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Elevation or Suppression? The Resolved Star Formation Main Sequence of Galaxies with Two Different Assembly Modes

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ABSTRACT

We investigate the spatially resolved star formation main sequence in star-forming galaxies using Integral Field Spectroscopic observations from the Mapping Nearby Galaxies at the Apache Point Observatory (MaNGA) survey. We demonstrate that the correlation between the stellar mass surface density (Σ_*) and star formation rate surface density (Σ_{SFR}) holds down to the sub-galactic scale, leading to the sub-galactic main sequence (SGMS). By dividing galaxies into two populations based on their recent mass assembly modes, we find the resolved main sequence in galaxies with the 'outside-in' mode is steeper than that in galaxies with the 'inside-out' mode. This is also confirmed on a galaxy-by-galaxy level, where we find the distributions of SGMS slopes for individual galaxies are clearly separated for the two populations. When normalizing and stacking the SGMS of individual galaxies on one panel for the two populations, we find that the inner regions of galaxies with the 'inside-out' mode statistically exhibit a suppression in star formation, with a less significant trend in the outer regions of galaxies with 'outside-in' mode. In contrast, the inner regions of galaxies with 'outside-in' mode and the outer regions of galaxies with 'inside-out' mode follow a slightly sublinear scaling relation with a slope ~0.9, which is in good agreement with previous findings, suggesting that they are experiencing a universal regulation without influences of additional physical processes.

Fig2. outside-in銀河の方が傾きが大きい傾向。

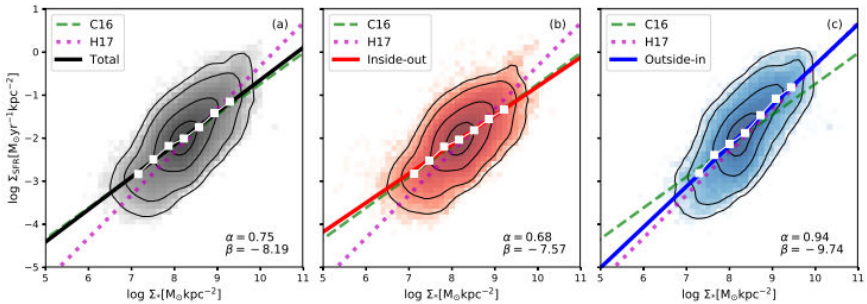


Figure 2. SGMS for our sample and subsamples. White squares show medians of Σ_{SFR} for Σ_* equally binned between 3% and 97% quantiles. The best OLS fittings are shown by colored solid lines in each panel in black (total), red ('inside-out') and blue ('outside-in'). α and β are slopes and zero points for the OLS fittings. The OLS fitting for 80% data of C16 and orthogonal fitting from H17 are shown by the green dashed line and the magma dotted line, respectively. In each panel, contours show levels of 30% / 1σ (67%) / 2σ (95%) / 3σ (99%) of data.

Mass assembly modeの違いによってMain sequenceはどう異なるか？

- SDSS/MaNGAデータを用いてDn4000でサンプルを分けて、MSを比較。
  - Inside-out / outside-in mass assembly
- inside-out, outside-in の2つのmass assembly modeではMSの分布が異なる 。
- Inside-outの内側とoutside-inの外側では星形成を抑制するプロセスが働いていて、傾き1の関係からズレているようだ。
- Inside-outの外側とoutside-inの内側では~0.9のほぼ線形な傾きを持つ → mass assembly modeによらないuniversalな星形成制御が働いているようだ。

星質量密度が高い領域 (中心部?) でstellar/AGN feedbackにより星形成が抑制される。

星質量密度が低い領域 (外側?) で compaction process (→角運動量喪失) や環境効果により星形成が抑制される。

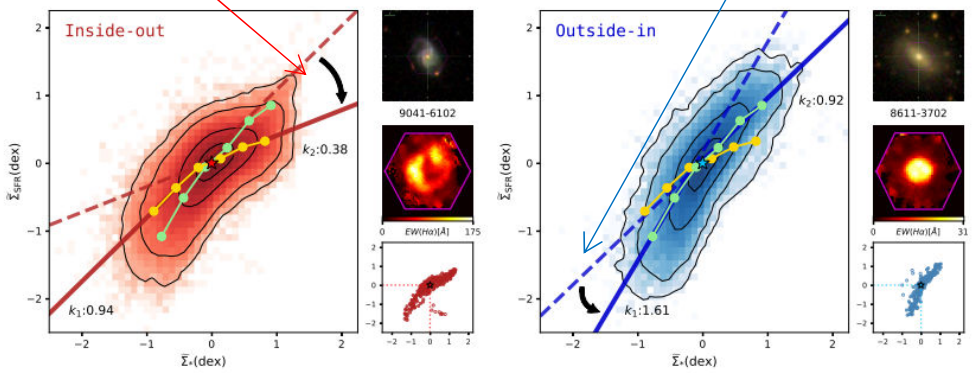


Figure 5. Stacking for G-by-G SGMS of two assembly modes. Colored dots (green for 'outside-in' and gold for 'inside-out') show modes of $\bar{\Sigma}_{SFR}$ for $\bar{\Sigma}_*$ in equal bins between 1% and 99% quantiles. Two-component linear fittings for the modes are show by solid lines, with dashed lines representing their extrapolations. The inner parts of 'inside-out' and outer parts of 'outside-in' galaxies appear to be in good alignment with slopes close to 0.9, which is consistent with results of Magdis et al. (2016) and Maragkoudakis et al. (2017). Contours show levels of 30% / 1σ (67%) / 2σ (95%) / 3σ (99%) of data. SDSS gri images, EW(Hα) maps and G-by-G SGMS of two typical galaxies (MaNGA ID: 9041-6102 and 8611-3702) showing a clear piecewise pattern on a G-by-G level are shown in small panels for each subsample. In the bottom small panels, outliers > 3σ are shown by empty circles. Colored stars show the characteristic values of SGMS, which are shifted to zero.

Wang et al. 2017, ApJ, 844, 144: Dn4000 (1-2Gyr程度の星種族を trace)によりmass assembly modeを判別。

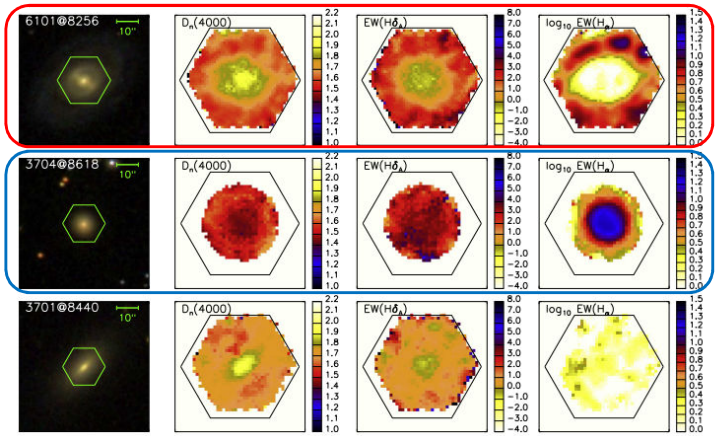
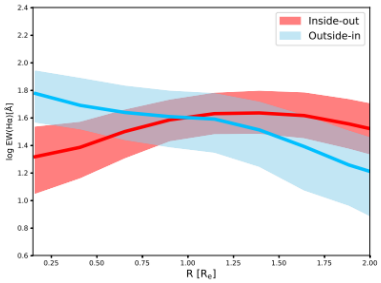


Figure 2. Examples of two-dimensional maps of SDSS images and diagnostic parameters. The top row shows an example of a galaxy in the BC sample with the inside-out assembly mode. The middle row shows an example of a galaxy in the targeted sample with the outside-in assembly mode. The bottom row shows an example of a galaxy in the RC sample. In each row, the columns show the SDSS color image, 4000 Å break, Hδ_A index, and $\log_{10}$EW(Hα) maps (left to right). The hexagons represent the area covered by IFS bundles for each galaxy.

Fig5. 各々の銀河のresolved MS の分布中心を合わせてプロット



EW(Ha) 内側ほど不活発 外側ほど不活発

Figure 6. EW(Hα) profiles of 'inside-out' galaxies (red) and 'outside-in' galaxies (blue) equally sampled along the radius. The solid lines stand for the median profiles of EW(Hα) and the translucent bands show the 30%–70% distributions. Star formation in 'inside-out' galaxies peaks in disks, wile star formation in 'outside-in' galaxies peaks in central regions and decreases with the radius.