Kinematics and stellar populations of 17 dwarf early-type galaxies*

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Abstract. We present kinematics and stellar population properties of 17 dwarf early-type galaxies in the luminosity range $-14 \geq M_B \geq -19$. Our sample fills the gap between the intensively studied giant elliptical and Local Group dwarf spheroidal galaxies. The dwarf ellipticals of the present sample have constant velocity dispersion profiles within their effective radii and do not show significant rotation, hence are clearly anisotropic. The dwarf lenticulars, instead, rotate faster and are, at least partially, supported by rotation. From optical Lick absorption indices, we derive metallicities and element abundances. Combining our sample with literature data of the Local Group dwarf spheroidals and giant ellipticals, we find a surprisingly tight linear correlation between metallicity and luminosity over a wide range: $-8 \geq M_B \geq -22$. The $\alpha$/Fe ratios of our dwarf ellipticals are significantly lower than the ones of giant elliptical galaxies, which is in agreement with spectroscopy of individual stars in Local Group dwarf spheroidals. Our results suggest the existence of a clear kinematic and stellar population dichotomy between dwarf and giant elliptical galaxies. This result is important for theories of galaxy formation, because it implies that present-day dwarf ellipticals are not the fossilized building blocks of giant ellipticals.

Keywords: stellar populations, dwarf galaxies, element abundances

1. Introduction

Although dwarf galaxies are by far more abundant than giant galaxies, our knowledge of the kinematics and stellar population properties of these objects is still very poor. In the framework of hierarchical clustering dwarf galaxies play an important role as they may be the seeds for the formation of larger galaxies. It is still not clear, however, whether dwarf elliptical galaxies are related to giant ellipticals or form a separate family. A continuity with respect to mean radii and surface brightnesses (Nieto, 1988) are arguments against, the vast differences in core properties (Kormendy, 1985), instead, support the existence of a dichotomy between dwarf and giant ellipticals. Are the present-day dwarf ellipticals the fossilized building blocks of giant ellipticals as

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early suggested by Dekel and Silk (1986)? We aim to address these questions via a detailed spectroscopic analysis of the internal kinematic structure and the stellar population properties, i.e. metallicities and element abundance ratios, of dwarf early-type galaxies.

In several observing runs (1995 to 2001) we used the TWIN spectrograph at the 3.5m telescope on Calar Alto Observatory (Spain) to take long-slit (along the major axis) spectra of 17 dwarf early-type galaxies in the Virgo cluster and in the field (Binggeli et al., 1985; Vader and Chaboyer, 1994). Covering the wavelength range 4800 \( \lesssim \lambda \lesssim 5400 \) Å, we obtained a spectral resolution \( \sigma \sim 30 \) km/s with \( S/N \sim 40 \) Å\(^{-1}\) (within 1/2 \( r_e \)). The line-of-sight velocity distributions were determined from the Mg triplet near 5175 Å with the Fourier-Correlation-Quotient method (Bender, 1990) and carefully tested with Monte Carlo simulations. From the Lick absorption-line indices H\(\beta\), Mg\(b\), Fe5270, and Fe5335 we derive average ages, total metallicities \( Z/H \), and \( \alpha/Fe \) ratios based on the stellar population models of Thomas et al. (2002).

## 2. Kinematics

In Fig. 1 we show the velocity dispersion (\( \sigma \)) profiles and rotation curves (\( v_{rot} \)) of the Virgo dwarf elliptical IC 3381 (well consistent with Simien and Prugniel, 2002) and the dwarf lenticular NGC 7626#15. All our 14 dwarf ellipticals have profiles similar to IC 3381 and do not show significant rotation. We therefore confirm for a significantly
larger sample the early result of Bender and Nieto (1990) and Bender et al. (1991), that dwarf elliptical galaxies are anisotropic. The 3 dwarf lenticulars, instead, show clear signs of rotation (see NGC 7626#15 in Fig. 1). Note that, still, the latter are not fully flattened by rotation, as the anisotropy parameter (Kormendy, 1982) is \((v/\sigma)_{\star} \approx 0.7\) (Bender et al., 1992).

These results are in good agreement with the recent studies by Geha et al. (2002) and Zeilinger et al. (this volume). Pedraz et al. (2002), instead, claim to detect fast rotation in dwarf ellipticals. We note that the three fast rotators in their sample are dwarf lenticulars (in agreement with the present result), and the remaining three dwarf ellipticals have only negligible rotational velocities and are not rotationally flattened. The absence of significant rotation sets the clear distinction from ‘normal’ low-luminosity ellipticals. Dwarf and giant elliptical galaxies apparently form separate families. Note that the objects for which Simien and Prugniel (2002) (see also this volume) detect significant rotation are more luminous and also have higher surface brightnesses, hence may be at the transition to ‘normal’ low-luminosity ellipticals.

3. Element abundances

In Fig. 2 we plot total metallicity and \(\alpha/\text{Fe}\) abundance ratio as functions of absolute blue luminosity. Our data (filled squares) covering \(-14 \geq M_B \geq -19\) nicely fill the gap between the Local Group dwarf spheroidals and giant elliptical galaxies. We find that ellipticals follow a surprisingly well defined linear correlation between absolute magnitude
and metallicity over 14 orders of magnitude. This result suggests that the gas fraction turned into stars, i.e. the efficiency of star formation, which basically determines the metallicity, steadily increases with increasing mass and potential well of the object. Hence, the smaller a galaxy, the larger is the gas fraction it looses through a galactic wind.

The detailed chemical enrichment process, in particular the partition between Type II and Type Ia supernovae constrained by the $\alpha$/Fe ratio, instead, seems to be very different in dwarf and giant ellipticals. The dwarf galaxy sample exhibits a large scatter in $\alpha$/Fe, with a median value of $[\alpha/Fe] = 0$, which is well below the typical $\alpha$/Fe of giant elliptical galaxies. These relatively low average $\alpha$/Fe ratios found here are consistent with the abundance determinations of individual stars in Local Group dwarf spheroidals (Shetrone et al. 2001; Tolstoy et al., this volume). With our larger sample comprising also fainter objects, we reinforce the conclusion of Gorgas et al. (1997), that also a stellar population dichotomy exists between dwarf and giant elliptical galaxies. Present-day dwarf elliptical galaxies are therefore not the fossilized building blocks of giant ellipticals.

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