KAOSS: turbulent, but disc-like kinematics in dust-obscured star-forming galaxies at $z \sim 1.3$–2.6

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ABSTRACT

We present spatially resolved kinematics of 31 ALMA-identified dust-obscured star-forming galaxies (DSFGs) at $z \sim 1.3$–2.6, as traced by Hα emission using VLT/KMOS near-infrared integral field spectroscopy from our on-going Large Programme "KMOS-ALMA Observations of Submillimetre Sources" (KAOSS). We derive Hα rotation curves and velocity dispersion profiles for the DSFGs. Of the 31 sources with bright, spatially extended Hα emission, 25 display rotation curves that are well fit by a Freeman disc model, enabling us to measure a median inclination-corrected velocity at 2.2 $R_{\rm d}$ of $v_{\rm rot} = 190 \pm 30\,{\rm km\,s^{-1}}$ and a median intrinsic velocity dispersion of $\sigma_0 = 87 \pm 6\,{\rm km\,s^{-1}}$ for these *disc-like* sources. By comparison with less actively star-forming galaxies, KAOSS DSFGs are both faster rotating and more turbulent, but have similar $v_{\rm rot}/\sigma_0$ ratios, median 2.4 ± 0.5. We suggest that $v_{\rm rot}/\sigma_0$ alone is insufficient to describe the kinematics of DSFGs, which are not kinematically "cold" discs, and that the individual components $v_{\rm rot}$ and σ_0 indicate that they are in fact turbulent, but rotationally supported systems in ~ 50 per cent of cases. This turbulence may be driven by star formation or mergers/interactions. We estimate the normalisation of the stellar Tully-Fisher relation (sTFR) for the disc-like DSFGs and compare it with local studies, finding no evolution at fixed slope between $z \sim 2$ and $z \sim 0$. Finally, we use kinematic estimates of DSFG halo masses to investigate the stellar-to-halo mass relation, finding our sources to be consistent with shock heating and strong feedback which likely drives the declining stellar content in the most massive halos.

Introduction

- Kinematics of dust-obscured star-forming galaxies (DSFGs) are poorly understood due to a lack of spatially resolved observations
  - Are they turbulent merger-driven systems like local ULIRGs?
  - Or do they resemble regular discs?

- Previous studies of DSFGs (about ~30 sources)
  - multiple kinematically distinct components
  - large amounts of turbulence
  - classified as interactions and/or mergers
    - Swinbank+2006, Alaghband-Zadeh+2012, Menendez-Delmestre+2013, Olivares+2016

Sample and Observations

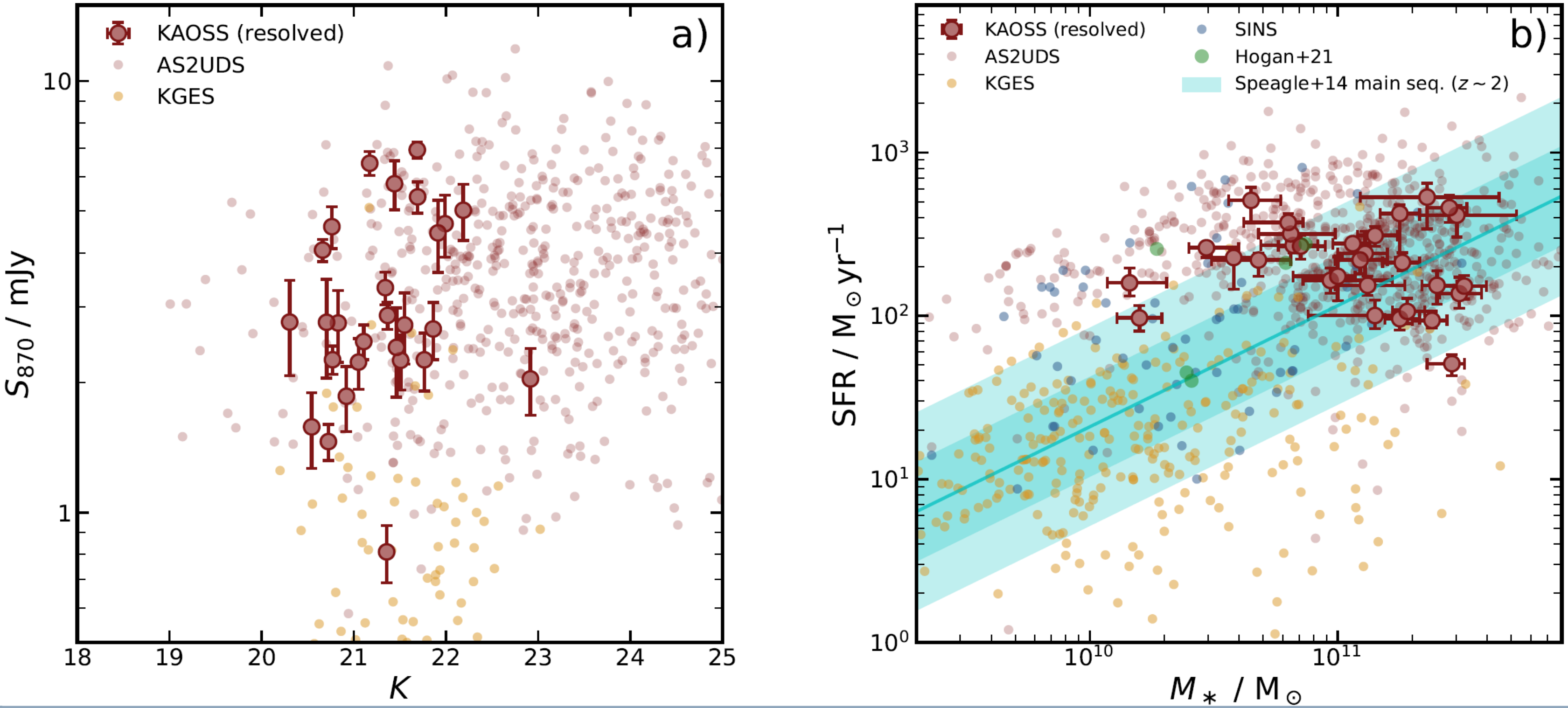
- KMOS Large Programme "KMOS+ALMA Observations of Submillimetre Sources" (KAOSS)
  - targeting ~400 DSFGs with KMOS in the HK filter
    - selected from four ALMA surveys (AS2UDS, AS2COSMOS, ALESS and BASIC, A3COSMOS)
  - covering Hα and/or [Oiii] emission lines at z ~ 1–3

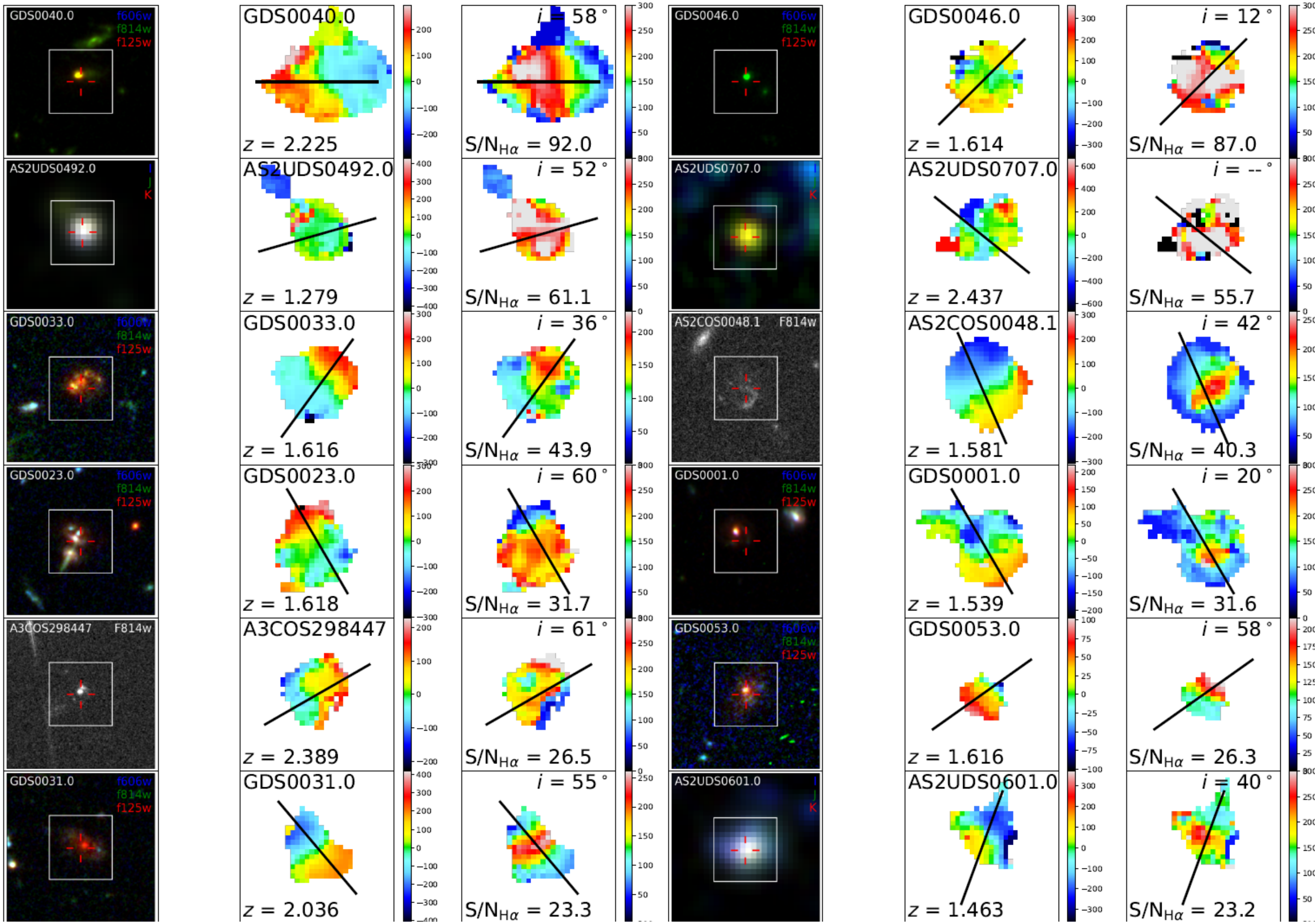
- This study selected KAOSS sources with Hα detections that are bright enough to search for resolved velocity structure

  ➔ 31 sources at z = 1.3-2.6

Sample

- representative of the range of 870-um flux in the DSFG population, but biased towards NIR-brighter sources
- an order of magnitude higher M* and SFR compared with K-selected SF galaxies at z ~ 1.5 (KGES)





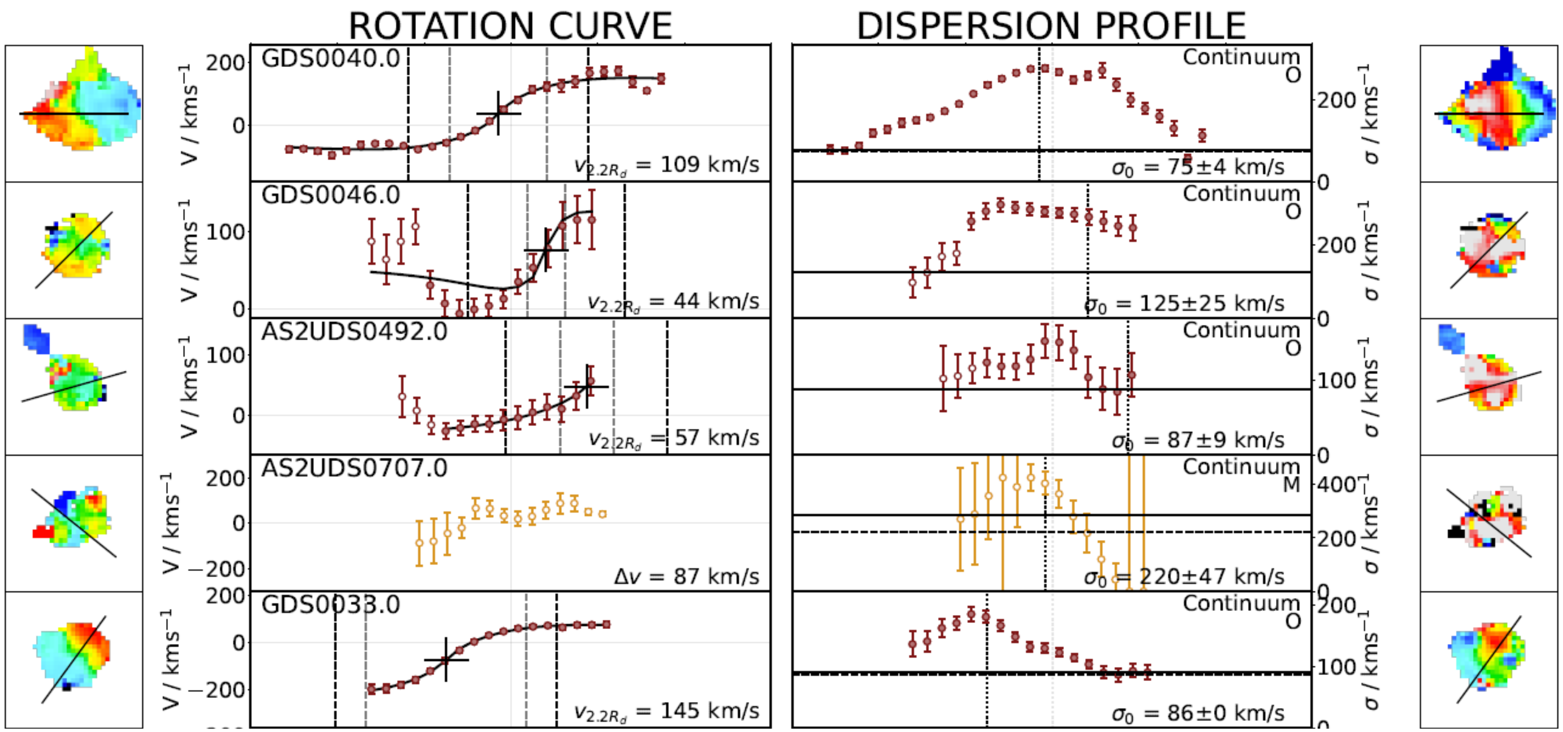
HST F160W or ground-based K-band images (left), velocity fields (middle) and velocity dispersion (right). Black lines indicate the kinematic PA.

Rotation Curve

Freeman disc model: $(v(r) - v_{\rm off})^2 = \frac{(r - r_{\rm off})^2 \pi G \mu_0}{h} (I_0 K_0 - I_1 K_1)$

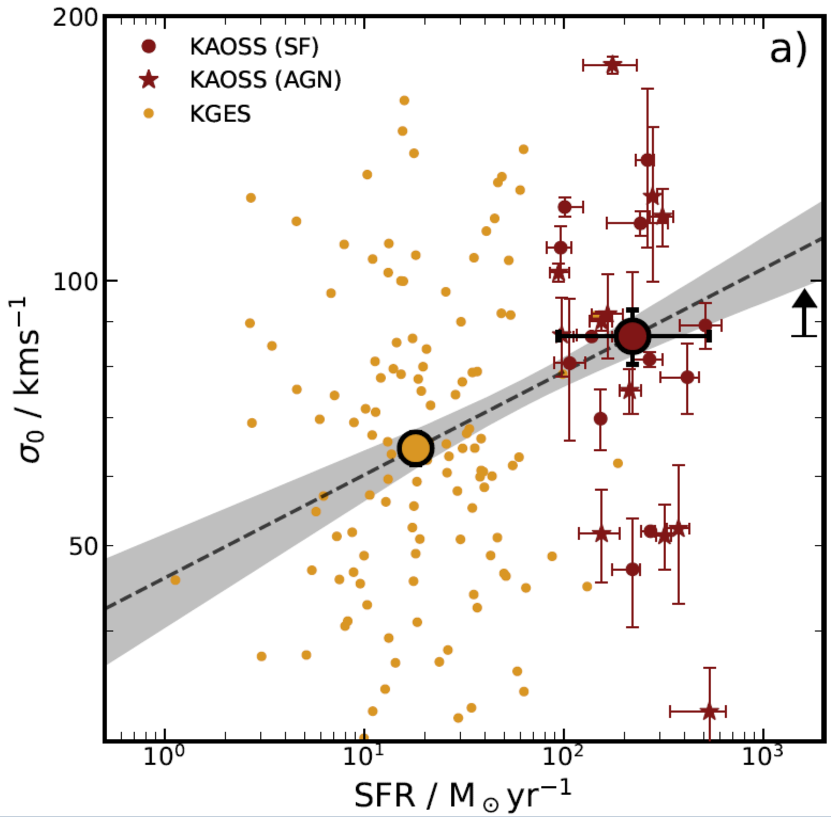
➔ 25 of the 31 sources (81%) are *disc-like*

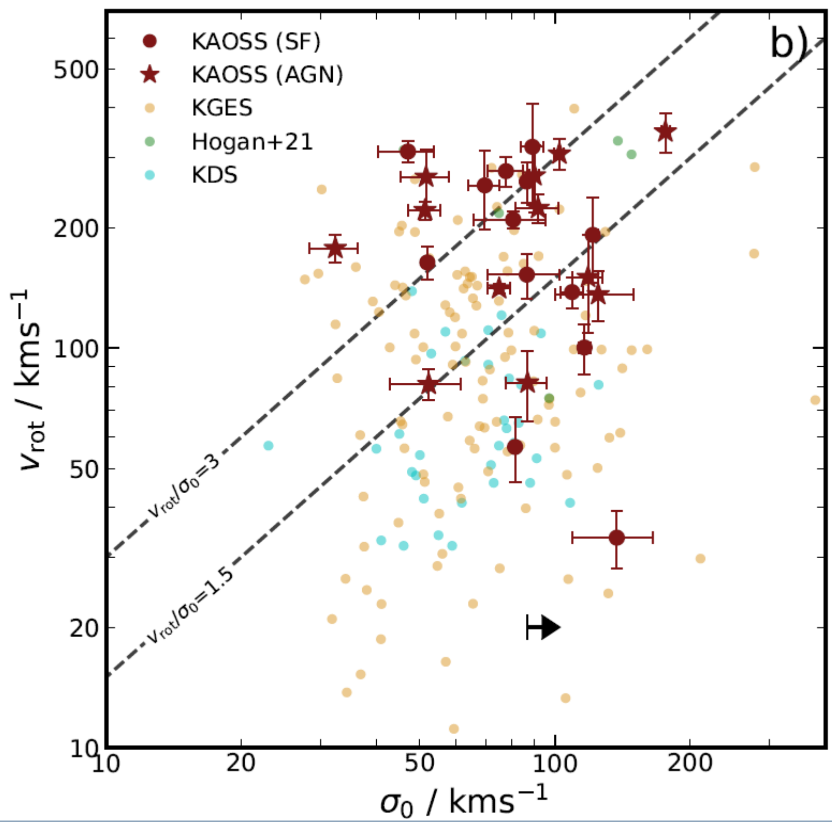
- no significant difference between disc-like sources and the rest in M*, SFR, and Av



Rotation Velocity and Velocity Dispersion

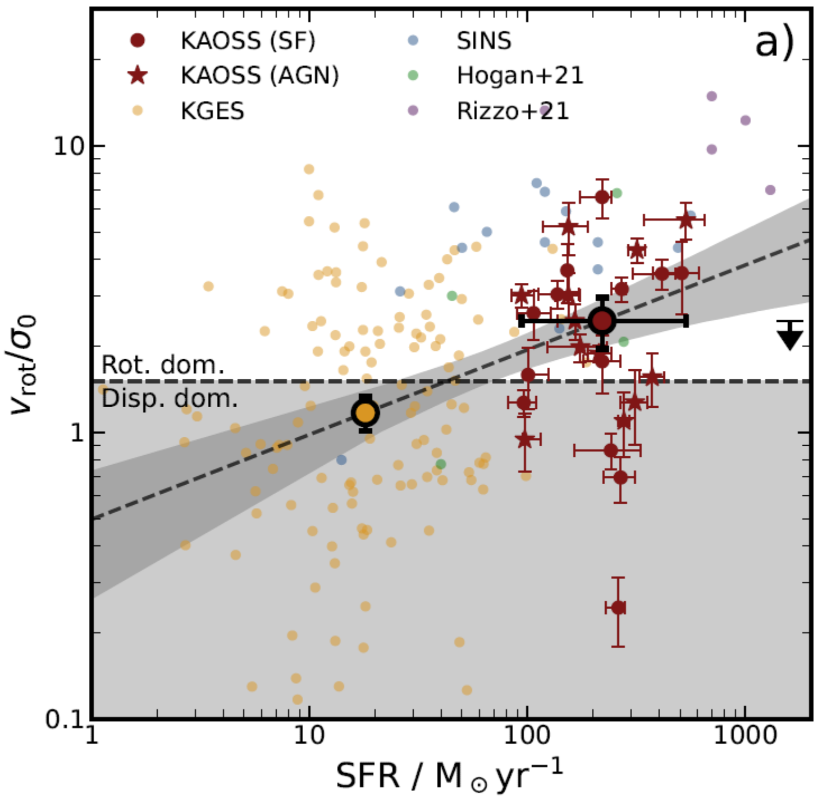
- DSFGs have higher V_{rot} and higher σ_0
  - The authors do not attempt to determine the origin quantitatively
  - but, correlation (5.3σ) between σ_0 and SFR ➔ a modest link

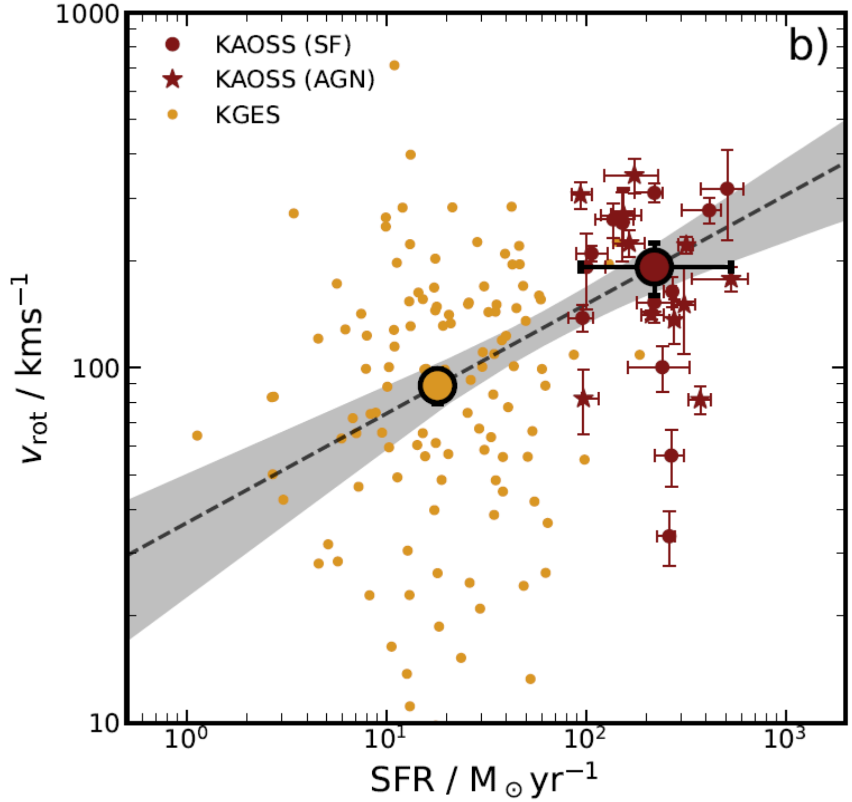




Rotationally Supported?

- 18 of the 25 sources (72%) have $V_{rot}/\sigma_0 > 1.5$
- Median value of $V_{rot}/\sigma_0 = 2.4$ is consistent with the KROSS comparison sample



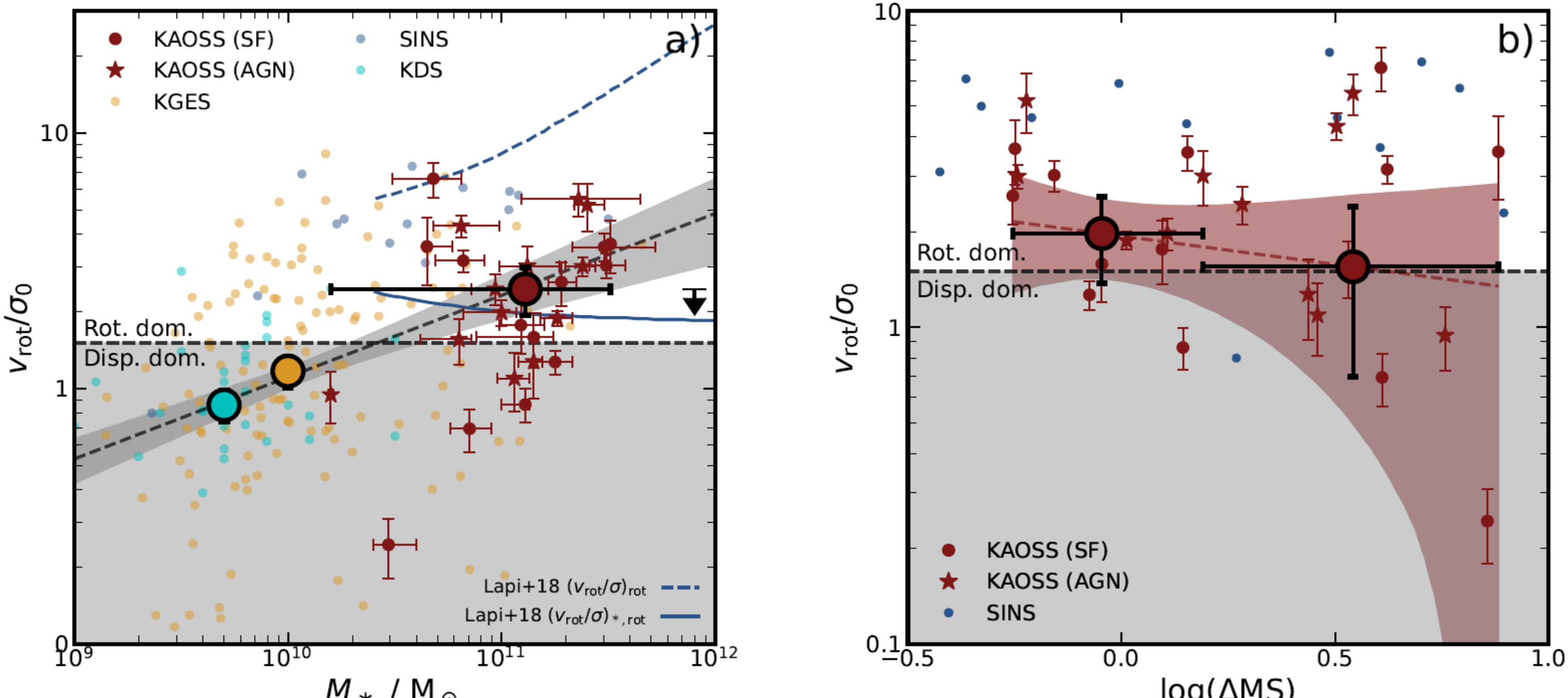


Rotationally Supported?

- Little evidence to suggest that DSFGs are more or less rotation-dominated than less active SFGs
- V_{rot}/σ_0 is not a useful parameter to describe the kinematics
- sources with $V_{rot}/\sigma_0 > 1$ are not dynamically "cold" discs: they are highly turbulent
- Correlation between V_{rot} –SFR, and σ_0 –SFR
  - ➔ cancel out the correlation between V_{rot}/σ_0 –SFR
- Correlation between V_{rot} –SFR likely reflects "main sequence" trend:
  - galaxies with larger stellar masses have higher SFR
  - galaxies with larger stellar masses have higher V_{rot}

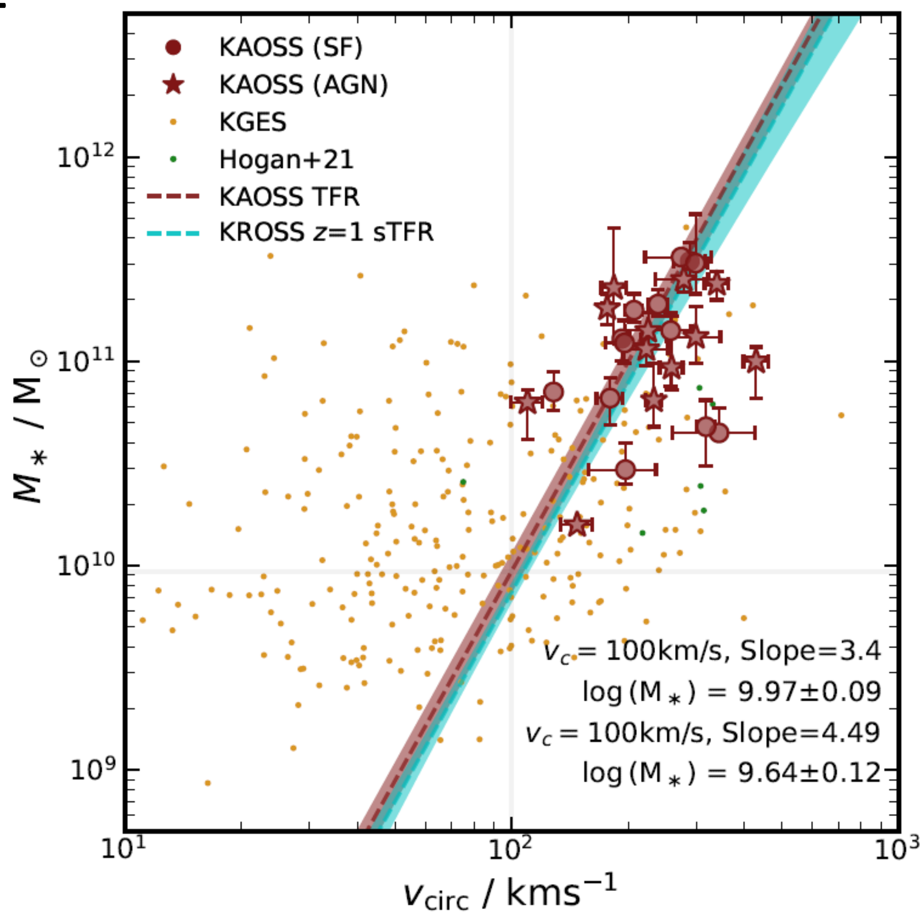
Rotationally Supported?

- Galaxies with higher M* are more rotation dominated
  - consistent with model predictions
- No evidence to suggest that MS-normalised sSFRs correlate with rotational support



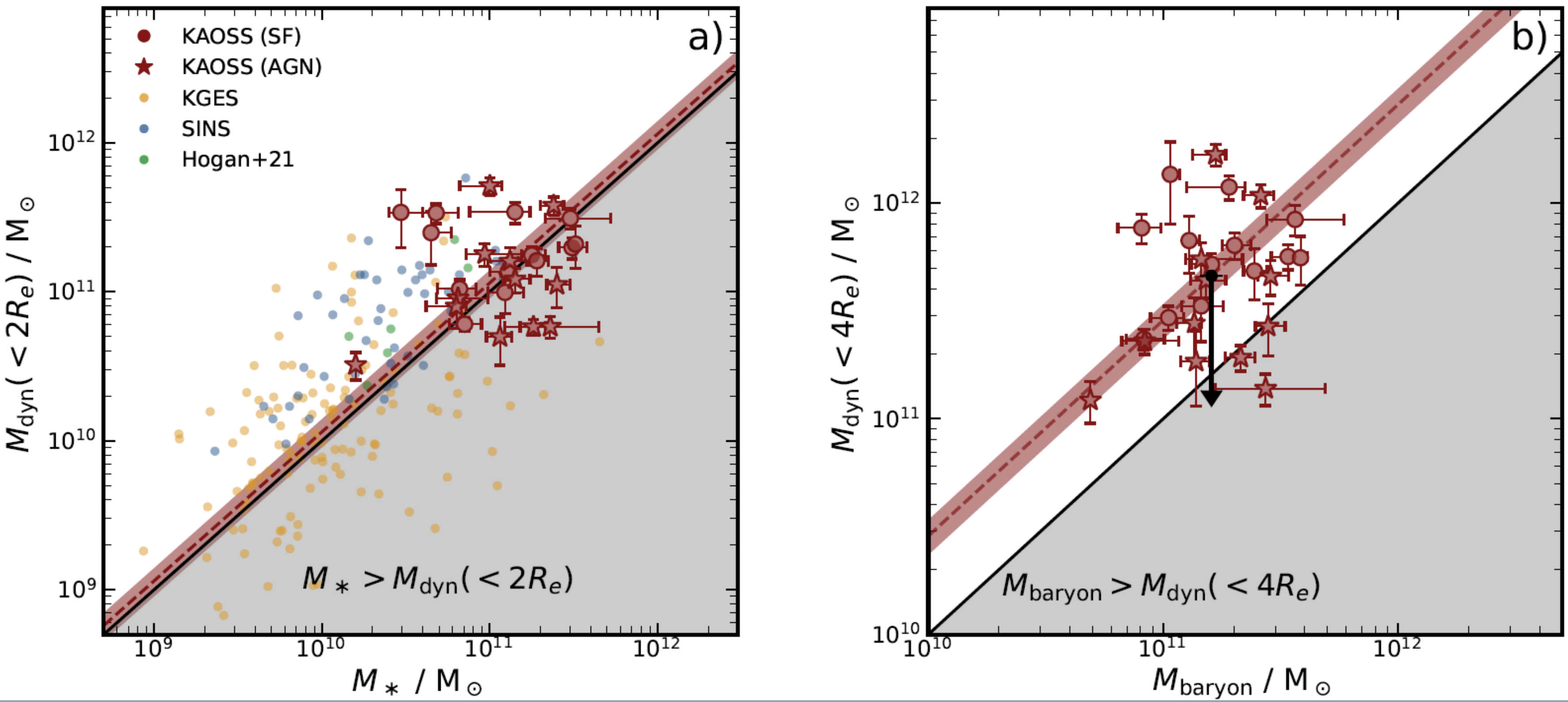
Tully–Fisher Relation (TFR)

- TFR connects the stellar or baryonic matter content of a galaxy to its dark matter
- No evolution in stellar TFR for *disc-like* galaxies from z ~ 0 to 2



Dynamical Mass

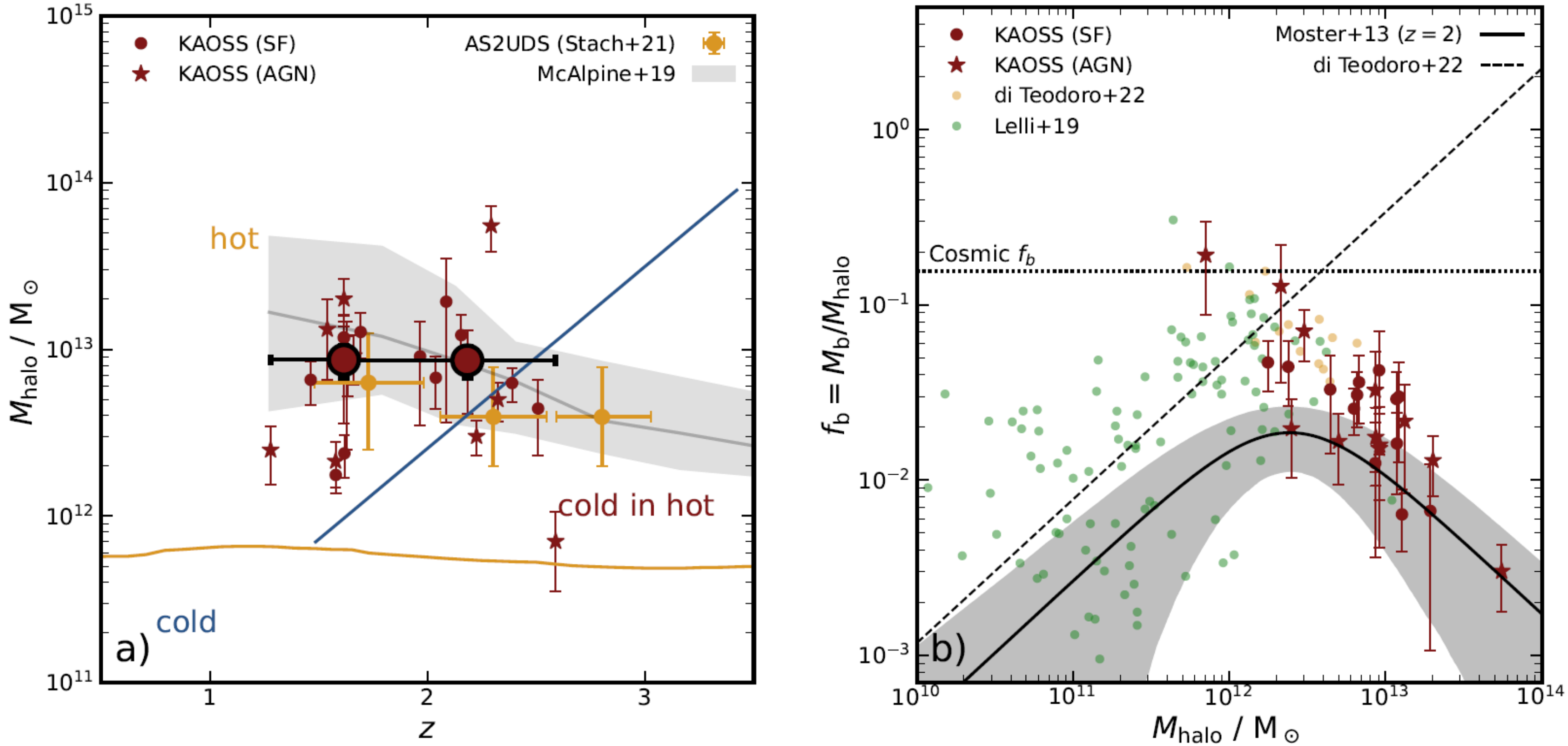
- No dark matter within a central radius ($2R_e$)
- $M_{baryon} > M_{dyn}$ ($<2R_e$) ➔ much of baryon (cold molecular gas) is situated on radii larger than the stars



Stellar-to-halo Mass Relation (SHMR)

- DSFGs have halo masses which suggest that they experience shock heating

➔ star formation can still be fed by cold streams?



Stellar-to-halo Mass Relation (SHMR)

- The majority of DSFGs are consistent with the SHMR relation (above the break at M_{halo} ~ 2e12 Msun)

➔ strong feedback which are inhibiting stellar mass growth