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Post-starburst galaxies in SDSS MaNGA

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Abstract. Post-Starburst Galaxies have recently undergone a burst of star formation, which was then rapidly quenched. In this work, we try to answer if the star formation stops in an outside-in or inside-out fashion, which could shed light on the mechanisms that drive this process. We select galaxies with post-starburst features observed as part of the MaNGA survey and divide them into CPSBs, with post-starburst signatures on their centers and EPSBs, with post-starburst features on external regions. We find CPSBs tend to have disturbed velocity fields, having weak or absent ionized gas emission in most spaxels, with the ionization source being classified as composite, LINER or Seyfert on the BPT diagram. EPSBs, however, fall into two groups: the first type of EPSBs show stellar and gas velocity fields dominated by rotation, with young stars powering the ionized gas emission. The second type of EPSBsshow disturbed velocity fields, while only spaxels in the center of the galaxy are classified as star-forming. Curiously, we observe spaxels in their outskirts to have either no detectable ionized gas emission or an ionization source classified as LINER/Seyfert, as observed in CPSBs. Considering the similarities between CPSBs and the external regions of type 2 EPSBs, it is possible that these galaxies are observed in different stages of the same evolutionary process.

Resumo. Galáxias *Post-Starburst* (PSB) sofreram recentemente um surto de formação estelar, que foi repentinamente interrompido. Neste trabalho, tentamos responder se a formação estelar nesse processo cessa de fora para dentro ou vice-versa, o que poderia ajudar a entender os mecanismos causadores desse processo. Para isso, selecionamos galáxias com traços de PSB observadas como parte do levantamento MaNGA e as dividimos em CPSBs, com assinaturas de PSB em seus centros e EPSBs, com características de PSB em regiões externas. Foi encontrado que as CPSBs tendem a ter mapas de velocidade irregulares, com emissão fraca ou ausente de gás ionizado na maioria dos *spaxels*, com a fonte de ionização sendo classificada como *composite*, LINER ou *Seyfert* no diagrama BPT. EPSBs, no entanto, se enquadram em dois grupos: o primeiro tipo de EPSBs apresenta mapas de velocidade estelar e do gás dominados pela rotação, com estrelas jovens alimentando a emissão de gás ionizado. O segundo tipo de EPSBs mostra mapas de velocidade irregulares, enquanto apenas *spaxels* no centro da galáxia são classificados como formadores de estrelas. Curiosamente, constatamos que *spaxels* em suas periferias apresentam emissão de gás ionizado indetectável ou uma fonte de ionização classificada como LINER ou Seyfert, como observado em CPSBs. Considerando as semelhanças entre os CPSBs e as regiões externas das EPSBs tipo 2, é possível que essas galáxias sejam parte do mesmo processo evolutivo observado em diferentes estágios.

Keywords. Galaxies: kinematics and dynamics – Galaxies: starburst – Galaxies: evolution

1. Introduction

Post-Starbursts (PSB) are galaxies that have had a recent burst of star formation rapidly quenched. They are believed to be a transition stage between star-forming late type galaxies and quiescent early-type galaxies. Which mechanisms are responsible for triggering and quenching the burst of star formation is still a matter of debate (see French (2021)). To constrain these mechanisms, it is important to determine if the quenching proceeds in an outside-in or inside-out fashion. With this goal, we studied a sample of galaxies presenting post-starburst signatures either in their centers (CPSBs) or in their outer regions (EPSBs).

2. Methods

2.1. Sample Selection

In this work, we make use of a sample of galaxies with post-starburst features selected in Chen et. al. (2019) from the SDSS-IV MaNGA survey Bundy et. al. (2015). Spaxels with PSBs signatures were selected according to the following criteria: $H\delta_A >$ 3Å, $EW(H\alpha) <$ 10Å and $log[EW(H\alpha)] < 0.23H\delta_A - 0.46$. Galaxies with more than 6 contiguous PSB spaxels were classified as PSBs. We divided this sample into two classes, CPSBs and EPSBs, as discussed in section 3.1.

2.2. Stellar kinematics

We use stellar velocity and velocity dispersion maps provided by the MaNGA Data Analysis Pipeline Belfiore et. al. (2019). The pPXF code Cappellari (2017) was employed to extract these maps from the stellar continuum.

2.3. Gas excitation

We use the non-parametric summed fluxes provided by the DAP, which were taken after subtraction of a stellar continuum model.

2.4. BPT diagram

We make use of the BPT diagram to classify each spaxel as Star-forming, composite, LINER or Seyfert according to the criteria outlined in Kauffmann et. al. (2003) and Kewley et. al. (2001).

3. Results

3.1. BPT diagram

The main sources of Ionization on CPSBs are composite, LINER or seyfert, indicating they have been fully or at least partially quenched (an example is shown on the top row of Figure 1). EPSBs show a different behaviour. Some form stars throughout almost all their extension (an example is shown on the middle

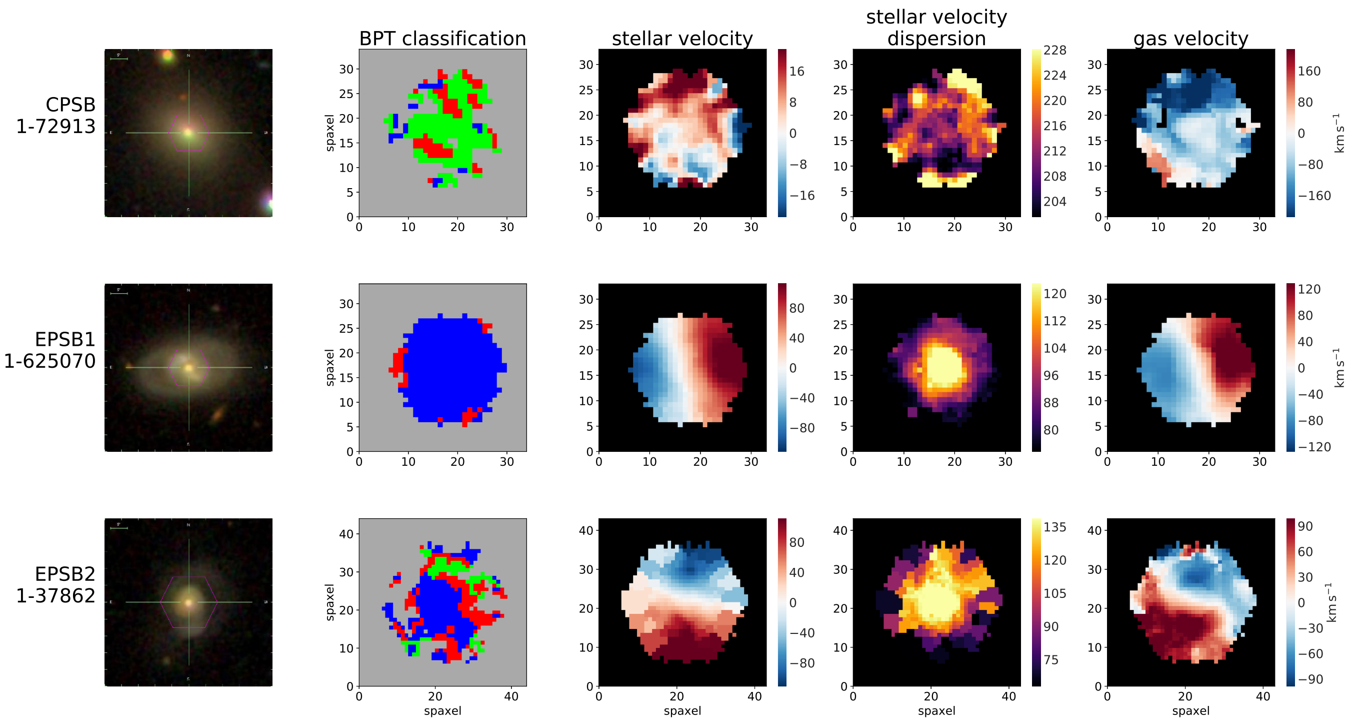

Figure 1. Images and Maps of a typical CPSB (MaNGA-ID 1-72913, top row), a typical type 1 EPSB (MaNGA-ID 1-625070, middle row) and a typical type 2 EPSB (MaNGA-ID 1-37852, bottom row). The leftmost column shows the SDSS Images on the visible spectrum. The left-middle column shows the BPT diagram classifications (Star-forming in blue, composite in green and LINER or Seyfert in red). The three last columns from middle to right, show the stellar velocity, stellar velocity dispersion and ionized gas ($H\alpha$) velocity maps respectively.

row of Figure 1), while others only in their center (an example is shown on the bottom row of Figure 1). Considering this, we classify EPSBs into two categories: type 1 EPSBs (EPSB1), where star-forming spaxels dominate in the outer regions, and type 2 EPSBs (EPSB2), where outer spaxels are mostly non-star-forming.

3.2. Kinematics

The stellar and gas kinematics maps of CPSBs show complex gas or stellar motions, sometimes even counter rotating gas, (see the three rightmost pannels of the top row of Figure 1). Type 1 EPSBs have organized gas and stellar rotation and symmetric velocity dispersion maps (right panels of the middle row of Figure 1). Meanwhile, type 2 EPSBs show complex motions and misaligned gas and stellar velocity fields, similar to CPSBs (right panels of the bottom row of Figure 1.c). The SDSS image of this particular EPSB2 shows a clearly disturbed morphology and tidal features, indicating a recent merger or interaction (see left of the bottom row of Figure 1).

3.3. Discussion

As we can see with the BPT diagram, CPSBs have been quenched in their centers and outskirts, which indicates, they may be at a late stage of an outside-in quenching process. It is also worth noting they typically have early-type morphologies as seen in the example shown in Figure 2. On the other hand, type 2 EPSBs are only quenched on the outskirts, having central star formation. This raises the possibility they might be at an early stage of the same outside-in quenching process acting on CPSBs. Furthermore, the disturbed kinematics of both type 2 EPSBs and CPSBs suggests a possible connection between these classes, as it points to recent mergers or interactions being the triggers of the recent burst of star formation they experienced. Considering that EPSB2 galaxies are still forming stars at their center while CPSBs are mostly fully quenched, it is also possible that these systems are part of the same class, but they are observed at early and late stages of their evolution through the PSB phase respectively. Type 1 EPSBs on the other hand form stars in all their extension, and considering their regular and well behaved kinematic maps, they are unlikely to have experienced any significant interactions in the recent past. Thus, the burst of star formation in these objects was likely triggered by a different mechanism than in CPSBs and EPSB2s.

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