SDSS-IV MaNGA: The Different Quenching Histories of Fast and Slow Rotators

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ABSTRACT

Do the theorised different formation mechanisms of fast and slow rotators produce an observable difference in their star formation histories? To study this we identify quenching slow rotators in the MaNGA sample by selecting those which lie below the star forming sequence and identify a sample of quenching fast rotators which were matched in stellar mass. This results in a total sample of 194 kinematically classified galaxies, which is agnostic to visual morphology. We use $u-r$ and $NUV-u$ colours from SDSS and GALEX and an existing inference package, STARPY, to conduct a first look at the onset time and exponentially declining rate of quenching of these galaxies. An Anderson-Darling test on the distribution of the inferred quenching rates across the two kinematic populations reveals they are statistically distinguishable (3.2σ). We find that fast rotators quench at a much wider range of rates than slow rotators, consistent with a wide variety of physical processes such as secular evolution, minor mergers, gas accretion and environmentally driven mechanisms. Quenching is more likely to occur at rapid rates ($\tau \lesssim 1$ Gyr) for slow rotators, in agreement with theories suggesting slow rotators are formed in dynamically fast processes, such as major mergers. Interestingly, we also find that a subset of the fast rotators quench at these same rapid rates as the bulk of the slow rotator sample. We therefore discuss how the total gas mass of a merger, rather than the merger mass ratio, may decide a galaxy's ultimate kinematic fate.

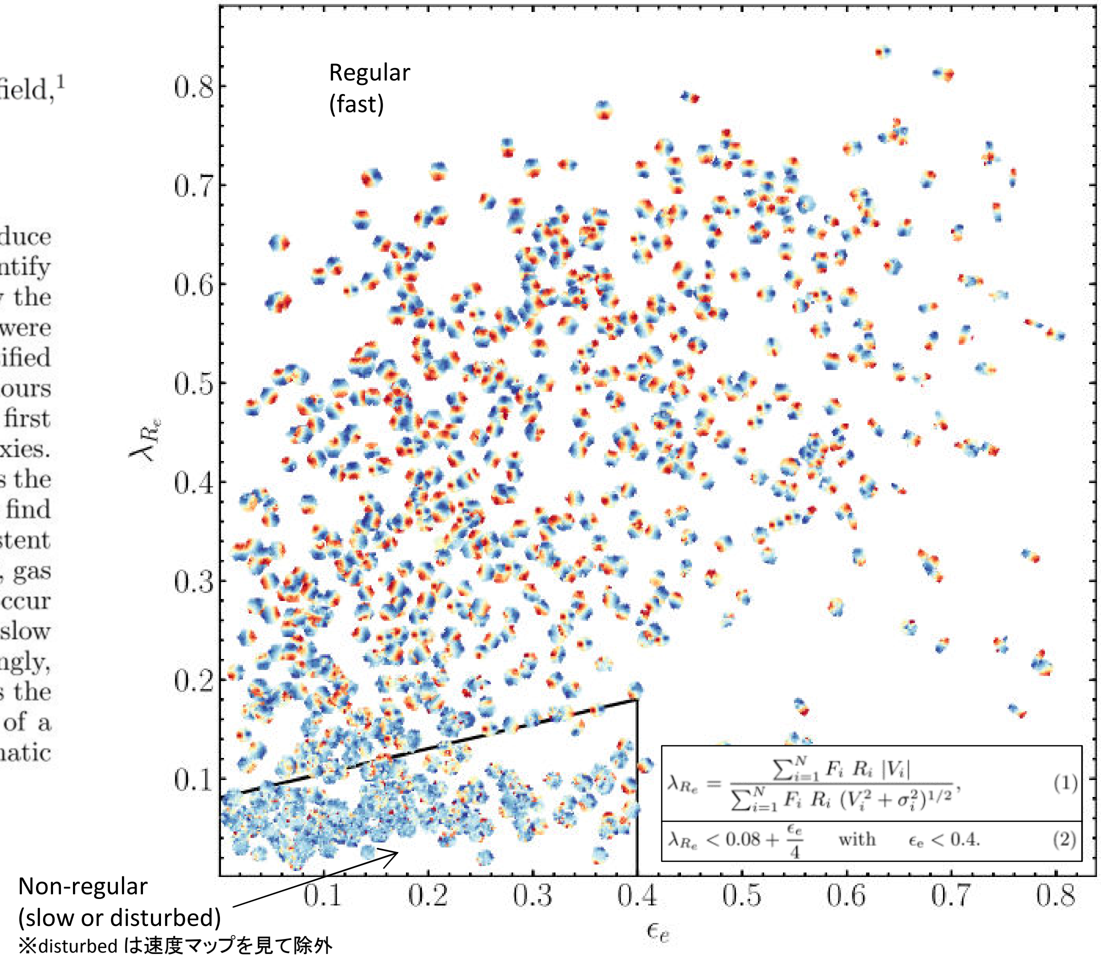


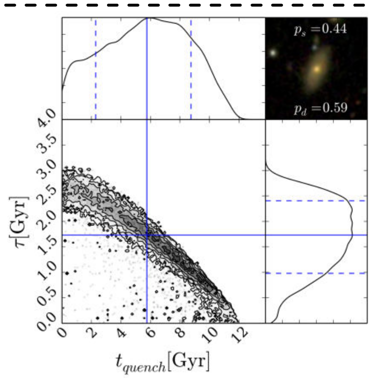
Figure 2. Ellipticity versus stellar angular momentum for the regular and non-regular rotators of the Q-MANGA-GALEX sample. Each point is shown by its stellar velocity map, each normalised to have a stellar velocity of 0 km s^{-1} shown by the colour yellow. We show the separation between regular (i.e. fast) and non-regular rotators (i.e. slow rotators and objects with kinematically decoupled cores) from Cappellari (2016) with the solid black line.

<u>Slow/fast rotatorの形成はどのような星形成史の違いによるのか？</u>

- SDSS-MaNGAサンプルから同星質量で slow/fast rotator を抽出。
- u-r, NUV-u から exp-decaying 星形成史を推定。
  → quenching のタイムスケールから星形成抑制メカニズムを推定。

Table 1. Summary of the generalised rates of theorised internal and external quenching mechanisms (see Smethurst et al. 2017).

	Internal Processes ('Nature')	External Processes ('Nurture')
Fast quenching	AGN feedback	Mergers
Intermediate quenching	Mass quenching	Environmental quenching
Slow quenching	Morphological quenching	Gas accretion



Exp-decay SFH fittingの例 (Smethurst+ 2015)

Figure 5. Example output from STARPY for a galaxy within the red sequence. The contours show the positions of the 'walkers' in the Markov Chain (which are analogous to the areas of high probability) for the quenching models described by $\theta = [t_q, \tau]$ and the histograms show the 1D projection along each axis. Solid (dashed) blue lines show the best fit model (with $\pm1\sigma$) to the galaxy data. The postage stamp image from SDSS is shown in the top right along with the debiased vote fractions for smooth (p_s) and disc (p_d) from Galaxy Zoo 2.

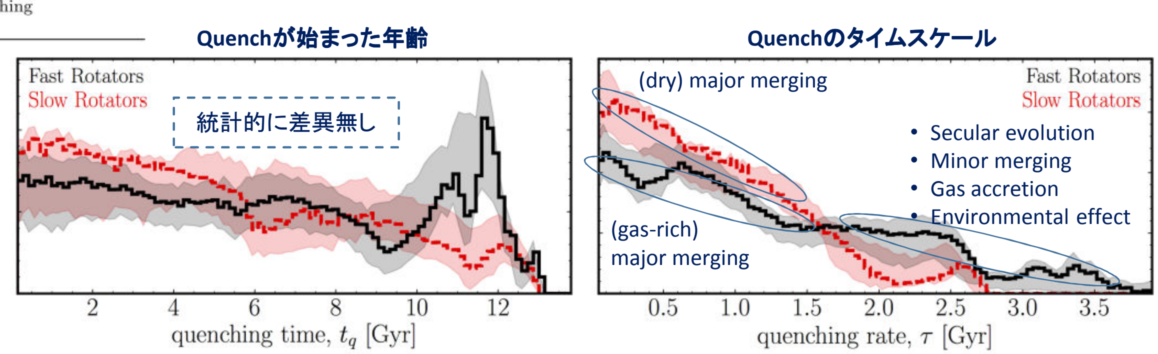


Figure 5. Population densities for the time, t_q (left) and exponential rate, τ (right) that quenching occurs in the MM-Q-MANGA-GALEX sample for the fast (black, solid) and slow (red, dashed) rotators. A high value of t_q corresponds to a recent quench, and a high value of τ corresponds to a slow quench. Shaded regions show the uncertainties on the distributions from bootstrapping.