What impact does AGN activity have on star formation?

Or: “How can we disentangle two things we don’t fully understand…”
For, fence sitters, and against

- “Strong” Shimizu, Dubois, Saintonge, Kocevski
- Hmm… Hickox, Azadi, Juneau (“it’s complicated”), Lamassa, Alonso-Herro, Lehnert (“may or may not”)
- “Not that much” Gabor, Roos

Not exhaustive! (It’s late!)
Results

• Do radio quiet AGN drive gas?
• Do radio quiet AGN prevent cooling?
• Do radio quiet AGN compress gas?

Statistically equivalent – but majority of presentations non-committal
Do radio quiet AGN drive gas?

A. Don’t agree
B. Agree
Results

- Do radio loud AGN drive gas?
- Do radio loud AGN prevent cooling?
- Do radio loud AGN compress gas?
Do radio quiet AGN prevent cooling?

A. Don’t agree
B. Agree
Model fidelity

Dust(!), Rad pressure, Multiphase ISM, Stellar winds, Photo-io/heating, AGN accretion, maintenance mode, quasar mode, black hole spin, black hole integration

Dimensionality is a given – we have to do 3d

Everyone?

multi-physics

physical complexity

spatio-temporal resolution

mono-physics

1D

2D

3D

4D

... hi-res.

Dubois, Gabor, DeGraf, Zubovas

Credit: Mike Norman
Resolution

• “As much as you can get” – fine, but often need statistics

• Inevitable that some scale is missed
  – At kpc scale – high z evolution is “spotty”
  – At 100 pc scale, still don’t resolve down to Bondi radius or GMCs
  – Is 10 pc good enough?

• How much does the “last pc” problem matter to the development of the whole galaxy?
Influence of AGN

Towards GR models

AMR model resolution

EAGLE resolution

Self-reg & Eddington limiting

$M_{\text{BH}} - \sigma$ & mass disposal

Regulate ISM

Galaxy formation

Heat halo & cluster gas

Dynamical evolution of galaxy centers & star-clusters

[L/M/H] and B

10^{-4} pc

10^{-1} pc

10^{1-3} pc

10^{3-4} pc

10^{4-8} pc

10^{6-8} pc

LSS

Matt Lehnert
If you can only choose one…

A. More/better physics in models
B. More/better resolution in models
AGN Feedback - how to make it “better”? 

• How should we implement it?
  – Schaye & collaborators: turn up the temperature to avoid energy being radiated away
    • AGN feedback temperature at $10^{8.5}$ K (~30 keV)
    • High enough on cooling curve not lose energy immediately
    • No wind/jet distinction
  – Gabor, Roos, Dubois, Zubovas: “Need the resolution”
  – DeGraf “Fix lower resolution accretion issues”
Getting more sophisticated

• What about more sophisticated implementations?
  – How can we incorporate FR-I & FR-II?
FRI is top of ADAF branch (low/hard state BHB) but $\Gamma=15$!

FRII/FSRQ

FRI/BL Lacs

Ghisellini et al. 2010
What about spin?

- c.f. Dubois talk
- Radiative efficiency increases by \( \sim 6 \) from Scharzwschild to maximal spin (\( a=0.998 \))
- Is it "impossible" to make statements about accretion at \( R_s \)?
  - Chaotic? (e.g. King & Pringle 2006) Would keep spins low and allow rapid growth
- And what about jets removing spin?
1000x more Fermi BL Lacs!!

- Maybe only highest spin have jets – but requires that high spin is RARE
- NOT true in prolonged accretion
Get Fermi number and distribution for chaotic accretion and $a>0.8$!!

Gardner & Done 2013

![Histogram of Fermi number and distribution for chaotic accretion and $a>0.8$.]
Getting more sophisticated

- Is cluster pressure enough to constrain jet and deposit energy (c.f. Cavagnolo et al. 2010)
- Implications for high z
What about super-Eddington accretion?

\[ M_{\text{dot}} < 0.01 \quad 0.01 < M_{\text{dot}} < 1 \quad M_{\text{dot}} > 1 \]

RMHD Ohsuga et al 2011 BAL QSO/UFOs??
Observational constraints on feedback

• SZ measurements on individual stacked large early types?
  – Energy input correlates directly to energy injection

• Variability? How do we pin this down?

• Ensemble vs phenomenology