Resolving the Extragalactic Background into Normal Star Forming Galaxies with ALMA



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Data

Number (Resolving EBL

Extragalactic Background Light (EBL)



EBL have not been fully resolved...

Galaxy Bias

Counterpart

This work: <u>Largest dataset of multi-field deep ALMA</u> <u>-> Resolve EBL</u>

) (Anal<u>ysis</u>

Number) (Resolving EBL

L) (Galaxy Bias)

(Counterpart)

Sample Selection

Data

DATA: ALMA Band 6 & 7

• Our quite deep 4 ALMA data

+

• ALL ALMA data so far archived (2011/12 - 2015/3)



- Noise level < 0.1 mJy
- No too Bright/Extended Sources

<u>Total</u>: ~51 maps (~100 pointings) <u>Survey Area:</u> ~7arcmin² (Largest Survey) <u>Noise level</u>: 8.5 - 100 uJy

) (<u>Analysis</u>

Number) (Resc

Resolving EBL

) (Counterpart

Cluster Data (1 map)

Data

- Multiple image: Diego+14
- Optical Catalog: Diego+14, Coe+10
- Software: GLAFIC (Oguri 10)

(e.g., Ishigaki+15)

Simulated cluster modelling challenge

- Simulated clusters can be found here: <u>http://pico.bo.astro.it/~massimo/Public/</u> <u>FF/ares.html</u> [login: FFmodeler passwd:FFmagnify]
- Color image: <u>http://www.stsci.edu/~dcoe/FF/MAX/ares/</u>
- Natarajan, Meneghetti & Coe will compare the results provided by different modellers => ultimate goal: improve lens modelling I



Jean Paul KNEIB - Yale Frontier Fields Workshop - Nov 13, 2014

(Organized by D. Coe+)



Galaxy Bias

Mass model uncertainty is reported <u>~ 20-30%.</u>

Analysis

Resolving EBL

Galaxy Bias Counterpart

Field Data (50 maps)

Data



Number Counts



Number (Reso

Resolving EBL) (Galaxy Bias



Data Analysis

Resolve EBL -> Derive <u>Number Counts</u>





(e.g., Hatsukade+13, Ono+14, Carniani+15)

* All flux densities (1.1-1.3 mm) are scaled to 1.2 mm

) (Analysis

Number (Reso

Resolving EBL

Galaxy Bias) (Counterpart

Number Counts at 1.2 mm

Data



) (Analysis

Number) (Reso

Resolving EBL

Galaxy Bias) (Counterpart

Resolve the EBL

Data

- Almost fully (102±30%) resolve the EBL
- < 0.01 mJy sources might be negligible



What are the faint ALMA sources ?



Data

Number Counts (Resolving EBL



1. Statistical Approach: Cluster Analysis



Field-to-Field Scatter - Poisson error = Galaxy Bias

<u>Counts-in-Cells</u>

$$b_g^2 \approx \frac{\sigma_N^2 - \bar{N}}{\bar{N}^2 \sigma_V^2(z)}$$

(e.g., Robertson+10)

 b_g : galaxy bias σ_V : matter variance σ_N : dispersion of source counts N: mean source counts

Faint ALMA Sources

 $b_g < 4.1$ (ACDM->) $M_{DH} < 8 \times 10^{12} M_{sun}$ 1. Statistical Approach: Cluster Analysis

Analysis

Number

Resolving EBL



Data

Intro

Faint ALMA Sources
 b_g < 4.1

Galaxy Bias

Counterpart

- <u>SMGs / DRGs / pBzK</u>
 b_g ~ 5 7
- <u>sBzK / LBGs / LAEs</u>
 b_g ~ 2 3

Faint ALMA Sources = sBzK, LBGs, LAEs?

Data

Number Counts (Resolving EBL

BL) (Galaxy Bias



2. Individual-basis Approach: Optical Counterparts

- Optical counterparts in SXDS, A1689 with rich multiwavelength data
- 25 sources in these fields effectively (N_{det} N_{spu})
- 15/25 Sources (~60%) have optical counterparts



Number

Resolving EBL

Galaxy Bias Counterpart

Photometric Properties

Data

Bzk & LBG Selection AGN or SB? DS-31 Arp220 (SB) Old galaxies star-forming galaxies LF Gs (z~3) 25 x > 1.4Mrk231 (AGN) FAS-SXDS-31 FAS-SXDS-11 20 FAS-SXDS-32 FAS-SXDS-10 FAS-CDS-12 (12-2.3) Star burst 1 $S_{24\mu m}/S_{8\mu m}$ FAS-SXDS-FAS-SXDS-31 S-SXDS-12 FAS-SXDS-11 FAS-SXDS-32 × 2 15 \mathcal{C} FAS-SXDS-7 U_n -1.0 1/2-1.71 FAS-SXDS-27 FAS-SXDS-10 10 FAS-A1689-12 Stars 0 AGN 0 1.5 1.5 2.0 5 2.5 3.0 2.0 2.5 3.0 4.5 3.54.0 0 0 2 6 4 2 3 5 0 0 1 2 B-z $S_{8\mu m}/S_{4.5\mu m}$ G-R

Faint ALMA Sources = sBzK / LBG(BX/BM)

- **Clustering (Statistical)**
- **Opt. Counterparts (Individual)**

Faint ALMA Sources Optically Selected SFGs

Summary





Largest ALMA Dataset (85 sources: down to 0.01 mJy)

Number Counts -> Resolve ~ 100% of EBL

What are Faint ALMA Sources ?

-> Opt. Selected SFGs (Clustering & Opt. Counterparts)

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