SDSS-IV MaNGA: Spatially resolved star formation in barred galaxies

ABSTRACT

Bars inhabit the majority of local-Universe disk galaxies and may be important drivers of galaxy evolution through the redistribution of gas and angular momentum within disks. We investigate the star formation and gas properties of bars in galaxies spanning a wide range of masses, environments, and star formation rates using the MaNGA galaxy survey. Using a robustly-defined sample of 684 barred galaxies, we find that fractional (or scaled) bar length correlates with the host's offset from the star-formation main sequence. Considering the morphology of the Hα emission we separate barred galaxies into different categories, including barred, ringed, and central configurations, together with Hα detected at the ends of a bar. We find that only low-mass galaxies host star formation along their bars, and that this is located predominantly at the leading edge of the bar itself. Our results are supported by recent simulations of massive galaxies, which show that the position of star formation within a bar is regulated by a combination of shear forces, turbulence and gas flows. We conclude that the physical properties of a bar are mostly governed by the existing stellar mass of the host galaxy, but that they also play an important role in the galaxy's ongoing star formation.

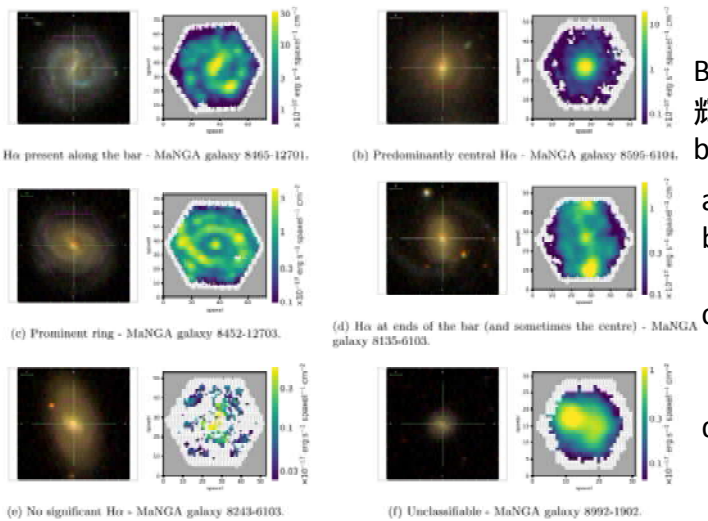

Figure 2. Examples of the six Hα morphology classifications devised for this work, with galaxies denoted by their MaNGA plate and IFU. For each class, we show the SDSS *gri* image of the galaxy with MaNGA field of view overlaid in magenta, and the logarithmically-scaled Hα flux map.

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Bar銀河サンプルをHa輝度分布で細分化してbar進化を考える。

a) Along the bar (18%)
b) Central (20%)
barを介した中心SB
c) Ring (21%)
bar重力とgas disk回転の共鳴
d) At ends of bar (18%)
weak shearとturbulenceの拮抗
e) No Ha (10%)
f) Unclassifiable (13%)

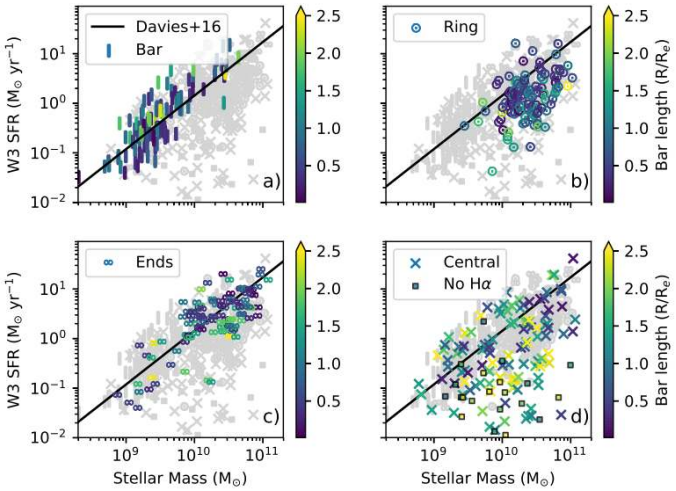

Figure 3. SFR-M_* diagram for MaNGA barred galaxies. Each panel highlights a different Hα morphology, and points are coloured by their scaled bar length. The black line is the W3 star formation main sequence (SFMS) relation from Davies et al. (2016). Galaxies with barred Hα morphology are lower-mass, and lie on (or sometimes slightly above) the SFMS line. Ringed Hα morphology belong to higher-mass galaxies that lie below the SFMS line. Galaxies with Hα at the ends of their bars are also generally higher-mass, and lie close to the main sequence line. Central Hα galaxies are distributed across the SFR-stellar mass plane, and galaxies with no Hα lie mostly below the main sequence line. Galaxies with central or no Hα possess bars of longer scale length than the other Hα morphologies.

a) low-mass on MS
b) 広く分布
• SF/AGN/LINERが混在
c) high-mass on/below MS
d) high-mass on MS

- 長いbarのほとんどはcentral/no Ha銀河に属する。
- quiescentには長いbarが多い
→quenchingへのbarの影響。

Barでの星形成

- barは星形成をenhanceもsuppressもするが、詳細な物理の理解は不十分。
  - Barを介したgas流入と銀河中心での質量集中、ring状の星形成、etc
- Barの形成・成長と母銀河の進化の関係
- MaNGAの大規模空間分解サンプルを用いて、母銀河の性質 (Ms, SFR) とbarの性質 (長さ、SF) の関係を調べる。

➢ 母銀河の質量はbarとその周辺の星形成に深く関わっているようだ。

・Massive銀河ほど長いbar。

Reで規格化すると、
・短いbarはSF銀河
・長いbarはquiescentも含む。

SF銀河のbarは最近形成されてまだ成長中のため、短いと考えられる。
z~0.8ではlow-mass銀河のbar fractionが小さいという報告もある。

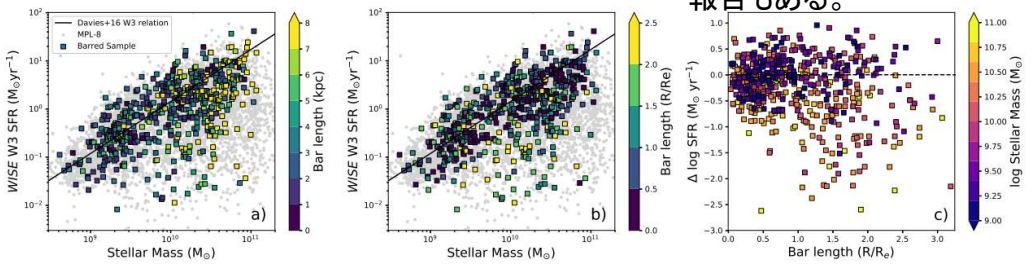

Figure 1. Measures of bar length as a function of galaxy stellar mass, star formation rate, and distance from the SFMS line. Panel a) & b): star formation rate vs. stellar mass plots of barred MaNGA galaxies, with main sequence line from Davies et al. (2016) shown in black. Grey points are all galaxies in MaNGA MPL-8, and squares overlaid are the barred sample, colour-coded by bar length in units of kpc (panel a) and R/R_e (panel b). Panel c): The log vertical distance from the SFMS line for galaxies as a function of scaled bar length and colour-coded by stellar mass. A negative value of $\Delta \log \mathrm{SFR}$ indicates a galaxy lies below the SFMS line. Galaxies lying below the main sequence line are more massive than those close to the line for a given bar length.

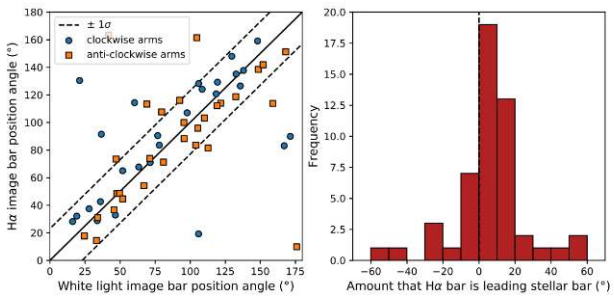

Figure 6. Differences between Hα and stellar bar position angles. On the left, we plot the Hα image bar position angle against the white light bar position angle, with points colour-coded by the direction of rotation of the galaxy. A solid black 1:1 line is shown, along with dashed 1σ lines. Galaxies that rotate clockwise have the Hα bar ahead of the stellar bar if they are above the black 1:1 line, and the opposite is true for anticlockwise-rotating galaxies. On the right is a histogram of the amount by which the Hα bar is leading the stellar bar (negative values indicate it is trailing). The majority of Hα bars lead their stellar bars by 0–20°.

- Spiral armでも見られるように、bar内の星形成はleading edgeに偏っている。
- それ以外の場所ではshearとturbulenceによりSFが起きにくい。