A single galaxy population? Statistical evidence that the Star-Forming Main Sequence might be the tip of the iceberg.

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ABSTRACT

According to their specific star formation rate (sSFR), galaxies are often divided into 'star-forming' and 'passive' populations. It is argued that the former define a narrow 'Main Sequence of Star-Forming Galaxies' (MSSF) of the form $sSFR(M_*)$, whereas 'passive' galaxies feature negligible levels of star formation activity. Here we use data from the Sloan Digital Sky Survey and the Galaxy and Mass Assembly survey at $z < 0.1$ to constrain the conditional probability of the specific star formation rate at a given stellar mass. We show that the whole population of galaxies in the local Universe is consistent with a simple probability distribution with only one maximum (roughly corresponding to the MSSF) and relatively shallow power-law tails that fully account for the 'passive' population.

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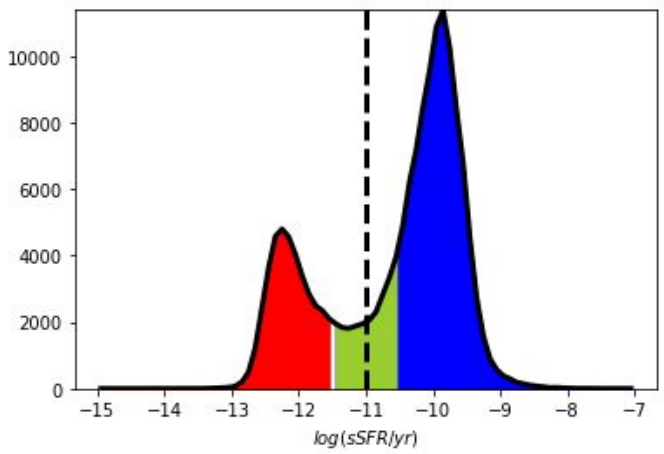
The paradigm: Galaxy Bimodality

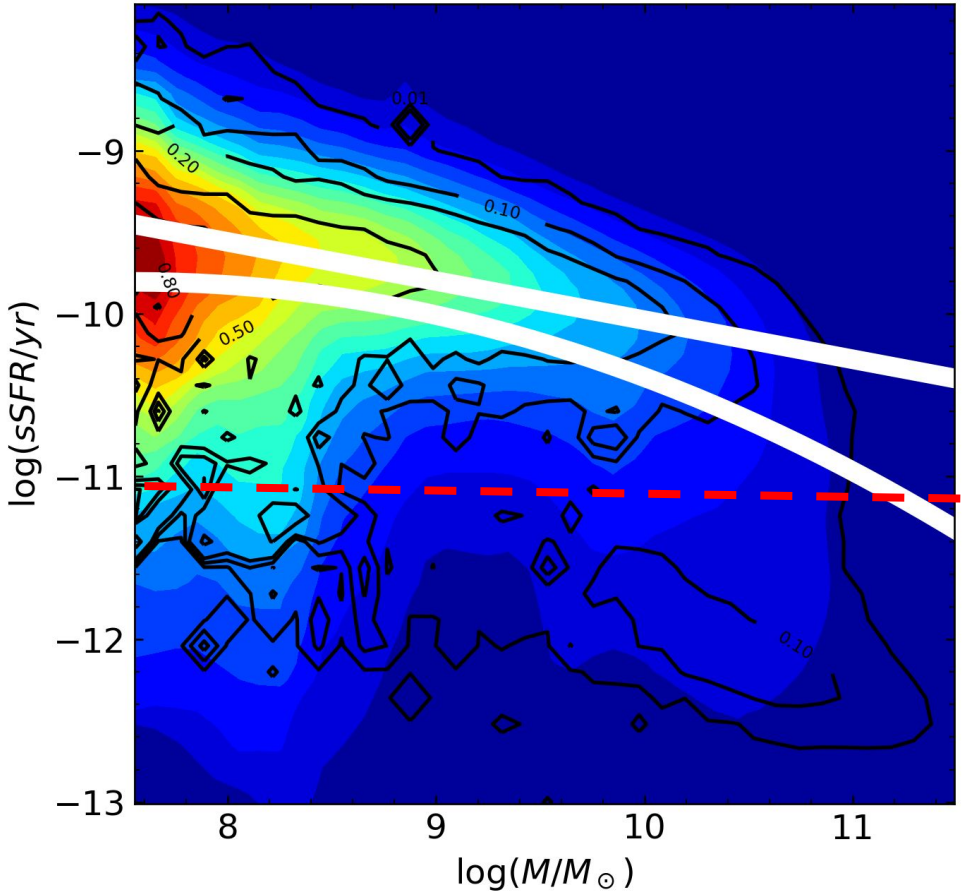
Two populations of galaxies

Passive (Negligible SFR) | Green Valley + Quenching ¿? | **Active (Star Forming)**



Traditionally, galaxies have been divided into **SF** and **passive** by imposing an **arbitrary threshold** on sSFR/SFR or a color cut (UV, optical)

Contour histogram of the sSFR-M_* plane



Imposing such distinction, active (SF) galaxies define a narrow region called **Main Sequence** of Star forming Galaxies that has typically been represented by a **power-law** with logarithmic slope close to linear (e.g. Renzini & Peng 15).

Alternatively, several authors have recently proposed that galaxies may form a **single sequence** encompassing all kinds (Eales et al. 17,18b, Feldmann et al 17).

The question: Is bimodality real in the local Universe?

We have explored the statistical **distribution of galaxies** in terms of their sSFR and M_* and the existence of **bimodality** by means of the **conditional probability**

$$p \equiv \frac{\mathrm{d}\,P(\log(\frac{sSFR}{\mathrm{yr}^{-1}}) \mid M_*)}{\mathrm{d}\log(\frac{sSFR}{\mathrm{yr}^{-1}})}$$

We have used two different samples of galaxies

~160,000 galaxies with SFRs from MPI-JHU catalog.

~16,000 galaxies with SFRs computed using MAGPHYS

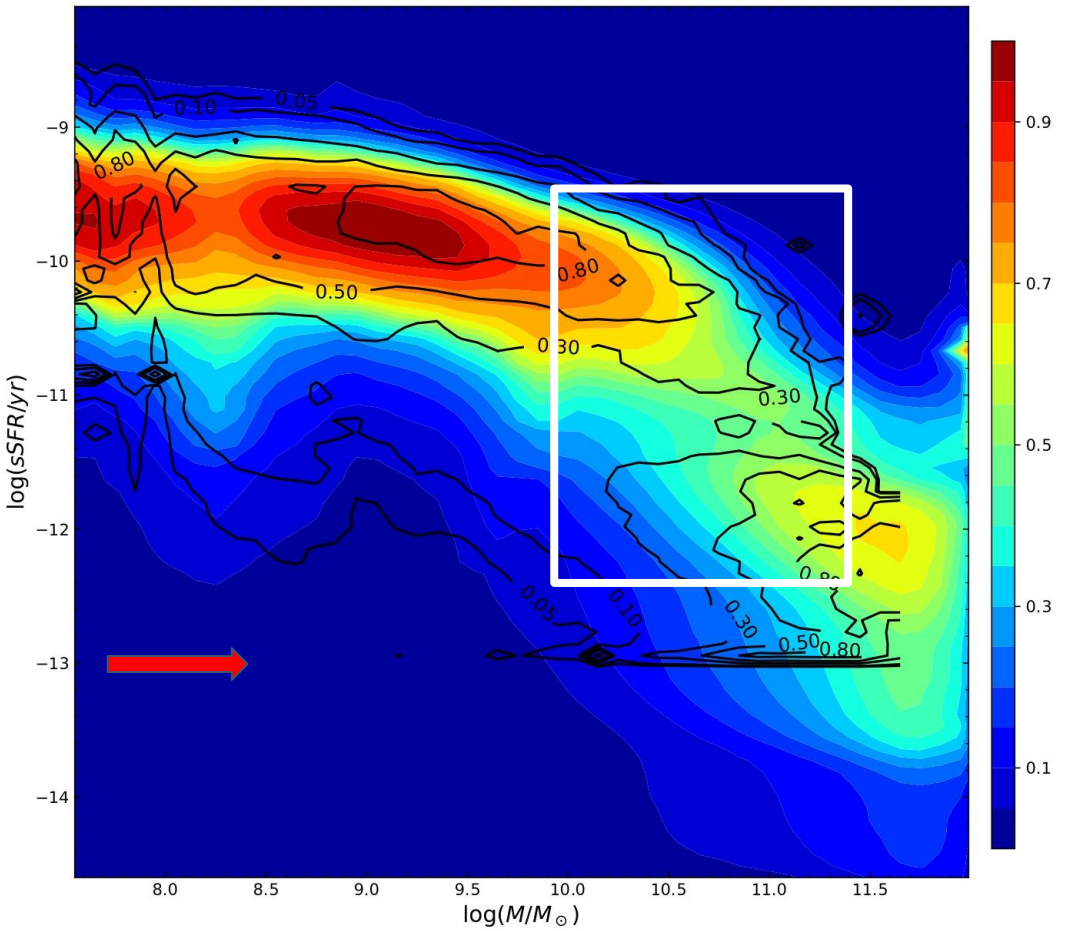
- For $\log(M/M_\odot)<10$ both distributions fairly agree.
- Between $10<\log(M/M_\odot)<11$ GAMA data is bimodal.
- There is a lower cutoff around $\log(sSFR/yr)=-13$ for GAMA galaxies that might modify their measured distribution.

We apply a careful treatment of the **individual errors** instead of using the median values for each galaxy

⟺

Not considering them may change dramatically the results!

Conditional probability plane
Colored contours → SDSS
Black contours → GAMA



Results: The conditional probability.

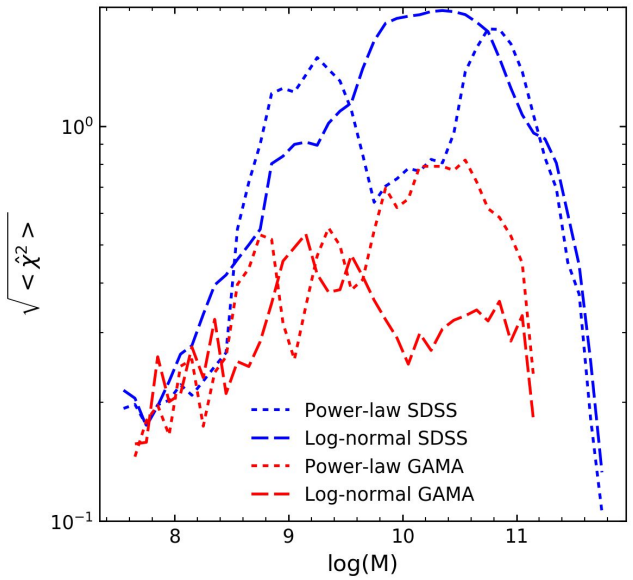
NONE OF THE MASS SLICES FOR SDSS ARE BIMODAL!

We fit the observed distributions according two different prescriptions

Classical interpretation: Bimodal distribution based on two lognormals

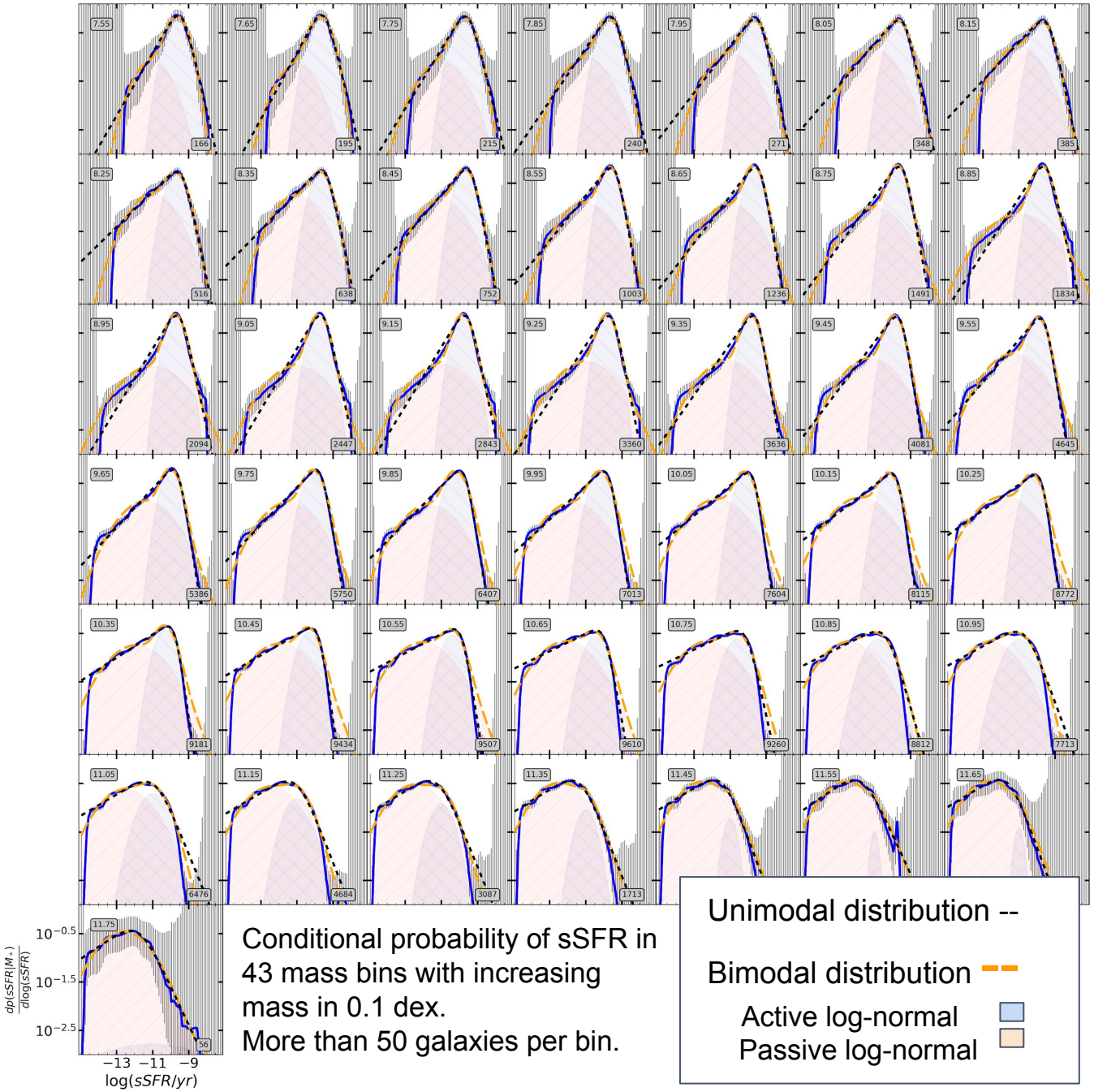
This work: Unimodal distribution with asymptotic power-law tails

Both models fit the data to the uncertainty level



The distribution of galaxies in the sSFR-M_* plane can be described in terms of a **single galaxy population**

The **main sequence** is just the **mode** of the distribution!?



Conditional probability of sSFR in 43 mass bins with increasing mass in 0.1 dex.
More than 50 galaxies per bin.

Unimodal distribution --

Bimodal distribution

Active log-normal

Passive log-normal

Results: The galaxy sequence.

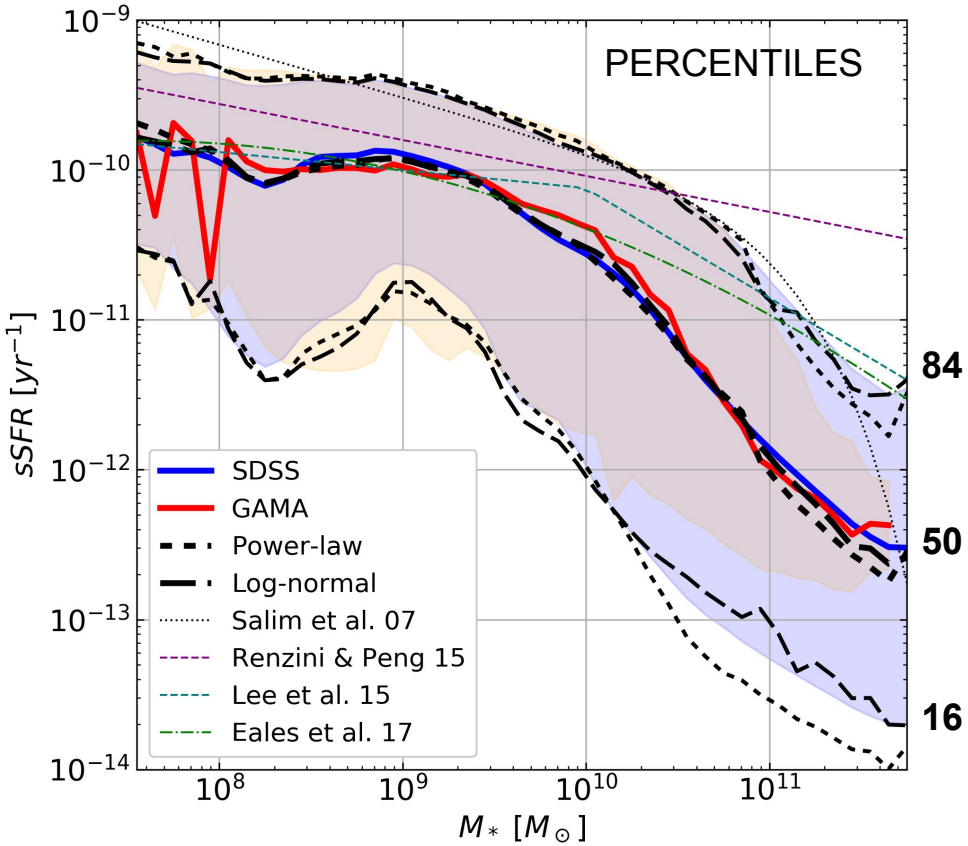
Most previous studies provide a good fit to the **mean** and/or the **mode** of the distribution.

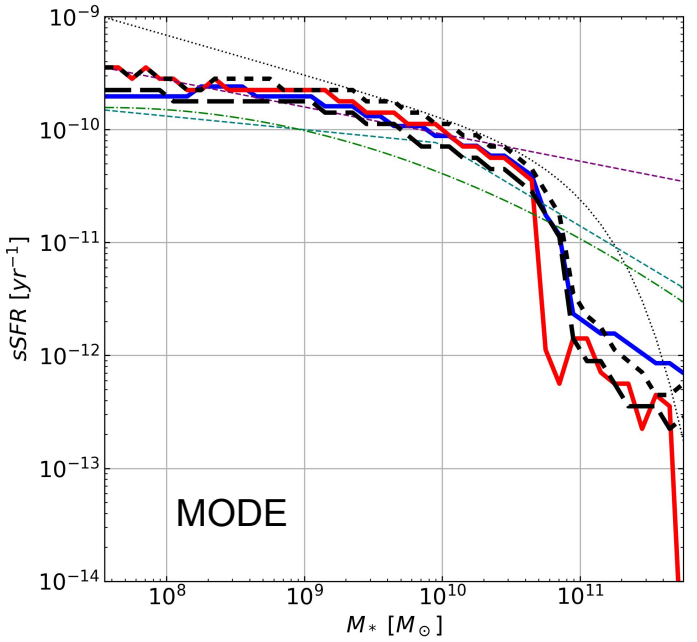
We compare our distribution with **previous studies** of the MSSF in the literature.

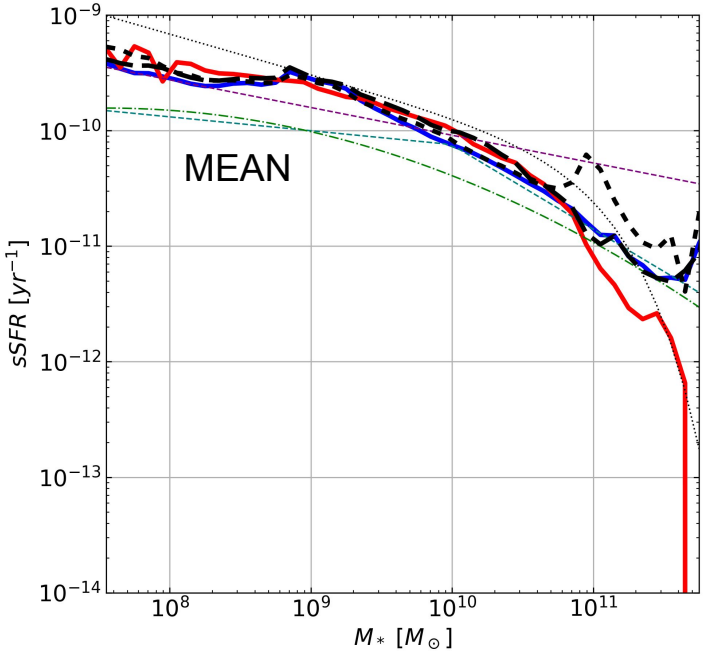
However, the extended power-law tails of the distribution cast doubts about the **meaning of a sequence** sSFR(M_*)

The shape of the distribution at the low and high mass ends is poorly constrained.

The smoothness of the median may indicate that quenching processes play a minor role and galaxies evolve steadily from high SF scenarios towards lower values.







The agreement between **SDSS** and **GAMA** is excellent.

Conclusions and prospects for the future

Main results

- We suggest that the distribution of sSFR-M_* in the local Universe **may not be bimodal**.
- The conditional probability distribution at fixed mass clearly shows asymptotic **power-law tails** that must be considered and characterised.
- They are relatively shallow, accounting for the whole plane and not only the region around the **mode** of the distribution, which may be identified with the previously reported MSSF.

Future prospects

- **Deeper surveys** must be considered in order to accurately characterize the population of **red dwarf galaxies**.
- Probing a **larger volume** is mandatory in order to constrain the **high-mass end**.