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Interacting Active Galactic Nuclei: A study case of galaxy SDSSJ0849+1114

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Abstract. The current paradigm for galaxy formation is based on a hierarchical model, in which throughout the history of the Universe smaller galaxies have merged in successive interactions until they reached their current state. At the same time, we know that most of the growth of supermassive black holes (SMBHs) found in the nuclei of galaxies occurred before $z = 1$. Therefore, more recent galaxy mergers necessarily imply the interaction between SMBHs and, eventually, their merger. The aim of this work is to understand the merger of black holes from the observation of systems in which they are still separate entities and to compare these observations with other interacting systems, in order to try to draw a more general picture that serves as a link for cosmological and galaxy evolution models. In this work we study integral field spectroscopy data obtained with the MUSE instrument, installed on the Very Large Telescope (VLT) of the European Southern Observatory (ESO). We used unpublished data from the trio of interacting galaxies SDSSJ0849+1114, which has three active nuclei confirmed by X-ray emission. Using the IFSCube software, we adjusted the emission lines and identified the presence of a region of narrow lines extended across all galaxies, with relative velocities between $\pm$100km/s, which suggests that the interaction is occurring mostly in the plane of the sky.

Resumo. O paradigma atual para a formação de galáxias é baseado em um modelo hierárquico, em que ao longo da história do Universo galáxias menores se fundiram em sucessivas interações até chegarem ao estado atual. Ao mesmo tempo, sabemos que a maior parte do crescimento dos buracos negros supermassivos (SMBH) que se encontram no núcleo das galáxias ocorreu antes de $z = 1$. Portanto, fusões de galáxias mais recentes do que isso necessariamente implicam na interação entre os SMBHs e, eventualmente, em sua fusão. O objetivo deste trabalho é compreender a fusão de buracos negros a partir da observação de sistemas em que estes ainda são entidades separadas e comparar essas observações com outros sistemas em interação, para tentar traçar um quadro mais geral, que sirva de vínculo para os modelos cosmológicos e de evolução de galáxias. Neste trabalho estudamos dados de espectroscopia de campo integral obtidos com o instrumento MUSE, instalado no Very Large Telescope (VLT) do Observatório Europeu Austral (ESO). Utilizamos dados inéditos do trio de galáxias em interação SDSSJ0849+1114, que possui três núcleos ativos confirmados por emissão de raio-x. Utilizando o software IFSCube, fizemos os ajustes das linhas de emissão, e identificamos a presença de uma região de linhas estreitas estendida em todas as galáxias, com velocidades relativas entre $\pm$100km/s, que sugere que a interação está ocorrendo majoritariamente no plano do céu.

Keywords. Galaxies: active – Galaxies: interaction – Galaxies: evolution – Galaxies: kinematics and dynamic

The science object

The SDSSJ0849+1114, SDSSJ0849 for short, is a trio of galaxies at $z = 0.076$. The three galaxies are interacting, and the three of them present their nuclei active (Foord et al., 2021), with X-ray emissions. The data for this work was obtained with the MUSE (Multi Unit Spectroscopic Observer) instrument installed on the VLT (Very Large Telescope), which is part of the ESO (European Southern Observatory). As can be seen in Fig. 1, the Hα, Hβ, [NII] and [OIII] emission lines are present in all three of SDSSJ0849 nuclei, which is used to trace a BPT diagram (Fig. 2).

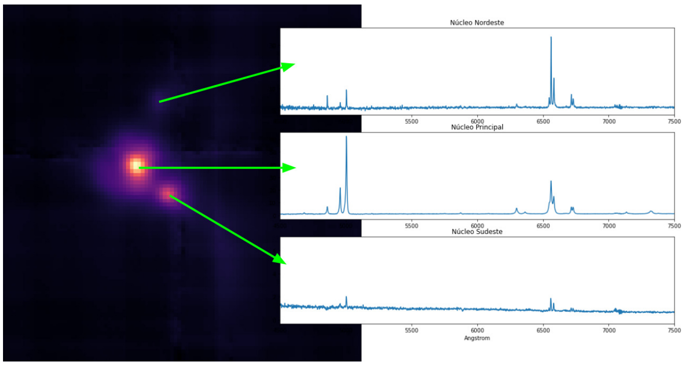

Figure 1. SDSSJ0849 white light plot along with the spectra of its three nuclei.

Results and discusions

Figure 2 shows the BPT diagram for SDSSJ0849's nuclei. The dashed line is the empirical limit for ionizing sources (Stasińska et al., 2006), while the solid line is the theoretical limit (**?**). All points below the dashed line can be explained by star formation ionization, while those above the dashed line need another source of ionization besides star formation. Since we are estimating the line ratio at the nuclei, we can assume that the gas surrounding all three nuclei is being ionized by their respective AGNs (Figure 2).

The analysis of ionized interstellar gas was based on the emission line profiles fitting, using the package of functions for integral field spectroscopy data IFSCUBE[1]. This software allows the simultaneous fitting of several spectral features, with or without constraints and limits for the parameters.

A set of two Gaussians was used to fit the emission line profiles of SDSSJ0849, one narrow component and one broad component. Figure 3 shows gas velocity and velocity dispersion throughout the galaxy. Even though the velocities in our line of vision are low, the blue shift around the Southern Nucleus sug-

[1] https://github.com/danielrd6/ifscube

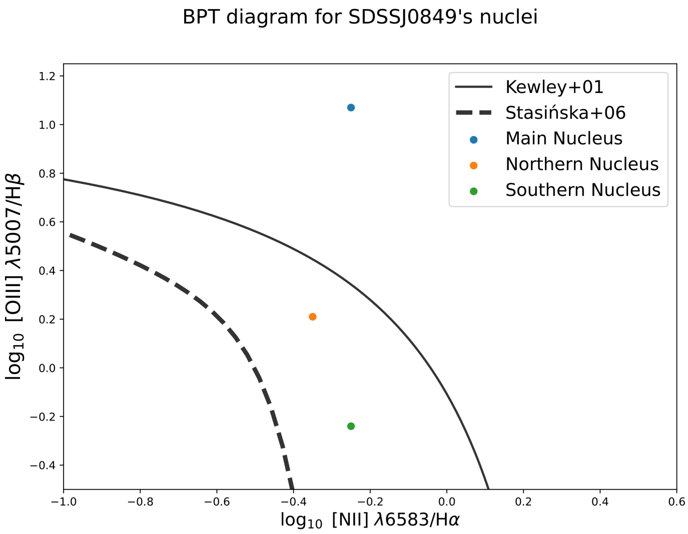

Figure 2. BPT diagram for SDSSJ0849 nuclei.

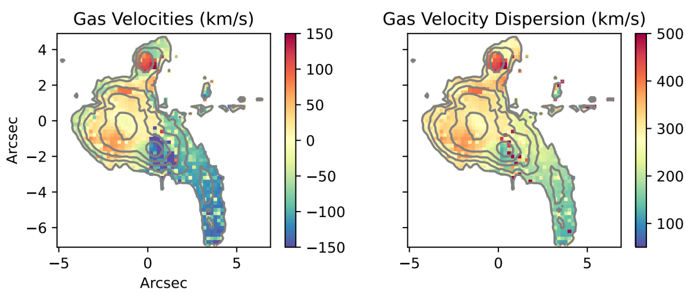

Figure 3. Plots of Gas Velocities and their Velocities Dispersion.

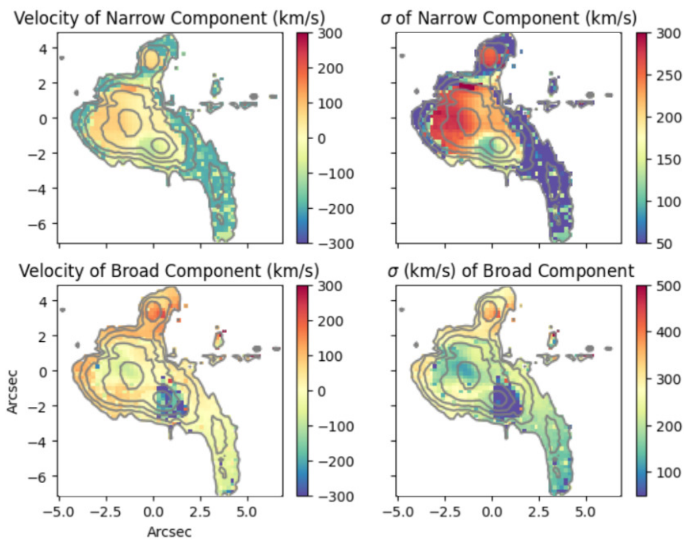

Figure 4. Velocity of the σ Components and the Narrow and Broad Components.

gests that it is moving towards us, while the Northern one is moving away. The velocity dispersion varies from ≈ 150km/s up to ≈ 500km/s, suggesting the gas present in the galaxy is being disturbed by the interaction.

The velocity of the southern nucleus narrow velocity is ≈ −150km/s while the broad velocity is almost zero. The Gaussian parameter σ of the narrow component is lower on the parts of the galaxy in which the narrow component velocity is higher, suggesting that the narrow component is the one that best fits the velocity in those regions. The velocity of the broad component is higher around the northern nucleus, velocity around ≈ 200km/s, while the narrow velocity is also almost zero. The parameter σ is also higher in those regions, which suggests that in this case, the broad component is the one that best fits the velocity there. This divides the galaxy in areas where one component can be found but not the other. Around the main nucleus the velocity of both components is zero, which suggests that part of the galaxy is moving on the plane of the sky, and its velocities are perpendicular to the field of view. Figure 4 also shows the blueshift around the southern nucleus and the rotation of the galaxy as a whole.

At this moment, we don't have strong enough evidences of the existence of inflow or outflow, but we expect that a more detailed modelling can give us new clues.

Conclusions

- The gas around each nuclei is being ionized by their respective AGN.
- Even though the velocities in our line of vision are low, the blue shift around the southern nucleus suggests that it is moving towards us, while the Northeastern one is moving away.
- The emission line analysis shows that the velocity components are dominated by either the narrow component or the broad component.
- It isn't clear if there is any inflow or outflow, but a more detailed analysis is to be conducted.

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References

Foord, A. et al. 2021, ApJ, 907, 71
Kewley, L. J. et al. 2001, ApJ, 556, 121
Stasińska, G. et al. 2006, MNRAS, 371, 972