

Internal kinematics and stellar populations of dE galaxies: clues to their formation/evolution

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Abstract. What is the origin of the numerous population of diffuse elliptical galaxies (dE)? These galaxies formed their stars several billion years ago and lost their gas. Though the stellar winds resulting from star formation and the interactions with the environment undoubtedly play a role, their respective role and details of this evolution are still debated.

In this presentation we will review the first 3D spectroscopic observations of a handful of dE galaxies. These data reveal complex kinematical structures, with embedded discs and counter rotating cores, and they open extremely promising perspectives for studying the history of the stellar population throughout these various features.

The presence of disks, which was already known from detailed image analysis, their complex kinematics, and the new constraints on the stellar population enforce the hypothesis of the evolutionary connection between dEs and disk galaxies.

Keywords. methods: data analysis, galaxies: dwarf, kinematics and dynamics, stellar content

1. Introduction

Though diffuse elliptical galaxies represent majority of the galaxy populations in dense regions of the nearby Universe like rich clusters, their origin and evolution remain still a matter of debate. Two main scenarios proposed so far are (a) early hierarchical collapse with a feedback of star formation (Dekel & Silk 1986, Nagashima & Yoshii 2004), and (b) environmental evolution: ram pressure stripping of disc galaxies in clusters (Mori & Burket 2000) and groups (Marcolini *et al.* 2003), or gravitational harassment (Moore *et al.* 1998). The predictions of the popular now CDM cosmological simulations for the number and intrinsic structures of the nearby dwarf galaxies does not agree with the real situation, as well as the multi-burst star formation histories of dSph of the Local Group are quite unexpected in the frame of the hierarchical concept (Koch *et al.* 2004). So observations remain the only valid way to find a clue to their formation and evolution.

The dynamical structure of the dEs is not clear too. From a sample of 35 dEs, only a few are not consistent with rotational flattening (prolate or triaxial) (Prugniel & Simien 2003). However, there are non-rotating ellipsoidal dwarfs like tidally stressed objects (like NGC205), or some other non-rotating flat objects, like IC 794, probably anisotropic. Fine structures, embedded bars and discs sometimes with spiral patterns, have been found in some dEs (Jerjen *et al.* 2000, Barazza *et al.* 2002). They may argue for a hypothesis of common origin of dEs and dIrrs.

By using the benefits of the integral-field spectroscopy providing two-dimensional distributions of the kinematical parameters, as well as of absorption-line indices, we aim to

Name	Date	seeing	t_{exp}	S/N _{cent}	σ_{cent}
IC 3468	2004/Mar/20	1.5"	2.5h	20	30
IC 3653	2004/May/24	1.4"	2h	35	70
NGC 770	2004/Oct/07	2"	2h	50	100

Table 1. Parameters of observations

search for (1) kinematical counterparts of the morphological fine structures revealed by the surface photometry, (2) related subpopulations in the stellar content.

2. Observations, data reduction and analysis

In 2004 we started to observe dE galaxies in the Virgo cluster with the MPFS integral field unit (IFU) spectrograph at the Russian 6-m telescope. The technique of 3D spectroscopy allows to obtain spatially resolved distribution of kinematical characteristics (radial velocity and velocity dispersion fields) independently for gas and stars, and stellar population parameters (for example, maps of line-strength indices) in a single exposure.

Observations of the galaxies have been performed with the MPFS IFU spectrograph on the 6m telescope of SAO RAS during three observing runs in 2004. The parameters of the observations are presented in Tab. 1

Data processing and analysis are discussed by Chilingarian *et al.* (this volume). We refer this paper for explanations of adaptive binning technique and fitting procedures.

3. Results

Here we present the results for three diffuse galaxies: IC 3468 and IC 3653 in the Virgo cluster, and NGC 770 in the NGC 772 group. We are modeling the simplest star formation history containing one burst.

3.1. IC 3468

Rather low S/N ratio doesn't allow very precise measurements. The results shown are obtained for tessellations with target S/N=10. No young subpopulation is detected. For a main burst with $t = 5$ Gyr with low metallicity ($[m/H] = -0.4$) we see some metallicity gradient (from -0.3 in the centre till -0.55 in the outskirts). Velocity dispersion map shows stripe with low values (near the limit of the measurements, about 20 km/s) aligned along the major axis of the isophotes. Radial velocity field is quite irregular and asymmetric, though showing some kind of rotation with the amplitude of 10 km/s.

3.2. IC 3653

Good S/N ratio allows to build precise maps of the parameters till $7''$ from the centre of the galaxy. Disc rotation with the amplitude of about 40 km/s is seen in the radial velocity field with the strongest gradient in the inner region, that is quite unusual for objects of such type. Velocity dispersion shows gradient from 70 km/s in the centre till 40 km/s in the outer regions. The age map is almost flat with a mean age of 7 Gyr, all details seen are not statistically significant except young values in the very centre. Metallicity distribution shows shallow gradient from $[m/H] = 0$ in the centre to $[m/H] = -0.2$ at the outskirts with a small metal-rich nuclear region ($[m/H] = 0.13$). There is a marginal detection of younger population $t \sim 1$ Gyr in the centre which may contain a mass fraction of 1 to 3 percent. The maps are computed for the target S/N values of 25.

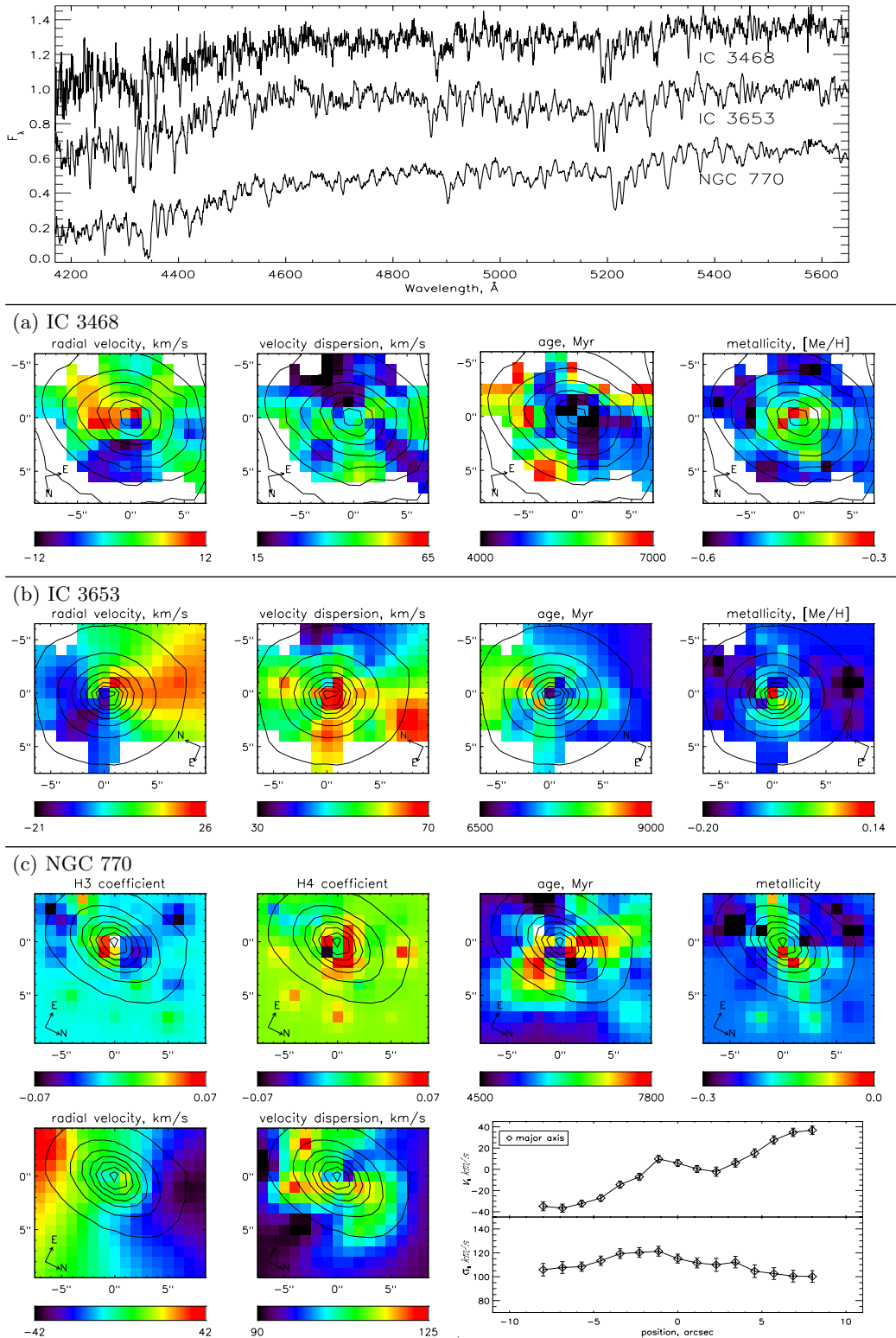


Figure 1. On the upper figure spectra of the central regions of three galaxies are shown. (a) and (b) Results for IC 3468 and IC 3653: 2D fields of radial velocity, velocity dispersion, age and metallicity in the single burst SFH model. (c) Results for NGC 770: the same as previous, besides the maps of H3 and H4 Gauss-Hermite coefficients, and kinematical profiles along major axis are shown.

3.3. NGC 770

The galaxy experiences strong tidal interaction with the giant spiral NGC 772. Its luminosity ($M_B = -18.4$) and velocity dispersion (110-120 km/s) place it between giants and dwarfs. Very good S/N ratio allows precise measurements of all the parameters (for example, $\Delta v \sim 1$ km/s). Good sampling of LOSVD due to high velocity dispersion allows to measure H3 and H4 Gauss-Hermit coefficients. We see impressive kinematically decoupled core in this object. This kinematical decoupling has been recently noticed by Geha *et al.* 2005. There are evidences for considering it to be a counter-rotating young metal-rich highly inclined stellar disc aligned almost with the major axis of the galaxy: (1) velocity dispersion map shows larger values on the “switches” of the velocity, there is a stripe with lower values orthogonal to the structures in age/metallicity distributions; (2) map of H3 coefficient shows regions with positive and negative values before and after “switch” of the velocity; (3) age and metallicity distributions clearly show the decoupled structure aligned almost along the major axis having younger age ($t \sim 4.5$ Gyr vs 7 Gyr) and higher metallicity ($[m/H] \sim -0.05$ vs -0.2) than the surrounding spheroid. The galaxy probably had a partially dissipative merger event, that induced a burst of star formation some 4.5 Gyr ago producing the central stellar structure that we see now as a counter rotating subpopulation with the high metallicity.

4. Conclusions

Kinematical features found in the dE galaxies strengthen the connection between dEs and dIrrs. Inner discs are probably the remnants of the stellar discs existing before gas removal.

Whatever the gas-removal mechanism is (winds or ram pressure stripping) the signatures would be the same. These systems probably did not undergo strong relaxation which would have erased the structures and population gradients. Most dEs should have the same origin, i.e. the same type of progenitors, but they had a different history, i.e. interplay between feedback, ram pressure stripping, and tidal effects. The study of the properties of the kinematical and population substructures will help to understand this history.

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