Exercises 12

The impact of AGN feedback on stellar properties of massive galaxies at z=0

1. Calculate the stellar baryon conversion efficiencies for the runs with and without AGN fb, plot them versus halo mass, and compare with predictions from semi-empirical models (e.g., *Moster+13*)
2. Plot the 3D distribution (or 3 diff. projected 2D distributions) of star particles ($<1/10 R_{vir}$) for both runs, color-coded by stellar age, how do the stellar ages and morphologies change with AGN fb?
3. Where are the galaxies located in the stellar age-stellar mass plane compared to observations (table 2 in Gallazzi+05)?
4. Derive the star formation histories from the stellar ages (binning star particles in time, and dividing the stellar mass formed by the time bin), plot them as a function of lookback time.
5. Plot the projected half-mass radii of galaxies against galaxy stellar mass, and compare to the observed mass-size relation of ETGs (*Nipoti+09*).

Explain the differences between both runs, and interpret your results!

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Helpful instructions:

- Stellar baryon conversion efficiency: $M_{stellar}/(f_{bar}*M_{halo})$,
  - stellar mass are star particles within 1/10 R_{vir} (as before)
- You will get two ascii-files, containing info for star particles, for runs of the same halo with and without AGN feedback
- These ascii files have the following format (code units as before):

  particle mass, x_position, y_position, z_position, a_birth

- The positions are centered on the main galaxy (center of mass: x=0.0, y=0.0, z=0.0)
- Note that the code outputs "the scale factor at the time of birth" of each star particle, meaning you have to convert that into birth time of a star particle, and by subtracting it from the Hubble, you get the stellar age.
- Projected half-mass radius along z-axis: Radius, at which half of the total galaxy stellar mass ($<1/10R_{vir}$) is contained; for simplicity, one projection is enough.

Further information:
2 cosmological hydrodynamic zoom-in simulation of a massive halo at z=0 with and without AGN feedback

- WMAP3 cosmology, IC details described in *Oser+10, Hirschmann+12* (Halo 204)
- Run with a modified version of Gadget-3, for code details see *Choi+17/Hirschmann+17*
- Grav softening DM: 800pc; grav softening gas/stars: 400pc; Number of neighbours: 100
- *First simulation run without AGN fb* (*termed as "noAGN" in the ascii file name*), M_{halo}= 5.2e12 $M_{\odot}$/h, R_{vir}= 281 kpc/h
- *Second simulation run with* AGN fb (*termed as "AGN" in the ascii file name*), M_{halo}= 4.3e12 $M_{\odot}$/h, R_{vir}= 265 kpc/h
- Both runs are taken from *Hirschmann+17 (similar to Choi+17)*

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- Reading suggestions (not relevant for final exam)
- In general:
  - Somerville & Dave+15: excellent review article on current state of the art in cosmological hydro sims and SAMs
  - Naab & Ostriker+16: excellent review article on current state of the art in cosmological hydro sims and small-scale hydro simulations
- More specifically about AGN feedback
    - Springel, Di Matteo & Hernquist 2005: "Black Holes in Galaxy Mergers: The Formation of Red Elliptical Galaxies"
    - Dubois et al. 2013: “AGN-driven quenching of star formation: morphological and dynamical implications for early-type galaxies”
    - Choi et al. 2018: "The Role of Black Hole Feedback on Size and Structural Evolution in Massive Galaxies”
    - Trebitsch et al. 2018: "Escape of ionizing radiation from high-redshift dwarf galaxies: role of AGN feedback”