CCAT

Characterizing Dusty, Star-Forming Galaxies at High Redshifts

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CCAT High-z Galaxy Science Goals via Large-Area Mapping

• Measure the luminosity function of dusty star-forming galaxies to $z = 5$ (resolving the majority of the CFIRB and identifying multi-$\lambda$ counterparts)
• Determine the dark matter environments of star-forming galaxies via clustering
• Determine the physical properties of the interstellar media of galaxies
Measuring the Obscured Star Formation in Galaxies

For $z > 1$, the luminosities of dusty galaxies and their star formation rates can be measured at submillimeter wavelengths without extrapolation from other wavebands.

Arp 220 spectrum figure from http://www.mpi-a-hd.mpg.de/homes/decarli/science.html
Galaxy Surveys and Counterpart Identification

Large galaxy surveys are required and angular resolution of a few arcseconds is needed to reliably identify multiwavelength counterparts.

350 $\mu$m simulations based on Bethermin et al. (2011)
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CCAT 350 \(\mu m\) beamsize: 3.5”
Resolving the Cosmic FIR Background

CCAT will directly detect the galaxies that produce almost all the submillimeter extragalactic background.

Herschel: Oliver, et al. (2010), Bethermin et al. (2012)
SCUBA-2 CLS first results: Geach, et al. (2012), 140 sq. arcmin
CCAT: Based on Bethermin et al. (2011)
Measuring the Luminosity Function of Dusty, Star-Forming Galaxies

3 tier (0.15, 2, and 10 sq. deg.), 4 color (350, 450, 750, 850 μm), 2000 hour survey with CCAT first-light instruments.

An ALMA survey of the first two tiers only at 850 μm with 350 and 450 μm follow-up of detected galaxies would take 5x longer (the 10 sq. deg. survey would not be feasible).

Model luminosity functions from Bethermin et al. (2011)

The luminosity function will be measured below $L^*$ to $z = 5$. 
Identifying High-z Galaxies and Challenging Structure Formation Models

The number of $z > 4$ SFR $\sim 1000 \, M_\odot$/yr discovered by Herschel already stresses galaxy formation models; CCAT will go much deeper.

$z > 4$ galaxies will be identified as 350 $\mu$m “dropouts”.
Measuring Host Dark Matter Halo Masses with Clustering

Using clustering measurements, CCAT will link the star formation history and AGN activity of galaxies to the dark matter halos that host them.

Simulations from Galacticus and Grasil (Benson et al).
At the peak epoch of star formation, multiple CO lines will be detectable per galaxy.

Thousands of galaxies per sq. deg. detectable in [CII] 158 $\mu$m (also [OI] 63 and 145 $\mu$m, [OIII] at 52 and 88 $\mu$m, [NII] 122 and 205 $\mu$m).

With a 70 beam X-Spec, 1500 z’s could be obtained at $z = 5$ for $L_{\text{FIR}}^{11.5} = 10^{11.5} L_\odot$ in 1100 hours.
Conclusions: CCAT High-z Galaxy Science Goals via Large-Area Mapping

• Measure the luminosity function of dusty star-forming galaxies to $z = 5$ (with counterpart identification and redshifts from spectroscopy)
• Determine the dark matter environments of star-forming galaxies via clustering
• Determine the physical properties of the interstellar media of galaxies
Resolving the Cosmic FIR Background

With stacking, CCAT will resolve all the submillimeter extragalactic background.

- Herschel:
  - Oliver, et al. (2010)
  - Bethermin et al. (2012)

- SCUBA-2 CLS first results: Geach, et al. (2012), 140 sq. arcmin

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**Percent of the CFIRB Resolved**

- Herschel 350 um: 69% (24 μm stack), 15±3%
- S2CLS (early) 450 um: 58% (24 μm stack), 16±7%
- CCAT 350 um: 97% (1 source per 12 beams), 83% (1 source per 30 beams)