Statistical characterization of the Fornax cluster with S-PLUS

J.P. Calderón[1, 2], A. Smith Castelli[1, 2], E.V.R. de Lima[3], A.R. Lopes[4], F. Almeida Fernandes[3, 5] & C. Mendes de Oliveira[3]

[1] Instituto de Astrofísica de La Plata, CONICET-UNLP, Argentina
[2] Facultad de Ciencias Astronómicas y Geofísicas, UNLP, Argentina
[3] Instituto de Astronomia, Geofísica e Ciências Atmosféricas, USP, Brasil
[4] Observatorio Nacional, Brasil
[5] Community Science and Data Center/NSF's NOIRLab, Estados Unidos

Abstract

*In the context of the **S-PLUS Fornax Project** (S+FP), we performed a statistical characterization of the galaxy population of the Fornax cluster (D ≈ 20 Mpc) in the 12 optical bands of the survey over a total area of about 45 square degrees.*

Using the S-PLUS photometric catalogs we carry out a principal component analysis (PCA) on the structural and photometric parameters of two spectroscopic galaxy samples, and a clustering analysis to obtain the natural distribution of the samples on their principal components. The samples correspond to Fornax confirmed members and confirmed background galaxies.

Our main goal is to apply the results of that analysis to a third sample of candidate galaxies with no radial velocities in order to identify new Fornax members not catalogued before.

Introduction

We obtained SExtractor photometry (Bertin & Arnouts, 1996) over 23 S-PLUS fields in the 12 filters of the survey (S+FP iDR3 run in Rodrigo Haack's poster).

The number of the detected (extended and point) sources is about ~663000, among which there are objects already confirmed as Fornax members or lying in the background through radial velocities.

Figure 1 shows the spatial distribution of the extended sources after cleaning spurious detections. We also indicate the location of NGC 1399 and NGC 1316, the two dominant galaxies of the cluster. To select no spurious extended sources (galaxies), we decided to keep all objects displaying MAG_AUTO_ERR < 0.15 mag and CLASS_STAR < 0.5 in the G,R,I and Z bands. We will call this sample as our full sample.

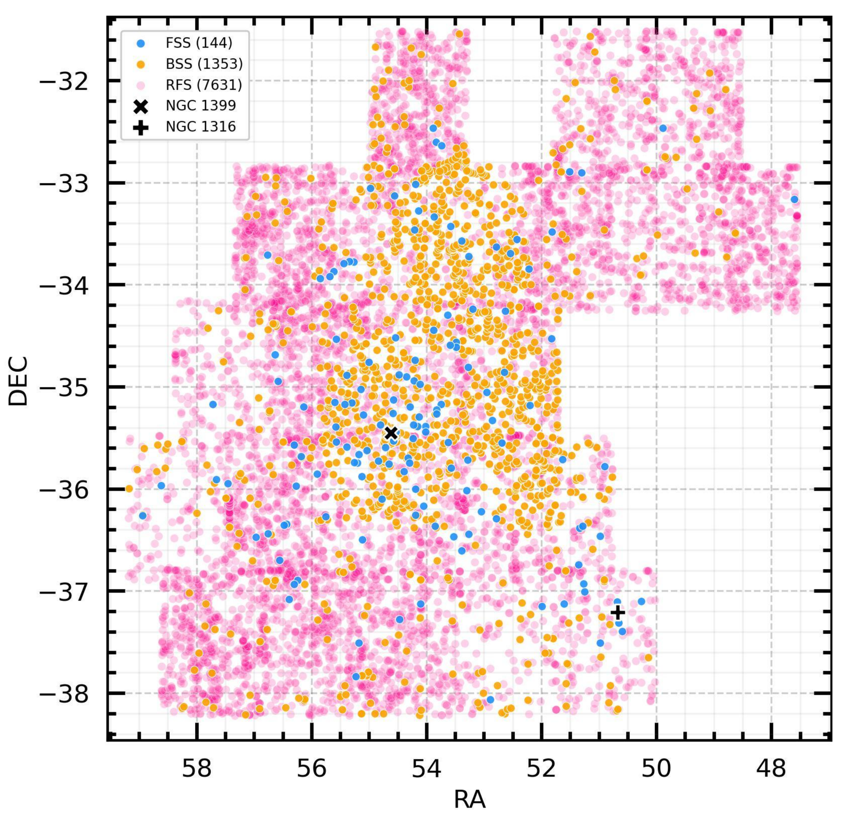

Figure 1: Spatial distribution of the samples (see text).

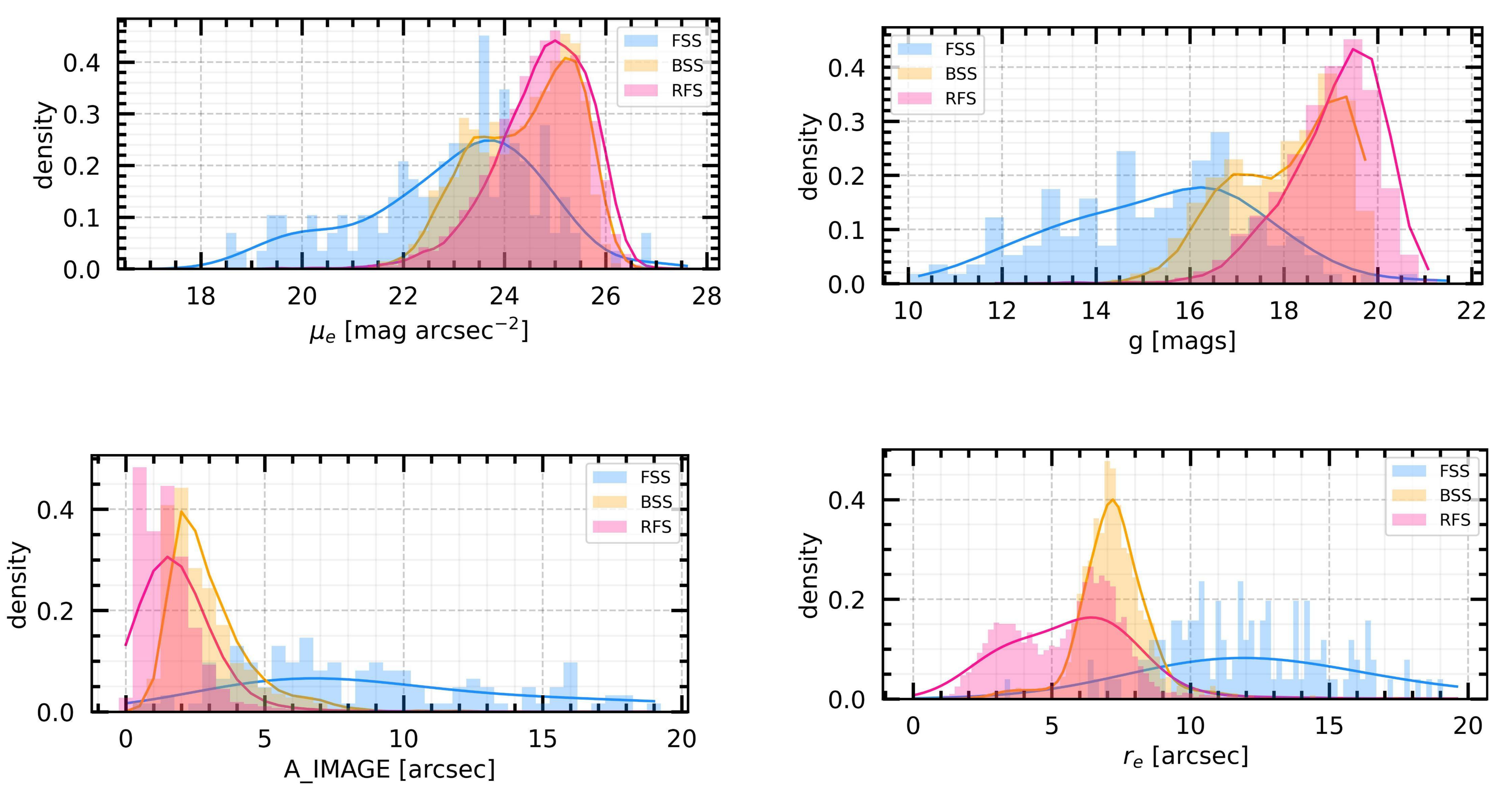

Figure 2: Histograms of some of the parameters studied for the three samples of our analysis.

Data and method

From the full sample, we divided the detected galaxies into three sub-samples. The first two correspond to *training samples* and have spectroscopy measurements: the **Fornax spectroscopic sample** (FSS) and the **Background spectroscopic sample** (BSS). The FSS was constructed using data from the literature and identifying the sources visually on the SExtractor aperture images (600 km/s < cz < 3000 km/s, Maddox et al., 2019) in order to check they were properly detected by SExtractor. The BSS was cross-matched with a compilation of radial velocities in the covered area.

These two training samples can be used to characterize the populations of Fornax and background galaxies and, as a consequence, they are useful to analyze their differences and similarities with a third sample of detected galaxies with no radial velocities: the **Restricted full sample** (RFS). **Figure 2** shows the histograms of some parameters used to characterize the three samples.

Our first attempt was to identify features of the Fornax galaxy population in a set of parameters and to select candidates that fit that description. However, we have found that is not practical to do that and we have decided to apply the principal component analysis (PCA) technique.

Results

Using the output parameters of SExtractor for the training samples (FSS and BSS), we performed different tests by varying the input parameters for PCA.

The first test consisted in using just scale parameters such as effective radius, major and minor axes of the detection ellipse as well as the elongation, the ellipticity and the position angle of that ellipse. We found that once the RFS sample is projected on the principal components of the training sample, it is not possible to clearly separate Fornax or background candidates.

In a second test we used the 12 S-PLUS MAG_AUTO parameters as input for the PCA algorithm for the training samples and obtained a similar results.

As a third test, we joined the photometric and structural parameters (20 in total), and we found that, in that case, it would be possible to separate Fornax and background candidates in the RFS. In **Figure 3** we show, for simplicity, the projections on the first three principal components (PC1, PC2, PC3). The top panels correspond to the projection on the components calculated for the FSS, while the bottom panels correspond to those obtained for the BSS. For the FSS, it is possible to explain 90% of the variance with the 3 first components, while for the BSS it takes 5 components to explain 90% of the variance. This result indicates that it would be better to use the FSS to search for Fornax candidates, as expected.

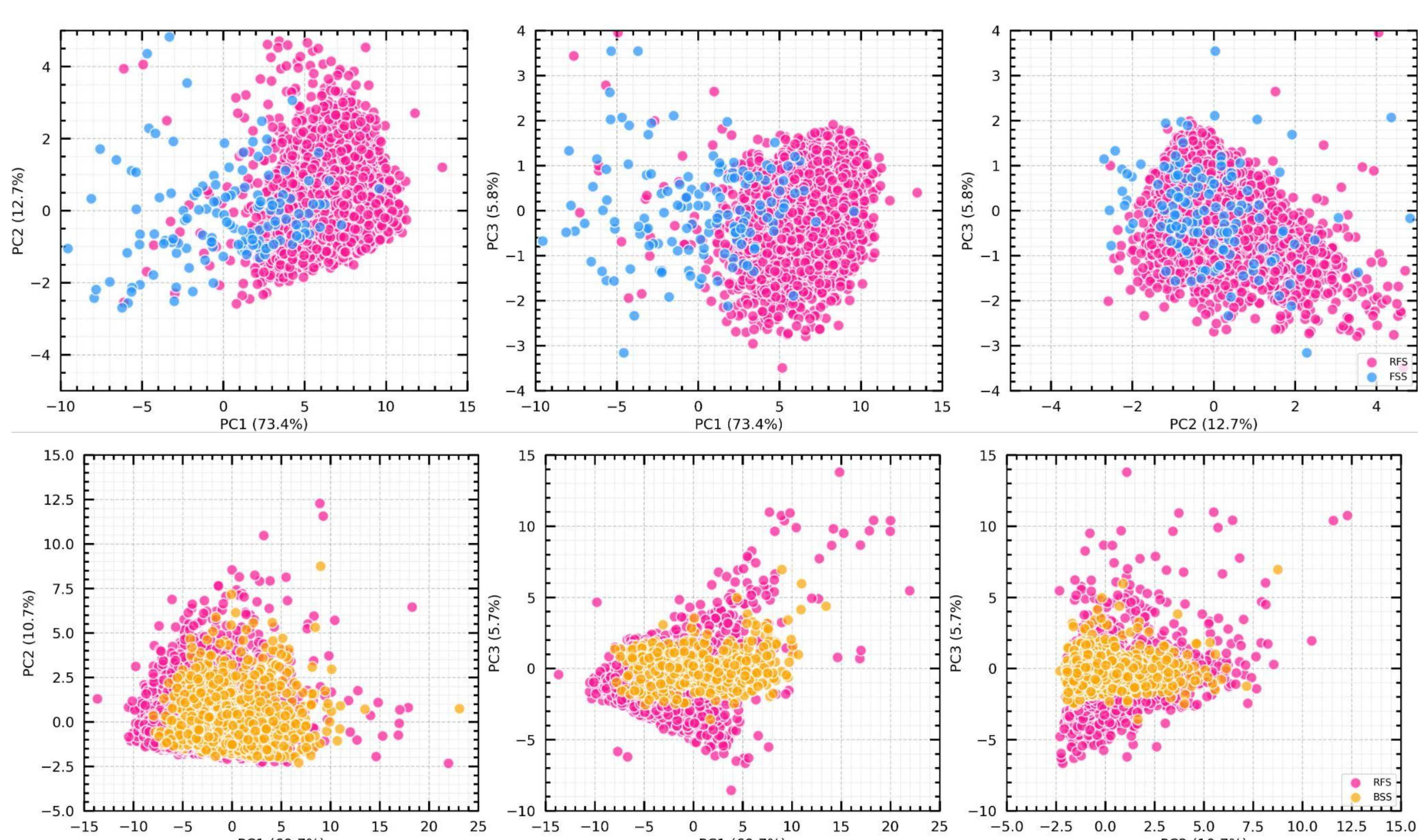

Figure 3: Principal components trained with FSS (tom) and BSS (bottom). The level of variance explained on each axis is indicated and the RFS are projected on each panel.

Conclusions

We use SExtrator photometry over 23 S-PLUS fields covering 45 square degrees of the Fornax cluster, and we obtained the scaling and photometric parameters of a sample of galaxies that we divide into three sub-samples: two spectroscopic samples (FSS and BSS) and a sample of Fornax or background candidates (no radial velocities available; RFS). We performed a Principal Component Analysis on the spectroscopic samples to obtain their characterization. Then we projected the candidate sample onto the axes produced by PCA for the FSS and the BSS. We found that it would be possible to use this method to indicate with a certain degree of confidence if an extended source belongs to Fornax or to the background according if it detaches or not from the spectroscopic sample of reference in the principal component space.

e-mail: jpcalderon@fcaglp.unlp.edu.ar