arXiv:2203.10880 / A&A 661, id.L7 (2022)

The bending of the star-forming main sequence traces the cold- to hot-accretion transition mass over $0 < z < 4$

Emanuele Daddi[1], Ivan Delvecchio[2], Paola Dimauro[3], Benjamin Magnelli[1], Carlos Gomez-Guijarro[1], Rosemary Coogan[1], David Elbaz[1], Boris S. Kalita[1], Aurelien Le Bail[1], R. Michael Rich[4], and Qing-hua Tan[5, 1]

Summary : Bending knee of MS evolves up to z~1, and stays constant toward higher-z. Corresponding CDM halo mass is consistent with transition mass of cold- to hot-accretion, indicating that MS bending may be due to lessening of cold-accretion.

Background:

- How cold gas feeding from the cosmic web happening?
- Theory : cold gas accretes if
  - Accretion : $M_{DM} < M_{Shock} \sim 10^{11.8} M_\odot$
  - Cold stream : $M_{DM} < M_{stream}(z) \sim 10^{12.5} M_\odot @ z = 2, 10^{13.5} M_\odot @ z = 3$
  - More massive galaxies can have gas supply at higher redshift
- Observation : LyA obs of clusters at z=2.2-3 (D22)
- Main sequence bending mass (M_0)
  - M_0 is similar to the value corresponding to M_{shock} @z=0
  - $M_0 = 10^{10-11} M_\odot$ @z>1, strong z evolution

Parametrisation:

$$\frac{\mathrm{SFR}}{\mathrm{SFR0}} = \frac{1}{1 + (\mathcal{M}_0/\mathcal{M}_*)^\gamma} \qquad (1)$$

- SFR0 : SFR saturation limit, γ : power-law slope of MS
- This is same as that of accretion parametrization in D22, if we assume M_* scales to M_{DM}
- Fit to existing datasets in COSMOS field (L15, D21)

M_0, M_{DM} vs z relation (Fig 2)

- M_0 is converted to M_{DM} by Behroozi+13 relation
- $M_{DM} = 4 - 8\times10^{11} M_\odot$ at z<1, consistent with M_{shock}
- M_{DM} shows steep rise at z>1, consistent with M_{stream}

$$\log M_{\mathrm{stream}} \simeq \log M_{\mathrm{shock}} + (0.67 \pm 0.15) \times (z - 0.9 \pm 0.1) \qquad (2)$$

M_{shock}, M_{stream} boundaries matches well with M_0 over 0<z<4

=> Bending of MS is due to disappearance of cold stream

=> However, complete shut down does not happen (SFR0 remains) ; total quenching requires another process (such as major merger)

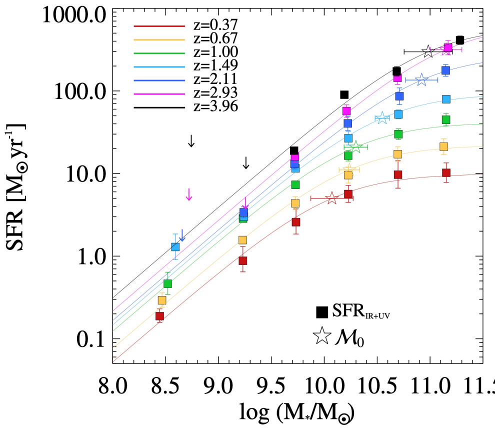

Fig. 1. The star-forming Main Sequence derived in redshift bins over $0.4 < z < 4.0$ (squares), adapted from Delvecchio et al. (2021). Solid lines show fits of Eq. 1 to the data. The bending stellar mass $\mathcal{M}_0$ (see text for details) is shown as an empty star for each redshift bin (with its error). Notice how it rapidly increases from low- to high-redshifts.

Table 1. Fitting of the star-forming MS with bending, in different redshift bins.

z	log $\mathcal{M}_0$ $M_\odot$	log SFR0 $M_\odot$ yr^{-1}	γ
Lee et al. 2015			
0.36	10.03 ± 0.14	0.80 ± 0.07	0.92 ± 0.06
0.55	9.82 ± 0.11	0.99 ± 0.05	1.13 ± 0.11
0.70	9.93 ± 0.11	1.23 ± 0.06	1.11 ± 0.09
0.85	9.96 ± 0.09	1.35 ± 0.05	1.28 ± 0.12
0.99	10.10 ± 0.10	1.53 ± 0.06	1.26 ± 0.11
1.19	10.31 ± 0.15	1.72 ± 0.08	1.07 ± 0.10
Delvecchio et al. 2021			
0.37	10.06 ± 0.18	1.02 ± 0.11	1.1
0.67	10.25 ± 0.09	1.34 ± 0.09	1.1
1.00	10.30 ± 0.11	1.62 ± 0.10	1.1
1.49	10.56 ± 0.07	1.98 ± 0.06	1.1
2.11	10.92 ± 0.14	2.43 ± 0.13	1.1
2.93	11.15 ± 0.16	2.81 ± 0.15	1.1
3.96	11.00 ± 0.21	2.79 ± 0.19	1.1

Notes: Lee et al. (2015) measurements were presented originally in their work, we have only scaled-up the uncertainties (see text). The parameters for Delvecchio et al. (2021) are derived in this work.

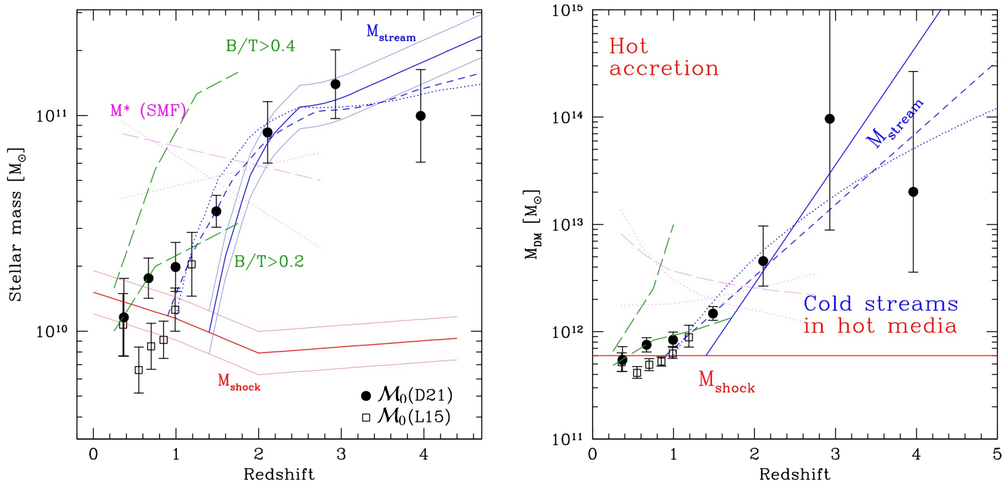

Fig. 2. Measurements of $\mathcal{M}_0$ are shown in both panels from L15 (empty squares) and D21 (filled circles), together with the M_{shock} and M_{stream} boundaries (DB06, solid blue line; from our fit to the $\mathcal{M}_0$ data as in Eq. 2, dashed blue line; based on Mandelker et al. 2020, dotted blue line), and stellar mass function' (SMF) M* values (Ilbert et al. 2013; linear fit to their redshift trends; solid for the total, dotted for those of quiescent/SF galaxies that are decreasing/increasing with redshift, respectively). The masses at which the average bulge/total (B/T) ratio in MS galaxies rises above 0.2 and 0.4 are based on Dimauro et al. (2022; green long-dashed). Measurements and relations are converted from stellar to halo masses (and vice-versa) using the SHMRs from Behroozi et al. (2013). In doing this we ignore the possible difference between the direct and inverse SHMR, which could have some impact at the highest masses (O. Ginzburg et al., in preparation). The effect of varying by ±0.1 dex the SHMR is shown by the thinner version of the DB06 tracks. This is larger than the statistical uncertainties of the best measurements (e.g., Shuntov et al. 2022) on average, but appropriate to encompass systematics from different methods (e.g., Behroozi et al. 2019).