A theoretical approach to the formation of galaxies

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on behalf of the Trieste+ numerical cosmology group

the question:

How do galaxies form?

MA1 meeting, Bologna, June 2016

A theoretical approach to the formation of galaxies

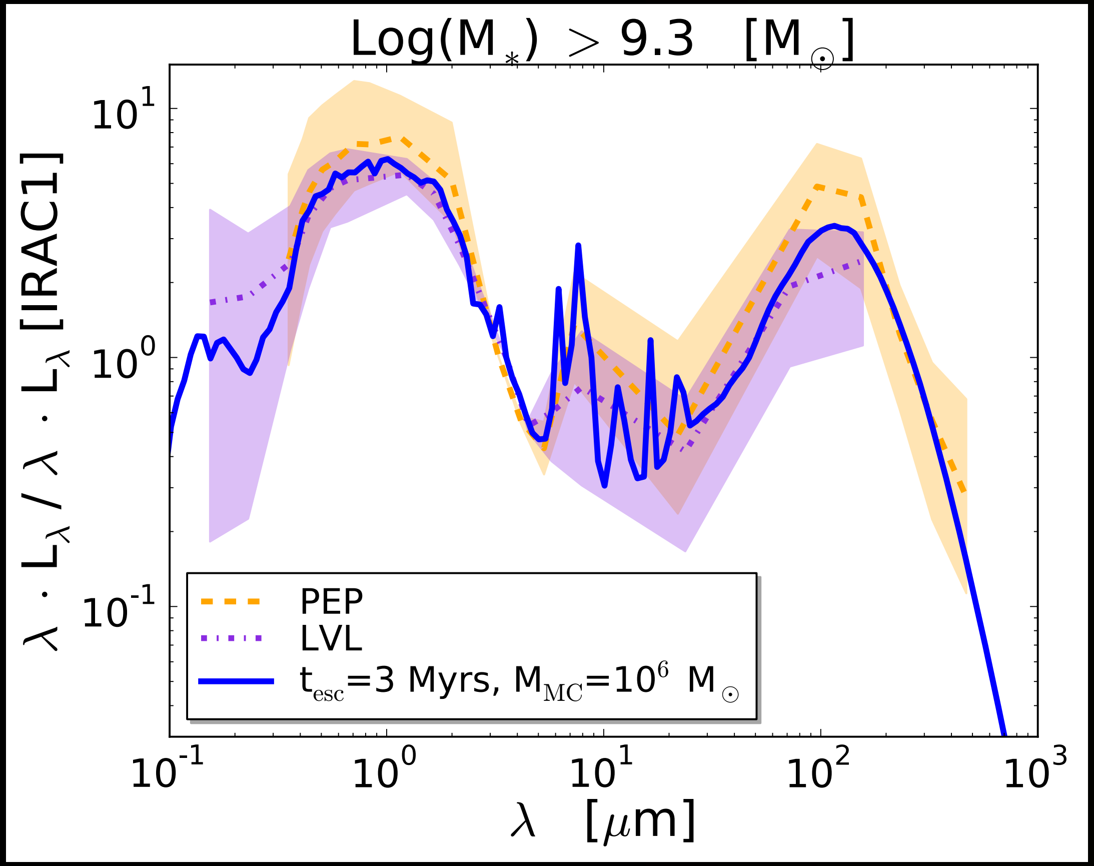
the specific questions:

- How do baryons cycle in and out the dark matter halos?
- What are the relevant feedback mechanisms and how efficient are they along the history of the Universe?
- What causes the "down-sizing" of galaxies growing in bottom-up halos?
- What is the history of angular momentum of gas and stars under accretion, major and minor mergers or secular instabilities?
- Why are some galaxies compact at high-z? Why do some galaxies quench at low-z? what is the interplay between size and SFR?
- To what extent can we apply local scaling relations of star-forming galaxies (Schmidt-Kennicutt, Blitz & Rosolowski) to distant galaxies?
- What is the role of black holes and AGN feeback? ➞ **Lapi**
- What is the role of environment? ➞ **Cucciati**

A theoretical approach to the formation of galaxies

How do we relate predictions and observations?

Are we ready for Jwst, Alma, E-ELT, Athena, SKA, Spica etc.?



Predicted SEDs of a local galaxy sample from a simulation, Goz et al. (2016)

→ **Hunt**

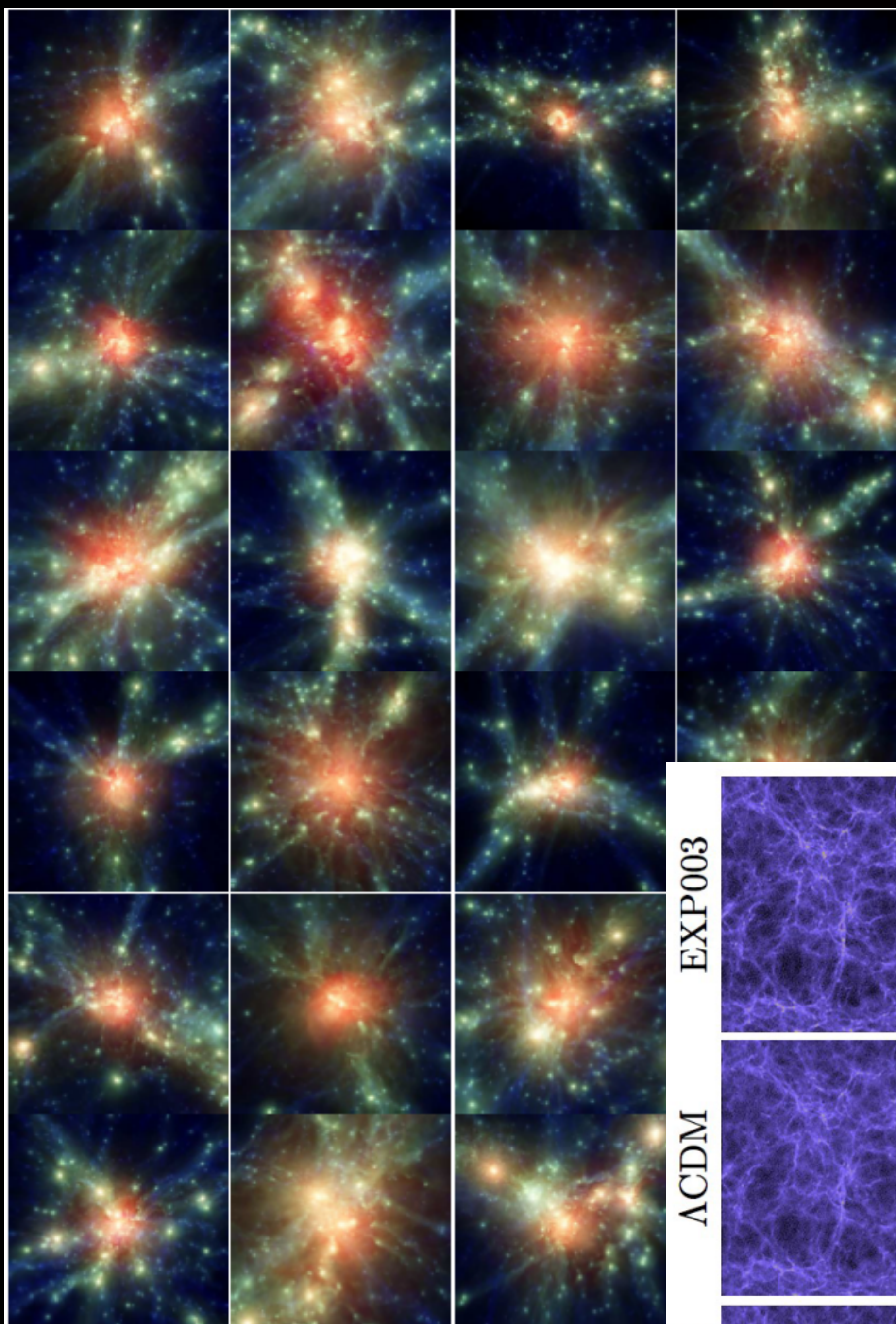
We should extend our tools:

- FIR side of galaxy SEDs
- emission lines
- IFU and internal kinematics
- large statistics
- absorption systems

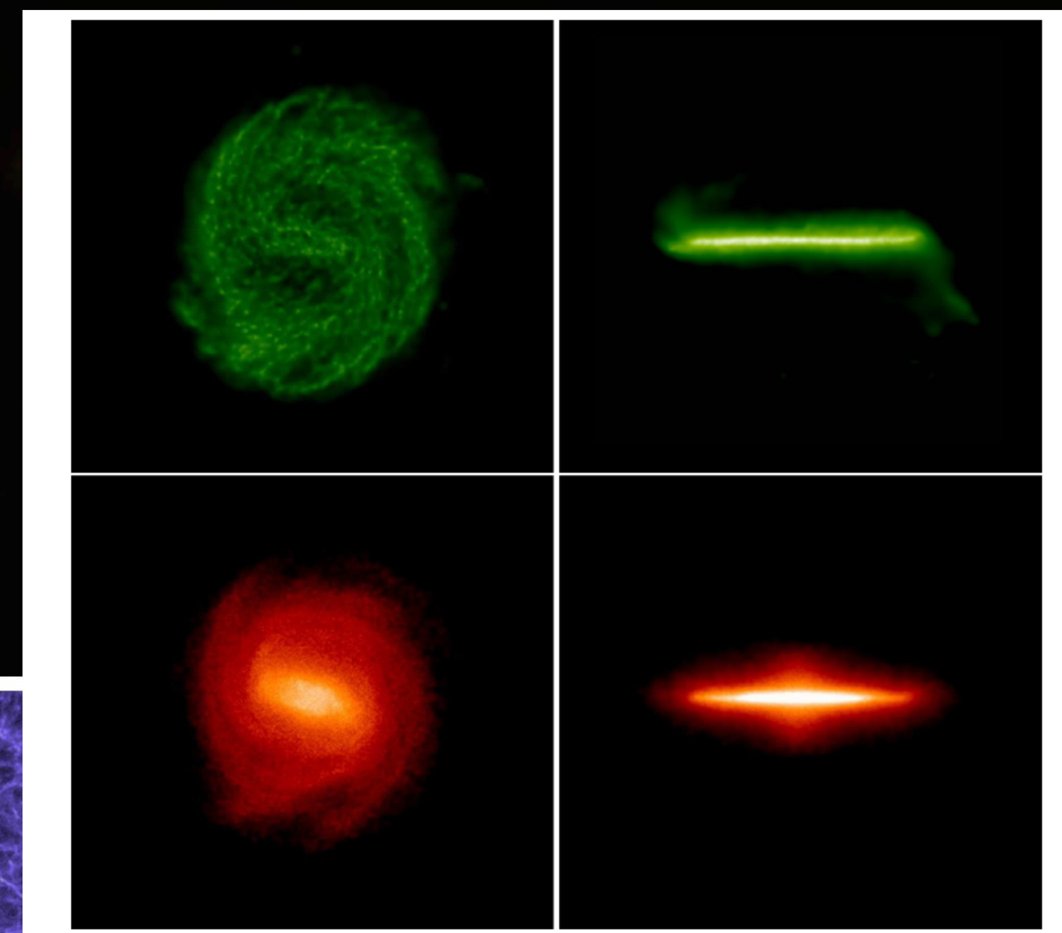
Tools

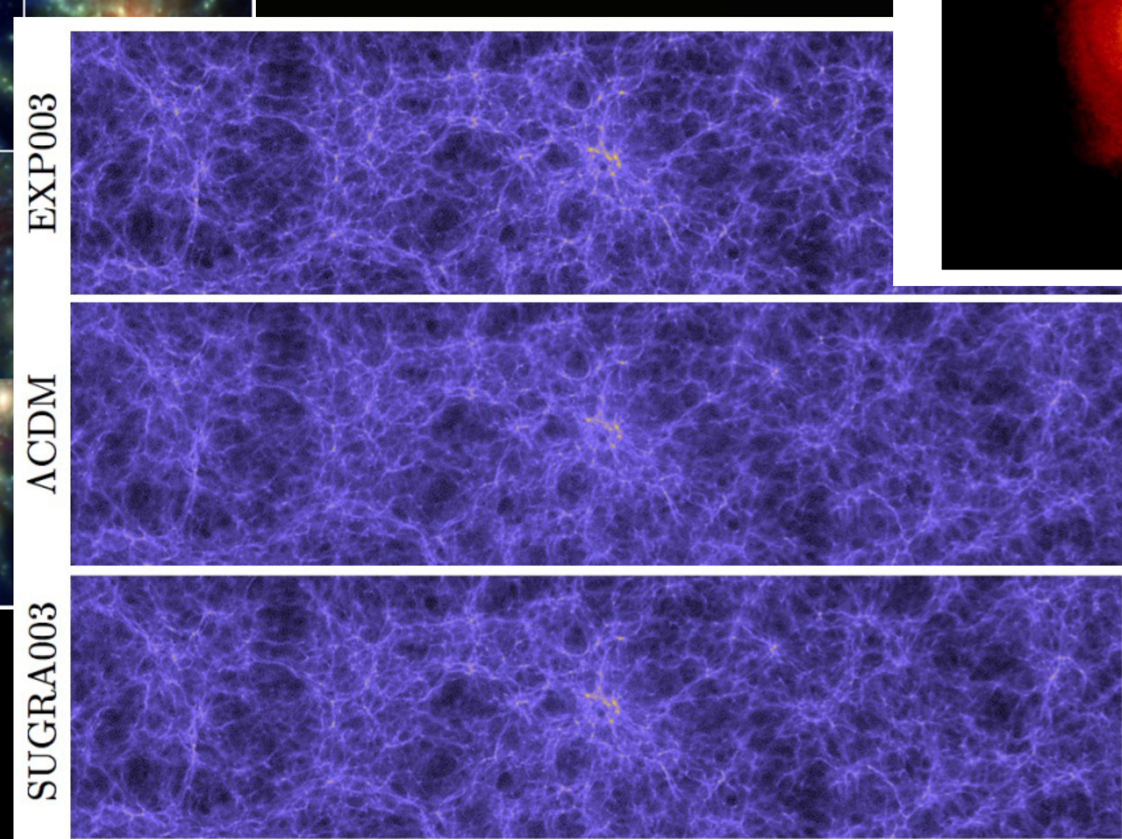
- Phenomenological models: schematic description of flows in galaxies
  - pro: easy to handle
  - con: little insight on the physics
- Semi-analytic models: simplified description of the fate of baryons in the "skeleton" of dark matter halos
  - pro: very fast, easy to sample the parameter space
  - con: difficult to include some processes (e.g. reaccretion of ejected gas)
- Cosmological hydro simulations: numerical evolution of a set of initial conditions as predicted by the ΛCDM model
  - pro: much more realistic setting (...yes, they are expensive)
  - con: need of sub-resolution prescriptions (semi-analytic...)

Cosmological (hydrodynamical) simulations



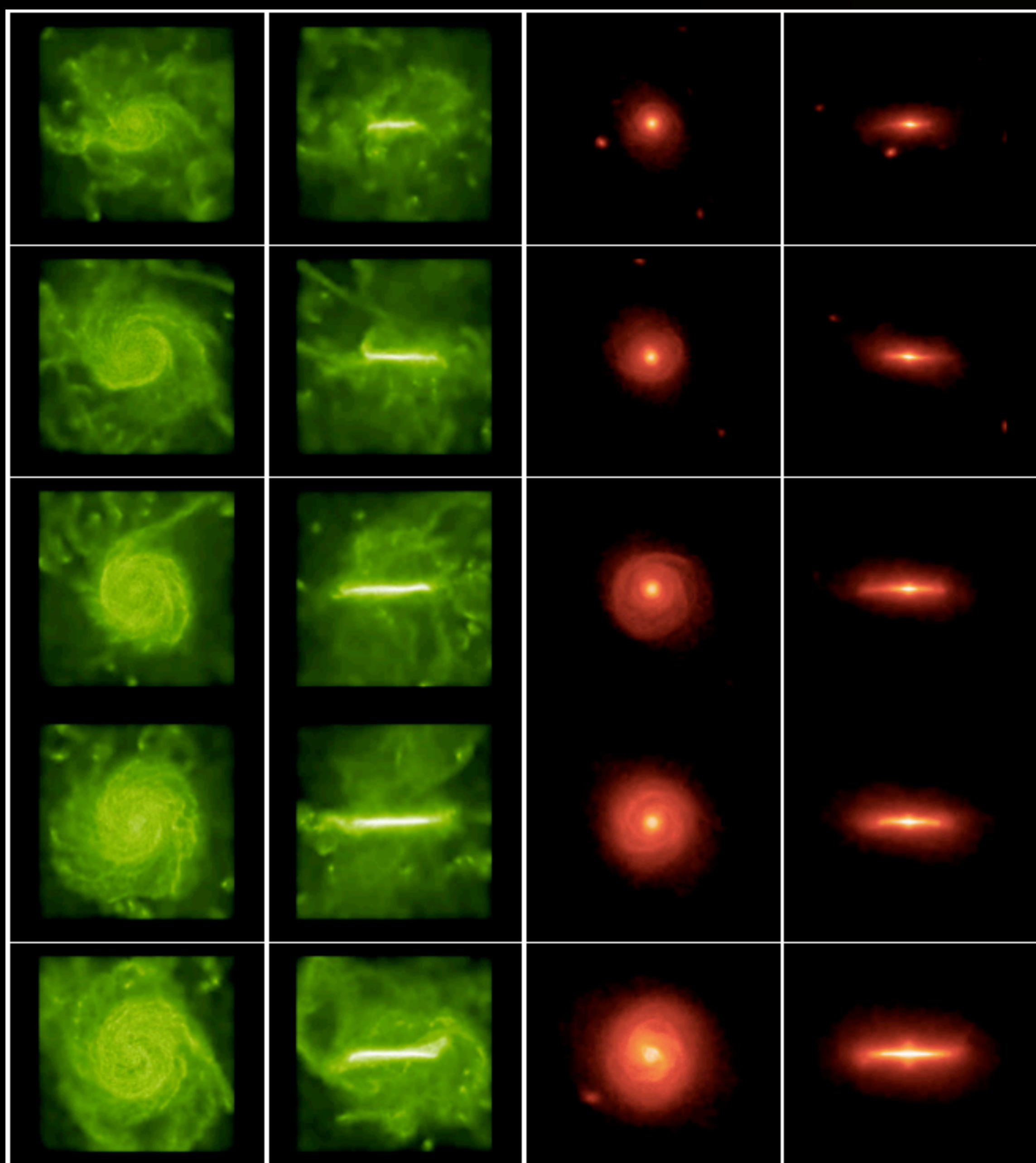
Galaxies
Galaxy clusters
Large-scale structure





Progress: recent breakthroughs

Disc galaxies, Murante et al. (2015)



Cool core clusters, Rasia et al. (2016)

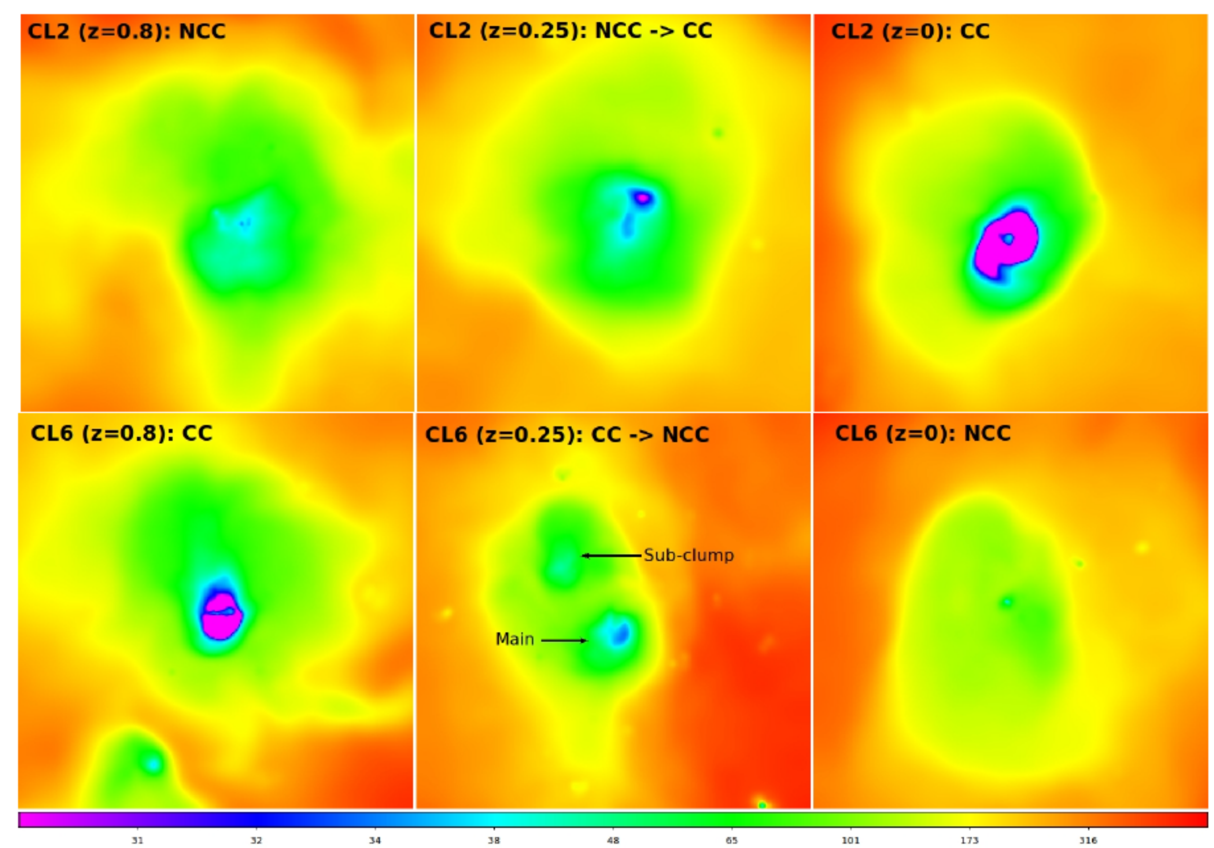


FIG. 2.— Maps of pseudo entropy of two simulated clusters that have masses $M_{500} = 2.4 \times 10^{14} h^{-1} M_{\odot}$(upper panels) and $M_{500} = 7.3 \times 10^{14} h^{-1} M_{\odot}$(lower panels) at $z = 0$. The size of the images is 1Mpc.

Towards exa-scale computing

- Codes will be required to scale up to **millions** of cores
- Coding must change: we need specialized staff, software engineers, to port our codes on the new architectures
- It is difficult to hire such professionals: low salary, loose connection to software industry
- Some "tecnologo" staff should be devoted to theory
- Scientists should only be concerned in developing physics modules (and exploit the code, write papers, teach to students...)

The role of INAF in the support of HPC

- It is dangerous to continue running simulations without a "change of paradigm" in the organization of our work
- If INAF **WANTS** to support HPC, then we need:
  - Infrastructure: Tier-2 supercomputer (…in house??)
  - Planning: hiring technological staff in support of theory
  - Lobbying to have a stronger participation in the national contest
- These are the same needs of technological development (e.g. Euclid) -> MA5
- If INAF **DOES NOT** want to support HPC, then please tell us... claiming to support HPC and not providing what listed above is like claiming to support optical astronomy and not to build telescopes