SED modeling of galaxies in simulations

Patrik Jonsson
Harvard-Smithsonian Center for Astrophysics

+Chris Hayward, Brent Groves, TJ Cox, Greg Snyder, Lars Hernquist
What controls the SEDs of galaxies?

Use hydrodynamic simulations and radiation transfer to investigate.
What goes into a galaxy spectrum?

- Stellar (continuum) emission
- Emission lines from HII regions
- Dust & PAH emission
- AGN emission

- Use radiation-transfer code *Sunrise* (PJ 06)

Far-infrared emission is an interplay between dust emission and self-absorption, plus IR emission from AGN and SF regions.
Sunrise outputs

Broadband photometry & images

Jonsson, Groves, & Cox 10
Comparing local disk sims to SINGS

See PJ, Groves & Cox 10. Samples: SINGS (Dale et al. 07)
Comparing local disk sims to SINGS

See PJ, Groves & Cox 10. Samples: SINGS (Dale et al. 07), SLUGS (Willmer et al. 09)
In progress: Testing hi-z models against observations
(+ testing AGN indicators)

w/Anna Sajina, Lin Yan (Spitzer FLS sample)
Population of optically faint sources detected in sub-mm (fiducial cut $S_{850} > \sim 5$ mJy)

99% of L is emitted in IR

Powered by SF rather than AGN

$L_{IR} \sim 10^{12} - \text{few} \times 10^{13} L_{\odot}$

$\text{SFR} \sim \text{few} \times 10^2 - 10^4 M_{\odot}/\text{yr}$

Median $z \sim 2.2$, $\sigma \sim 1.2 \Rightarrow \text{sub-mm traces} \sim 200-400 \mu \text{m emission (longward of peak)}$
Merger evolution

Merger of two z ~ 2 disks:

$M_{\text{halo}} = 9\times10^{12}$

$M_{b} = 4\times10^{11}$

initially 60% gas

Burst consumes gas, lowers dust mass, increases dust T

Inefficient at boosting submm flux (~15x in SFR but <2x in $S_{850}$)
Merger evolution

Two SF regimes:
1. Quiescent disk (during infall)
2. Merger-driven burst

SMGs are not just the high-SFR tail of galaxy population
SMG bimodality

- SCUBA/AzTEC beams ~15" (~130 kpc at z = 2) ⇒ easy to fit two disks in beam
- Very efficient way to boost submm flux
- Early-stage merger; no strong interactions yet
- SMGs are a mix of merger-driven starbursts (near coalescence) and blended galaxy pairs (early-stage)
Summary

Simulations of local disks replicate local SEDs well, but real galaxies are a more diverse population.

(U)LIRG samples at low and high z are now beginning to cover FIR - will be able to test predictions of mergers.

Intense starbursts are an inefficient way of boosting submm flux.

Merger SMGs fall into two classes:

1. Late-stage merger: starburst induced at coalescence

2. Early-stage merger: two progenitor disks blended into one submm source

Unlike local ULIRGs, SMGs are a mix of quiescent and bursting sources -- clear observational tests of this.
Summary

- Intense starbursts are an inefficient way of boosting submm flux
- Merger SMGs fall into two classes:
  1. Late-stage merger: starburst induced at coalescence
  2. Early-stage merger: two progenitor disks blended into one submm source ("galaxy pair SMGs")
- Unlike local ULIRGs, SMGs are a mix of quiescent and bursting sources -- clear observational tests of this
New: Kinematics

- Taking into account velocities of sources and scatterers
- Can generate emission and absorption line profiles at high resolution (R~16000)

(requires high-res SEDs; in the works...)
IFU-style outputs
Spectral Energy Distributions