A Spatially Resolved Spectroscopic Observation of a Possible E+A Progenitor SDSS J160241.00+521426.9

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Abstract

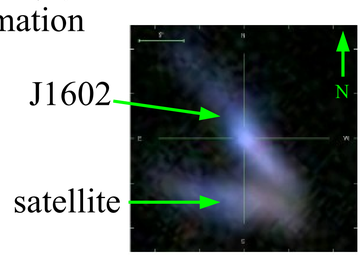
E+A galaxies have metal and strong Balmer absorption lines but no emission line. Although they are considered to be post-starburst galaxies, their evolution process has not yet been understood. We observed a possible E+A progenitor SDSS J160241.00+521426.9 (J1602 hereafter) with its satellite galaxy in order to investigate how E+A galaxies evolve. We used the integral field spectroscopic mode of the Kyoto Tridimentional Spectrograph (Kyoto3DII) mounted on University of Hawaii 88-inch telescope, as well as slit-spectroscopic mode of the Faint Object Camera and Spectrograph (FOCAS) on Subaru Telescope. It is for the first time to carry out spatially-resolved spectroscopic observations of E+A progenitors.

We find a post-starburst region at the center of J1602 and a starburst region at a location offset from the center towards its satellite galaxy. The fact that this galaxy has both starburst and post-starburst regions indicates that it is in an evolving phase. The recession velocity differs only ~100 km s^{-1} between J1602 and its satellite. Thus, they are a physical pair and are considered to have experienced galaxy interaction. The local velocity field of 90 km s^{-1} is detected in the starburst region. Comparing the observed equivalent widths of Balmer absorption lines and color indices with those predicted from stellar population synthesis model, we find that suddenly quenching star formation is plausible for the star formation history of the post-starburst region. We consider that in J1602 star formation started due to galaxy interaction and quenched in the central region, while star formation at the offset location still continues.

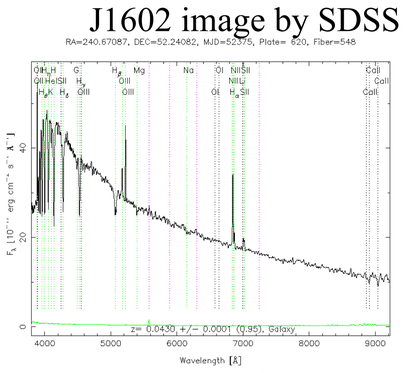
1. Introduction

E+A galaxies
- metal absorption lines ← elliptical galaxy (age: ~10Gyr)
- strong Balmer absorption lines ← A type stars (age: ~1Gyr)
- no emission line ← no ongoing star formation
- post-starburst galaxy
- merger/interaction (Yang et al. 2004, 2008)
- often have companion galaxies (Goto 2005; Yamauchi et al. 2008)

But, they are already in the post-starburst phase.
What are progenitors of E+A galaxies?
→ spatially-resolved spectroscopic observation for a possible E+A progenitor galaxy



J1602 image by SDSS



J1602 spectrum by SDSS

target galaxy
- selection EW: Hδ > 5 Å, Hα > -3 Å, [OII] < -2.5 Å (from Hδ strong galaxies catalog, Goto 2005)
- some emission lines
- an apparent companion galaxy

→ SDSS J160241.00+521426.9 (J1602 hereafter)
- redshift z = 0.0430 (1" = 0.82 kpc)

2-1. Kyoto3DII data

observation
- telescope: University of Hawaii 88inch telescope (UH88)
- instrument: Kyoto3DII IFS mode
- exposure time: 1800 sec. × 2
- field of view: 16" × 12"
- spatial resolution: 1".5
- spectral range: 4200 – 5250 Å
- spectral resolution: R ~ 1000 (4.8 Å)

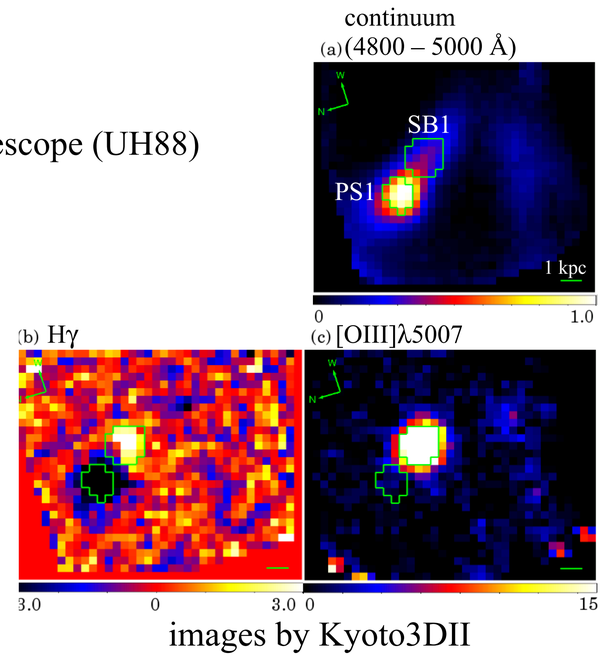
result

PS1 (post-starburst region 1)
- at center of J1602
- strong Balmer absorption (EW(Hγ) = 7 Å)
- no emission line

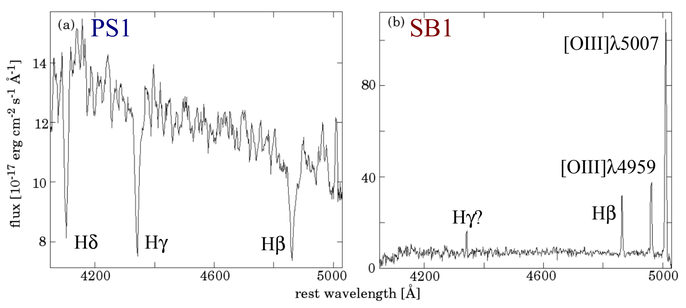
→ post-starburst region

SB1 (starburst region 1)
- 2 kpc southwest from PS1
- strong emission lines EW([OIII]λ5007) = 97 Å

→ starburst region
- local velocity field (90 km/s)

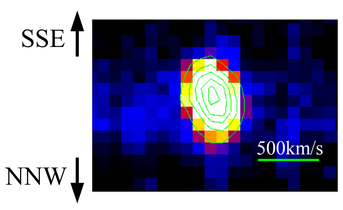


images by Kyoto3DII



spectra by Kyoto3DII

satellite galaxy
- weak detection of [OIII]λλ4959,5007 emission lines
- almost same redshift



spectra in the pseudoslit around [OIII]λ5007 in color presentation at SB1

2-2. FOCAS data

observation
- telescope: Subaru Telescope
- instrument: FOCAS slit-spectroscopy mode
- exposure time: 600 sec. × 3 (J1602), 300 sec. × 3 (satellite)
- field of view: ~3' (on major axis of each galaxy)
- spatial resolution and slit width: 0".8
- spectral range: 3700 – 7100 Å (without filter)
- spectral resolution: R ~ 600

result

PS2
- 2 kpc northeast from PS1
- strong Balmer absorption

→ post-starburst region

SB2
- at center of the satellite galaxy
- some emission lines

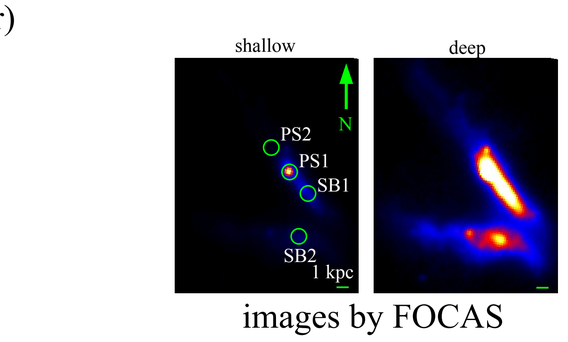
→ starburst region
- recession velocity difference ~ 100 km/s between J1602 and satellite

→ a physical pair

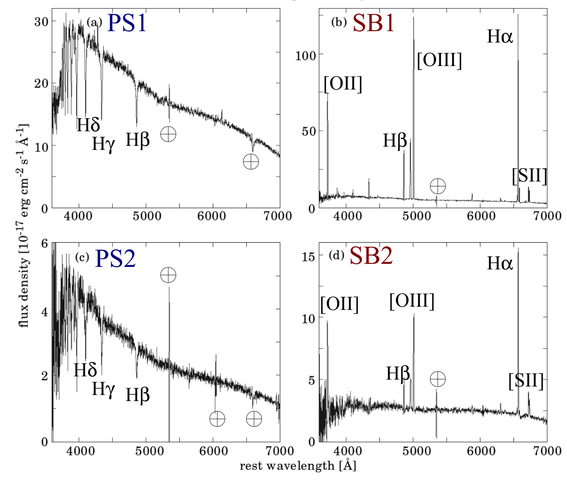
→ galaxy interaction

Are there AGNs in SB1 and SB2?
- [OIII]λ5007/Hβ is large, ~ 3
- but, [NII]λ6583/Hα < 0.1, [SII]/Hα < 0.3

→ no AGN activity



images by FOCAS



spectra by FOCAS

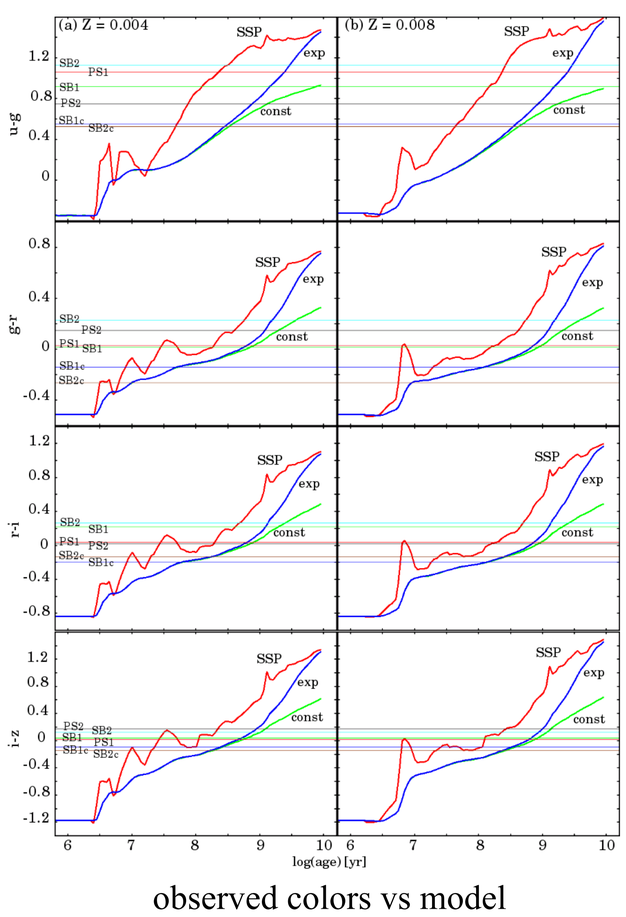
3. Discussion

star formation history

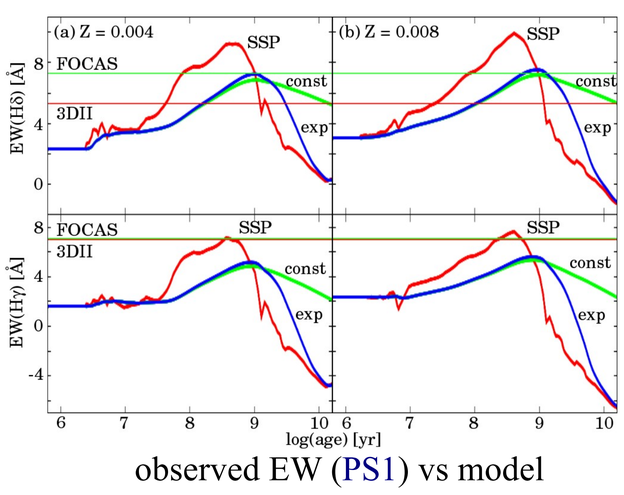
We compare observed equivalent widths and color indices with those predicted by stellar population synthesis model.

- model: GALAXEV (Bruzual & Charlot 2003)
- star formation history: SSP, constant, and exponential (τ = 1Gyr)
- metallicity: Z=0.004 or 0.008 (estimated from R_{23} at SB1)

- equivalent widths: Kyoto3DII and FOCAS at PS1 ($H\gamma_A$, $H\delta_A$; Worthey & Ottaviani 1997) error (1σ) ~ 1 Å
- color indices: SDSS DR7 data error (1σ) ~ 0.03 mag



observed colors vs model



observed EW (PS1) vs model

PS1
- For u-g color, SSP 0.2 Gyr, exp 2 Gyr, or const 10 Gyr is possible.
- For other colors, SSP ~0.7 Gyr or exp or const ~0.7 Gyr is possible.
- For EW, SSP 01.-0.2 Gyr, SSP 1Gyr, or exp or const 1 Gyr is possible.

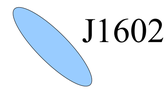
→ Considering equivalent width and color indices, SSP 0.1-0.2 Gyr is more likely.

→ Galaxy interaction may start and suddenly quench starburst.

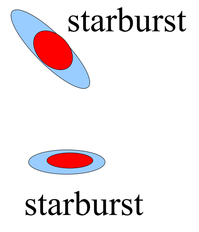
SB1 and SB2
- "SB1c" means extinction and emission line corrected color index.
- Exp or const 0.1-0.3 Gyr is possible.

history of J1602

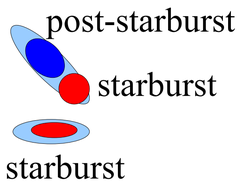
1) before interaction



2) interaction



3) now



4) future