Feedback in Galaxy Formation

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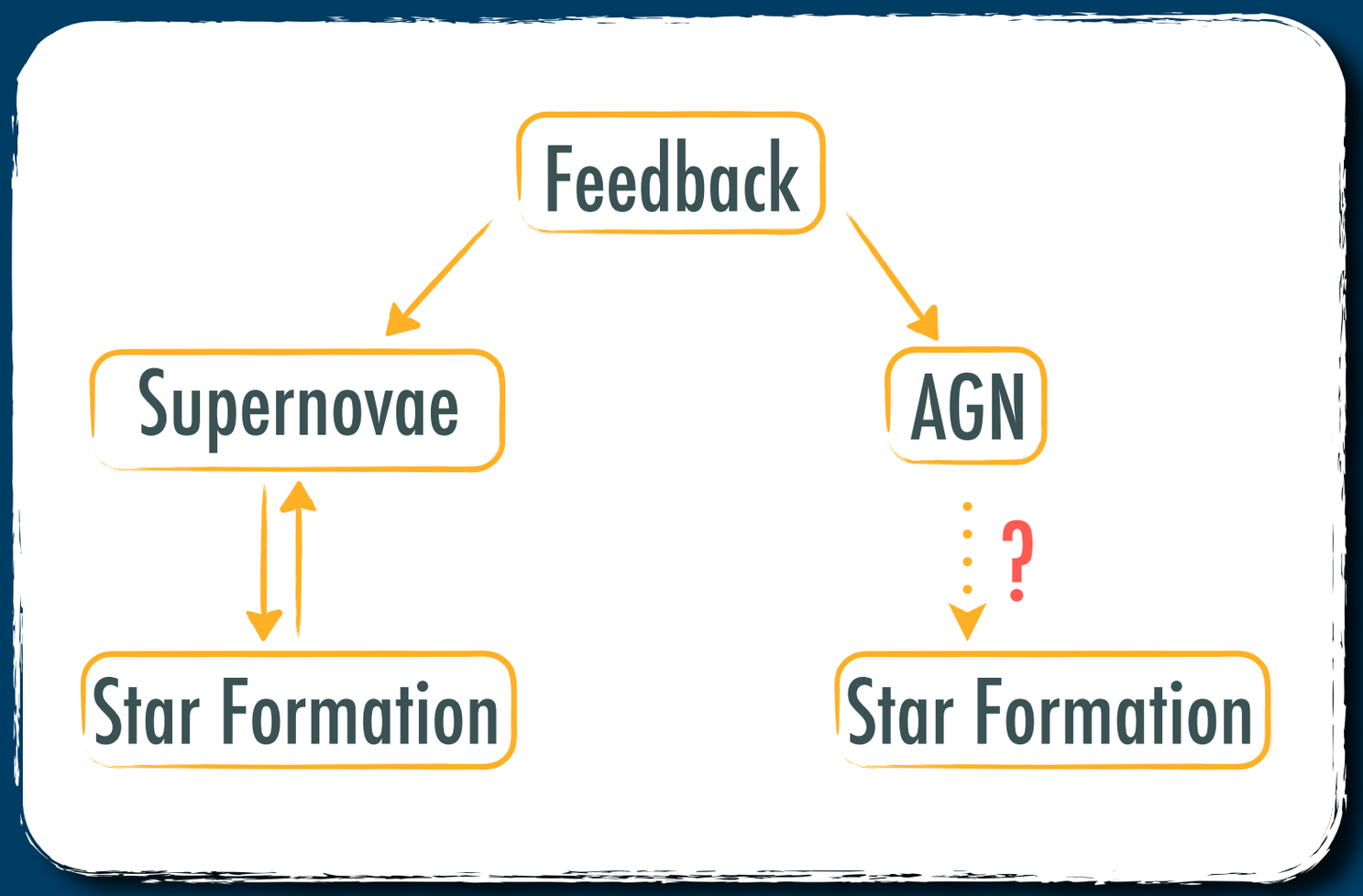
Outline

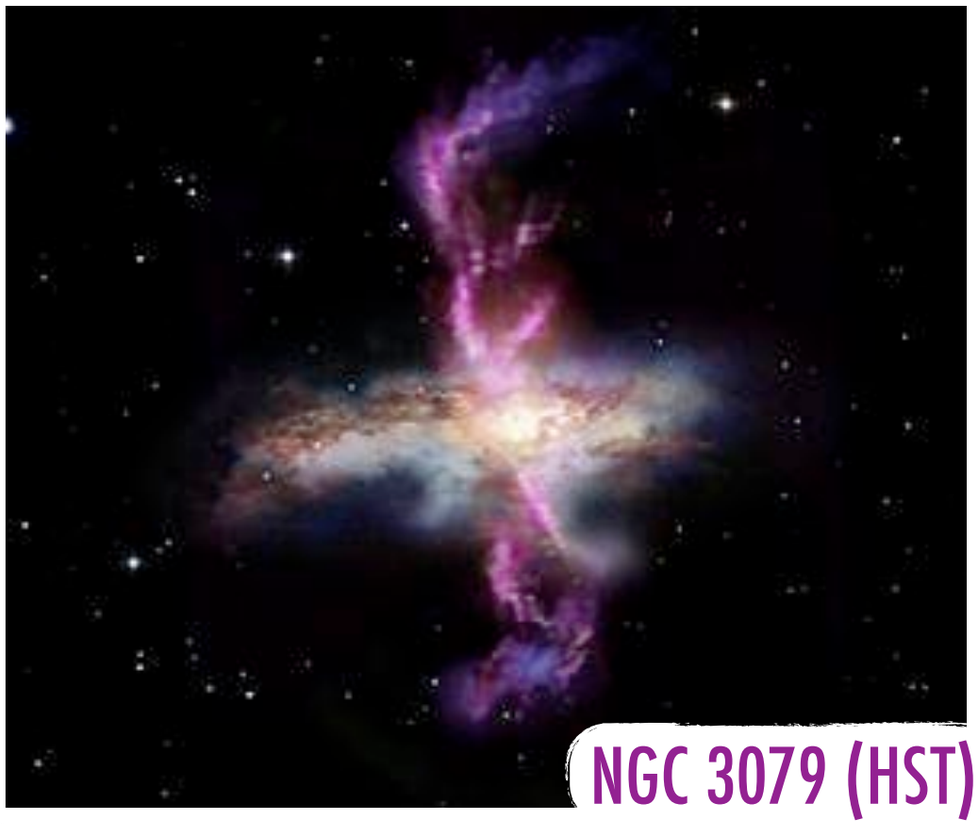


Why is feedback important?

Shuts off Cooling in Clusters

Perseus A

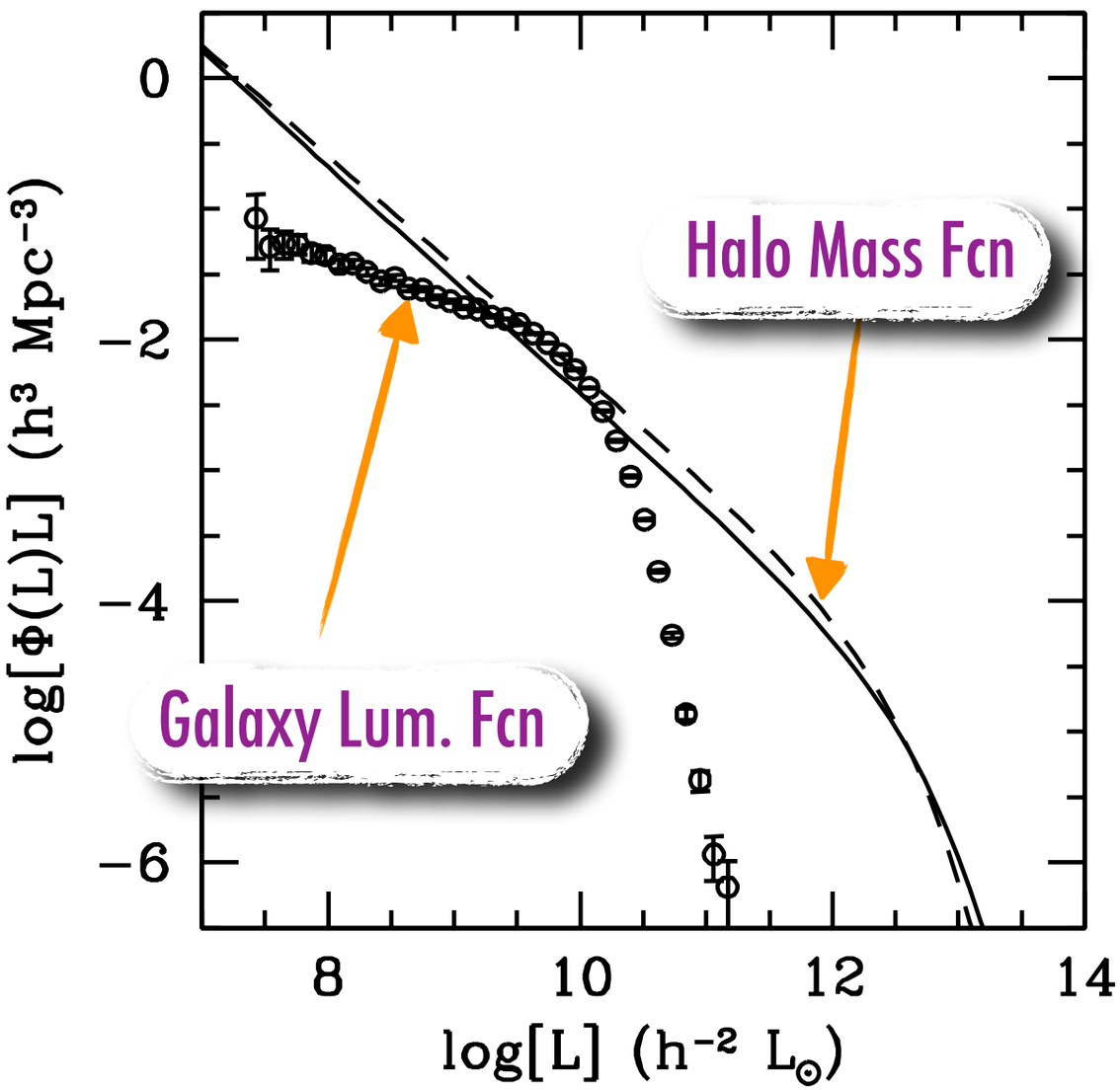
Ejects gas/metals out of a galaxy



NGC 3079 (HST)

Why is it important?

Better understanding Luminosity Function



Yang et al. 2003

Supernovae

Cassiopeia A nebula

- Drives evolution of low mass galaxies
- Expel baryons
- Enriches IGM with metals
- Influenced by SF and vice versa

Simulations

- SNe-driven winds limit accretion/SF?
- Sufficient mass outflow rate?

Powell+ (2010), Governato+ (2007), Scannapieco+ (2009), Agertz+ (2010)

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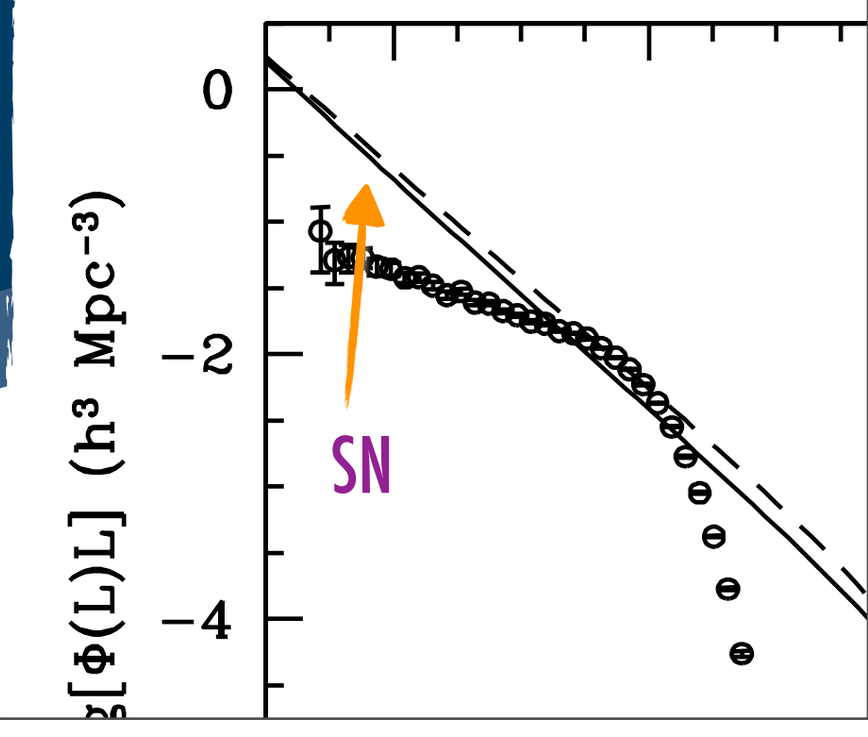
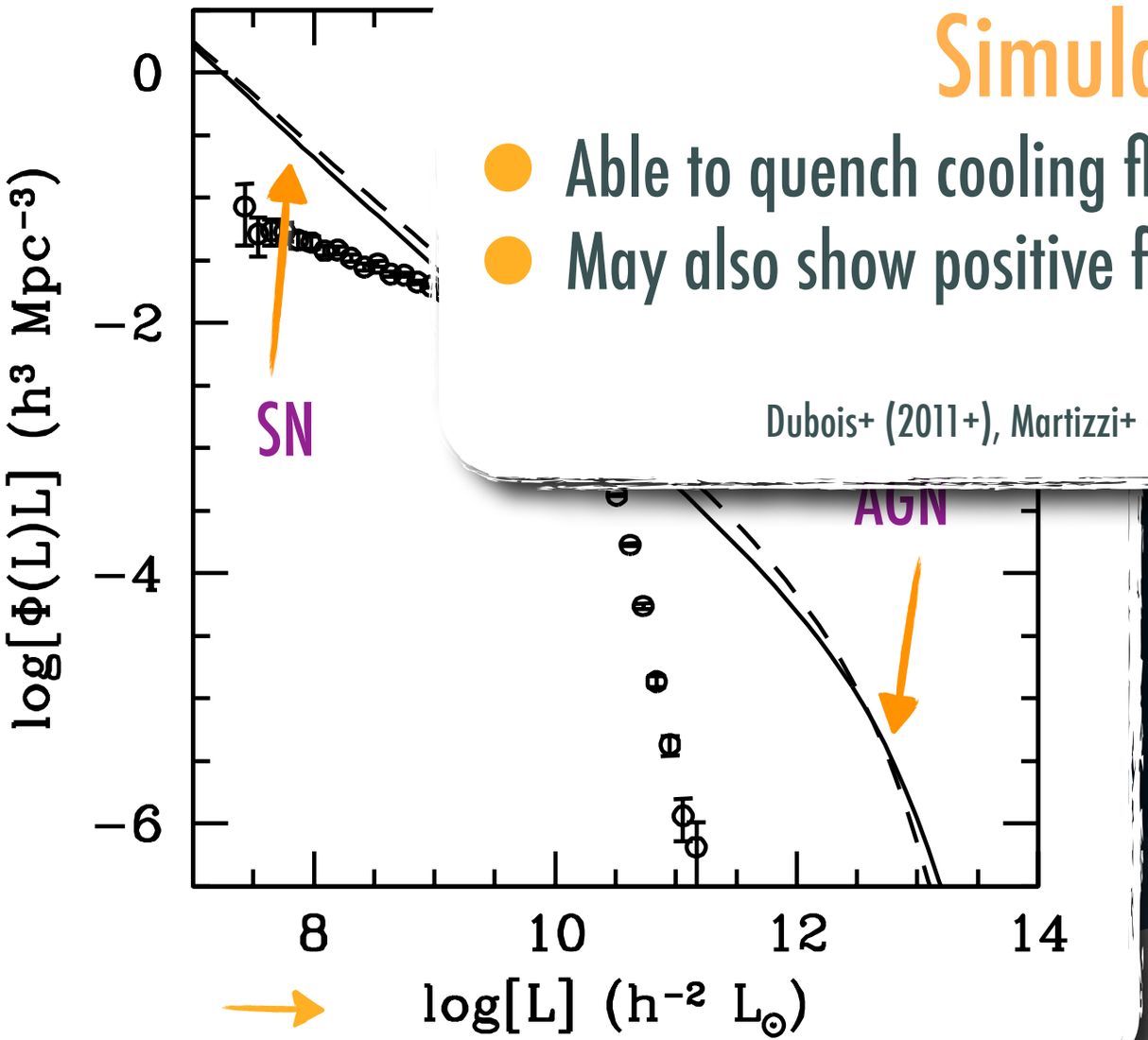


Active Galactic Nuclei

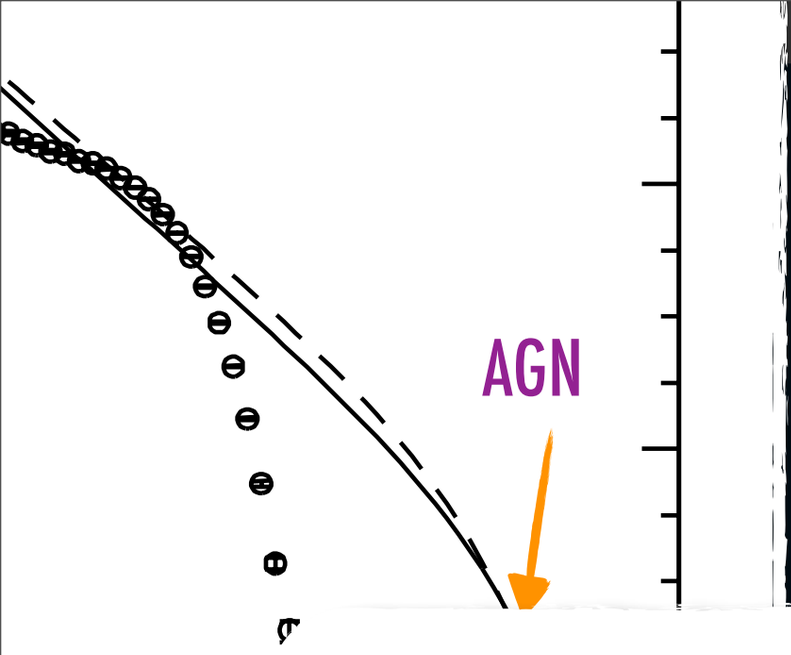


Simulations

- Able to quench cooling flows in clusters
- May also show positive feedback? (Gaibler+ 2012)

Dubois+ (2011+), Martizzi+ (2012+), Springel+ (2005), Di Matteo+ (2005+)

Yang et al. 2003



Active Galactic Nuclei

Artist Impression

Simulations

- Able to quench cooling flows in clusters
- May also show positive feedback? (Gaibler+ 2012)

Dubois+ (2011+), Martizzi+ (2012+), Springel+ (2005), Di Matteo+ (2005+)

- Drive evolution of high mass galaxies
- Negative Feedback:
  - Expel Baryons
  - Heat interstellar gas → Halt cooling
- Possible positive feedback? (Croft+ 2006, Mould+ (2000), Morganti+ (2010))

Star Formation in Simulations

- Models impose 'local Schmidt-law': $\dot{\rho}_* = \epsilon_* \frac{\rho_{\rm gas}}{t_{ff}}$

- Some additional criteria or restrictions are included:
  - **Density threshold** ($n > 0.1 {\rm cm}^{-3}$) (most common, RAMSES)
  - Restricting star-formation to gas below some temp
  - Jeans unstable
  - Convergent flows
  - Short gas cooling time
  - Molecular criteria (restricting SF to the 'molecular gas')
  - Turbulence criteria
  - Other possibilities?

Physical interpretation depends on resolved dynamic range of simulation and the mean properties of the galaxy

Star Formation in Simulations

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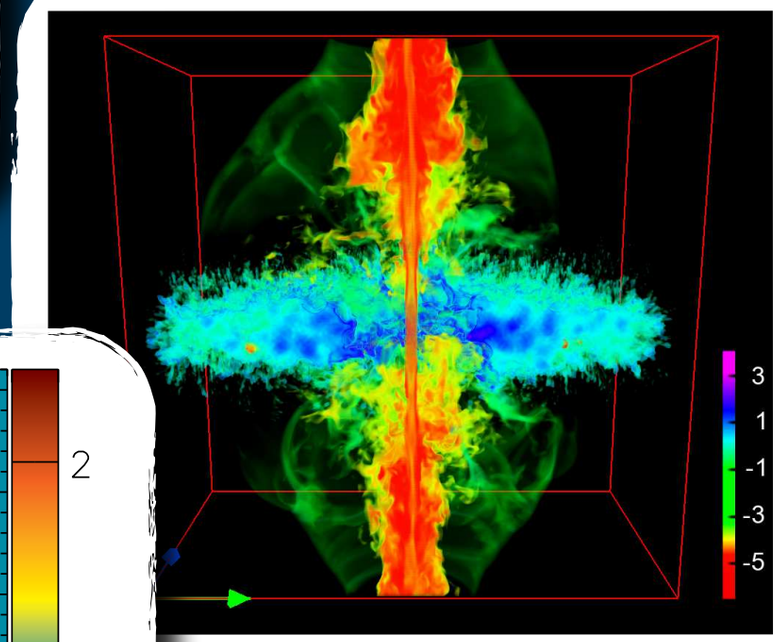
Physical interpretat
dynamic range of si
properties

Positive Feedback?

Feedback influences Star Formation

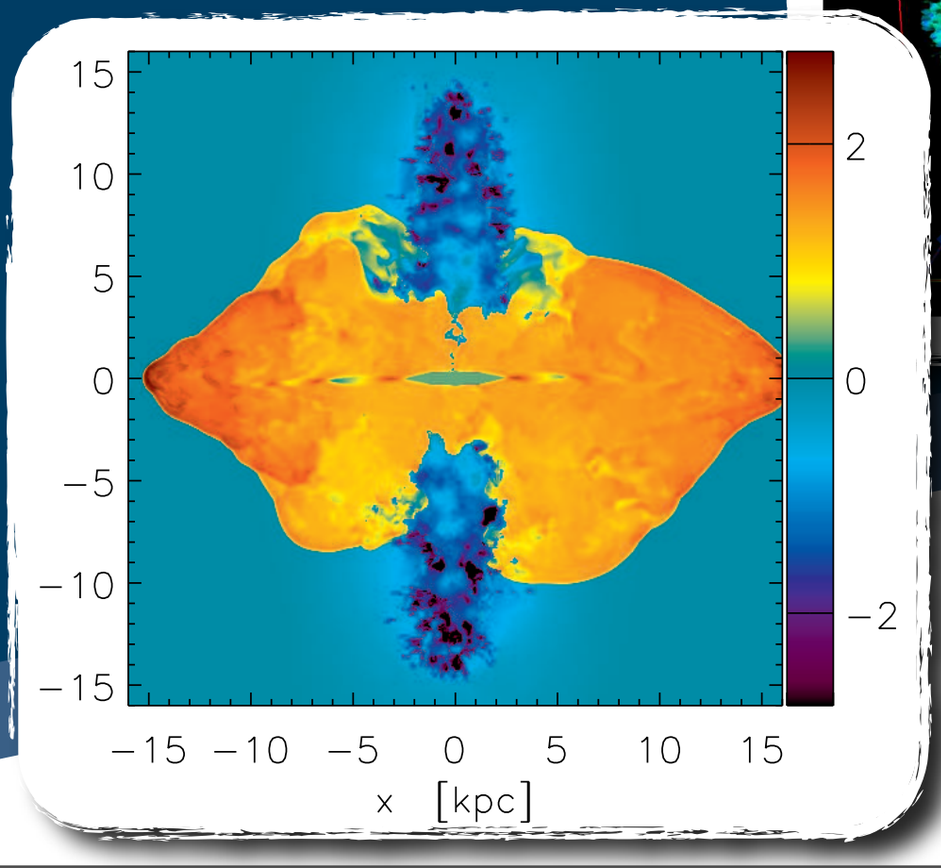
Supernovae (SNe bubbles) ⇄ Star Formation

AGN → Star Formation (jet induced)?

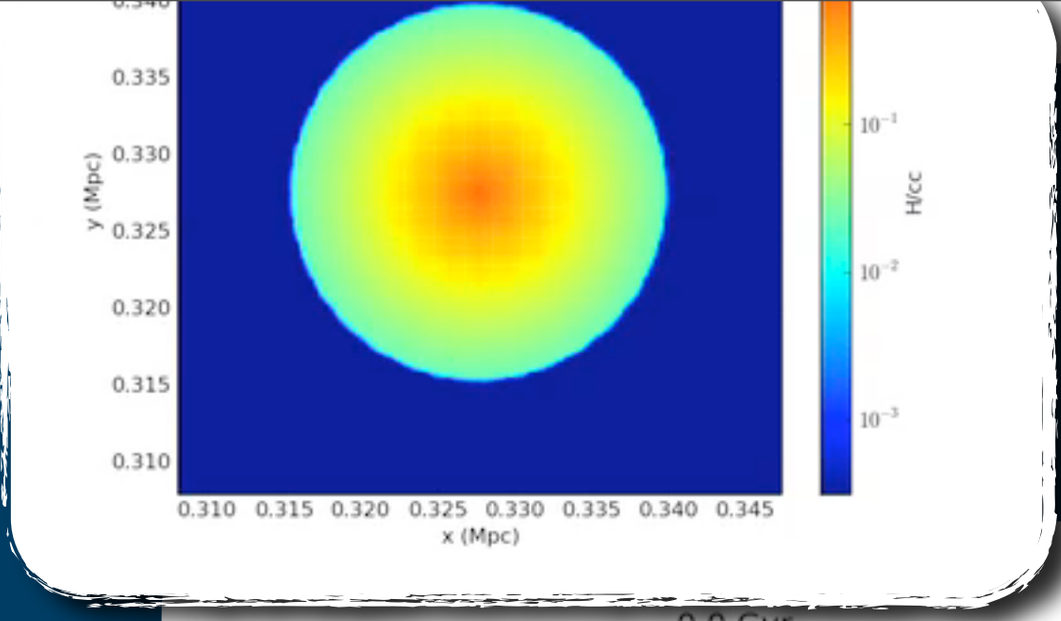


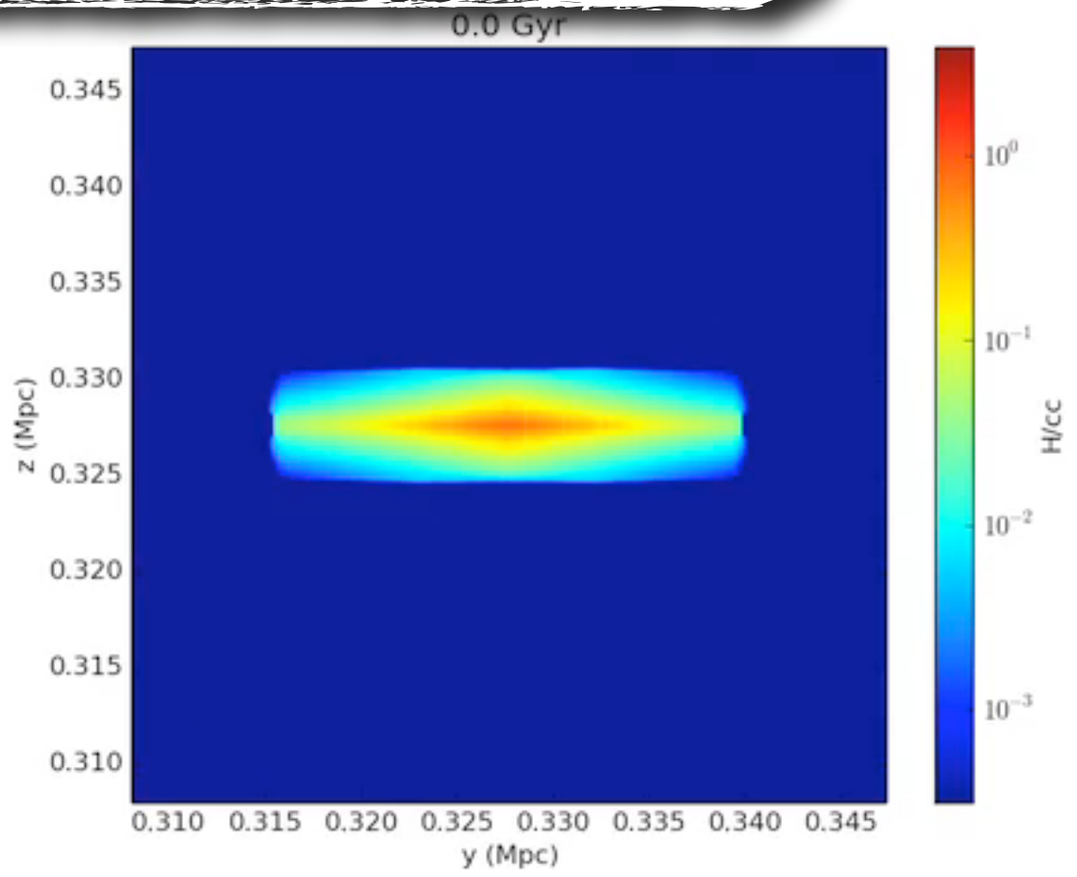
Gaibler+ (2012)

- Jet pressurises disc



Pressurised Disk



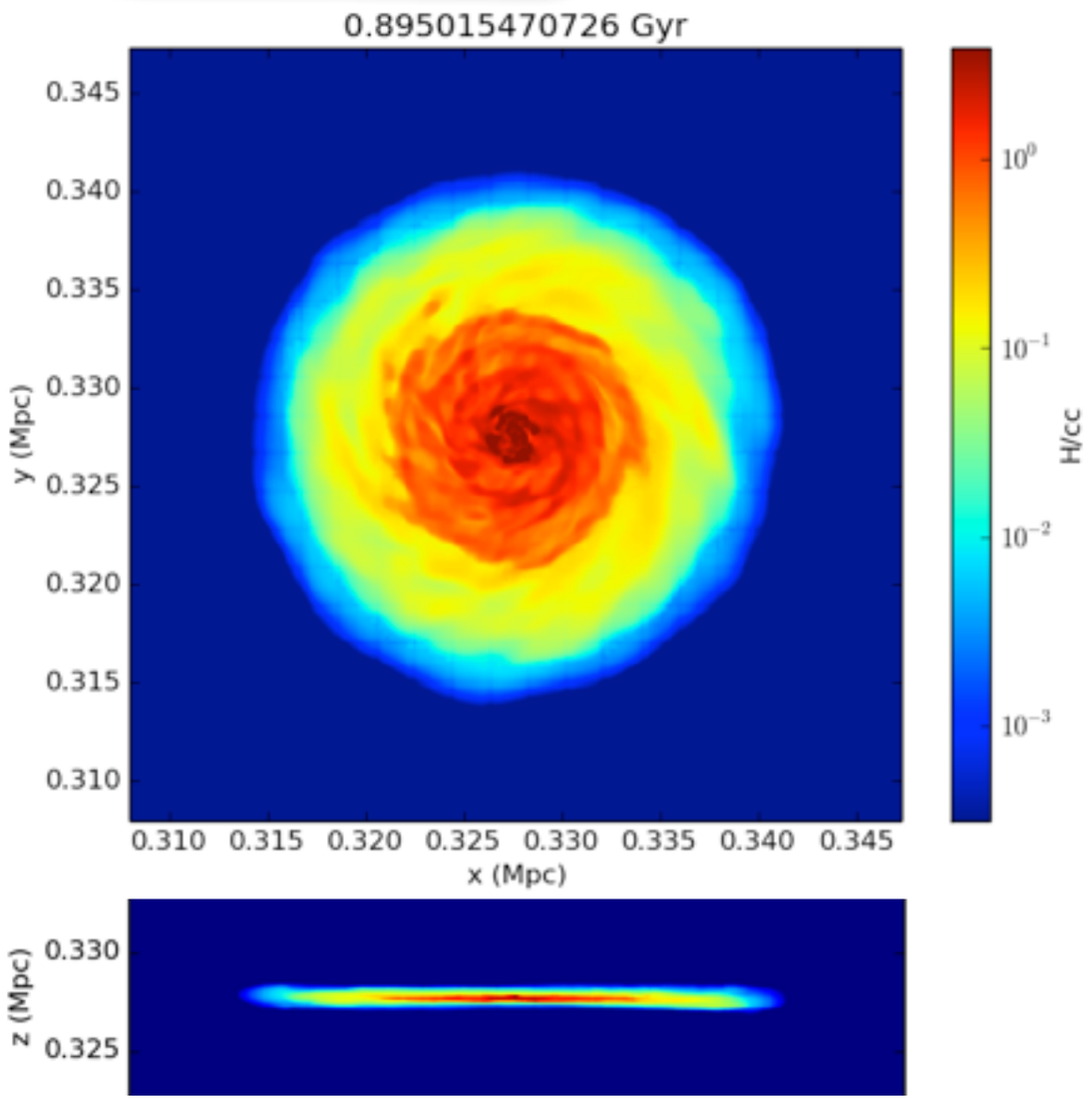


Simulations:

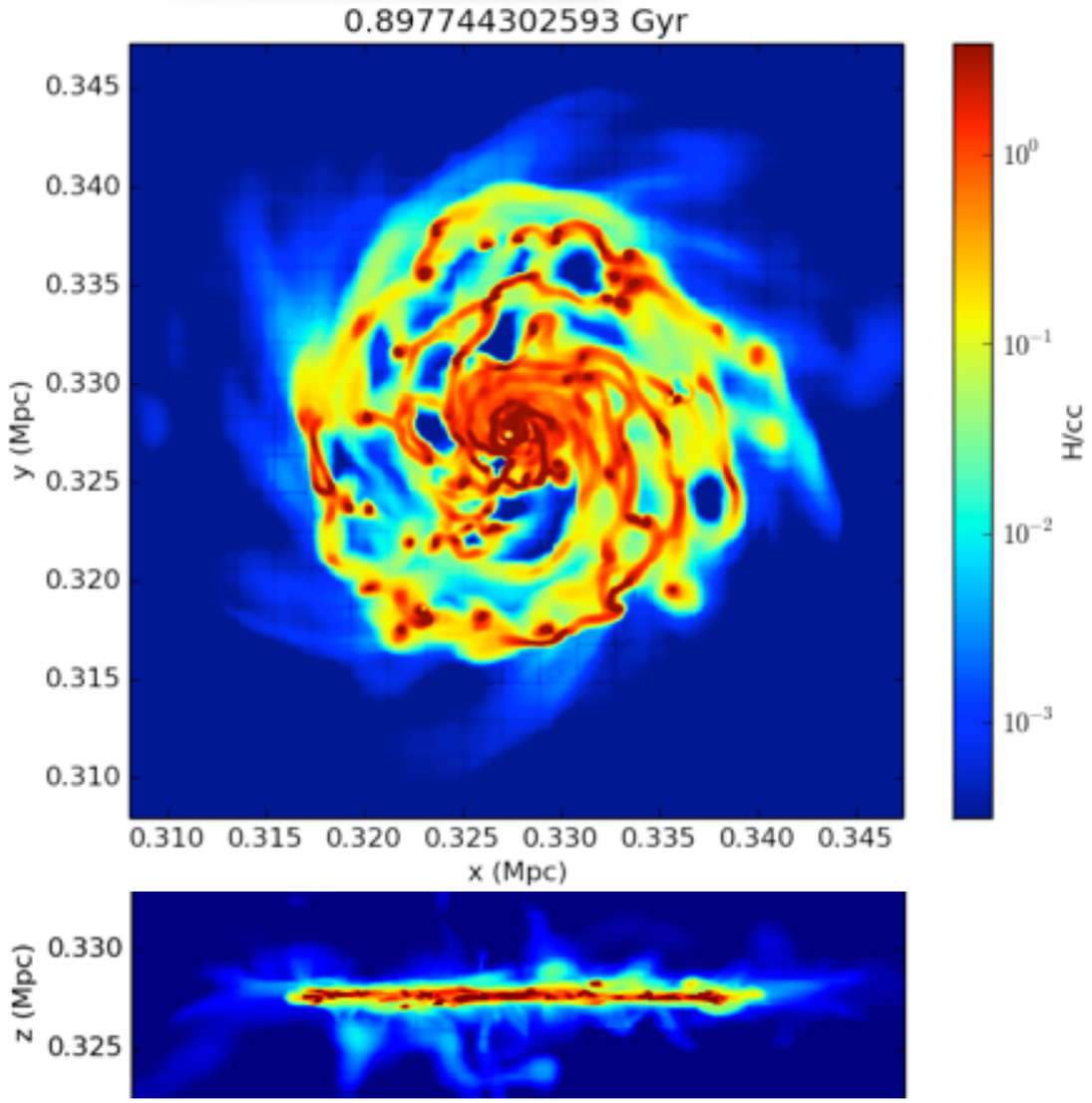
- Runs with **RAMSES** code, 40 pc resolution:
  - Pure adiabatic hydrostatic case (Teyssier 2002)
  - Pure cooling and star formation
  - Stellar feedback (Teyssier+ 2013)
- NFW halo, 11.4 10^{10} $M_{\odot}$, Bulge
- **galaxy1**: 10% gas, v200(km/s)=70, typ radius = 3.4 kpc
- **galaxy2**: 50% gas, v200(km/s)=70, typ radius = 3.4 kpc
- **galaxy3**: 50% gas, v200(km/s)=70, typ radius = 1.2 kpc

Non-pressurised Disk

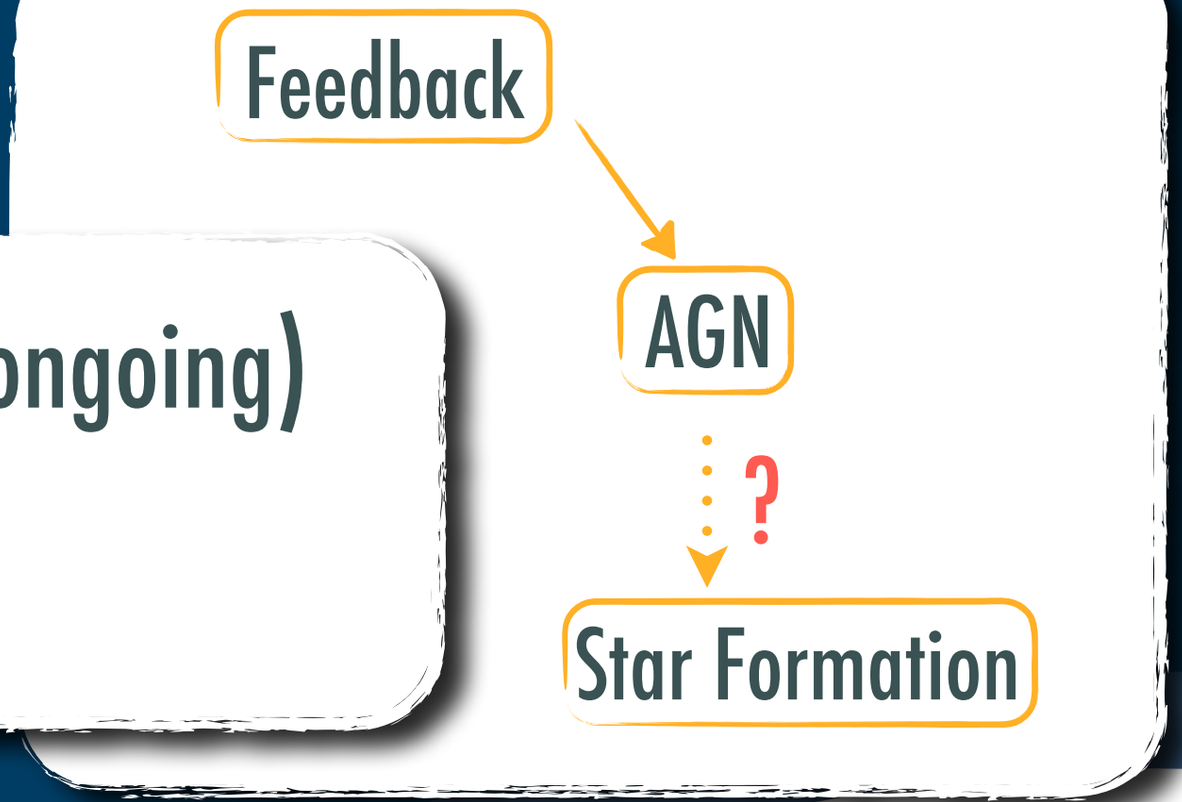
10% Gas



50% Gas



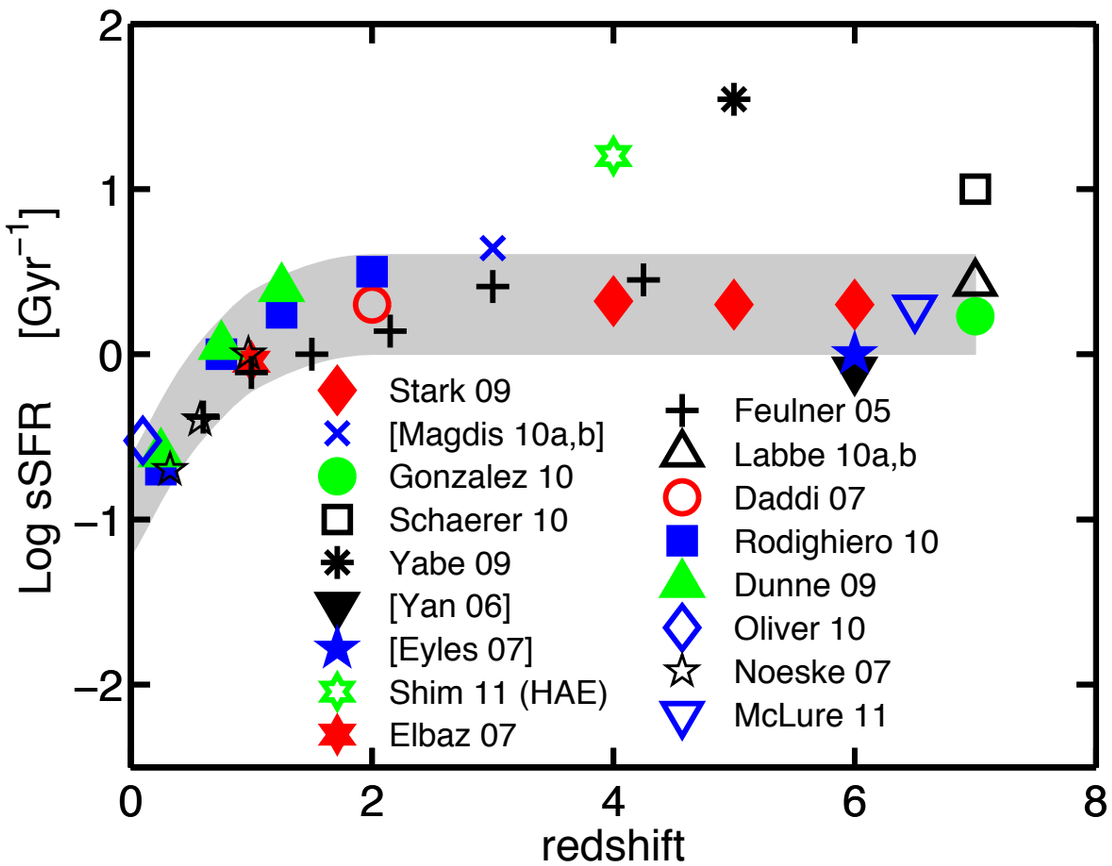
Merci pour votre attention



1. Pressurised disc (ongoing)
2. AGN jet

Merci pour votre attention

Slows down Star Formation in Galaxies



Weinmann 2011