Cosmic Star-formation from $0.5 < z < 20$
with Spitzer

Ranga-Ram Chary
Spitzer Science Center
rchary@caltech.edu

May-June 2006 Crete Meeting
MIPS 24μm are insensitive beyond z~3

ISO CAM HDF-N depth of 0.1 mJy vs MIPS GTO (~80μJy)/GOODS (~20μJy)
Use IRAC emission line diagnostics

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1 hour of IRAC integration + $\times 4.5$ lensing

- $z=6.56$ Ly-$\alpha$ emitter called HCM6A lensed by Abell 370
- Discovered by Hu et al. 2002
SED of HCM6A

Difference is from Hα in emission.

UV SFR < 10 M☉/yr
Hα SFR ~ 100 M☉/yr

Indirect evidence for Aᵥ ~ 1 mag of dust

Hα EW ~ 0.2μm

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GOODS 25 hr depth HAEs:
z>5 is pushing limits of current technology

• 66 z>5 sources in GOODS-N and GOODS-S. Extensive spectroscopy from ESO/VLT (Eros Vanzella et al.) and Keck (Daniel Stern et al.)
• 33 are Spitzer detections at either 3.6μm or 4.5μm or both
• 5/33 (i.e. 15±7%) appear to have 4.5μm/3.6μm flux ratios consistent with HAEs
Comparison between IRAC colors of $z > 5$ sources

Sloan QSO
Vanden Berk et al.

Old Stellar Pop.

R-J tail for young Stellar Pop.

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Colors of an evolving stellar population

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Deep Spitzer Observations Enable Extending ISOCAM’s work to \( z \sim 3 \) and fainter down the IR Luminosity Function.

Overestimates? Or a hot dust component which may not be traced by SCUBA?

Need more spec-z

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Redshift distribution of $z > 1.5$ Sources

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Stern/McDonald/Dickinson at Keck to get more
24 μm bright LBGs are all drawn from the “red half” of the distribution of UV continuum slopes (and hence of inferred extinction)

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Comparing UV and IR Luminosity Density: LBOL/LUV@1.5<z<3.0

"IRX-β" diagram (as per Meurer et al. 1999)

L_{IR}/L_{UV}(corr.) ~ 1 for many objects at L_{IR} < 10^{12.5} L_{\odot}, but >>1 at higher L_{IR}
Specific SFRs vs. stellar mass

- Objects with high 24mu SFRs tend to be among the more massive galaxies

- Similar results seen for ISOCAM at z~1

- Does the infrared luminous phase of galaxy evolution only occur in massive galaxies? Needs to last shorter than 100MYr to avoid overestimating the mass.

- Or is there a selection effect?
• 20 very hard X-ray sources at $z>1.5$ of which $\sim 60\%$ are radio detected.

• Gamma values suggestive of strong AGN activity irrespective of radio detection.

• Radio-LIR trend is higher than seen in the local Universe indicating AGN contribution to radio flux.

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Radio-LIR Correlation?
$Z>1.5$ very difficult to use radio as a SF tracer

Radio-loud AGN?

Radio-FIR correlation from local Universe

Seems to be an AGN contribution of $\sim 30\%$ to the LBol

Glenn Morrison leading reduction of radio data
Conclusions

- Finding strong Hα emitters with large equivalent widths. Probably due to a very young stellar population and NOT an AGN.
- Hα/UV ratio indicate modest amounts of extinction (A_V>0.2 mag) in about 15% of objects which would boost ionizing flux by a factor of 2 (need to find more to account for re-ionization).
- HCM6A is the strongest Hα emitter ⇒ A_V~1 mag
- Origin of dust is unclear - SNe or first generation of stars forming at z>10?

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Equivalent Width Evolution with Time

Fig. 43.—Equivalent width of Hα vs. time for an instantaneous burst. Parameters as in Fig. 1.

Fig. 44.—Equivalent width of Hα vs. time for a continuous star-formation rate. Parameters as in Fig. 2.

Leitherer & Heckman 1995

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