Downsizing of Star Formation: Weighing Dark Matter Haloes Hosting Dusty Star-Forming Galaxies

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• Goal: Investigate the redshift evolution of physical properties of Dusty Star Forming Galaxies (DSFGs) responsible for the Cosmic Infrared Background (CIB)

• Physical properties of interest:
  ○ Dark matter halo mass
  ○ IR Luminosity

→ Star formation rate
Dark matter physics → Evolution to large scale structure

Dark matter collapses into halos → Galaxies form and evolve inside
Dark matter halo mass is correlated with galaxy properties.
→ e.g. Stellar mass, stellar growth rate

Behroozi et al. 2013
How exactly do galaxies populate dark matter halos?
- Linking the bulk of star formation in the universe to the dark matter halo masses of the host galaxies
Halo Occupation Distribution Model

Zehavi et al. 2004

Volume-limited Sample

K. Hall - KICC10 - Sept. 19, 2019 - pages.jh.edu/~khall33
\[ <N(M)> = <N_{\text{cen}}(M)> + <N_{\text{sat}}(M)> \]
Herschel Space Observatory SPIRE Maps

Herschel Stripe 82 Survey (HerS)

HerMES Large Mode Survey (HeLMS)
Herschel Space Observatory SPIRE Maps

SPIRE beam sizes at 250, 350, and 500 μm are 18", 25", 36", respectively → confusion limited

Nguyen et al. 2010
Cross-correlate SPIRE Maps & Quasar Catalog
A physically-motivated model: Dark matter

- Dark matter halo clustering is fixed
A physically-motivated model: Dark matter

- Quasar HOD, bias from other studies

\[ <N(M)> = <N_{\text{cen}}(M)> + <N_{\text{sat}}(M)> \]
A physically-motivated model: Dark matter

Relate IR emission to the most efficient halo mass at hosting DSFGs, $M_{\text{eff}}$

$$<N(M)> \rightarrow f(M) \propto N \times L_{\nu}(M)$$
Consistency with cosmic star formation rate density

\[ \rho_{\text{SFR}} \left[ M_\odot \text{yr}^{-1} \text{Mpc}^{-3} \right] \]

\[ 10^{-1} \quad 10^{-2} \]

\[ 0.5 \quad 1.0 \quad 1.5 \quad 2.0 \quad 2.5 \quad 3.0 \quad 3.5 \]

- Evolving QHOD
- Constant QHOD
- Madau & Dickinson 2014
- Gruppioni et al. 2013
- Rodighiero et al. 2010

Hall et al., 2018 MNRAS, 480, 149
Most efficient halo mass at hosting DSFGs

Downsizing:

Mean halo mass hosting DSFGs

Archaeological Downsizing:

More massive halos host galaxies that assembled their stars earlier (Behroozi et al. 2013; Tojeiro 2016; Cochrane et al. 2017)
One more reason this study is important...

Quantifying the clustered infrared background = Quantifying a bias in other stacking analyses

- SEDs of quasars in the far-infrared, then the clustered background component needs to be understood/quantified

⇒ Other very exciting work by me and my research group and the ACT collaboration
See also: Crichton, Gralla, Hall et al. 2016
Summary: Clustering of star forming galaxies around quasars

- Halo masses of DSFGs as a function of $z \Rightarrow$ Cosmic downsizing
  1) Most efficient halo mass at hosting DSFGs decreases from $z \sim 3$ to $z=0.5$
  2) Mean halo mass of DSFGs indicates galaxies in today’s most massive halos formed their stars at higher $z$
  3) $\rho_{SFR, DSFG}$ consistent with $\rho_{SFR, cosmic}$

- Cross-correlations are extremely useful for studying quasars, their clustered environments, and clustering in general