Searches for z>7 galaxies in the mid-IR - a prelude to JWST

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Massive galaxies at high-z

- Galaxies at z~6 surprisingly easy to detect with IRAC (Eyles et al., Yan et al., Wiklind et al…).
- $2 \times 10^{10}$ solar masses at z~6 is $\sim 1 \mu Jy$ at [3.6]
- But what about higher-z?
- Lack of large area, ultradeep IR surveys a limitation
- A few candidates from HUDF (Bouwens & Illingworth 2007), emission line survey (Stark et al 2007), but SRFD and stellar mass density very uncertain.
Strategies: emission line surveys

• Ly$\alpha$ relatively easy but Ly$\alpha$ flux very uncertain if reionization incomplete
• H$\alpha$ much better in some respects
  – Not absorbed by IGM
  – No resonant trapping/dust absorption
  – But redshifted to mid-IR (higher background than near-IR in space, can’t be done from the ground)
• Spitzer/IRS could, in principle, find H$\alpha$ emitters at $z>7$, but only the brightest would be detectable.
Where are good places to look?

- Candidate Ly-alpha emitters at z~8 (Stark et al. 2007)
- Cluster caustics/critical lines (blind search)
- Objects with excesses in band-3 of IRAC undetected in I/z-band with ACS.
Lyα candidate search

• Picked two objects from Stark et al. (2007) in Abell2219; c1, z=8.99, and c2, z=8.94.
• Neither detected to 3-sigma limits of 1-1.5x10^{-19} Wm^{-2} (c1,c2) in deep integrations, implying Hα/Lyα <~2.7 (cf CaseB = 0.1) - can rule out extreme Lyα absorption scenarios.

IRS SL 2D spectrum
Blind search

• Also search along slits close to caustics/critical lines for serendipitous objects in the A2219 observations and one slit position in A2218
• Total volume sampled at \( \sim 10x \) mag is \( \sim 100(10/\mu) \) Mpc\(^3\).
• Limiting SFR is \( \sim 40(10/\mu) \) M sun/yr
• SFRD \( \leq 0.4 \) Msun/yr/Mpc\(^3\) (ignoring clustering)
The IRAC dark field

- The IRAC shutter cannot be used in flight
- “skydarks” are therefore taken at a very low background region near the NEC.
- Good coverage at range of sky PAs means artifacts very effectively removed, PSF very smooth.
- Used inner 188 arcmin² (>10ks in first 2.2 years of data), depth of inner few arcmin² up to 100ks (>200ks by end of mission).
- ACS F814W data to AB~29 for point sources.
- Unfortunately no deep near-IR data so far, so results preliminary.
Selecting z~7 galaxies

- 30000 objects in dark field
- Start by rejecting all objects detected in ACS F814W, MIPS 24 and obvious blends, artifacts etc.
- Put in flux cut of 1\(\mu\)Jy at [4.5].
- Leaves \(~50\) objects.
- \(~50\%\) complete.
- High-z objects still a minority. Most are just very red z~2-4 galaxies.
Filtering the candidates

- Do a very simple photo-z. Allow for bump corresponding to H-alpha emission in the [5.8] band.
- Major contaminant are “bump 3” sources with the 1.6mu bump in the [5.8] mu band. Hence need for very accurate 4-band photometry, especially in the absence of near-IR data.
- But brown dwarfs have very different mid-IR colors
Low-z rejects
z~7? example
Results

• 4 fair $z \sim 6.5$-9 candidates

• Preliminary - obviously can do better with near-IR data (and really need spectra!).

• Derived stellar mass density (just from these objects) $\sim 3\times10^5$ solar masses/Mpc$^3$, compared to $1\times10^5$ from 2 (much fainter) HUDF objects (Labbe et al 2008).

• Model predictions from de Zotti, Lapi, Bressan & Danese (p.c.): $\sim 5.5 [4.5]>1\mu$Jy $6.5<z<9$ objects in field.
Summary

- $\text{H}_\alpha$ emission in the rest-frame mid-IR is potentially important for quantifying star formation in luminous $z \gtrsim 7$ galaxies.
- No resonant trapping problems, less affected by dust than UV or Ly$\alpha$ emission.
- Unaffected by GP trough absorption.
- High observed frame EWs will be large enough to affect broad-band photometry (see also Chary et al. 2005).
- Probably need JWST/MIRI to detect though…