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PROBING OPTICAL AND RADIO-LOUD AGN FRACTIONS : A COMPARATIVE ANALYSIS BETWEEN BCGs AND NON-BCGs SAMPLES at z < 0.1

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Abstract

Brightest cluster galaxies (BCGs) are the most massive and luminous galaxies located near the center of relaxed, virialized, and undisturbed galaxy clusters in the local Universe ([12, 16]. According to several observational studies ([6], [13]), these objects experience a special formation process differing from general galaxy evolution. Current theoretical models (e.g., [4, 3]) predict that dry mergers are the dominant mechanisms responsible for their mass assembly at $z < 1$. These objects are often observed to host a supermassive black hole (SMBH) in their center ([11]). The process of matter accretion into these SMBHs may release a large amount of energy, resulting in Active Galactic Nuclei (AGN). There are two primary modes in which SMBH accretion can occur: the so-called 'quasar mode' and the 'radio mode'. The quasar mode involves a high accretion rate of the SMBH via an optically-thick and geometrically-thin disk, with most of the energy being released in the form of radiation. In a radio mode scenario, the SMBH accretion of hotter gas occurs at a low rate in an optically-thin and geometrically-thick disk configuration, releasing energy in the form of relativistic particles, i.e. radio jets. The latter is typically observed in BCGs.

The evolutionary processes of BCGs are still not fully understood, and there are no specific studies comparing the frequency of different types of AGN in BCGs with respect to other types of galaxies (e.g., [5]).

The main scientific question driving the project of my thesis is to understand whether the different evolution of BCGs, along with their "special" environment, affects the accretion of SMBHs in their centers compared to other types of galaxies in the local universe, at $z < 0.1$. To address this question, I analyzed a sample of BCGs derived from the combination of the Sloan Digital Sky Survey Data Release 7 (SDSS DR7; described in [1]) and the C4 BCGs catalogue produced by [8]. For this BCG sample at z=0.02-0.1, I use the fluxes of optical lines ($H\alpha$, [OIII], $H\beta$, [NII], and [SII] doublets)

obtained by the MPA-JHU team using methods described in [9] to obtain a census of optical AGN through the NII and SII BPT diagnostic diagrams. Additionally, by cross-matching the previous catalogs with a collection derived from NVSS and FIRST radio surveys, as presented in [2], I identify the BCGs exhibiting radio loud emission, implying the presence of radio jets.

Following this classification, I finally estimate the fraction of BCGs classified as Optical and Radio Loud AGN. Subsequently, I derive the same fractions for the non-BCG selected galaxies according to the cross-match with the C4 catalogue ([8].

The analyses reveal that BCGs exhibit a higher fraction of optical AGN $\sim$ 50% compared to the non-BCG sample, which shows a percentage of $\sim$ 21%, consistent with results found by [14]. Simultaneously, the analysis of Radio Loud emissions indicates that BCGs are more inclined to host Radio Loud Activity, with a fraction of $\sim$ 12%. This fraction is found to be 20 times higher than the $\sim$ 0.6% observed in the non-BCG sample of selected galaxies.

In conclusion, these results strongly support the idea that BCGs are more likely to exhibit typical ionization due to AGN activity and radio emission. This implies that their privileged position supports frequent accretion of SMBHs in both accretion modes. Previous studies, such as [18, 10, 15], have already shown a prevalence of radio AGN among the BCG population in the local Universe. On the other hand, the larger fraction of BCGs selected as optical AGN compared to normal galaxies is intriguing. Future studies will aim to test the results obtained with this sample and understand if this higher fraction is specifically driven by differences in properties between BCGs and non-BCGs, such as mass, star formation rate, metallicity, and kinematics.

Contents

Chapter 1

Introduction

1.1 The Active Galactic Nuclei Feedback

1.2 The Brightest Cluster Galaxies

One of the main branches of cosmic structure formation is covered by the Hierarchical model in which galaxies grow in both stellar and mass magnitude, by accreting the surrounding matter.

One of the most extreme examples in this context involves the study of Brightest Cluster Galaxies (BCGs), a unique class of galaxies typically elliptical, often situated at the center and typically standing out as the most luminous and massive objects within the entire cluster.(e.g. [17]).

Considering the environment, also their evolution is proven via observational studies e.g. [13], to be slightly different to normal galactic ones, resulting in the current main model assumes that BCGs mass assembly is dominated by dry mergers [4, 3].

Thanks to their exclusive environment in which they live, consisting in a BCGs often host a Super Massive Black Hole (SMBH) ([11]) resulting in Active Galactic Nuclei (AGN) activity such as Radio Jets that feedback into the Intra-Cluster Medium (ICM)[7].

As seen in previous studies (e.g. [15]) BCGs more likely host Radio Loud Emission than in other type of galaxies, as a result of the influence of the environment other than its nuclei.

1.3 The Aim of this thesis

Chapter 2

Methods

2.1 Data Description

A description of the Data Samples Utilized, and its peculiarities, starting from The SDSS DR7 description, and following the work provided by the MPA-JHU team.

2.2 Data Analysis

How we analyzed the data, where do we defined the fractions calculated ?

2.2.1 Optical analysis

Describe each population of the BPT diagram and its peculiarities, before starting the description of how we collected and processed the data to finally create BPT diagrams . Finally there's the need to explain how we interpreted the diagrams to finally calculate the fractions (in this case you need to explain which algorithm has been chosen and why)

2.2.2 Radio Analysis

I certainly need to focus on how i have chosen the range of identification, to recognize which element of sdss was effectively recognized as a Radioloud.

Following to this it is necessary to explain how we selected the elements in which define the fractions, by selecting elements of SDSS nearby the location in which best et al finds mostly its radio-emitting elements!

Chapter 3

Results

A complete description of the results produced !!

3.1 The Prevalence of AGN activity in BCGs

Describe how the evidence of the data analysis we conducted leads to the description of BCGs in a confrontation to non-BCGs, and in how different is still from a pure optical view the response of the AGN feedback.

Present absolutely the Table with all of the percentage (and the counting) values of the populations of both BPT NII and BPT SII diagnostics and introduce a confrontation with also the results found in Vitale et AL and others.

3.2 The Radio activity of BCGs

Explain the evidences found in the analysis and possible ways to improve results obtained.

There's certainly also the need to add a discussion on how it is possible that we ignore some of the BCGs in the counting, issue that should be resolved by choosing a more complete source of data regarding Radio Emitters galaxies.

Conclusions

The final chapter of the thesis is a summary of the work done. Therefore, in its first part it resembles much the introduction, adding to it the actual result of the work, its future evolution and prospects, in the view of the writer.

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