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Redshift Evolution of the Galaxy Velocity Dispersion Function

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We present a study of the evolution of the Velocity Dispersion Function (VDF) to z=1.5 in the UDS and NMBS Surveys, using velocity dispersions inferred from stellar mass, size and Sérsic index. We see that the VDF flattens with redshift. It appears that galaxies with low inferred velocity dispersions become more common and high dispersion galaxies become less common with time.

Introduction

Velocity dispersion

Stellar velocity dispersion is a fundamental property of galaxies. It is a key parameter in the Fundamental Plane for early-type galaxies and correlates strongly with many other galaxy properties, such as specific star formation rates, color and black hole mass. Furthermore the evolution of an individual galaxy's velocity dispersion carries information about the mechanisms responsible for its growth.

Velocity Dispersion Function (VDF)

The galaxy VDF has been measured directly at z~0 using the SDSS. The observational evidence of the evolution of the VDF could constrain modes of galaxy growth, provide avenues for direct comparisons with simulations and give clues about the growth of supermassive black holes.

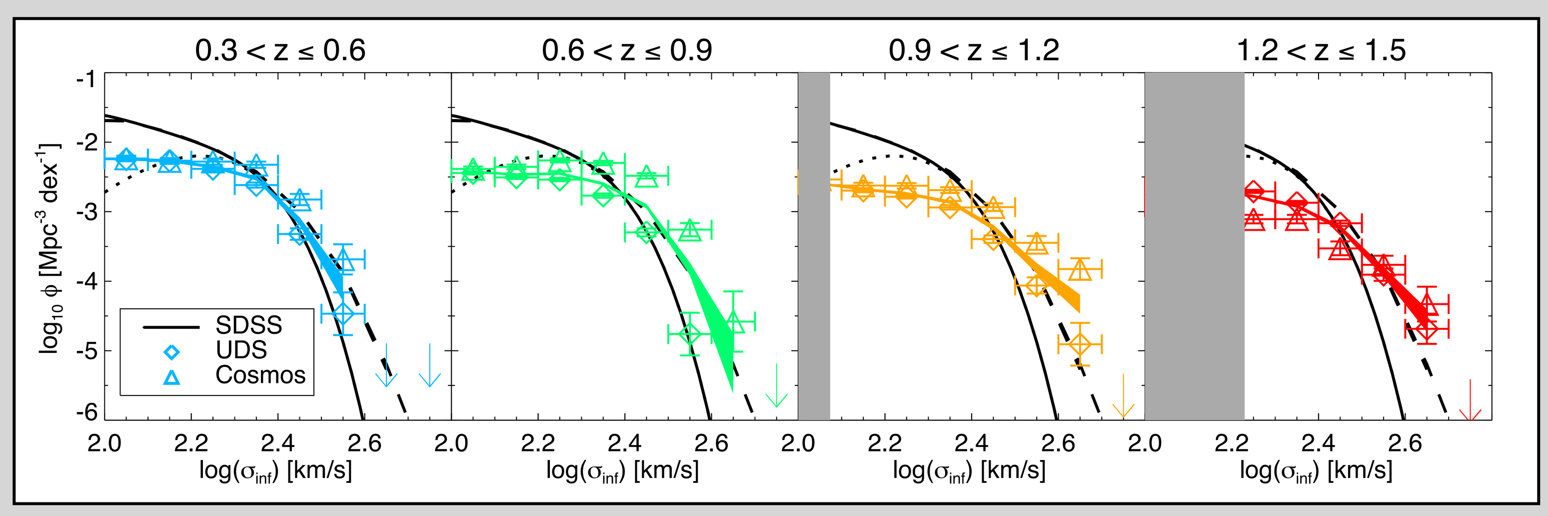
Measuring the VDF at higher redshifts

Although direct measurement of stellar velocity dispersions are possible out to z~1.5, they become extremely expensive, rendering the direct measurement of velocity dispersions of thousands of galaxies necessary to probe the VDF untenable.

The Evolving Velocity Dispersion Function

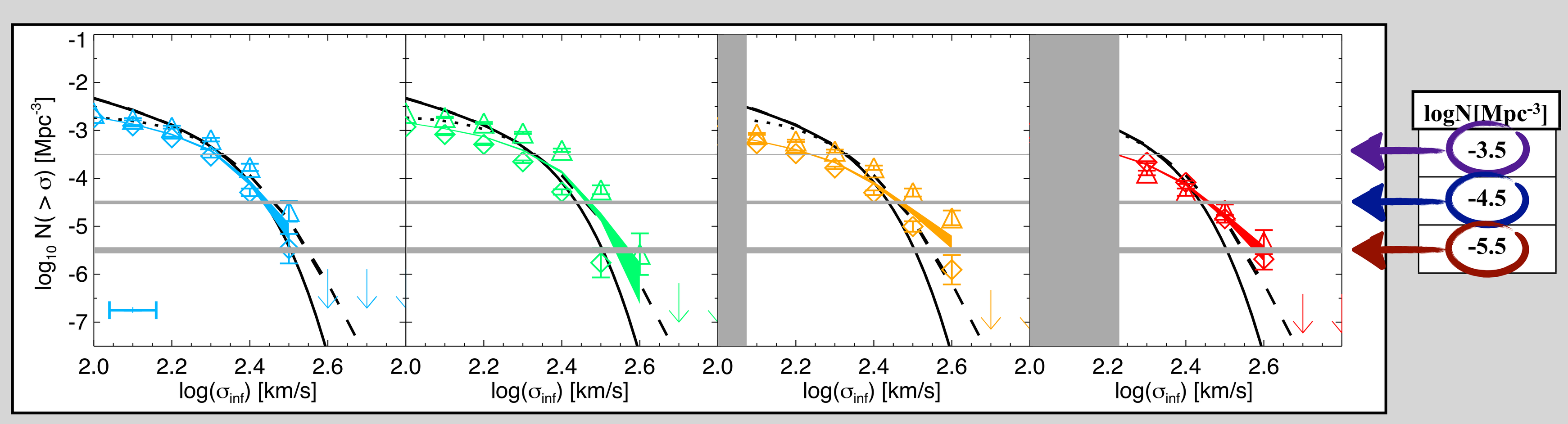
The inferred VDF

The inferred VDF at each redshift bin is shown in color, as compared to the local Sheth (2003) VDF.



The cumulative inferred VDF

We highlight three number density thresholds at which the behavior is distinct: increasing, constant and decreasing with time.



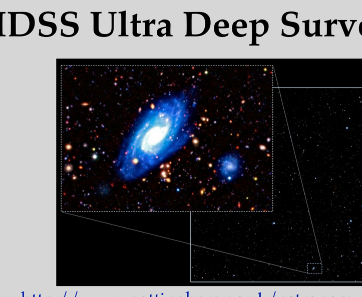
Data

Local Galaxies -- SDSS

We use several publicly available catalogs from SDSS DR7, including galaxies from 0.05<z<0.07 with good photometric measurements and low relative errors in velocity dispersion (<10%). We include photometric information from the main DR7 catalogs (Abazajian et al. 2009) and redshift and velocity dispersions from the Princeton pipeline. All velocity dispersions are aperture corrected to $r_e/8$ (Cappellari et al. 2006). We adopt the best-fit r′ band Sérsic (1968) effective radii from the NYU-VAGC (Blanton et al. 2005). Stellar masses are computed by the MPA-JHU group (http://www.mpa-garching.mpg.de/SDSS/DR7/).

0.3 < z < 1.5 Surveys

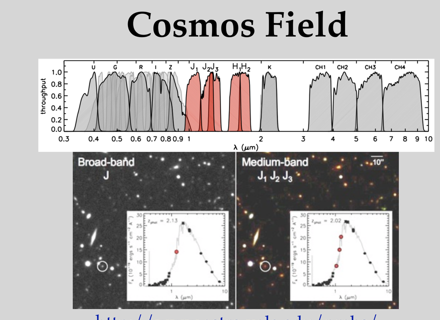
UKIDSS Ultra Deep Survey (UDS)



http://www.nottingham.ac.uk/astronomy/UDS/

The 0.77 deg² UKIDSS Ultra-Deep Survey (UDS) K-selected galaxy catalog (Williams et al. 2009, 2010) includes near-infrared (JHK), optical and 3.6/4.5 μm photometry. Sizes are measured in the J, H and K images for all bright sources (K<22.4).

Newfirm Medium Band Survey Cosmos Field



http://www.astro.yale.edu/nmbs/

The 0.21 deg² NEWFIRM Medium Band Survey (NMBS) of the Cosmos field (Whitaker et al., 2011) includes medium-band NIR (J1,J2,J3,H1,H2,K), optical (ugriz) and IRAC imaging and MIPS 24μm data. Sérsic models for all bright galaxies (K<22) are measured from Ks WIRDS 0''.186 pixel image (Bielby et al., in prep) and ACS F814W (v.1.3) mosaic (Scoville et al. 2007).

Photo-z and SED fitting

Photometric redshifts for all galaxies were calculated using the EAZY code (Brammer, van Dokkum, & Coppi 2008). Stellar masses were computed using FAST (Kriek et al. 2009), from Bruzual & Charlot (2003) models with Solar metallicity and a Chabrier (2003) IMF.

Inferred velocity dispersions

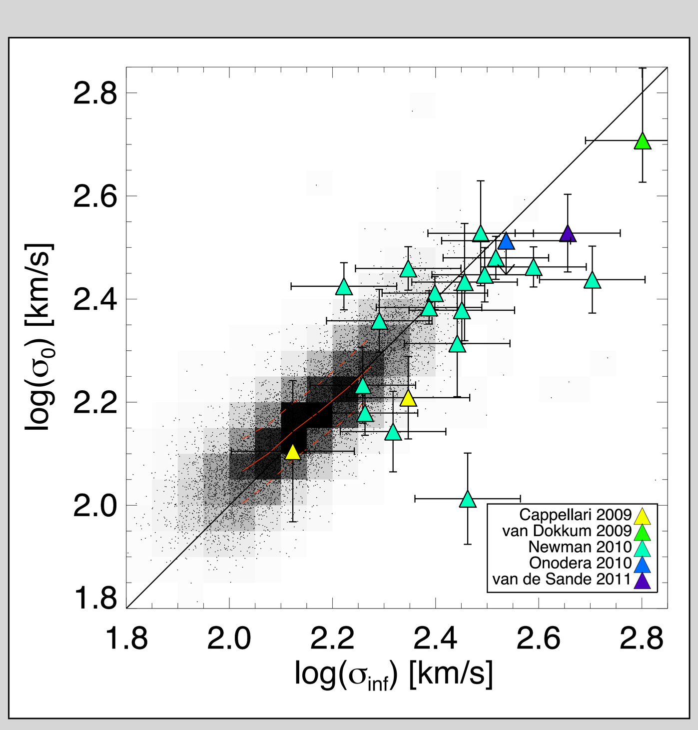
Velocity dispersions are calculated for all high-z galaxies in two bandpasses and interpolated to the rest-frame r′ band to minimize bandpass effects.

Inferred Velocity Dispersion

$$\sigma_{\mathrm{inf}} = \sqrt{\frac{GM_{\mathrm{dyn}}}{K_v(n)r_e}} = \sqrt{\frac{GM_\star}{K_\star(n)r_e}}$$

Sérsic dependent inferred velocity dispersion

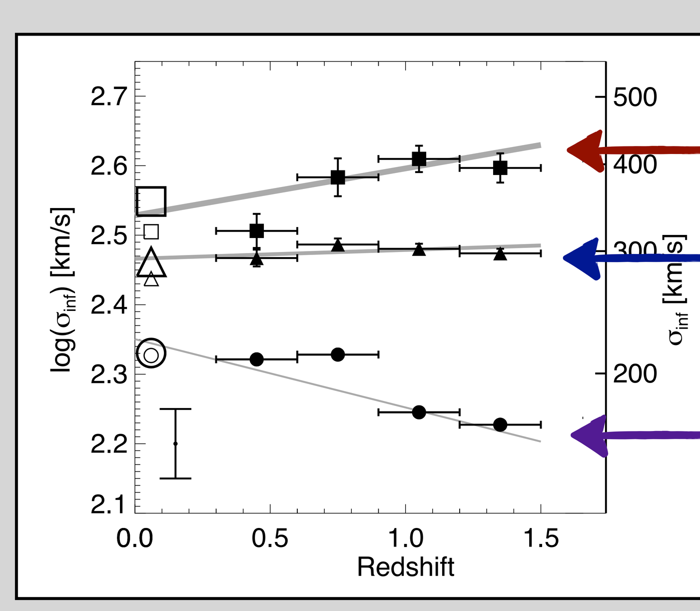
Taylor et al. (2010) showed that stellar mass is proportional to dynamical mass when structure is correctly taken into account. Following this framework, we define the inferred velocity dispersion based on the stellar mass and effective radius including a virial constant dependent on Sérsic parameter (Bertin, Ciotti, & Del Principe 2002) and the ratio between stellar and dynamical mass.



Calibrating inferred velocity dispersion

We use this sample to calibrate the constant $K_\star$ such that inferred velocity dispersion to predicts the measured central velocity dispersions for the SDSS galaxies. We include published z > 1 dispersion measurements, which are consistent with their inferred dispersions.

Differential Evolution of the VDF



logN[Mpc^-3] <	Slope
-5.5	0.066±0.059
-4.5	0.014±0.054
-3.5	-0.098±0.053

Evolution at fixed cumulative number density

To describe the flattening of the VDF, we show the evolution of the velocity dispersion at fixed constant number density to study behaviors of roughly the same populations of galaxies. The average velocity dispersion of galaxies below $10^{-3.5}$ Mpc^{-3} increases with time by a factor of ~1.4 from z~1.5 to 0, whereas the average dispersion of galaxies with lower number density are approximately constant or decrease with time.

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