CONICET

UNC Universidad Nacional de Córdoba

I A T E

FAMAF Facultad de Matemática, Astronomía, Física y Computación

Galaxy pairs in S-PLUS DR2

M.C. Cerdosino[1], M.A. Taverna[2,3], F. Rodríguez[2,3], A.L. O'Mill[2,3] & L. Sodré Jr[4]

(1) Facultad de Matemática, Astronomía, Física y Computación, UNC, Argentina - (2) Instituto de Astronomía Teórica y Experimental, CONICET - UNC, Argentina - (3) Observatorio Astronómico de Córdoba, UNC, Argentina - (4) Departamento de Astronomia, Instituto de Astronomia, Geofísica e Ciências Atmosféricas, USP, Brasil

From April 18th to 22nd - XI FoF Meeting 2022

Abstract:

In this poster, we present details of the implementation and testing of the purity and completeness in the Southern Photometric Local Universe Survey Data Release 2 (S-PLUS DR2) of an isolated galaxy pairs identification algorithm. To this end, we use a simulated galaxy catalogue that imitates the characteristics of S-PLUS. The final goal is to study isolated galaxy pairs using the information provided by the photometric bands and photometric redshifts. With the systems identified in the S-PLUS DR2, we will carry out a study from different approaches to better understand the evolution of galaxies in low-density regions and the environmental effects in these regions.

Contact email: candelacerdosino@mi.unc.edu.ar

1- Introduction

In this work, we study galaxy pairs in large catalogs with photometric redshift information. The study of galaxy pairs is very important, they provide relevant information about the early stages of the formation of the most massive systems. Also, they are important laboratories where the interactions between galaxies are common, causing significant changes in the physical properties and evolution of the galaxies. In addition, they are important for estimating the mass and mass-luminosity relation of their galaxies members, being of great utility for testing the presence of dark matter halos.

Today, it is a challenge to obtain a reliable sample of galaxy pairs that both belong to the same halo, especially using photometric data. Therefore, it is important to apply accurate tests that ensure the recovery of truly bound systems, avoiding losses and contamination. We will emphasize this point in this poster.

In this work we develop and test an algorithm for the identification of galaxy pairs in the Southern Photometric Local Universe Survey Data Release 2 (S-PLUS DR2, Almeida-Fernandes et al. 2021), an imaging survey that plans to cover 9300 deg^2 of the southern hemisphere sky in the optical range, using a robotic telescope located at Cerro Tololo Interamerican Observatory (CTIO), Chile.

The method proposed for identification is similar to those applied to spectroscopic surveys but takes into account the uncertainties of the photometric redshifts. In addition, a simulated catalog with the physical properties of the S-PLUS DR2 is constructed to corroborate the performance of the algorithm and validate the parameters used for the identification.

2- Data

We use the observations of the S-PLUS DR2 in the STRIPE 82 region (0°<RA<60°, 300°<RA<360°, and -1.4° <Dec<+1.4°) which were made with the 12 S-PLUS optical filter system: 5 broadband filters similar of the Sloan Digital Sky Survey (SDSS, York 2000): u, g, r, i, z, and 7 narrow-band filters. This filter system is ideal for a better photometric redshift estimation of the galaxies in the nearby Universe (Cenarro et al. 2019). Consequently, it allows the development of a reliable method to identify pairs of galaxies and their properties. S-PLUS DR2 has magnitude completeness in the r-band of $m_{lim} \leq 20.6$ as is shown in Fig. 1.

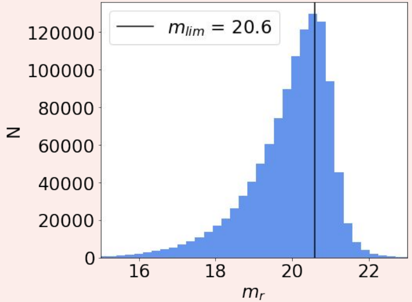


Fig 1: Apparent magnitude distribution in r-band for galaxies in S-PLUS DR2.

3- Identification algorithm

The algorithm follows the traditional approach of galaxy pairs searching, using a maximum projected distance (rp_{max}) between the members and a maximum velocity difference (ΔV_{max}) between them, where de ΔV is calculated from photometric redshifts. In this work we introduce improvements in the algorithm:

- We consider that the brightest galaxy central in the system has an absolute magnitude $Mr_c < -19.5$ and a r-band $mr_c < m_{lim} - 2 = 18.6$.
- We set an apparent magnitude difference r-band between the members: $\Delta m=2$.
- We added an isolation criterion: there are no galaxies within ΔV_{max}, located in the ring between rp_{max} and $3rp_{max}$ (see Fig. 2).

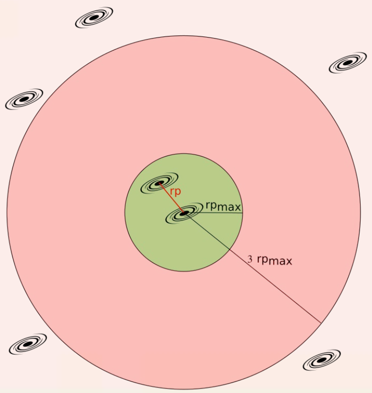


Fig. 2: Example of a pair of galaxies identified with the algorithm.

The value assigned for ΔV_{max} and rp_{max} will be those that imply higher purity and completeness on the identification algorithm.

4- Algorithm testing

As a first step, we build a simulated catalog from the photometric properties of the S-PLUS DR2. For this purpose, we use the IllustrisTNG300-1 simulation, developed by Nelson et al. 2019, a magneto-hydrodynamical cosmological simulation, characterized by a cubic box of side 205 $\hbar^{-1}$Mpc that follows the evolution of 2500^3 dark matter particles of mass $4.0 \times 10^7\ \hbar^{-1}\ M_\odot$ and 2500^3 of gas of mass $7.6 \times 10^6\ \hbar^{-1}\ M_\odot$.

To construct our synthetic catalog, from the simulated cube at redshift z=0, we first place the observer at one corner of the cube, and, considering its periodicity, the volume of the S-PLUS is obtained by adding the TNG300 volume repeatedly. From the information in 3D space, we calculate the coordinates (α,δ), the spectroscopic redshift (zs) and the apparent magnitude for each galaxy. The photometric redshift (zph) was calculated as a Gaussian distribution centered in the redshift, with a variance corresponding to the S-PLUS error ~0.01 and the expected S-PLUS error ~0.001.

Then, following the procedure described in Section 3, we apply the identifier to the simulated catalog. In order to select the best combination of parameters that would allow the correct identification of galaxy pairs in S-PLUS, we performed different identifications varying the maximum rp and ΔV. Three samples with different maximum projected distances between the central galaxy and its companion (rp_{max}=100, 150, and 200 kpc) were analyzed and the velocity difference between them was varied in ΔV_{max}=500, 1000, and 2000 km s^{-1} for the two S-PLUS errors.

5- Preliminary results: Purity and Completeness

We measured two properties that characterize an individual galaxy pair: purity and completeness. For this, we applied the identification algorithm with different parameters in the mock catalog, and for each pair identified, we select their associated halo. We define:

Individual purity: $P_i = N_{common}/N_{par}$ and
Individual completeness: $C_i = N_{common}/N_{halo}$

where, N_{common} is the number of common members between the pair members and the associated halo, N_{par} is the membership of the pair (N_{par}=2), and N_{halo} is the membership of the associated halo.

We consider a "reliable" pair when their two members are in the same halo, and this halo has no additional members. Therefore, it has a high percentage of individual purity and completeness at the same time.

Fig. 3 shows the mean purity and completeness results for the differents samples obtained from the values of rp_{max} and ΔV_{max} that we analyzed.

From the purity plots, we can see that the values obtained are stable in all the range of ΔV_{max} and it is higher for rp_{max}= 100 kpc. For the completeness plots, we see that it increases with ΔV_{max} and is higher for rp_{max}= 200 kpc. Therefore, we decided to use a ΔV_{max}= 1000 km s^{-1} and rp_{max}= 150 kpc for the identification of our pairs.

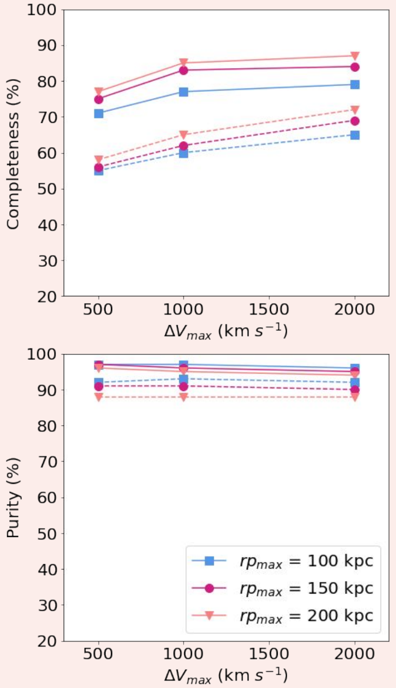


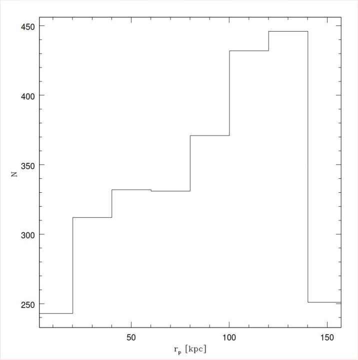
Fig 3: Purity and completeness values of the algorithm for each pair of parameters analyzed. The solid line shows the results for the expected S-PLUS error and the dashed line shows the S-PLUS error.

6- Conclusions

We applied the parameters obtained from the purity and completeness analysis (rp_{max} = 150 kpc and ΔV_{max} = 1000 km s^{-1}) for the S-PLUS DR2, using a volume-limited sample in a redshift range z≤0.6. We obtained 5714 galaxy pairs and after applied the isolation criterion 2718 pairs.

Fig. 4 shows the distribution of rp and ΔV for the isolated galaxy pairs. We can see the rp distribution increases, reaching a maximum between 100 and 130 kpc. These values are in agreement with previous works, e. g., Lambas et al. 2003 suggest values of 100 kpc for the identification of galaxy pair, but using spectroscopy and in the nearby universe.

On the other hand, ΔV distribution shows a maximum at about 400 km/s. Although the ΔV_{max} that we apply in the identification is 1000 km s^{-1}, we find that most systems have ΔV_{max} < 750 km s^{-1}, with a maximum at 400 km s^{-1}, which would indicate that they are physical systems.



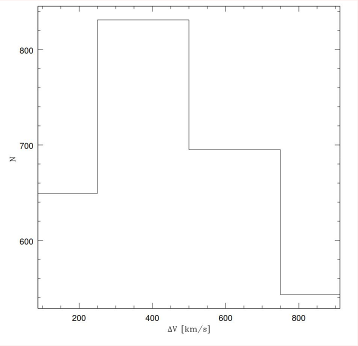


Fig 4: Top: Projected distance distribution between members of isolated galaxy pairs. Bottom: velocity difference distribution between members of isolated galaxy pairs.

Bibliography:

- Almeida-Fernandes, F. et al. (2021). *arXiv preprint arXiv:2104.0002*
- Cenarro, A. J. et al. (2019). *A&A*, *622*, A176.
- Lambas, D. G. et al (2003). *MNRAS, 346(4), 1189-1196.*
- Nelson, D. et al. (2019). *Computational Astrophysics and Cosmology*, *6*(1), 1-29.
- York, D. G. et al. (2000)*. The Astronomical Journal, 120(3), 1579.*

Acknowledgments: The work was carried out in the framework of a "Beca Estímulo a las Vocaciones Científicas" from CIN.