# Strongly baryon-dominated disk galaxies at the peak of galaxy formation ten billion years ago

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**In the cold dark matter cosmology, the baryonic components of galaxies - stars and gas - are thought to be mixed with and embedded in non-baryonic and non-relativistic dark matter, which dominates the total mass of the galaxy and its dark matter halo[1]. In the local Universe, the mass of dark matter within a galactic disk increases with disk radius, becoming appreciable and then dominant in the outer, baryonic regions of the disks of star-forming galaxies. This results in rotation velocities of the visible matter within the disk that are constant or increasing with disk radius – a hallmark of the dark matter model[2]. Comparison between the dynamical mass and the sum of stellar and cold-gas mass at the peak epoch of galaxy formation ten billion years ago, inferred from ancillary data, suggest high baryon factions in the inner, star-forming regions of the disks[3-6]. Although this implied baryon fraction may be larger than in the local Universe, the systematic uncertainties (stellar initial mass function, calibration of gas masses) render such comparisons inconclusive in terms of the mass of dark matter[7]. Here we report rotation curves for the outer disks of six massive star-forming galaxies, and find that the rotation velocities are not constant, but decrease with radius. We propose that this trend arises because of a combination of two main factors: first, a large fraction of the massive, high-redshift galaxy population was strongly baryon dominated, with dark matter playing a smaller part than in the local Universe; and second, the large velocity dispersion in high-redshift disks introduces a substantial pressure term that leads to a decrease in rotation velocity with increasing radius. The effect of both factors appears to increase with redshift. Qualitatively, the observations suggest that baryons in the early Universe efficiently condensed at the centres of dark matter halos when gas fractions were high, and dark matter was less concentrated.**

- SINFONI, KMOSによる z~1-2 SFGs の Hα IFS サンプル
  → 外側で turn over する rotation curve が (高いS/Nで) 確かめられた。
- 外側で flat curve にならない (= DM dominant にならない) 要因
  - Compact (dense), gas-rich star formation → baryon-dominated at inner disk
  - Large velocity dispersion → slowing down the velocity
  - Strong stellar & AGN feedback → DM halo not yet in equilibrium

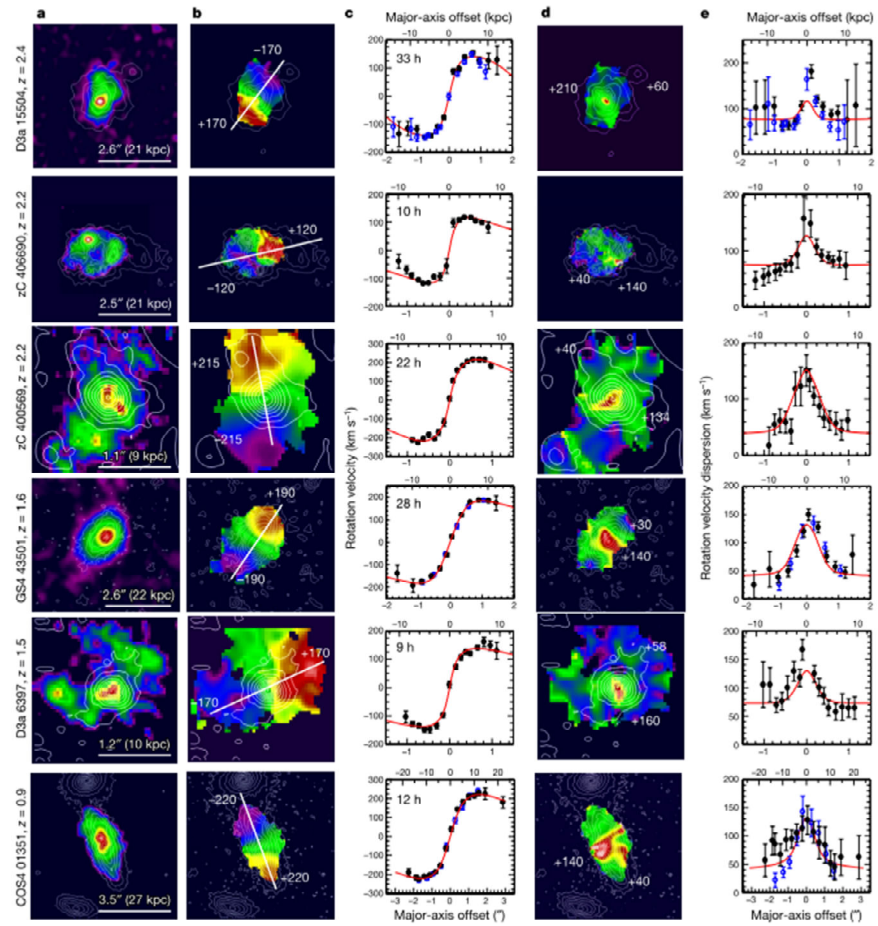


**Figure 1:** 左からHα分布、2D・1D速度構造、2D・1D速度分散。赤線はbulge + exp.disp + NFW DM halo モデルのbest-fit。

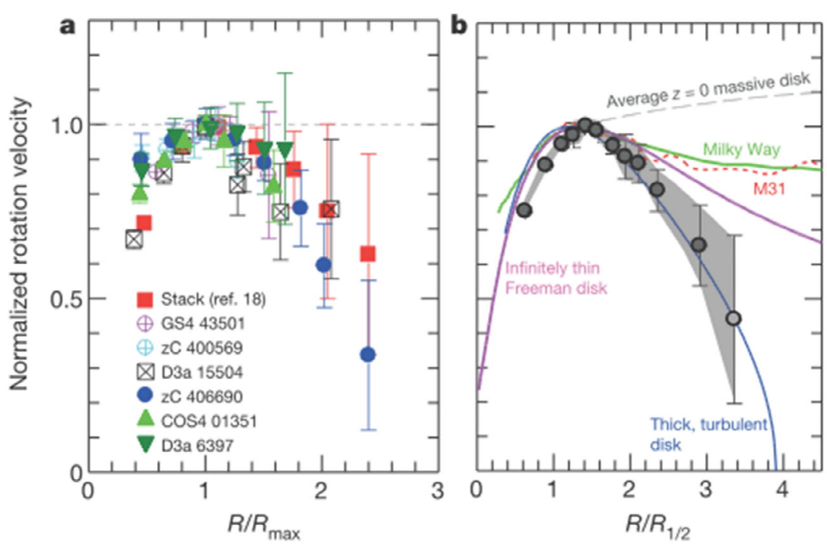


**Figure 2:** Hα rotation curve。
左は各サンプル。右は近傍銀河およびモデルとの比較。

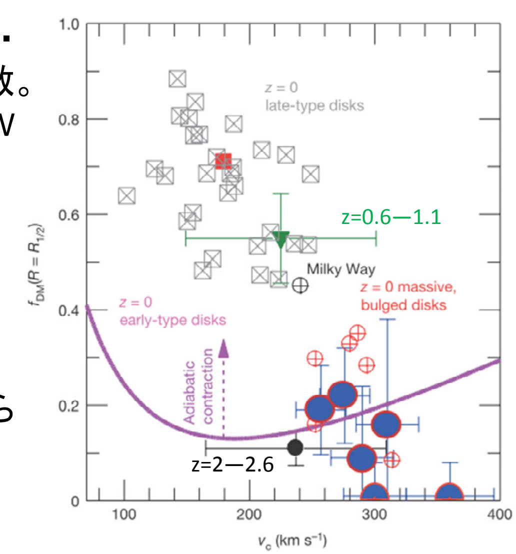


**Figure 3:** Rotation curveから見積もられるDM fraction。
●がFigure1のサンプル。