A SAMI and MaNGA view on the stellar kinematics of galaxies on the star-forming main sequence arXiv:2102.13342

Abstract

Galaxy internal structure growth has long been accused of inhibiting star formation in disc galaxies. We investigate the potential physical connection between the growth of dispersion-supported stellar structures (e.g. classical bulges) and the position of galaxies on the star-forming main sequence at $z \sim 0$. Combining the might of the SAMI and MaNGA galaxy surveys, we measure the λ_{Re} spin parameter for 3781 galaxies over $9.5 < \log M_\star[\mathrm{M}_\odot] < 12$. At all stellar masses, galaxies at the locus of the main sequence possess λ_{Re} values indicative of intrinsically flattened discs. However, above $\log M_\star[\mathrm{M}_\odot] \sim 10.5$ where the main sequence starts bending, we find tantalising evidence for an increase in the number of galaxies with dispersion-supported structures, perhaps suggesting a connection between bulges and the bending of the main sequence. Moving above the main sequence, we see no evidence of any change in the typical spin parameter in galaxies once gravitationally-interacting systems are excluded from the sample. Similarly, up to 1 dex below the main sequence, λ_{Re} remains roughly constant and only at very high stellar masses ($\log M_\star[\mathrm{M}_\odot] > 11$), do we see a rapid decrease in λ_{Re} once galaxies decline in star formation activity. If this trend is confirmed, it would be indicative of different quenching mechanisms acting on high- and low-mass galaxies. The results suggest that while a population of galaxies possessing some dispersion-supported structure is already present on the star-forming main sequence, further growth would be required after the galaxy has quenched to match the kinematic properties observed in passive galaxies at $z \sim 0$.

- **Background**
- $logM_\star$と$log(SFR)$は直線的な関係を持つ

⇨しかし高質量の銀河($logM_\star[M_\odot] \geq 10.5$)では、低質量銀河の関係を外挿した時よりも低いSFRを持つ(SFMSのbending)

- SFR、銀河の形態、スピンパラメータには関連性がある

⇨本研究では、IFS データを用いてSFMS全体の運動学的な傾向を調べ、SFMS上とそれから離れている両方の銀河のスピンパラメータを比較する。

- **データと手法**
- **Sample**

GSWLC-2にマッチした、SAMI,MaNGAの5733銀河のうち、R_eよりPSFのHWHMより小さいものと、$1R_e$以内のスパクセルが20%以上マスクされたもの(MaNGAのみ)をカットした3289銀河

- スピンパラメータλ_R

$$\lambda_R = \frac{\langle R|V| \rangle}{\langle R\sqrt{V^2+\sigma^2} \rangle} = \frac{\sum_{i=0}^{N_{spx}} F_i R_i |V_i|}{\sum_{i=0}^{N_{spx}} F_i R_i \sqrt{V_i^2+\sigma_i^2}}$$

- **SFMS**

GSWLC-2の銀河のうち $\log(SFR) > 0.704 \times \log = (M_\star) - 8.21$ を満たすような銀河についてscipyのoptimize.curvefitを用いてフィットした曲線

$$\log(SFR[M_\odot\ yr^{-1}]) = 0.256 - \log_{10}\left(1 + \frac{10^{10.064}}{10^M}\right)$$

- **結果と議論**
- 図6,7より、主系列上の銀河(ΔMS=±0.25dex)が円盤銀河を示す $0.6 < \lambda_{Re,PSF\ corr+deproj} < 0.8$に入っている

⇨主系列は回転支持された円盤銀河　　※最高質量ビンを除く

- 図7のMaNGAではΔMS=0でのλ_{R_e}に質量依存性

⇨高質量の銀河は短いディスクスケール長で回転曲線のピークを迎える(Catinella et al. 2006)ことを支持

- ΔMS>0のところでは明らかに相互作用している銀河を除くとλ_{R_e}はほぼ一定で円盤銀河の値を持つ　　※最小、最大質量ビンを除く

⇨バルジはΔMS>0の領域で成長しているという証拠は見られない

⇨これはcompactation senarioを否定するものではない

⇨回転支持の性質を壊さないようにガス注入が起きれば良い

  - この結果は以下の二つのシナリオと合う
    1. クエンチが起きてから形態変化が起こる(SFMSから外れてからλ_{R_e}の減少が起こる)
    2. クエンチと形態変化は同時に起こるが形態変化はクエンチに比べて十分ゆっくり起こる

- ΔMS<0の領域では質量が大きくなるに従って$\lambda_{R_e} - \Delta MS$の傾きが急峻になる
    1. 分散支持構造の優位性の高まり
    2. 低sSFRでのSFR指標の信頼性の低さ
    3. 高質量でのバイモーダリティの消失とSFMSのbendingにが原因の分散支持銀河によるλ_{R_e}測定の汚染

- 図8によると、$logM_\star[M_\odot] > 10$では低λ_{R_e}がSFMSからΔMS<0側に逸脱し始め、$logM_\star[M_\odot] > 11$では高λ_{R_e}銀河がSFMSからΔMS>0側に逸脱し始める

1. SFMSのbending領域には分散支持の割合が大きい銀河が存在

⇨分散主体のバルジが高質量のSFMSには既に存在

⇨ λ_{R_e}の減少の少なくとも一部はバルジ成長によると考えられる

2. 高質量では分散支持の優位な銀河より回転支持の優位な銀河の方がSFRが大きい

⇨Martig et al.(2009)のmorphological quenchingによって説明可能

Figure 5. A 2D histogram of median λ_{Re} for bins of stellar mass and star formation rate for the combined SAMI and MaNGA sample. The SFMS line of Equation 3 is shown in green, and for comparison, the linear main sequence line fit to low-mass galaxies of Equation 4 is shown in blue.

Figure 6. Median λ_{Re} for SAMI galaxies as a function of distance from the SFMS line of Equation 3 (Δ MS) in bins of stellar mass. Each panel highlights a different mass bin, with all other mass bins shown in grey for comparison. Shaded regions denote the 25th and 75th percentiles for each mass bin. The vertical dashed line denotes the locus of the main sequence. In general, the SFMS is populated by discy galaxies, with little change in λ_{Re} within ± 1 dex of the SFMS for all but the most massive galaxies.

Figure 7. Median λ_{Re} for MaNGA galaxies as a function of distance from the SFMS line of Equation 3 (Δ MS) in bins of stellar mass. Each panel highlights a different mass bin, with all other mass bins shown in grey for comparison. Shaded regions denote the 25th and 75th percentiles for each mass bin. Solid lines depict the full MaNGA kinematic sample, and dotted lines with white circles are the MaNGA sample with obvious interactions removed from the highest two Δ MS bins. The extra high-mass bin for MaNGA galaxies is due to the greater number of high-mass galaxies in this sample.

Figure 8. Histograms and their associated kernel density estimate (KDE) plots of the combined SAMI and MaNGA kinematic sample (grey), galaxies with $\lambda_{Re} > 0.6$ (blue), and $\lambda_{Re} < 0.6$ (red) in bins of stellar mass for $-1 < \Delta$ MS < 1. Δ MS = 0 is shown in black. At low stellar masses, there is no deviation away from the main sequence. At higher stellar masses, low λ_{Re} galaxies deviate towards lower sSFRs, while high λ_{Re} galaxies move above the main sequence line. We interpret these trends as evidence that more dispersion-dominated galaxies populate the 'bending' region of the SFMS.