Feedback – observational challenges

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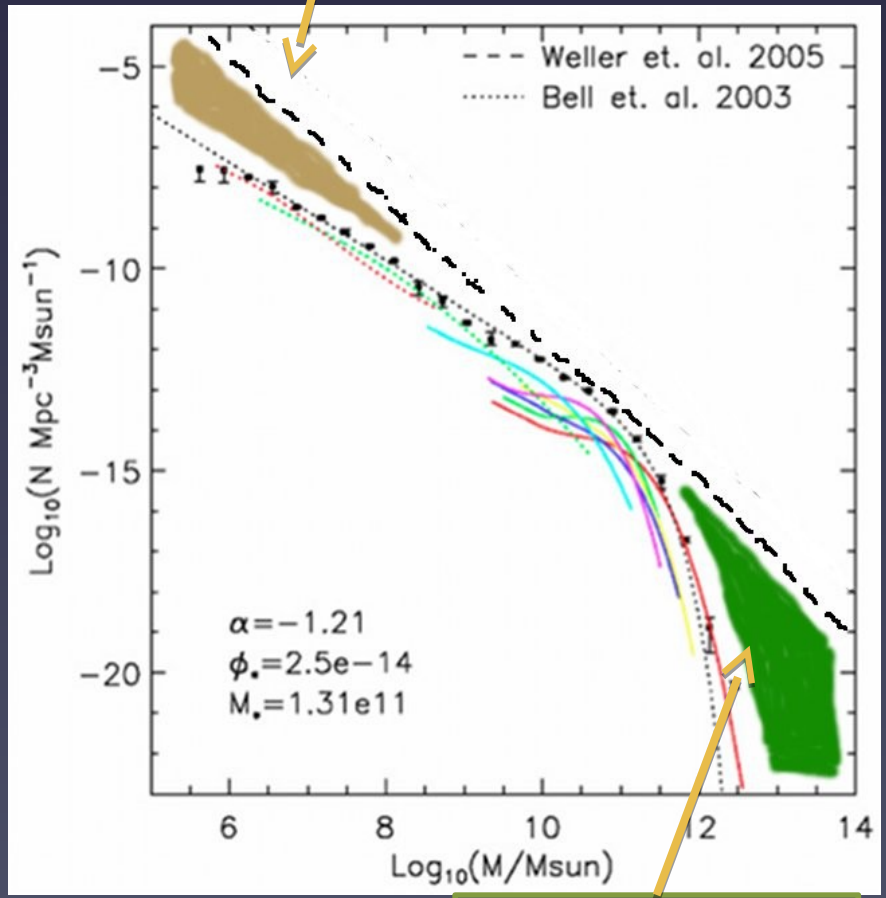
Why feedback?

- Critical (and so far “unsolved”) problem in galaxy formation is to make gas cool less efficiently
- The growth of stellar mass in galaxies at the high end is repressed at higher rates than expected from simple Jeans pressure arguments.
- Supernova explosions versus feedback from SMBH in nucleus.

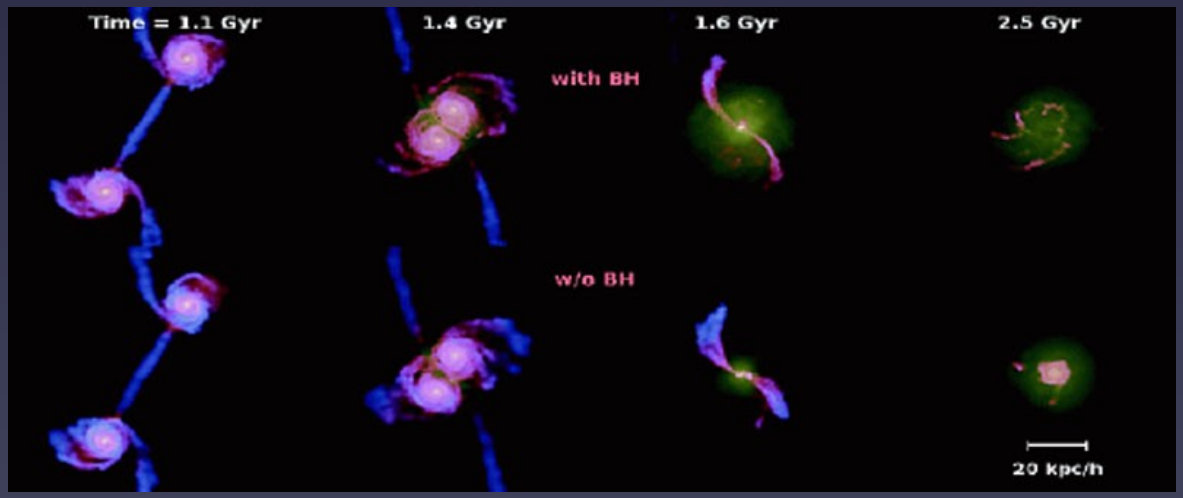
Single SN can destroy low mass dwarf?



Massive ellipticals had (merger) AGN

The “need” for feedback - 1

My simulations say so!



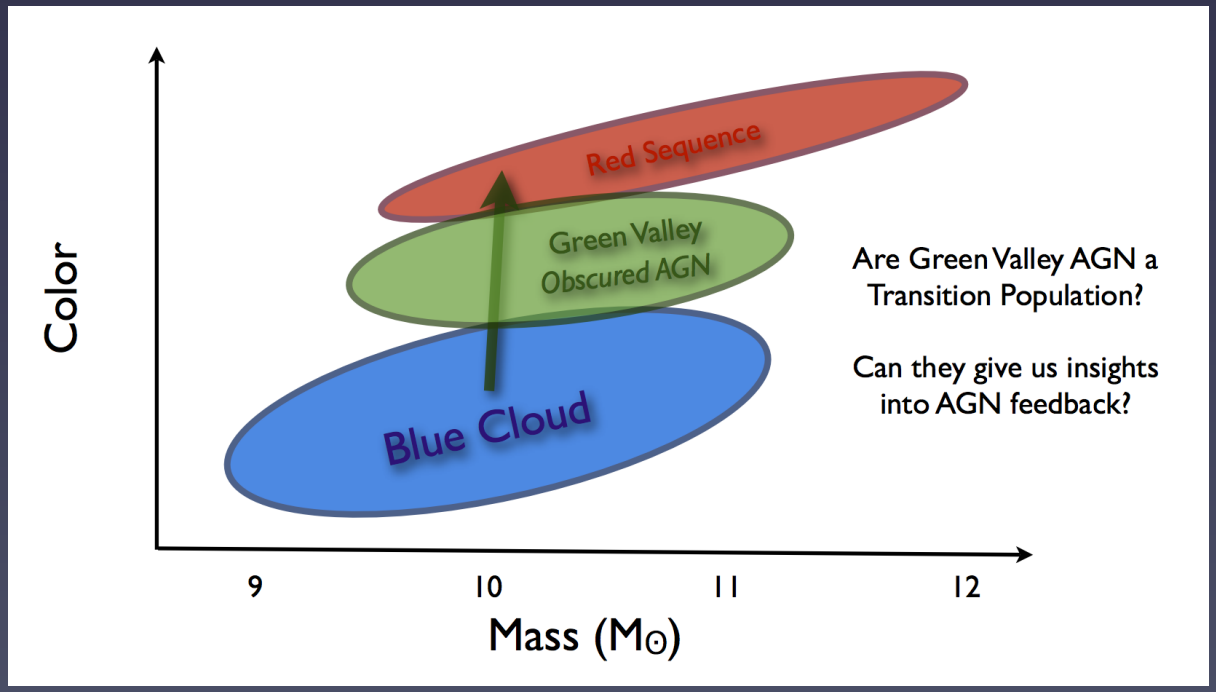
“Old” merger simulations very successful at reproducing many galaxies’ properties.
New recipes (FIRE, e.g.) more realistic...

- Very good and interesting model for the formation of most massive ellipticals
- BUT... feedback is just a numerical recipe. What happens BH ✉ galaxy, small scales difficult to simulate. Overestimation of mergers? ✉ theory session!

The “need” for feedback - 2

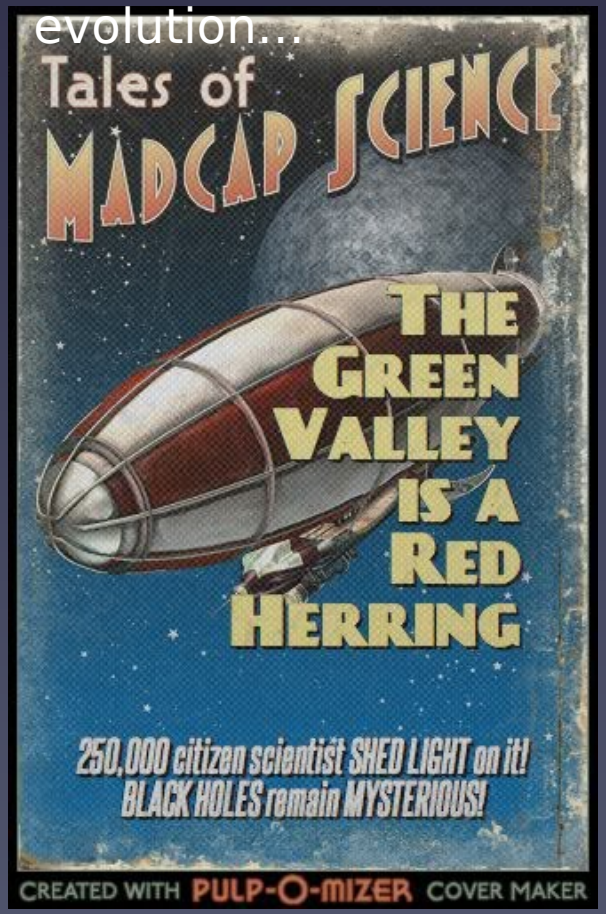
Shutting down of star formation to move from blue cloud to red sequence

Faber 07+ others



Apparent over-representation of AGN host galaxies in green valley

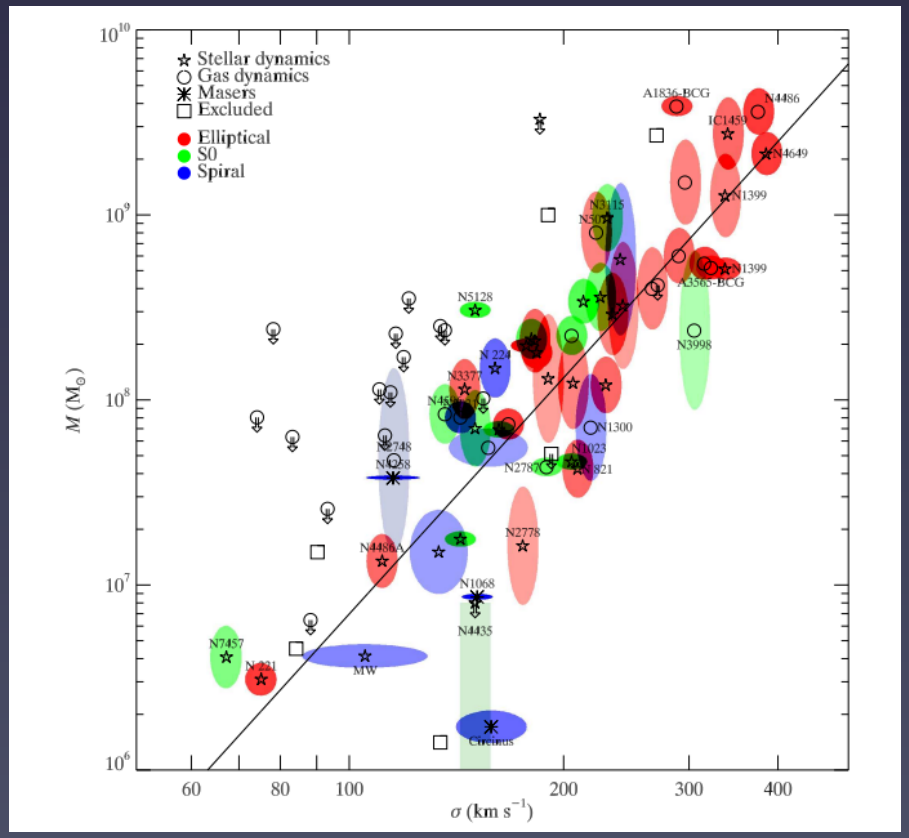
BUT… Schawinski et al. 2014 – secular evolution…



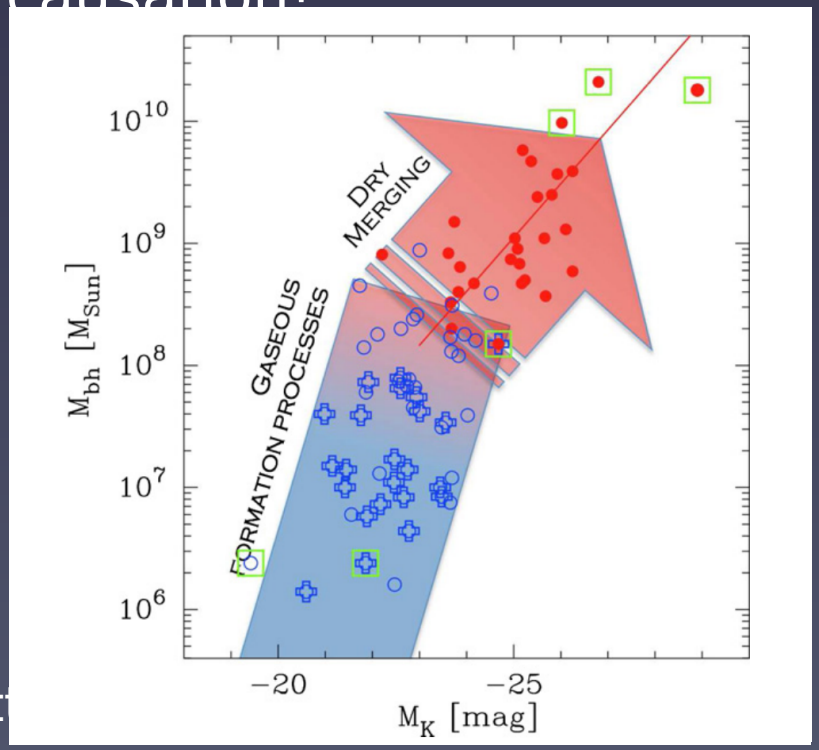
The “need” for feedback - 3

ck hole mass – host galaxy properties scaling relatio
asar feedback?

- “Intimate” interplay between BH and host galaxy
- BUT… correlation is not causation!



Gültekin+ 2009

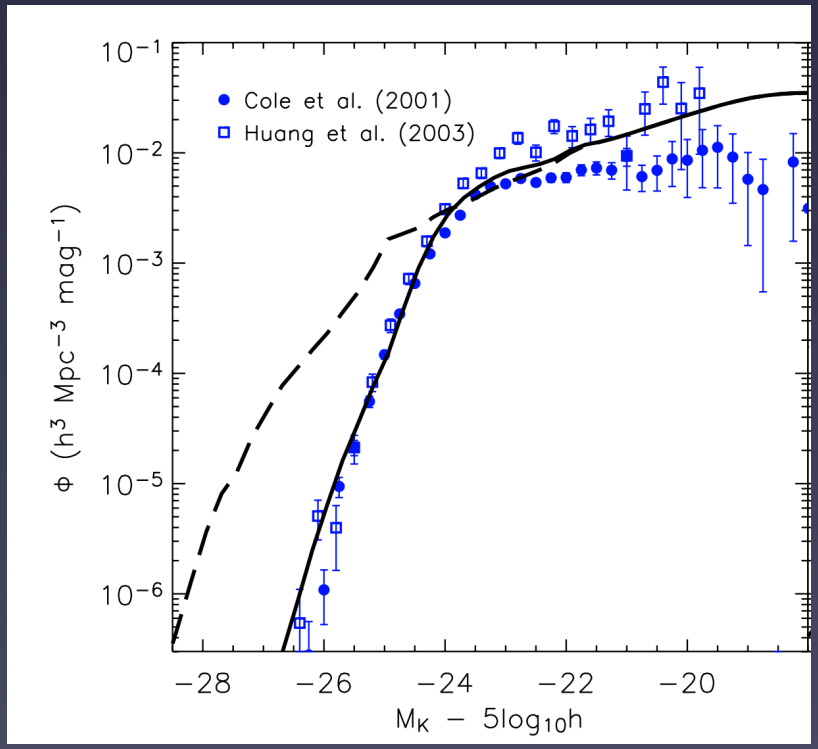


Jahnke & Maccio 2011, Graham & Scott 2013

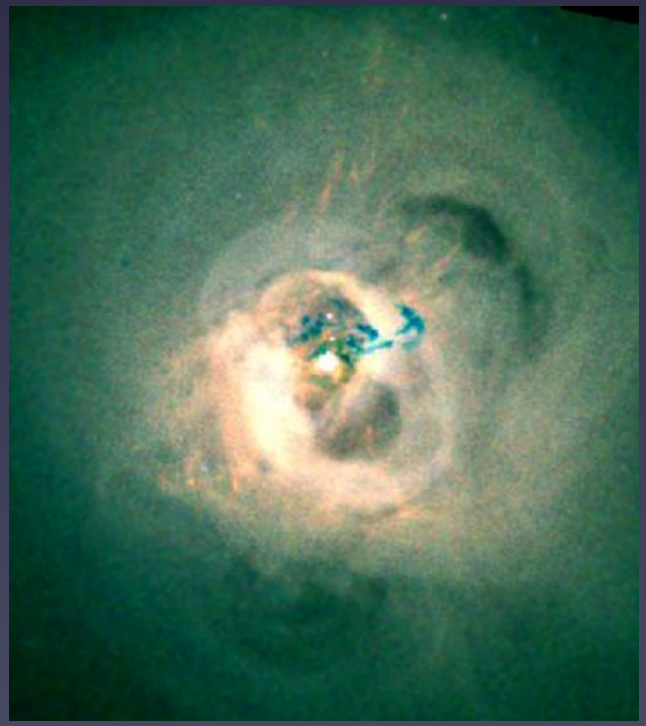
The “need” for feedback - 4

My semi-analytic models work out really well!

Croton+ 2006



Fabian+ 2006

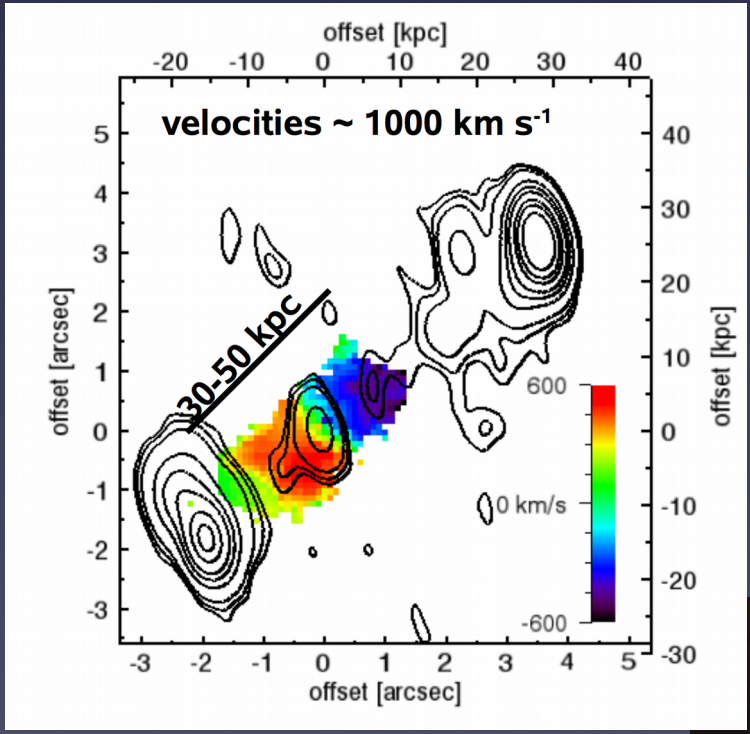


- Radio-mode (AGN heating) feedback is actually the best candidate for the BH affecting the host galaxy.
- BUT… it’s not powerful enough to turn star formation off, just to keep it off. “Maintenance phase”

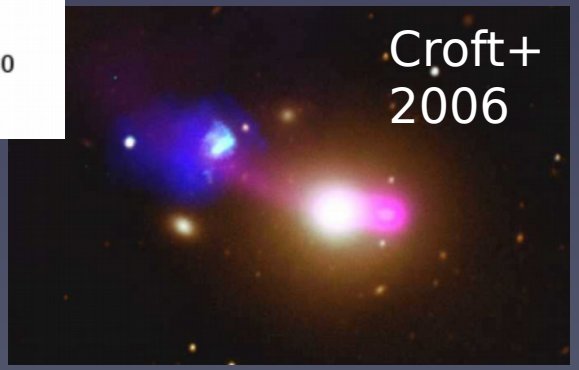
The “need” for feedback - 5

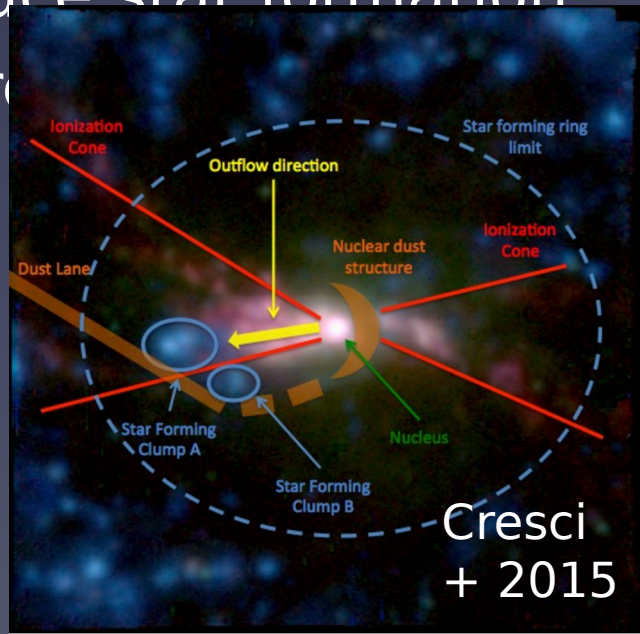
Jets extent many kpc into the host. They should have an effect, right?

- Outflow of large quantities of OII gas in HzRG correlates with jet outflow.
- BUT… Jets are rare (10%). Jets can also induce star formation rather than r



Nesvadba+ 2010





Timescales?

- Quenching vs. feedback?
  - Is the process in which less stars are formed a violent event (Starburst, AGN) or a slow “secular” sort of starving (Q-quenching, dynamical quenching)?
- Do we need “explosions” or are these just special cases (at different stellar masses)?
- Observables supporting that picture – jets, winds, high energy processes (SN,AGN) vs. (indirect bars, stellar shear)?
- **Are we biased because violent processes are easier to observe?**

What is dominant?

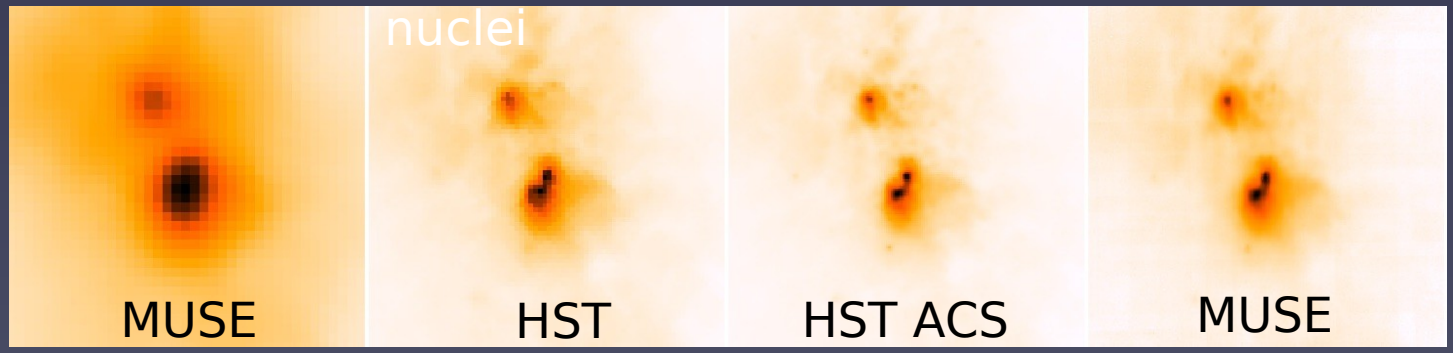
Galaxy Game of Thrones

- Many unpleasant ways for galaxies to be quenched…
  - Starvation (Winter is coming…)
  - Strangulation
  - Ram pressure stripping
  - Exploding dwarfs
  - Secular processes
  - Collisions/mergers
  - Shocks
  - DrAGoNs
- Which one sits on the Iron Throne?

Are new facilities providing answers?

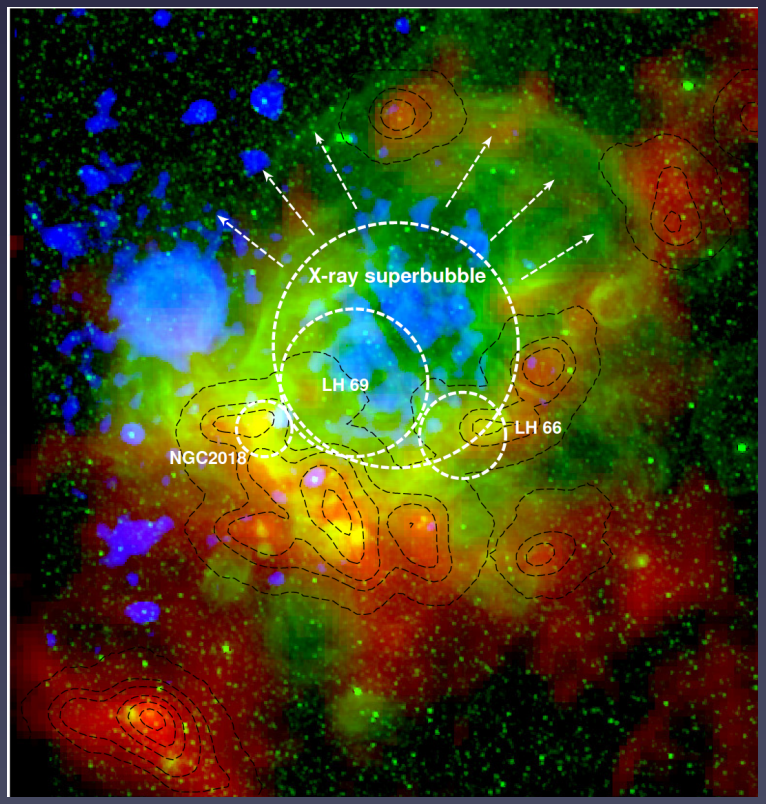
- ALMA, MUSE, SKA precursors and [your favorite facility here] have recently come online coming with
  - Higher spatial resolution
  - 3D information
  - Large FoVs letting us probe from nucleus to outskirts of galaxies

NGC 6240 – nearby double AGN



What else do we need? (besides JWST)

Do we have a small large scales problem?



Ramachandran+ 2018, 2 WR stars contribute about same mechanical luminosity than rest of stars put together (E_{mec} = 1.3 x 10^{52} erg in 5Myr)

Veilleux posing challenge to simulators to explain M82, but the challenge goes to observers, too connecting the scales.

Other caveats / observational party poopers

Theorists – solve, please!

- Dust – do we understand extinction models well enough? (tensions in the empirical derivation of dust laws) – Conroy+13,Salim+18
- Metallicity – we observe our well known “relations” or “conversions” or “SF recipes” break down at very low metallicities. - e.g. Cormier+15
- Varying IMFs or non-constant M/L ratios? -Capellari+12

Predictions for observers?

May be controversial...

- Are theorists trying too hard to match observations?
- Were cold flows the last models theorists predicted for observers to prove/falsify?