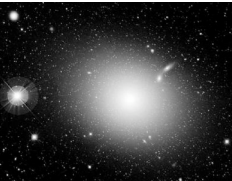


FORMATION AND EVOLUTION OF GALAXIES

Lecture 18: Evolution, final stages

- Starburst galaxies
 - Global vs nuclear starbursts
- How to kill a galaxy (The effect of environment on galaxy evolution)

Somak Raychaudhury

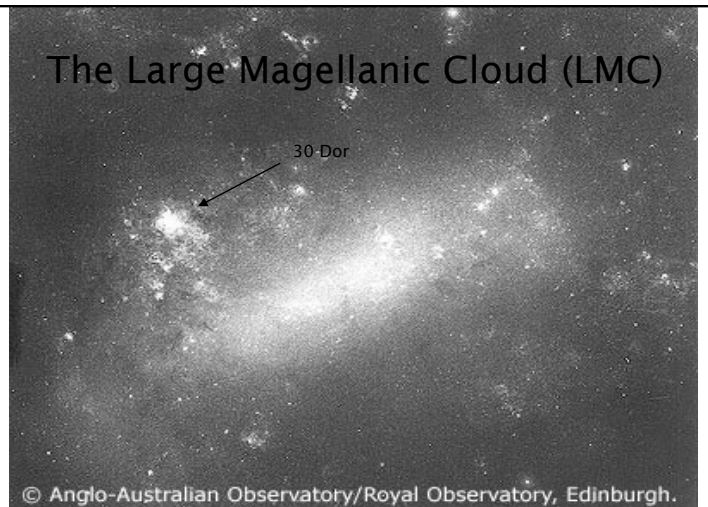


What is a starburst?

There is no well-established definition of the starburst phenomenon but many would agree that in a starburst

- The mean gas consumption timescale is significantly smaller than the Hubble age (as in blue compacts)
or
- That this is true for a local region in the centre – a *nuclear starburst* (prototype: NGC 7714).
and that
- Starbursts have *high star formation efficiencies*, i.e they use up a larger proportion of the molecular cloud it is formed from than normal before the cloud disperses or dissociates. The normal efficiency is 5%. In starbursts it may be *10 times higher*.

The Large Magellanic Cloud (LMC)



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A few facts about 30 Doradus

The uv flux in 30 Doradus (400 pc diam.) corresponds to approximately 1000 O stars.

The stellar mass function in the central cluster R136 (2.5 pc diam.), reaches between 0.1-0.6 and 120-150 $M_{\odot}$.

The IMF is well described by the Salpeter value for stars above a few $M_{\odot}$. This could be a 'real' upper limit for starburst regions.

A starburst galaxy prototype, M82



Why are starbursts interesting?

- If the gas consumption rate is high a gas rich galaxy may rapidly turn into a gas poor. E.g. in a merger $S+S \rightarrow E$
- Starbursts may trigger active galactic nuclei - AGNs.
- They may produce superwinds that could overcome the gravitational potential and pollute the IGM.
- Starbursts in dwarf galaxies may be the main driver of the reionization.

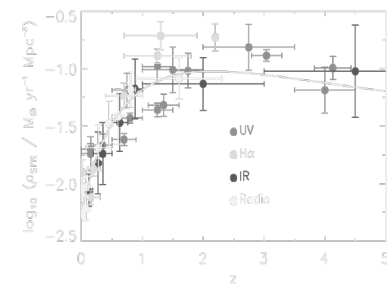
Global vs. nuclear starbursts

- Global SB affects a substantial part of the of the galaxy and the total gas reservoir is consumed in $\ll$ Hubble time
- Nuclear starbursts are actually circumnuclear and occur in many massive young clusters

Important questions:

- Is there a fundamental difference in IMF?
- Can starbursts be distinguished from AGNs or other energy sources in the centre?

Why Does Star Formation Stop?



(Hopkins et al 2004)

- A) Internal? i.e. gas consumption and “normal” aging
 B) External? Hierarchical build-up of structure inhibits star formation

Galaxy clusters: the end of star formation?

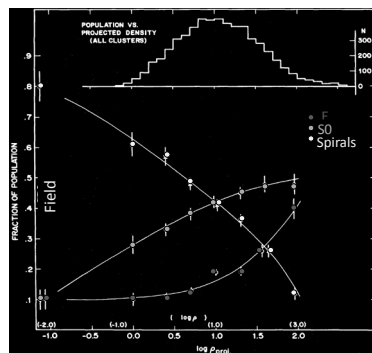


- “Dead” galaxies (i.e. little gas or star formation) found in rich clusters
- Hierarchical formation models predict number of clusters increases with time.
- So perhaps dense environments are responsible for terminating star formation?

Nature or Nurture?

- Nature? Elliptical galaxies only form in protoclusters at high redshift. Rest of population is due to infall.
- or Nurture? Galaxy evolution proceeds along a different path within dense environments.
 - If this is true in groups and clusters, then environment could be the driving force of recent galaxy evolution...

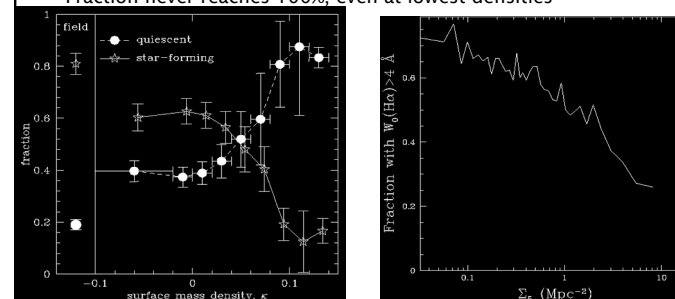
Morphology–Density Relation



Dressler 1980

Star formation

- Fraction of emission-line galaxies depends strongly on environment, on all scales
- Trend holds in groups, field, cluster outskirts (Lewis et al. 2002; Gomez et al. 2003)
- Fraction never reaches 100%, even at lowest densities



Additional physics?

- Ram-pressure stripping (Gunn & Gott 1972)
- Collisions / harassment (Moore et al. 1995)
- “Strangulation” (Larson et al. 1980; Balogh et al. 2000)