Fossil groups candidates at lower X-ray luminosity in miniJPAS/JNEP field

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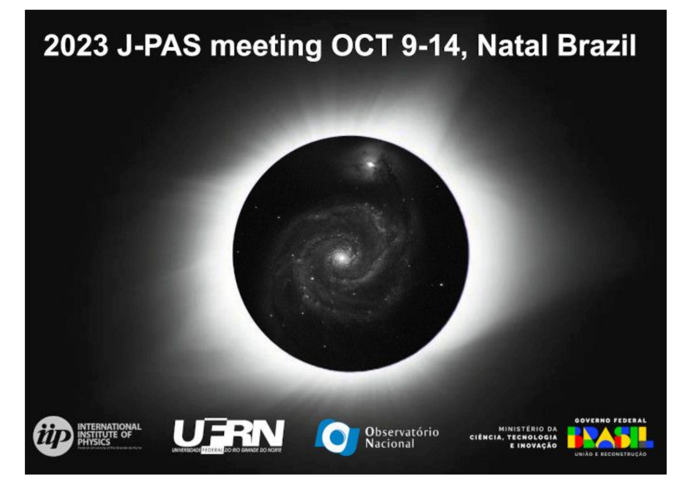


INTRODUCTION AND MOTIVATION

Fossil groups (FGs) of galaxies are thought to be old and isolated groups of galaxies that merged due to energy loss by dynamic friction [1, 2]. However, studies of X-ray-selected FGs present some contradiction to this scenario [3, 4, 5, 6]. The origin of fossil groups of galaxies is still very debated, even though fossil groups have been known for more than two decades.

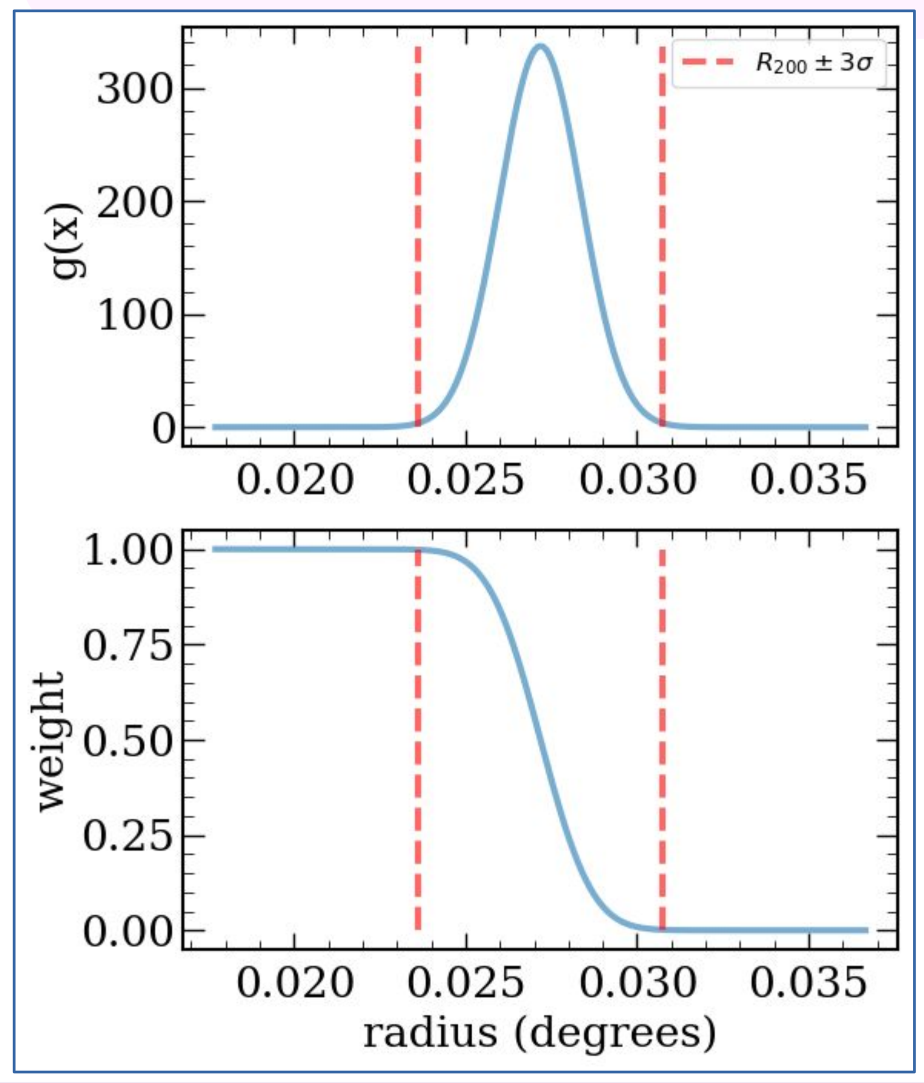
Fossil groups are galaxy systems empirically defined as having: (i) a dominant central galaxy, whose magnitude difference in the R band with the second-brightest galaxy member (Δm_{12}) is at least two magnitudes within $0.5R_{200}$ of the system, and (ii) an extended X-ray luminous halo emission $L_{X,bol} \geq 10^{42} h_{50}^{-2}$ erg/s [7]. However, the later definition (i.e., X-ray luminosity) may bias a sample to detect only X-ray massive halos.

GOAL

We propose to search for FGs candidates using the gap definition but also including the lower X-ray luminosity systems and, consequently, lower massive halos in the miniJPAS and later in the JNEP field.

SELECTION CUT

To select FGs candidates from groups and clusters detected by AMICO on miniJPAS, *we determine the magnitude gap properly, considering the uncertainty associated to a galaxy being a member*. Therefore, we developed a Bayesian treatment for the probability membership of member galaxies taking into consideration this characteristic.



We aim to select galaxies within R_{200} [8] considering its statistical error. For this, we consider a normal probability distribution centered in R_{200} implementing a weight function as

$$weight = \int_{a=+\infty}^{b=r} g(x)dx,$$

where r is the galaxy radius/separation from the center in degrees. We build this weight in the way that a galaxy

- at a distance of R200+3σ has weight ~ 0;
- at a distance of R200-3σ has weight ~ 1.

Fig 1: Top: The normal distribution associated to the nominal value of R200 (calculated from the scaling relation from [8]) and the limits of 3σ confidence level. Bottom: The weight function applied to select the members considered in the Bayesian approach.

ANALYSIS AND RESULTS

To calculate the combined probability between the j[th] and n[th] galaxies ($P_{j,n}$) to use to calculate the $\Delta m_{j,n}$, we consider (i) the individual probabilities of the j[th] and n[th] galaxy to belong to a certain cluster (p_n/p_j), provided by the AMICO catalog; (ii) the probability of being the brightest galaxy in the cluster. So, we have:

$$P_{j,n} = P_j \, p_n \prod_{\substack{i=j+1 \\ n-j \geq 1}}^{n-1} (1 - p_i)$$

where, P_j is the probability of the j[th] galaxy to belonging to the cluster and being the brightest within it.

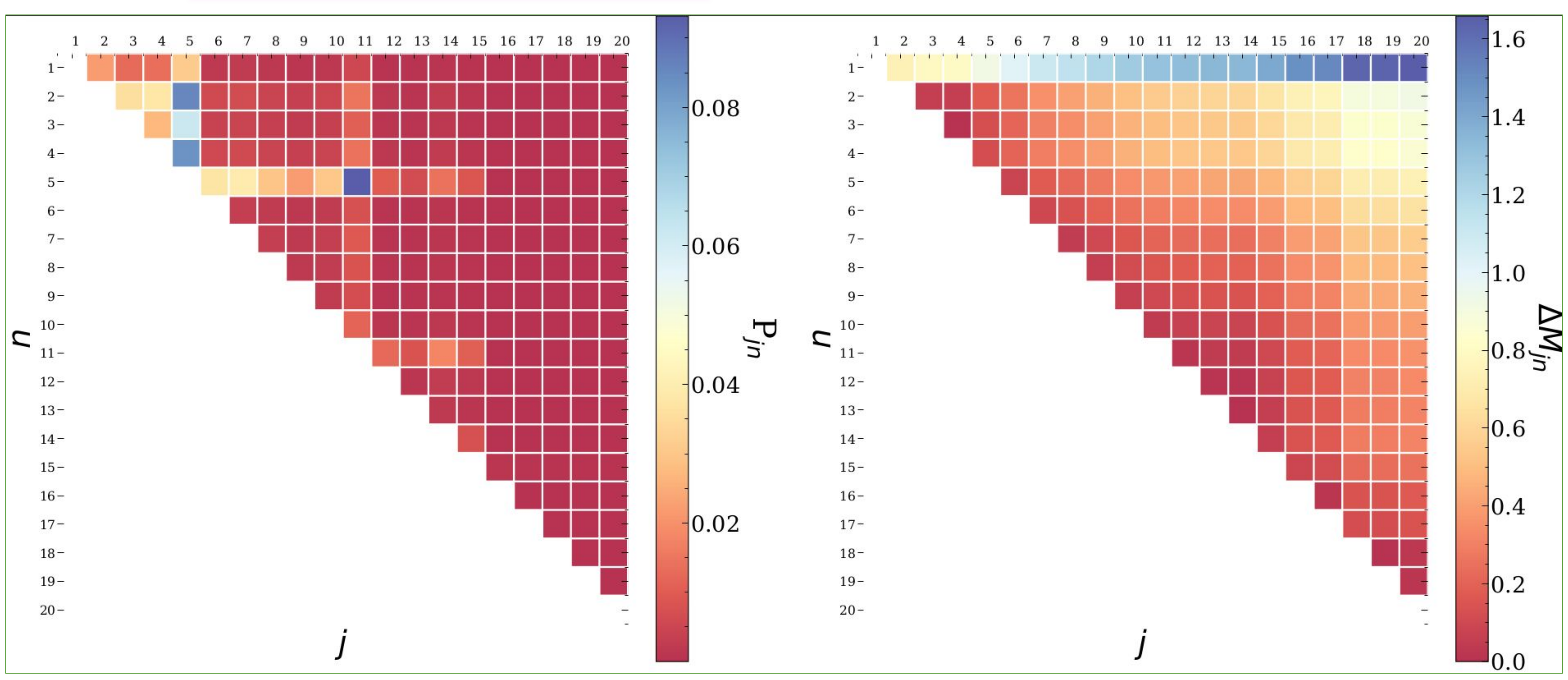


Fig 2: Combined probability (left) and the magnitude gap calculations (right) of every combination of j[th] and n[th] galaxies belonging to the cluster after the selection cut of R_{200} in the cluster ID 1144. The colors bars representing the values combined probability (left) and the magnitude gap calculations (right), where bluer squares representing the j[th] and n[th] galaxies with higher combined probability and higher magnitude gaps.

Using this Bayesian approach to select and calculate the magnitude gaps and following the empirical definition of FGs (Δm_{12}), we found 4 FG candidates in the miniJPAS field using the AMICO catalog:

cluster ID	ΔM_{12}
108	3.27
1056	2.20
1024	3.11
1083	2.37

Table 1: Results of FG candidates based on the magnitude gap definition and using the Bayesian approach described in this work.

We also compared the result in this table with the FG candidates obtained by making the 80% cut on the probabilistic association to each galaxy.

We found that the FG candidates are different, mainly due to the fact that having an arbitrary and fixed threshold can lead to smaller or no number of galaxies belonging to a cluster. As shown in the figure below:

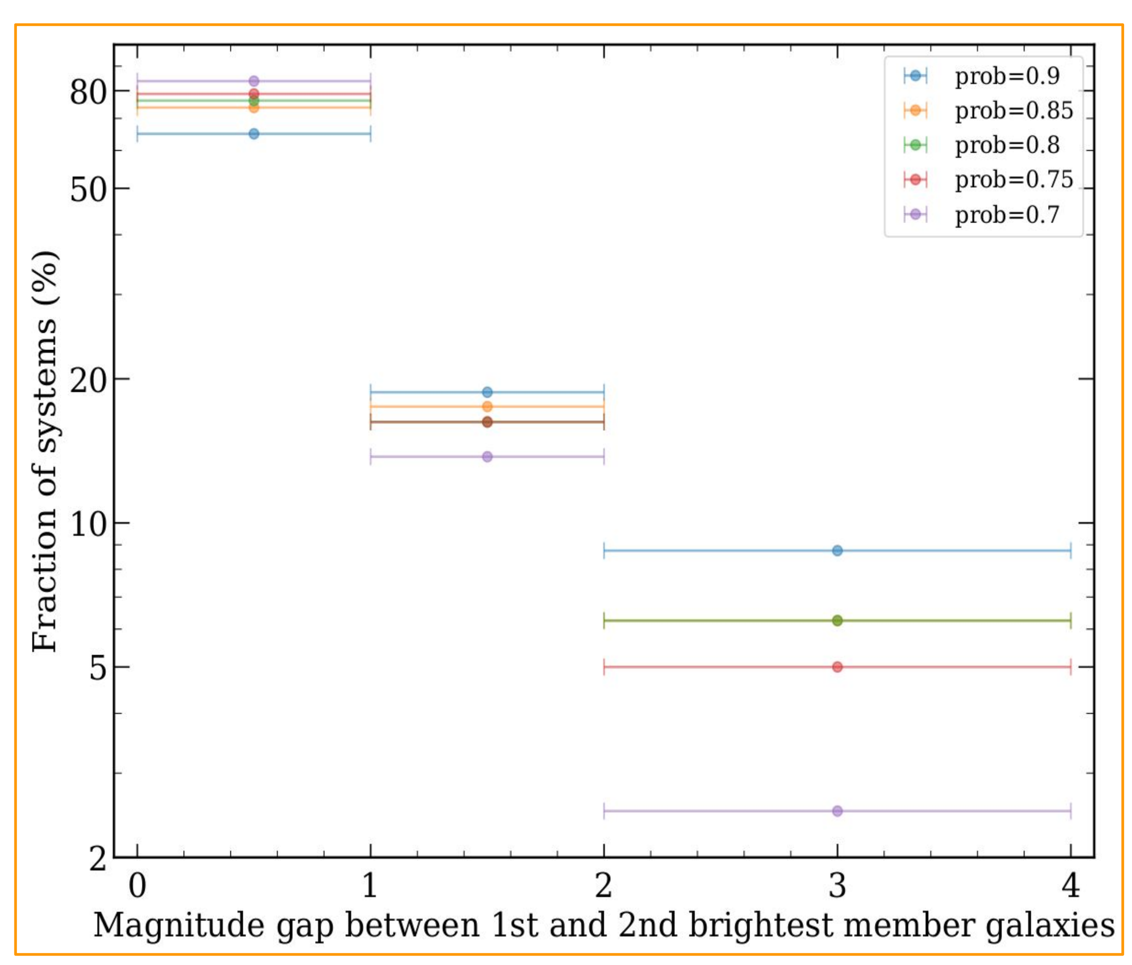


Fig 3: The fraction of FG candidates in different magnitude gap bins using cuts of 70 (prob=0.7) to 90% (prob=0.9) on the probabilistic association P to each galaxy. It shows that the lower the P, the lower the number of systems with higher magnitude gaps. It occurs because the number of cluster members increases for the lower P. Therefore, a cluster with more members is more likely to have smaller magnitude gaps between the brightest galaxy members.

CONCLUSIONS

Applying the Bayesian approach to the AMICO catalog to characterize the extended systems of miniJPAS has yielded promising results. This method eliminates the need for arbitrary probability cut-offs, which can potentially skew the results, particularly in cases where magnitude gaps of systems are of interest. We also intend to apply this approach to the JNEP field.

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