Star formation in early-type galaxies since $z \sim 1$

Sugata Kaviraj
MSSL/Oxford

Collaborators: Sukyoung Yi, Kevin Schawinski, Ignacio Ferreras, Eric Gawiser and Richard Ellis

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Early-type galaxies

• Passively evolving systems? (Bower+ 92, Thomas+ 05)

• Need to measure the recent star formation

• Reconstruct (observationally) the SFH at late epochs (z~1)
UV-optical colours of nearby early-types

GALEX & SDSS

- Expected tight relation in optical (g-r) CMR
- NUV CMR shows spread of 6 mags

Schawinski et al., 2007, ApJS, 173, 512
Expected tight relation in optical (g-r) CMR

NUV CMR shows spread of 6 mags

Taking into account UV from old stars – at least 30% of ETGs are star-forming today

1-5% of galaxy mass forms within last 0.5 Gyrs
High-redshift early-types
The Chandra Deep Field South (CDFS)

- Optical filters traces rest-frame UV beyond $z \sim 0.5$

- No old stars

- Need depth in U and B bands, redshifts and morphologies

- **MUSYC** (UBVRIzJK) + **COMBO-17** (photo-z) + **VVDS** (spec-z) + **GEMS** (HST images)

SUGATA KAVIRAJ, SFHs of early-type galaxies
UV colours of high-redshift early-types
(0.5<z<1)

• Luminous galaxies ($M_V<-21$) form up to 10-15% of their mass after $z=1$ (consistent with model predictions)

• Low-mass galaxies form 30-60% of their mass after $z=1$

What drives the recent star formation?
Indirect evidence for minor mergers

- Minor merger simulations (mass ratios 1:4 to 1:10)
- Satellite gas fractions > 20%
- Convolve with LCDM merger statistics
- Good agreement with observed UV and optical CMRs

What drives the recent star formation?

Relaxed ETGs

205  721  734  912  1073

1618  1912  2575  3156  3796
What drives the recent star formation?

Relaxed ETGs

Disturbed ETGs (30% of the ETG population)

SUGATA KAVIRAJ, SFHs of early-type galaxies
What drives the recent star formation?

Rest-frame (NUV-g)

COSMOS
z=0.6

Kaviraj & Ellis, in prep

SUGATA KAVIRAJ, SFHs of early-type galaxies
What drives the recent star formation?

- **Internal mass loss**
  Not enough gas at low redshift (Kaviraj et al. 2007)

- **Condensation from hot gas reservoir**
  Hot gas fraction of the order of total recent star formation (O'Sullivan et al. 2003)

- **Major mergers**
  Major merger rate (e.g. Conselice 2007) does not seem enough to satisfy disturbed ETG fraction (~35-40%)

- **Minor mergers**
  Several factors more frequent than major mergers
  Consistent with disturbed ETGs dominating the blue cloud and mass fractions forming in young stars

Not expected to perturb the morphology of the galaxy
Early-types of all luminosities form stars over the last 10 Gyrs, although bulk of the stars do form at high redshift

Massive early-types form up to 10-15% of their mass after $z \sim 1$, low-mass early-types form 30-60% of their mass after $z \sim 1$

Negligible fraction of early-types are consistent with purely passive ageing since $z=2$

Primary driver of recent star formation is probably minor merging – this needs to be verified using better data