf type. In this contribution, I will focus on the results obtained for dwarf elliptical galaxies (dEs) using long-slit optical spectroscopy obtained with the NOT. We derive mean luminosity-weighted ages and metallicities using Lick indices for 25 dEs.

The dEs show a large spread in both ages and metallicities, but overall they are younger and less metal-rich than normal ellipticals (Es). The [α/Fe] ratios of the dEs are compatible with solar ratios, or are even slightly underabundant, pointing at prolonged star formation histories for dEs.

1. Introduction

Dwarf galaxies, the most abundant galaxy type in the universe, play an important role in extragalactic astronomy. Being low-mass systems, dwarf galaxies are very sensitive to both internal processes and environmental influences, such as galactic winds, ram pressure stripping and tidal interactions. This makes dwarf galaxies key objects to understand galaxy formation and evolution.

Dwarf galaxies can be subdivided in two main groups: the star forming and the quiescent dwarfs (dIrrs and dEs respectively, see Grebel (2001)). Those two groups are traditionally selected and studied separately. The stellar populations of dEs are generally studied in connection to their bigger cousins (Es), whereas dIrrs are studied using their gas emission lines. However, the strong morphology-density relation for dwarf galaxies (Binggeli, Tammann & Sandage (1987)) and the finding of rotating dEs (Pedraz *et al.* (2002); van Zee, Skillman & Haynes (2004)) hint at an evolutionary connection between the different dwarf galaxy types.

In order to address these issues, the EU MAGPOP Network is currently compiling a unique dataset of ∼100 dEs and dIrrs in the field and in the Virgo Cluster. The sample was carefully selected on the availability of UV and optical imaging with GALEX and SDSS, irrespective of whether the galaxy seems to be star forming or not. Using the 4 large telescopes in La Palma, we are collecting optical continuum, Hα and NIR imaging,

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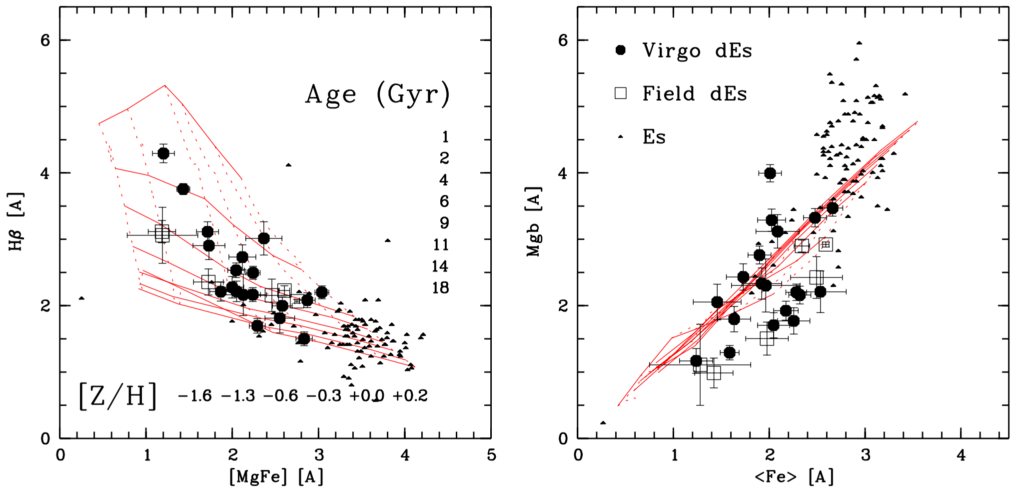

Figure 1. Index-index plots for our dEs and Sánchez-Blázquez *et al.* (2006b) Es, overlaid with Vazdekis (1999) SSP models (symbols as indicated on the plot). *Left:* Hβ vs. [MgFe] diagram. dEs are less metal-rich and span a wider range of ages than Es. *Right:* $\langle$Fe$\rangle$ vs. Mgb diagram. The models represent solar abundance ratios. While Es show Mg overabundance, the dEs are compatible with the models.

and optical spectroscopy for all the galaxies (see also the poster by E. Toloba in this conference). Combined with archive data from the literature (e.g. HST and GOLDMine), we can study the star formation history, and its relation to morphology and environment. In this contribution, we present some first results of this programme, based on the optical spectroscopy of Virgo and field dEs.

2. Sample and observations

The sample consists of 25 dEs: 18 Virgo dEs, 5 Field dEs, M32 and a low-luminosity elliptical in the Cancer Cluster. The observations were carried out using ALFOSC mounted on the 2.5m NOT in La Palma, on 29-31 December 2005 and 4-6 April 2006. We used grism#14, with a 1 arcsec slit. This gives a wavelength range of 3500 - 5100 Å and a resolution of 7.8 Å (FWHM). Integration times varied between 40 minutes and 3 hours, depending on the surface brightness of each galaxy. Integrating over the central 4 arcsec gives one-dimensional spectra with a S/N $\sim$ 20-40 per resolution element. We also observed 12 standard stars in common with the Lick/IDS and MILES stellar libraries (Worthey *et al.* (1994); Sánchez-Blázquez *et al.* (2006a)). These stars are used both as photometric and velocity standard stars and are used to transform the spectral indices to the Lick/IDS system. Having flux-calibrated spectra and models (Vazdekis *et al.* (2007)), this transformation is actually redundant, but we do it here to compare the indices to literature data for Es, taken from Sánchez-Blázquez *et al.* (2006b).

3. Results

3.1. *Central Lick indices*

In Fig. 1 we show Lick/IDS index-index diagrams with SSP model grids (taken from Vazdekis (1999)). From the Hβ - [MgFe] diagram we can read the luminosity-weighted ages and metallicities of the galaxies (see also Fig. 2). The dEs occupy the whole model

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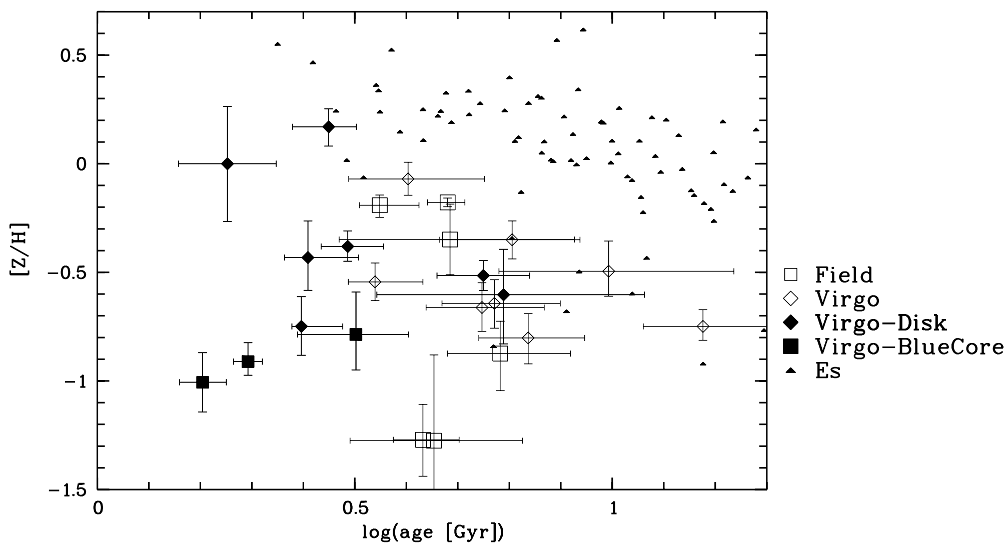

Figure 2. Ages and metallicities for the dEs, derived from Fig. 1. We have indicated those Virgo dEs with (possible) disk structure, and with blue cores (Lisker *et al.* (2006a, 206b)). The blue–core dEs are indeed amongst the youngest systems, with spectra that resemble post-starburst galaxies.

grid, whereas the Es are clustered towards the old and metal-rich corner. There appears to be a continuation in decreasing metallicity going from Es to dEs, representing the well-known mass-metallicity relation (Brodie & Huchra (1991)).

The ⟨Fe⟩ - Mgb diagram gives an estimate of the α/Fe element ratio, relative to the solar values of the models. The Es show overabundance, which indicates that they formed the bulk of their stars in a rapid burst, before supernova type Ia could enrich the interstellar medium with Fe. The dEs however do not show this overabundance, and are compatible with solar abundance, or are even slightly underabundant. This implies that dEs had a prolonged star formation history.

Although the numbers are small, there is no systematic difference in the Virgo and field dE properties. The paucity of field dEs however, is a real reflection of the morphology-density relation: it is very hard to find genuine field dEs.

3.2. *Ages and metallicities*

In Fig. 2, we show the luminosity-weighted ages and metallicities for our dEs. There is considerable spread in both ages and metallicities and no clear trend of increasing metallicity with increasing age, as in the Es. The Virgo dEs with a blue core are indeed young systems that have apparently switched off their star formation very recently. dEs with a (possible) disk feature are not systematically more metal-rich than other dEs, which would have indicated their originating from harassed/stripped larger disk galaxies.

3.3. *Special case VCC 21*

One of the Virgo dEs in our sample, VCC 21, has been observed with ACS/HST (Côté *et al.* (2006)) and shows a double nucleus along the mayor axis. Separating the light from the nuclei and the host galaxy, we find that the nuclei are ∼1 Gyr younger than the rest of the galaxy. We might be witnessing a dwarf galaxy in transition, or the formation of a nucleus.

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4. Conclusions

The MAGPOP-ITP is compiling an extensive data set for a carefully selected sample of nearby dwarf galaxies in the Virgo cluster and in the field. Eventually we will aquiere continuum, Hα and NIR imaging, and optical spectroscopy. Combined with UV and optical imaging from GALEX and SDSS, these data will be used to study the star formation history of dwarf galaxies, and the relation with galaxy type, environment, etc.

Based on the optical spectroscopy of 25 dEs presented here, we show that dEs are generally less metal-rich than Es, continuing the mass-metallicity relation. However, the α/Fe ratios imply that dEs had a different star formation history. Whereas Es are formed in a short burst, dEs have a more extended star formation history.

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Discussion

Chilingarian: You have long-slit data; beside the special case of VCC 21, did you detect any pecularities such as chemically or evolucionary decoupled cores in any other objects?

Michielsen: The spectral resolution is not good enough to measure kinematics in these systems. The results here are central values, I haven't looked at gradients yet.

Knapen: Could your double-nucleus galaxy have only one nucleus and a bright star-forming region?

Michielsen: No, there are no optical emission lines, nor signs of heavy dust-enshrouding.

Trager: It appeared that there were some low [α/Fe] dwarfs in your sample, do we need models with [α/Fe]<0? Are these available, or need to be compilated?

Michielsen: Yes, I think we are going to need models with underabundant element ratios. They might already exist?

Thomas: Comment: Compared to the TMB models, the data did not appear to be significantly underabundant. In fact, there are models available with [α/Fe] underabundance.

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