HETDEX: Evolution and Environmental Drivers of Star Formation Over 12 Gyr

S.Jogee (UT), K. Gebhardt (UT), R. Ciardullo (PSU), C. Gronwall (PSU), S. Khochfar (MPE), S. Finkelstein (UT), R. Overzier (UT), C. Papovich (TAMU), Niv Drory (UNAM) and the HETDEX Collaboration

Summary

We will use the Hobby-Eberly Telescope Dark Energy Experiment (HETDEX; Fig. 1) spectroscopic survey, along with optical and near-IR photometry to conduct a powerful exploration of how galaxies form stars and grow their dark matter halos (Figs. 3+4) in different environments over $0 < z < 3.5$. This dataset will deliver orders of magnitude more spectroscopic redshifts, photometric redshifts, spectral energy distributions, and stellar masses than all previous surveys. Our study will use Lyα at $1.9 < z < 3.5$ over 28 deg^2, and [O II] λ3727 at $z < 0.5$ over 450 deg^2 from HETDEX to trace the cosmic web over two gigantic comparable comoving volumes (0.3–0.5 Gpc^3). This will enable us to explore galaxy growth across a very wide range of environments (Fig. 2) at two critical epochs: the era $1.9 < z < 3.5$ where massive proto-clusters form, the cosmic star formation (SF) and AGN activity peak, and galaxies grow much of their mass, and the era $z<0.5$ where more mature environments develop over the last 5 Gyr.

HETDEX and Ancillary Data

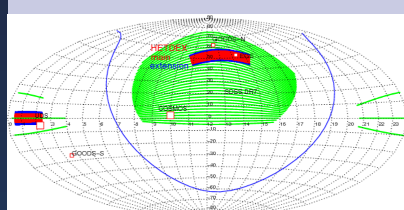

Fig. 1: HETDEX sky coverage in relation to other surveys

- HETDEX is a blind spectroscopic survey, covering a 300 deg^2 northern field and a 150 deg^2 equatorial strip over a 3-year period (Fig. 1). It will provide IFU data (R=800) over λ = 3500-5500 A, reach over 4 mag. deeper than SDSS, and trace 8x10^5 Lya emitters (LAEs) at $1.9 < z < 3.5$, 10^6 [O II] emitters at $z<0.5$, 10^5 AGN at $z < 3.5$.
- The Dark Energy Survey (DES) and Subaru Hyper Suprime-Cam (HSC) surveys will provide deep optical imaging over the HETDEX field.
- The Spitzer-HETDEX Exploratory Large Area (SHELA) provides deep IRAC data over 28 deg^2 of HETDEX.

A powerful leverage on environment galaxy growth at $1.9 < z < 3.5$

Our study at $1.9 < z < 3.5$ will focus on the 28 deg^2 field covered by HETDEX, DES, and SHELA where :

- HETDEX will provide 200,000 *spectroscopic redshifts from LAEs -- over an an order of magnitude larger than all current spectroscopic surveys.*
- It will measure the local density field, bias, and halo mass to an *unprecedented accuracy of σ(bias)/bias=0.02 and σ (log(M_h)=0.04 dex for log(M_h/M_o) = 12–13.*
- At $1.9 < z < 3.5$, we map a huge comoving volume of 0.5 Gpc^3, hosting several 10s-100s high mass (log(M_h/M_o)>13.5) halos (Fig. 2a) -- *the first statistically significant sample of proto-clusters at z > 2.* This volume *hosts the progenitors of several 10s of Coma-type clusters, over 100 Virgo-mass systems, and several 100s of group-like structures* (Fig. 2b).

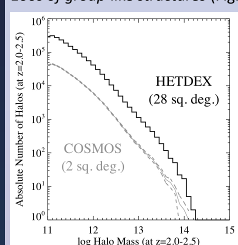

Fig. 2a: Based on the Millennium 1 simulation, which covers a 0.3 Gpc^3 volume, , we expect that at $2 < z < 3$, the 28 deg^2 HETDEX/SHELA field will contain 10-100 massive (log(M_h/M_o)>13.5) halos -- over an order of magnitude more than the 2 deg^2 COSMOS survey.

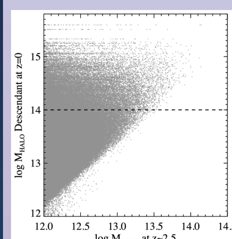

Fig. 2b: These massive (log(M_h/M_o)>13.5) halos at z = 2.5 will evolve into today's rich clusters (log(M_h(z=0)/M_o)>14), such as Coma and Virgo.

- SHELA IRAC data will provide stellar masses *for over 300,000 galaxies,* down to 1–3 × 10^{10}M$_o$, *nearly a dex below the characteristic stellar mass at z = 2.*
- DES will provide SEDS + photometry for 10^6 galaxies.

Science Questions

- How does environment manifest itself on different scales (e.g., halo mass, galaxy density, galaxy mergers)?
- When and where does the relation between SF, color and environment emerge?
- At z>1, is SF enhanced or suppressed in regions of highest densities or in the most massive halos (Fig. 3)?

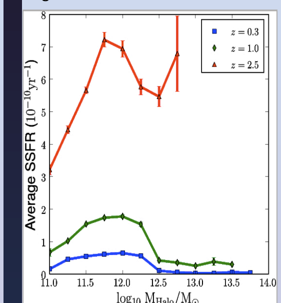

Fig. 3 -- HETDEX will map the specific SFR (SSFR) as a function of dark halo mass. The plot shown theoretical predictions (Khochfar & Silk 2011): the mean SSFR rises with redshift due to shorter cooling and dynamical times. The SSFR drops in halos with mass > 10^{12} M$_o$ due to the cooling shut off applied.

- How efficiently do galaxies of different halo masses build their stars? The relation between stellar and halo mass at z > 1 is under debate, with a large mismatch between theory and empirical abundance matching. HETDEX/SHELA will make one of the most accurate measures of (M_*/M_h) over $0 < z < 3.5$ (see Fig. 4)

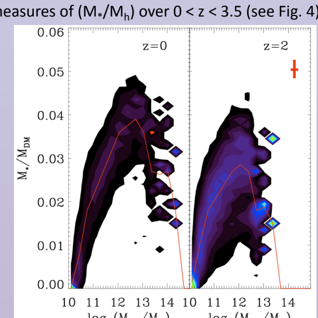

Fig. 4 -- The Stellar-Halo Mass Relation: The red error bar in the RHS panel is the statistical error we expect from HETDEX/SHELA for a halo of log(M_h/M_o)=12.5 at z=2.5. The two panels show theoretical predictions (Khochfar & Ostriker 2008) : the efficiency of stellar mass growth rises with dark halo mass till feedback and environmental effects reverse the trend above some mass

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