

DEEP SURVEY SCIENCE WITH ALMA/GSMT

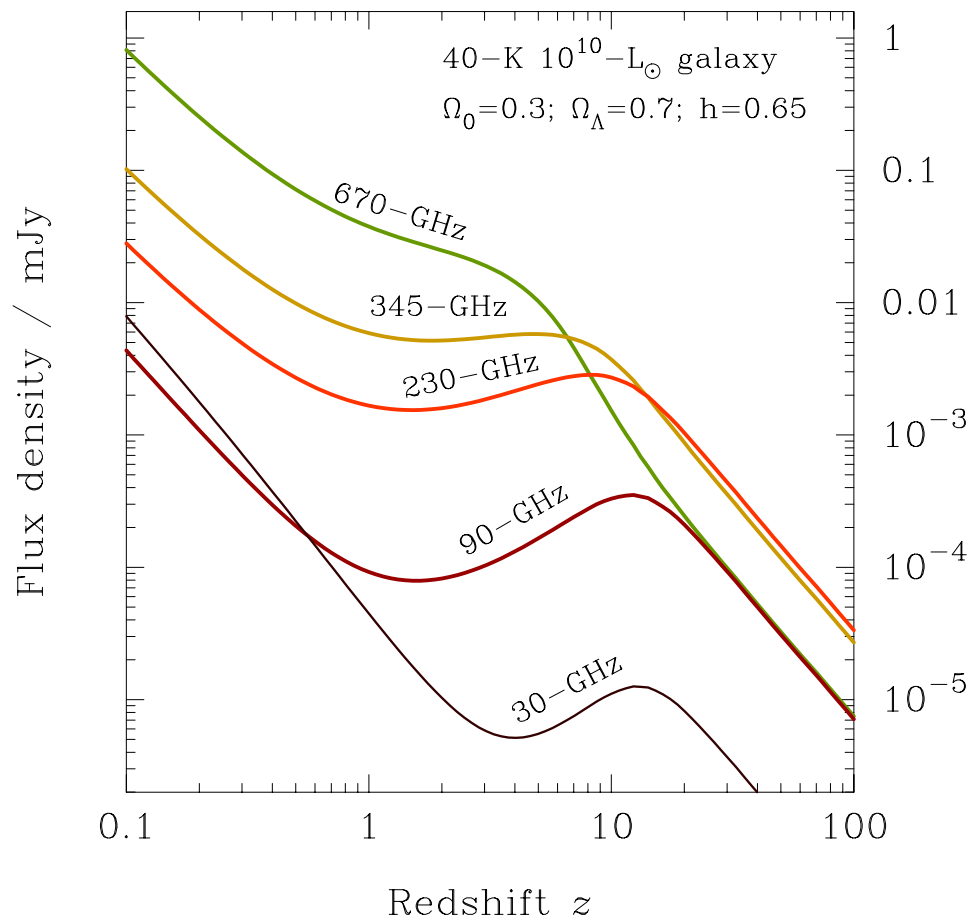
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- From an ALMA/submm-based perspective
- ALMA reveals whole dusty/molecular Universe!
Fully resolves detail (but small fields!)
Suffers effectively no source confusion
Can identify dusty sub- L^* galaxies at 'any' z ,
although hits CMB trouble in range $10 < z < 20$
May see 'first light', but when does dust form?
- Deep ALMA surveys probe history of dusty energy generation and all metal formation
- ALMA maps 100 times deeper than SCUBA:
NB: Many SCUBA galaxies have R_{27} !
- ALMA needs optical follow-up for full picture

ALMA AND THE DEEP UNIVERSE



- Sensitivities of ALMA (5σ in 1 hour) are 70, 10, 5.8, 2.3 and $1.7 \mu\text{Jy}$ (down figure)
- 100-hour ALMA Deep Field images this galaxy in 345- and 230-GHz bands to $z=10$
- Hard to be sure of optical properties: from SCUBA experience typical $R > 30-35$?

OBJECTIVES AND REQUIREMENTS

- To trace the earliest evolution of galaxies during process of re-ionization
- GSMT required to provide complementary astrophysical information in near-IR, as ALMA cannot detect starlight or nebular emission
- Optical follow-up imaging at $R > 30$ with resolution to match ALMA's 10 milliarcsec
 - Important to see what's missed in far-IR
 - Important to find any dust-free 'protogalaxies'
 - Important for 'first light' from stars/SN/GRBs
- Near-IR (IFU?) spectroscopy at $K \gtrsim 26$
 - Resolve velocity structure from stars/hot gas
 - Compare with CO structure
 - Important for best resolution of lenses
- Extremely deep (~ 100 hour) integrations
- Need other space and ground-based resources

OTHER FACILITIES

- Complementary space-based resources:
 - NGST for mid-IR morphology/dust features
 - Future cryogenic mid/far-IR interferometer
 - Growing beyond SIRTf and FIRST/Herschel
 - Cold single-aperture (30-m+) space telescope?
 - Very sensitive high-R X-ray spectroscopy
- Complementary ground-based resources:
 - SKA (eVLA?): HI, low-J CO, continuum

DISCUSSION/STUDY REQUIRED

- What is the highest-redshift Universe like?
- Can GSMT follow-up faintest ALMA sources?
- Do ALMA/GSMT see same or different objects?
- Is NGST or GSMT better for imaging ALMA sources?