

# Exercises — 8

## Stellar feedback and the evolution of the gas content in the GAEA SAM:

How can strong stellar-driven outflows affect

1. the evolution of the cold gas fractions vs stellar mass over cosmic time?
2. the evolution of the mass-metallicity relation over cosmic time?

How does this compare to observations. Explain your results.

### Helpful instructions:

- You'll get galaxy catalogues at  $z=0, 1, 2$  from the GAEA model, each of them adopting a strong and a weak stellar fb model; they have the following format:

**$M_{\text{halo}}, M_{\text{stellar}}, M_{\text{coldgas}}, M_{\text{Cgas}}, M_{\text{Ogas}}, M_{\text{Fegas}}, M_{\text{rest}}, \text{SFR}$**

- All masses are in code units ( $1e10/h$ ), SFR in  $M_{\text{solar}}/\text{yr}$ ; Select only galaxies with  $M_{\text{stellar}} > 9$ ,  $M_{\text{coldgas}} > 0$ , and  $\log(\text{sSFR}) > -11$  (no emission lines otherwise!)
- Plot the median cold gas fractions  $\langle M_{\text{cold}}/(M_{\text{cold}}+M_{\text{stellar}}) \rangle$  as a function of galaxy stellar mass at  $z=0, 1, 2$  and compare to observations (e.g. Peebles+11, Popping+15)
- Plot the mean oxygen gas-phase metallicities  $\langle 12+\log(\text{O}/\text{H}) \rangle$  as a function of galaxy stellar mass at  $z=0, 1, 2$ , and compare to observations (e.g. Maiolino+08, Zahid+14)
- Remember that gas metallicity in observations as commonly given in Oxygen abundances in units of  $12+\log(\text{O}/\text{H})$ , i.e. you need to convert mass abundances in number density abundances!

## Information for this exercise:

- Galaxy catalogues are constructed with the new *GAEA semi-analytic model* (DeLucia+14 & Hirschmann+16)
- GAEA was run over merger trees from the famous *Millennium simulation* (Springel+05), having a box length of 500 Mpc
- Your GAEA catalogues include only 1/10 of the original volume
- WMAP1 cosmology is adopted (main difference to modern cosmological model is the lower  $\sigma_8$ )
- “Strong feedback” catalogues correspond to a run adopting the “FIRE” stellar feedback model based on simulations
- “Weak feedback” catalogues correspond to a run adopting the “fiducial”, energy-driven wind model

Note: For further info and model details, have a look into Hirschmann+16...

## INTERESTING READING SUGGESTIONS:

In general:

- Baugh (2006) — Review
- Somerville et al. (2008) — Description of Santa Cruz SAM
- Henriques et al. (2015) — Munich SAM with MCMC approach
- Hirschmann et al. (2016) — GAEA SAM, Effect of stellar feedback

One of the most influential studies using the SAM approach:

- **Croton et al. 2006** “The many lives of active galactic nuclei: cooling flows, black holes and the luminosities and colours of galaxies”
  - Which solution is proposed for the “over-cooling” problem in galaxy formation?
  - Which are the consequences for other galaxy properties?