The KMOS Deep Survey: Dynamical measurements of star-forming galaxies at z ~ 3.5

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Introduction

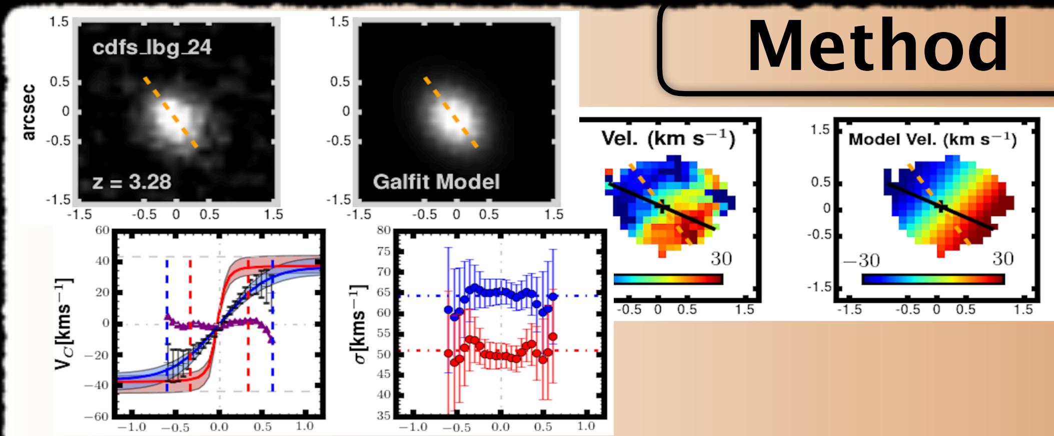
Evolution/Resolution

Interpreting observations of star-forming galaxies over cosmic time helps us understand galaxy evolution. In particular, dynamical measurements trace the gravitational force exerted on the particles in a galaxy, and monitor the partition of kinetic energy between rotational and random motions. By connecting the dynamical results of surveys spanning between high-redshift and the local universe, an evolutionary picture emerges whereby random motions decrease as galaxies stabilise to form a thin, rotating disk[1,2].

However there are two main problems – as we look further out, flux and spatial resolution decrease, both of which lead to observationally lower ratios of rotation velocity to velocity dispersion (which traces the partition of gravitational support). On top of this, star-forming populations may not form an evolutionary cohort. However, progress can be made in disentangling dynamical evolution from spatial resolution effects by observing large samples of typical star-forming galaxies at high-redshift, with beam-smearing effects taken into account.

With the KMOS Deep Survey (KDS), we have observed 78 galaxies at z = 3.5 with the KMOS IFUs in order to further understand the behaviour of star-forming galaxies in the epoch of galaxy formation. In this poster we discuss the dynamical properties of these galaxies.

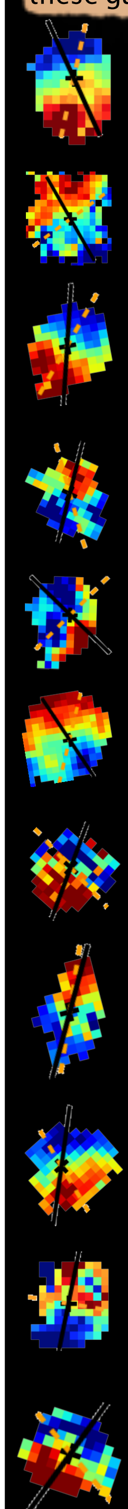
Method

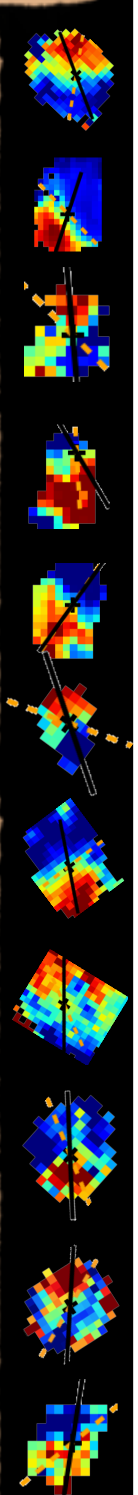


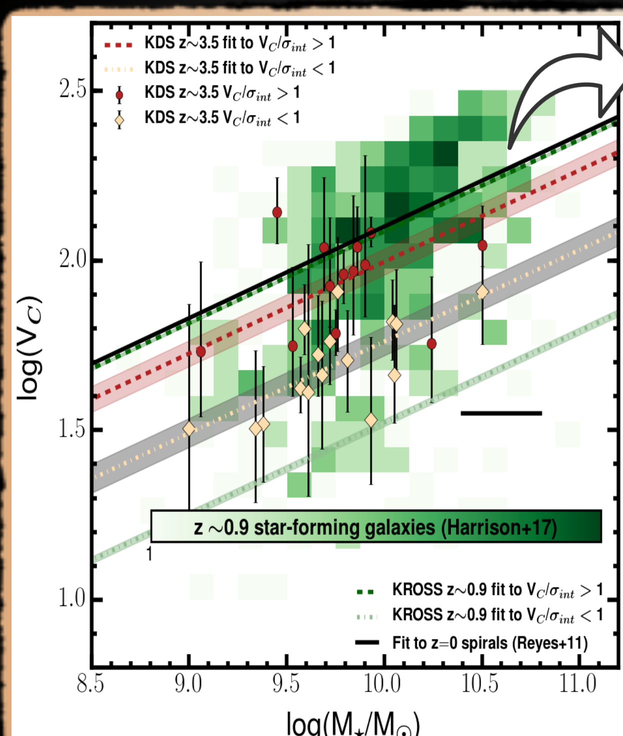
We were interested in extracting the sizes, rotation velocities and velocity dispersions (tracer of random motions) of a representative sample of isolated star-forming galaxies. Our chosen method for doing so is briefly summarised below.

- We visually inspect the high-resolution HST H-band images to remove merger candidates and fit exponential light profiles with GALFIT to measure disk sizes (top figure above)
- We fit a model arctangent velocity field, convolved with the PSF of the observations, to the observed velocity field inferred from the [OIII]λ5007 emission line. The rotation velocity is extracted from the intrinsic model at twice the half-light radius (middle right and bottom figures above)
- Using information from the fit, we correct the observed velocity dispersion field and extract an estimate of the intrinsic dispersion

Using this morpho-kinematic information we define an 'isolated field sample' of 33 KDS galaxies and construct rotation-dominated and dispersion-dominated subsamples on the basis of $V_C/\sigma_{int} > 1$.



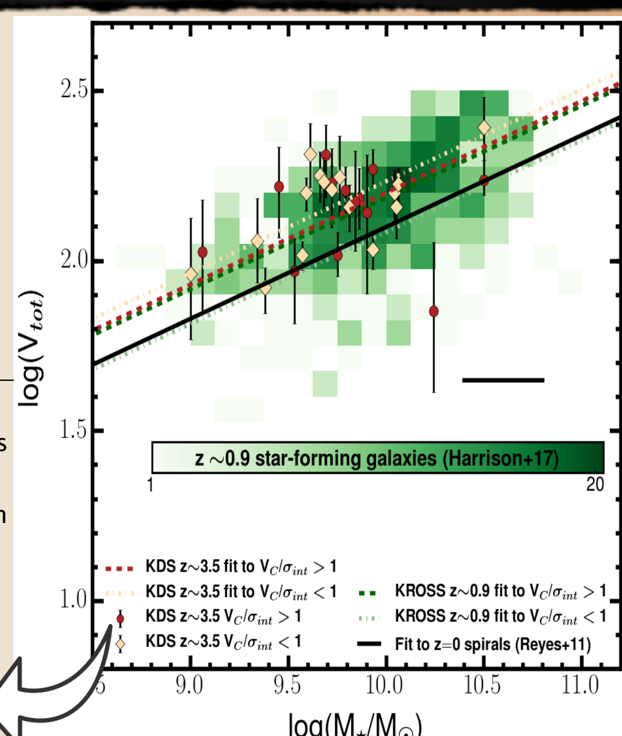


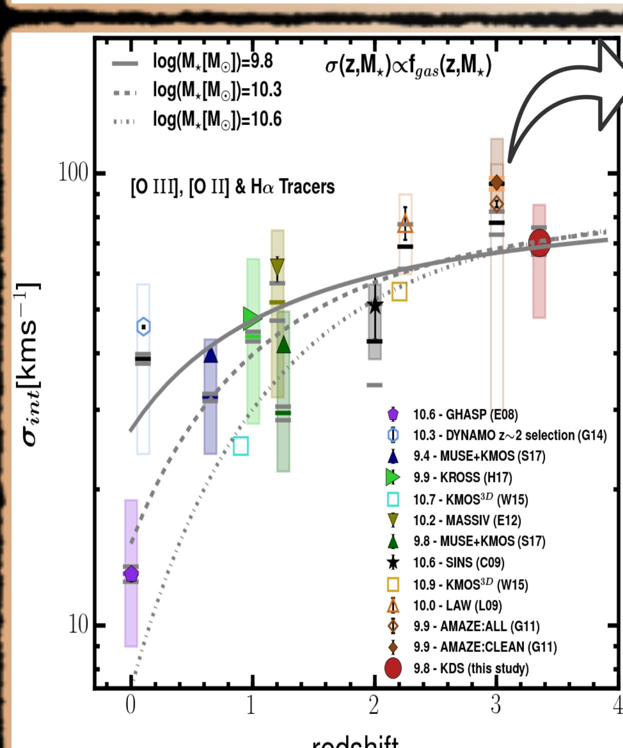


We plot the inverse stellar mass Tully-Fisher relation for the isolated field sample galaxies, and fit the rotation and dispersion-dominated subsamples separately (red and beige symbols respectively). The zero-points fall below the relation defined at z = 0[3] and at z = 0.9[4], suggesting a decrease in rotation velocity at fixed stellar mass (in contrast to results from AMAZE[5]). This may be the result of a larger contribution from velocity dispersions towards gravitational support.

Results – I

To follow this up, we compute a 'total' velocity, which contains a contribution from velocity dispersions. In the total velocity vs. stellar mass plane (right), the discrepancy between rotation and dispersion-dominated galaxies is reduced and consequently the full galaxy samples follow a single relation which is offset to higher velocities at fixed stellar mass in comparison to the local sample. To explore the evolution of this scaling relation, it is important to include the dispersion contribution in order to get the 'full picture' (see also [6]).

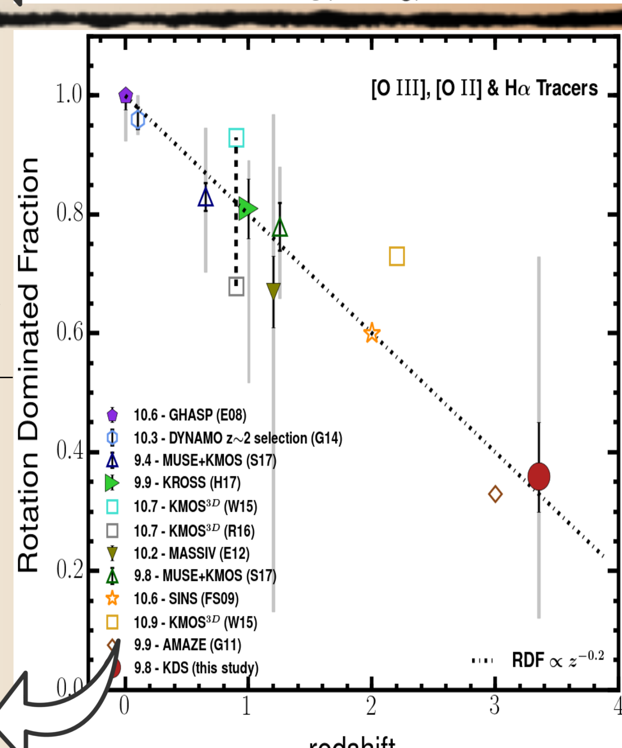




Turning to the velocity dispersions, we measure the average intrinsic value found in several carefully selected comparison samples (left). The increase with redshift appears to be related to the increase in galaxy gas fractions[1], governed by the mean stellar mass of the samples. Turbulence, sustained by stellar feedback and gravitational instabilities[7] also boosts the observed dispersions and complicates the interpretation of random motions as simply providing gravitational support.

Results – II

As a result of the low rotation velocities and high velocity dispersions, the fraction of galaxies dominated by ordered rotation is declining with increasing redshift, dropping to 1/3 at z = 3.5 (right). This suggests that typical star-forming galaxies at z > 2.5 are dominated by pressure support.



Conclusions

- The RDF of star-forming galaxies drops with redshift as a result of low velocities and high velocity dispersions
- We must account for pressure support when searching for evolution in the stellar mass Tully-Fisher relation

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based on arxiv:1704.06263

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