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Simba-C: A large-scale cosmological simulation and beyond

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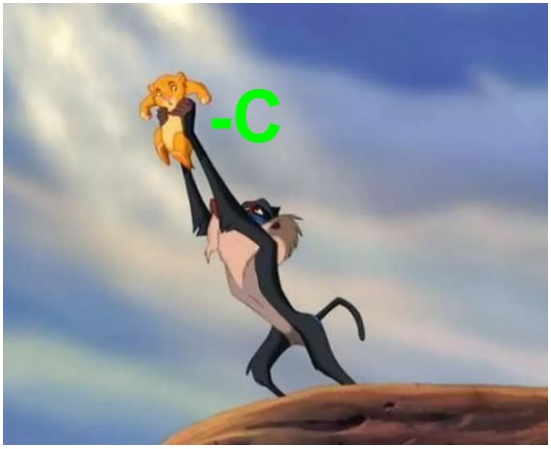
A transition phase!

From ΛCDM galactic simulations and observations to probing the effects of modified gravity theories on baryonic matter in the Universe!

Simba + Chem5 = Simba-C
Hough et al. (2023)

Implementation and parameter calibrations:[1]

- Chabrier IMF.
- Dust mapping in the simulation.
- $f_{\mathrm{SNII}} = 0$.
- Black hole jet activation range parameter:
  - From $4 \times 10^7\,\mathrm{M}_\odot - 6 \times 10^7\,\mathrm{M}_\odot$
  - To $7 \times 10^7\,\mathrm{M}_\odot - 1 \times 10^8\,\mathrm{M}_\odot$
- Wind velocity scaling:
  - $1.6 \rightarrow 0.85$

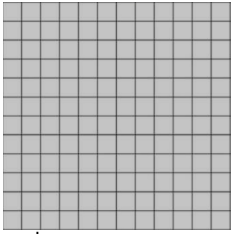


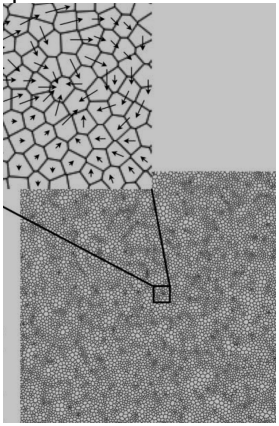
[1] Romano et al. (2005), Muratov et al. (2015)

The Simba simulation

Simba is a large-scale cosmological simulation and consist out of two components:[2]

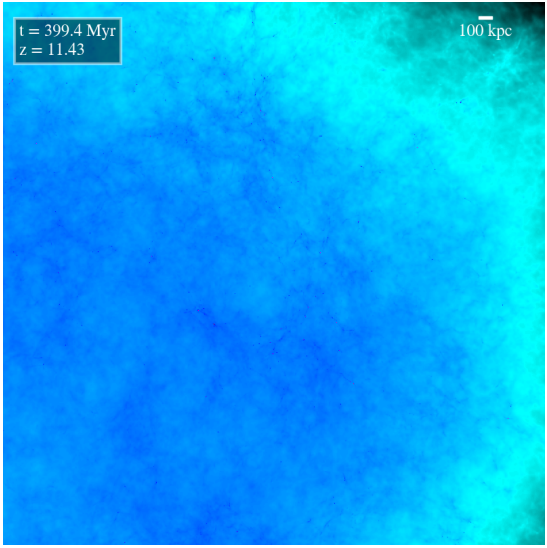
- Gizmo (Hydrodynamical Lagrangian MFM)
  - Main simulation.
  - Gravity.
  - Hydrodynamics and thermal evolution.
- Simba (Sub-grid/sub-resolution models)[3]
  - Stellar and black-hole formation.
  - Feedback systems and interaction with environments.
  - Chemical evolution, passive dust models, etc.



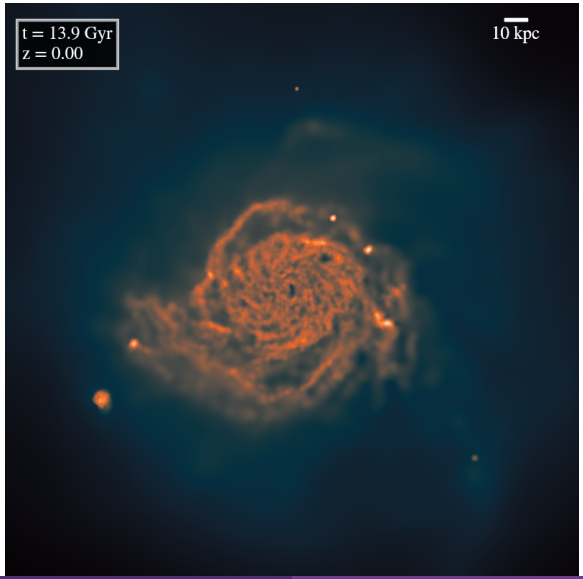


[2] Davé et.al (2019).
[3] Davé et.al (2016).

Formation of a galaxy cluster



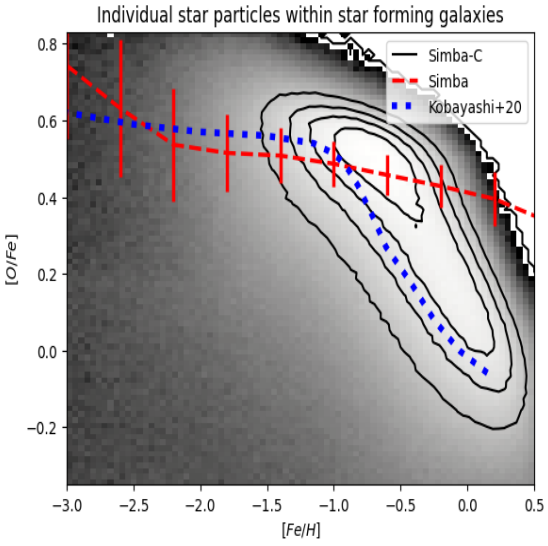
Spiral galaxy

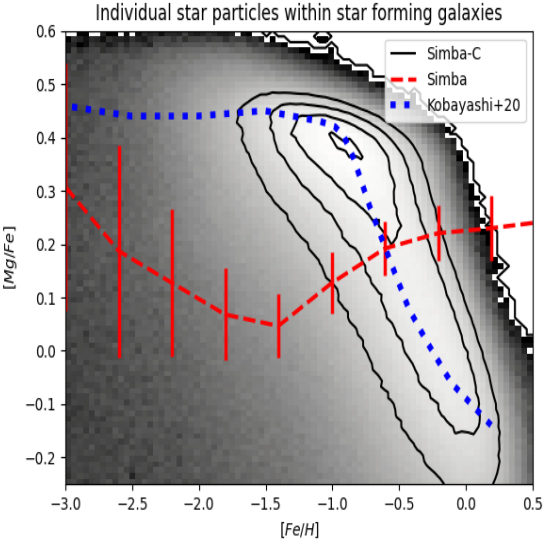


- Chem5 model developed by Kobayashi et al. (2007) and continued improvement.[4]
- Self-consistent 3-D chemodynamical model.
- Tracks 32 elements (H $\rightarrow$ Ge).
- Physical processes for metal production:
  - Stellar feedback does not use instantaneous recycling of the metals!
  - Treats star particles as evolving stellar populations that eject thermal energy, gas mass, and heavy elements.
  - Feedback systems: SNe Ia/II, stellar winds, AGBs, Super AGBs, HNe, and 'failed' SNe.

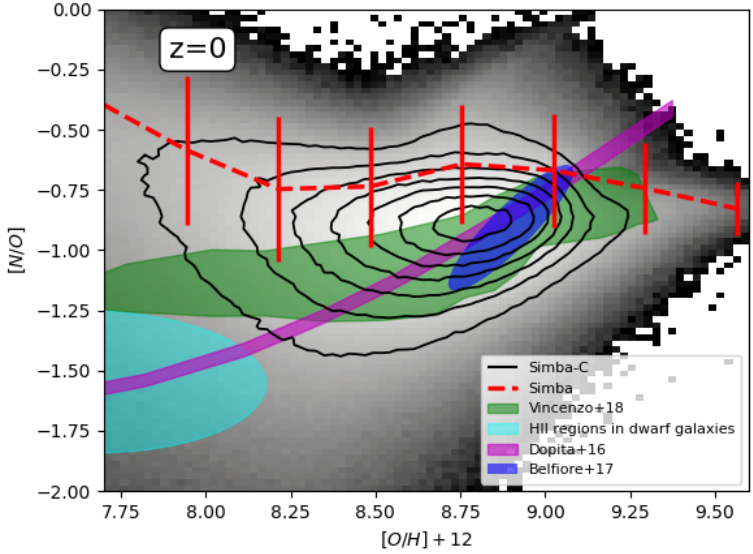
[4] Kobayashi & Nakasato (2011), Kobayashi et.al (2020)

Stellar [α/Fe] abundance ratios for MW-like galaxies

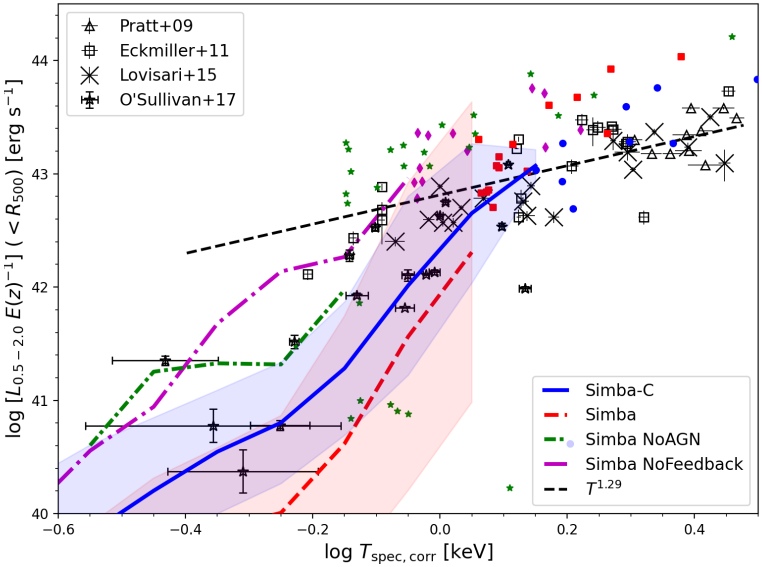




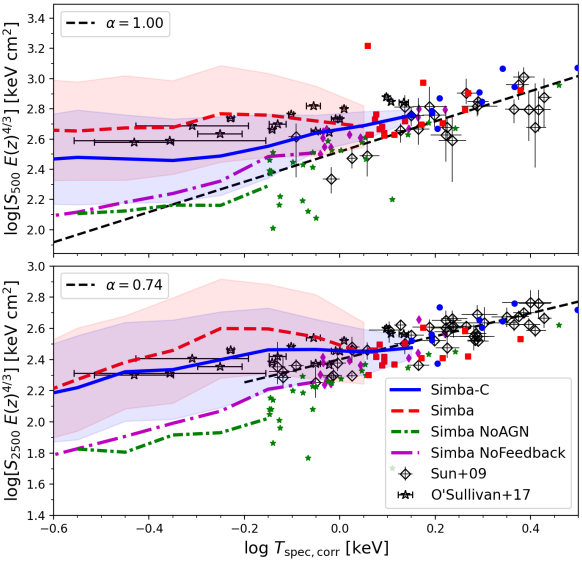
Gas-phase Nitrogen abundance ratio



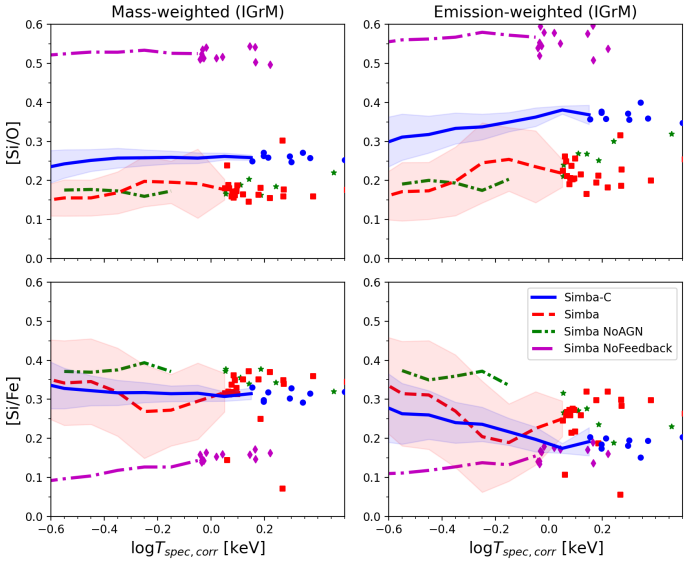
Group $L_x - T_{spec,corr}$ relation



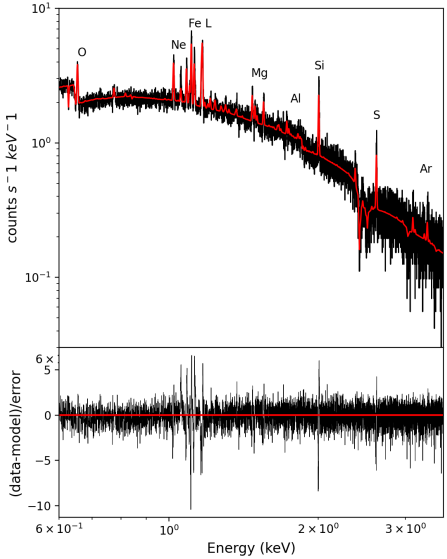
Group $S_{2500/500} - T_{spec,corr}$ relation

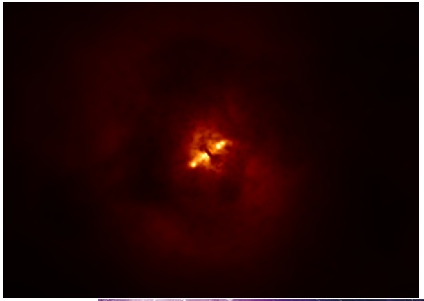


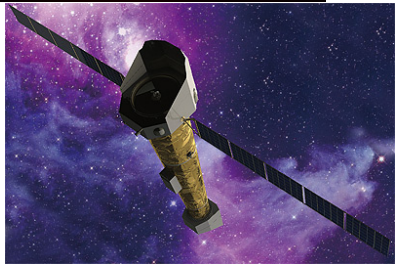
Group [Si/Fe] and [Si/O] abundance ratios



Mock Athena X-IFU observations (Moxha) - Preliminary



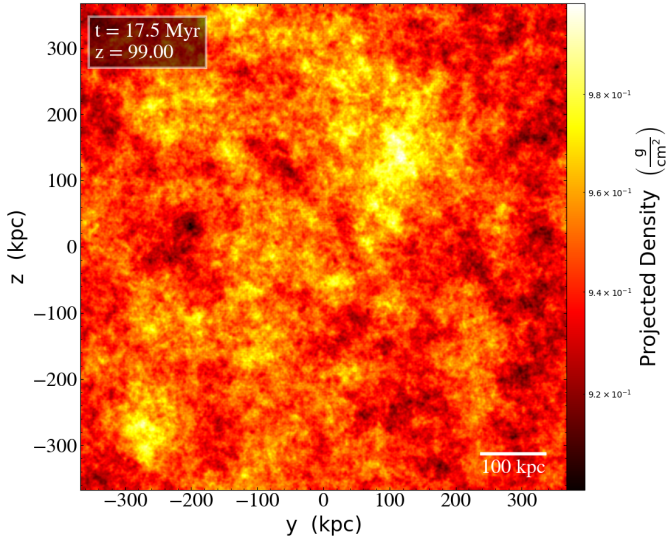




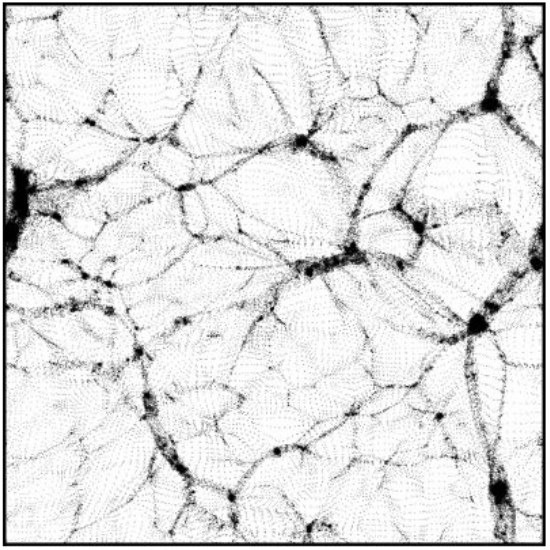
What is the impact of gravity/cosmology on the simulation?

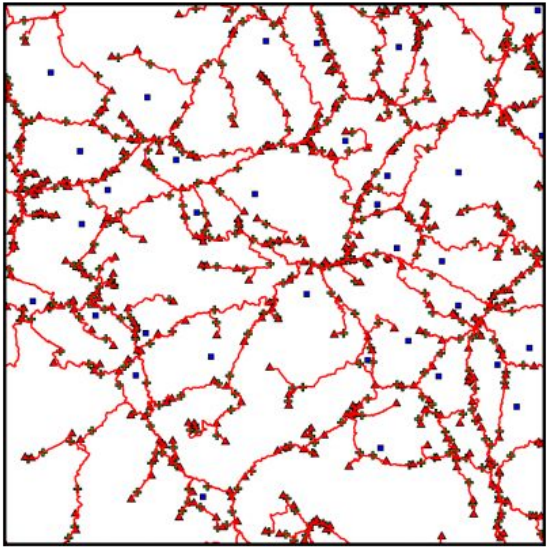
- Where do we even start?
- Does changing the gravity model change the baryonic properties in the simulation?
- How will we determine whether the change (if any) is physical and realistic?

Large-scale structure evolution

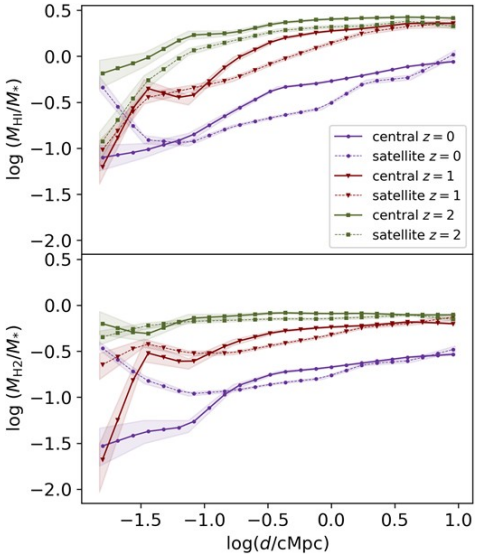


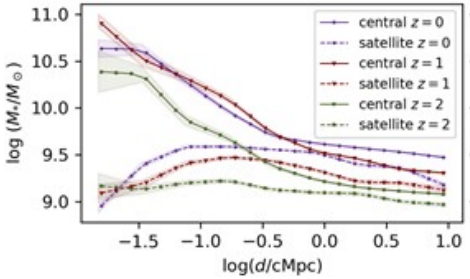
Filament distribution

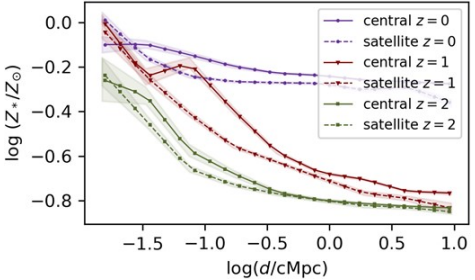




Galaxy properties as a function of distance from filaments (Bulichi+24)







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THANK YOU!!!

SIMBA-C: an updated chemical enrichment model for galactic chemical evolution in the SIMBA simulation
Hough R. T., Rennehan D., Kobayashi C., Loubser S. I., Davé R., Babul A., Cui W., 2023, MNRAS, 525, 1061.

Simba-C: the evolution of the thermal and chemical properties in the intragroup medium
Hough R. T., Shao Z., Cui W., Loubser S. I, Babul A., Davé R., Rennehan D., Kobayashi C., 2024, MNRAS, 532, 476.

Simba-C: mock X-ray observations of the chemical abundance in the intracluster/group medium
Hough R. T., Jennings F., Sonkamble S., Loubser S. I, Davé R., Babul A. (authors to be confirmed). Planned submission to MNRAS in 2024.