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Are active galaxies different at large-scale than their non-active twin galaxies?.

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Abstract

In this contribution, we will show our results from a sample of 20 pairs of nearby seemingly isolated twin galaxies differing in nuclear activity. Firstly, we present a comparison of the parameter of the spin (λ_R), measured in a region dominated by the galaxy disc. This parameter allows us to assess the rotational support of a galaxy taking advantage of IFU data. Secondly, we will also present our most recent results on the stellar content of the sample. For this, we used full spectral fitting of the optical spectra recovering the star formation history (SFH) of our galaxies. The idea that every massive galaxy goes through a few short active phases during its life is becoming popular. In this scenario, we should not expect to find large-scale differences between the twins either in dynamics or stellar population properties over longer-timescales than the current AGN episode. However, the results presented here indicate that some galaxies are more likely to go through active phases than others, at least in the redshift ($0.005 < z < 0.03$) and mass ranges ($10^{10} < M_\odot < 10^{11}$ $M_\odot$) considered in this work.

1 Introduction

Active galaxies are these showing strong emission coming from their nuclei. In the case of normal galaxies the nuclear emission has a stellar origin, but in active galactic nuclei (AGN) the emission is produced by accretion of matter into a super-massive black hole (SMBH) (see [13, 1] for reviews). Although only a small percentage of galaxies in the nearby Universe currently show nuclear activity (< 10% according to [16]), it is thought that all massive galaxies might experience episodes of activity for at least some part of their evolution. In fact, AGN are considered as key ingredients to the evolution of galaxies. Therefore, unveiling the mechanisms that trigger AGN is crucial for our understanding of the formation and evolution of galaxies (see [9] for a review). While major mergers are often associated with the triggering of powerful AGN, less luminous AGN would be driven by secular processes, like disc instabilities or bars. Over the last few years, several observational studies have tried

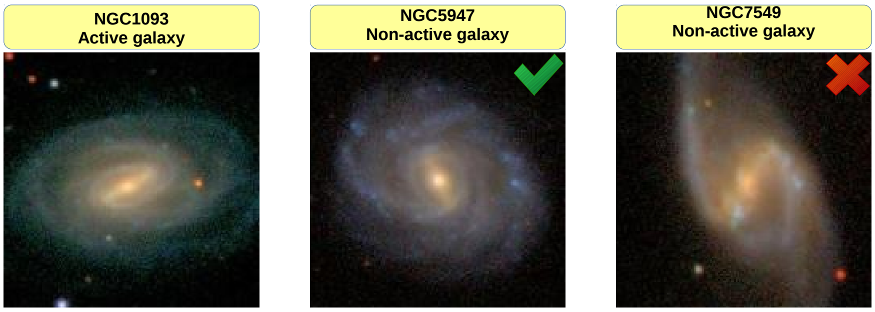

Figure 1: Color-composite SDSS images of an active galaxy (left panel) and two possible non-active twin candidates (middle and right panels, respectively), according to our numerical criteria. The green (red) tick (cross) identifies the selected (discarded) NGC1093 twin candidate according to our visual criteria. Each image has a field of view of 90"×90". North is up and east to the left.

to identify AGN triggering mechanisms in the local Universe (e.g. [11, 12]). Despite these efforts, the main drivers for AGN triggering in isolated galaxies still remain unclear.

The aim of this work is to try to shed some light on this topic by focusing on isolated nearby spiral galaxies. Unlike previous works, which have usually identified a sample of active galaxies and compared with the general population of galaxies (e.g. [16, 10]), we built a sample of pairs of galaxies differing only in nuclear activity (twin galaxies) and performed one to one comparisons. Following this approach, we can identify differences in the kinematics and stellar populations that might be connected to nuclear activity.

2 Sample

We use data from the third Data Release of the CALIFA survey [15]. It provides data cubes for ∼600 galaxies in the Local Universe ($0.005<z<0.03$). Details on the observational strategy, data quality, data reduction and statistical properties of the CALIFA survey can be found in [14, 17, 8, 15].

We select isolated active galaxies (see [3] for isolation criteria). For each AGN we then selected a control sample of non-active galaxies with similar galaxy properties. Additionally, we visually inspected the SDSS images of each active galaxy and its corresponding twin candidates to select the most similar one (best twin hereafter) and discard only those that clearly have different appearances (see Fig. 1 for an example). After doing this we end up with five AGN with two or more non-active twins. In these cases, we always identified the best twin but we did not discard the others. Furthermore, five non-active galaxies are selected as twins of two different AGN. In total we have 20 pairs of isolated twin galaxies differing in nuclear activity.

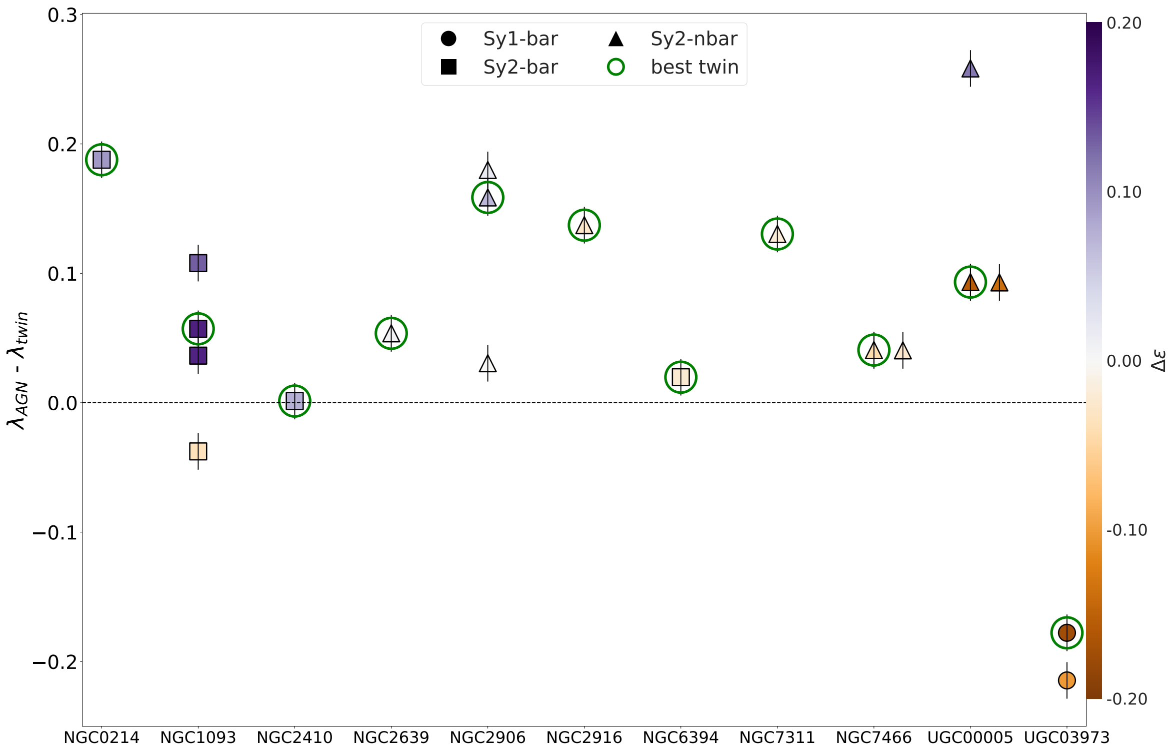

Figure 2: Differences in stellar λ_R between the pairs of twin galaxies. The best twin of each AGN is indicated with a green circle. Each column corresponds to an active galaxy and each symbol to the difference in λ_R with each of its twins. The colour code indicates the difference in ellipticity ($\epsilon_{AGN} - \epsilon_{twin}$). Error bars correspond to propagation of the individual uncertainties. Figure taken from [6]

3 Results

Firtsly, we present a comparison of λ_R measured in the disc-dominated region. We found that active galaxies show higher values of λ_R than their corresponding non-active twins (80% of the pairs; see Fig. 2). Considering only the unbarred pairs, we found that 100% of the active galaxies show larger λ_R than their twins. These results indicate, for the first time, that active galaxies present larger rotational support in the disc than non-active galaxies. We suggest that they could be explained by a more efficient angular momentum transfer from the inflowing gas to the disc baryonic matter in the case of the active galaxies. This inflow of gas could have been induced by disc or bar instabilities, although we cannot rule out the effect of minor mergers, which might not be detectable in the shallow SDSS images.

Secondly, we also characterised the stellar population properties of the sample of pairs [7]. For this, we used full spectral fitting of the optical spectra recovering the star formation history (SFH) of our galaxies. We computed average ages and metallicities, but we also

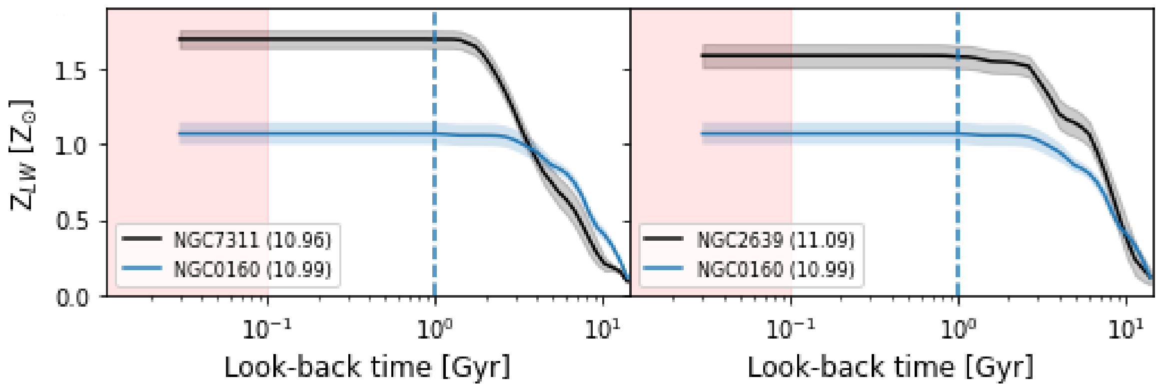

Figure 3: Evolution of the stellar metallicity as a function of look-back time for the bulge-dominated region of two pairs of twin galaxies. The galaxies stellar masses are shown between parentheses on each panel. The metallicity profiles corresponding to AGN are always represented by black lines. Red areas indicate the tentative lifetime of the current episode of nuclear activity and blue dashed lines correspond to the last Gyr.

analysed different stellar sub-populations according to their ages (i.e. young, intermediate and old). Additionally, we stacked the spectra of three different regions within the galaxies (bulge-dominated, disc-dominated and total), and we characterised the chemical enrichment histories of the pairs of galaxies (see Fig. 3). We found that AGN show a higher tendency to have older stellar populations and are more metal rich than their non-active twins in the bulge-dominated region, indicating that active galaxies have a different chemical enrichment history. Our results suggest that the differences in metallicity would not be predominantly associated with the current active phase but they are prior to it.

4 Conclusions

The idea that every massive galaxy goes through a few short active phases during its life is becoming popular. If all galaxies go through active phases, considering that the lifetime of these active phases are estimated to be a tiny fraction of that of galaxies, we should not expect to find large-scale differences between the twins either in dynamics or in stellar population properties over longer-timescales than the current AGN episode. Different active phases in both the active and non-active twins should dilute them. However, the results presented here support the idea that some galaxies are more likely to go through active phases than others, at least in the redshift ($0.005 < z < 0.03$) and mass ranges ($10^{10} < M_\odot < 10^{11} M_\odot$) considered.

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