Refining the E+A Galaxy: A Spatially Resolved Spectrophotometric Sample of Nearby Post-Starburst Systems in SDSS-IV MaNGA (MPL-5)

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Abstract

Post-starburst galaxies are crucial to disentangling the effect of star formation and quenching on galaxy demographics. They comprise, however, a heterogeneous population of objects, described in numerous ways. To obtain a well-defined and uncontaminated sample, we take advantage of spatially-resolved spectroscopy to construct an unambiguous sample of E+A galaxies - post-starburst systems with no observed ongoing star formation. Using data from the Mapping Nearby Galaxies at Apache Point Observatory (MaNGA) Survey, in the fourth generation of the Sloan Digital Sky Survey (SDSS-IV), we have identified 30 E+A galaxies that lie within the green valley of color–stellar mass space. We first identified E+A candidates by their central, single-fiber spectra and (u-r) color from SDSS DR15, and then further required each galaxy to exhibit E+A properties throughout the entirety of the system to 3 effective radii. We describe our selection criteria in detail, note common pitfalls in E+A identification, and introduce the basic characteristics of the sample. We will use this E+A sample, which has been assembled with stringent criteria and thus re-establishes a well-defined sub-population within the broader category of post-starburst galaxies, to study the evolution of galaxies and their stellar populations in the time just after star formation within them is fully quenched.

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面分光情報を加えてE+A種族を精度よく選択する手法。

- Post SB銀河は星形成抑制のメカニズムを探る上で重要な種族。
  - 中でも、E+A銀河 (early-type spectrum + bluer cont. than E + strong Balmer abs., no/weak Ha and [OII] emission) は星形成を終えて間もない (~1Gyr) 頃を捉えられる。が、銀河種族全体の1%にも満たない。
- SDSS fiber + MaNGAデータでE+A銀河を抽出する手法を確立した。
  1. fiberデータ (＝銀河全体の平均的な性質): blue g-r, Dn(4000)>1.5, no Ha emission, strong Balmer absorption, no-weak [OII] emission。
  2. MaNGAデータ (＝場所ごとの性質): 0-1, 1-2, 2-3 Re の3区間全てで上記を満たす。

↓Figure 5. WHAN輝線比診断

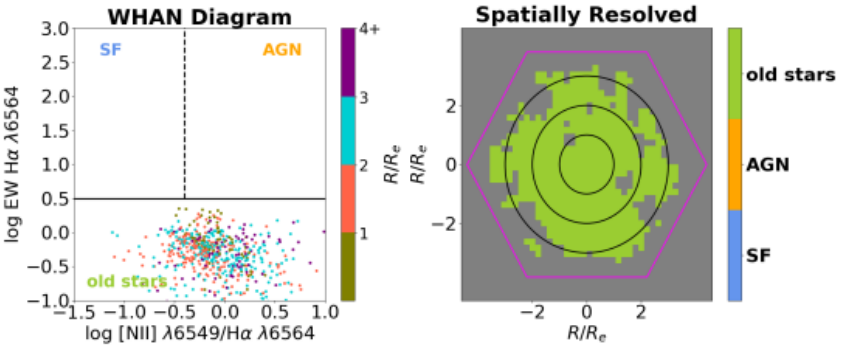


Figure 5. Line-Ratio and spatially resolved WHAN log [EW Hα / ((NII)/Hα)] diagram for galaxy 8315-3703. Left: the line ratios for each spaxel, color-coded by annuli in units of effective radius. Right: Galaxy image color-coded by sectors in the WHAN diagram: old stars, AGN or star formation (see 3.2). (Bundy et al. 2015; Belfiore et al. 2015)

WHAN diagram

(1) *Old Stars* if EW(Hα) < 3Å.
(2) *AGN* if EW(Hα) > 3Å and [NII]/Hα > -0.1
(3) *Star Forming* if EW(Hα) > 6Å and [NII]/Hα > -0.1

↓Figure 6. E+Aと判定されなかった銀河の例

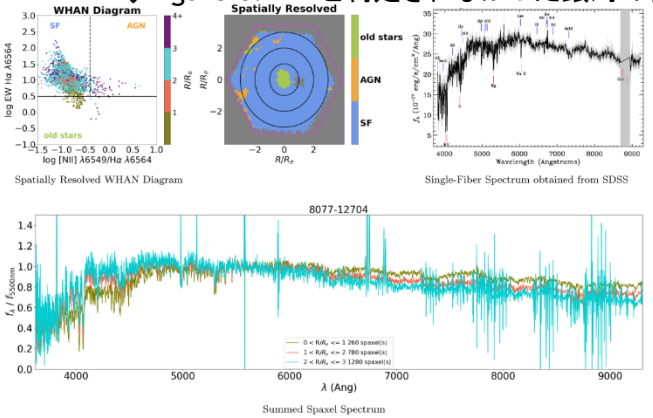


Figure 6. The line-ratio & spatially resolved WHAN diagram (top left), single-fiber spectrum obtained from the SDSS SkyServer (top right), and summed spaxel spectra (bottom) for galaxy 8077-12704. This is a prime example of how the SDSS optical single-fiber spectrum could lead us to believe this galaxy was an E+A; however, the WHAN diagram revealed that the vast majority of the galaxy is actually star-forming, and probably going through an inside-out quenching process. The annular summed spaxel spectra clearly deviates from an E+A galaxy as well, with strong Hα evident in the 2nd and 3rd R_e annulii.

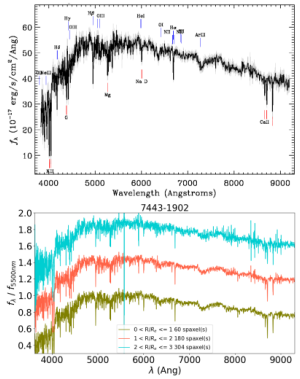


Figure 3. The single-fiber spectra of 7443-1902 (above) and the summed spaxel spectra out to 1, 2 and 3 R_e (below). The spectra in the bottom plot are normalized to 5500±50 Å, and offset from the 0-1 R_e aperture by R_e/2.3. The spaxel count in the legend indicates how many spaxels were summed to produce these spectra. The nearly identical continua in the MaNGA central and annular apertures, compared to the single-fiber spectrum, shows that all three regions could be observed independently and still be categorized as E + A.

↑Figure 3. E+Aと判定された銀河のMaNGA 3区間スペクトル

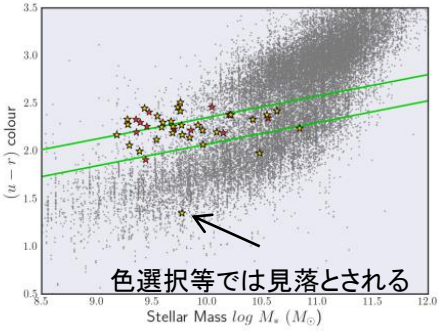
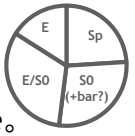


Figure 7. $u-r$ color versus stellar mass. Gold: 30 E + A galaxies from MPL-5. Red: excluded E+A candidates, plotted over a random sample of background SDSS galaxies from the Mendel mass catalog (Mendel et al. 2014). Note that the majority of the E+A galaxies lie squarely in the *green valley* (Wild et al. 2009), the region approximately defined by Schawinski et al. 2014, and represented by the two green lines.

Figure 7. color-mass図

- 今回E+Aと判定された銀河(★)はgreen valley (GV)に位置する。
- MaNGAデータで除外された銀河(★)も似たように分布している。
- →E+A⇒GVだが、GV⇒E+Aとは限らない。



形態分布:
過半数はearly-type。
形態は星形成を抑制しE+Aにする要因の一つか。

- 他論文のE+Aサンプルはどれも (post SBではあるかもしれないが) 今回の条件を満たさなかった。
- EWの条件の違いやSDSSカタログ値の誤りによるところが大きい。
- 後続論文で、S0形成やAGNの影響等、quenchingの過程を議論。