EAGLE

Producing Realistic SPH Simulation Data

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Background : DM simulation of full Eagle volume

Purpose

- EAGLE – Evolution and Assembly of GaLaxies and their Environments
- Simulated galaxies which reproduce the stellar mass function from the flat faint end to large clusters, which has not yet been achieved in a hydro simulation
- Cosmological simulation with resolution sufficient to resolve the Jeans mass below the star formation threshold
- Volume large enough to measure galaxy clustering and produce ~10,000 MW galaxies

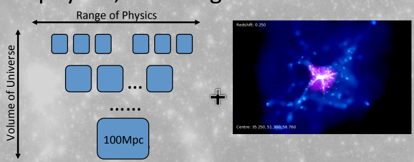
Image of an Eagle galaxy generated using SKIRT

Set Up

- Code: Gadget3 (Springel 2005), a parallel hydro code using SPH
- Full simulation size: 100Mpc box, 1500^3 particles, resolution of 10^6 M_o
- Data available to redshift zero
- Physics: Cooling, Star Formation, Chemodynamics, Black Holes, Feedback
- Variables: strength & scaling of SNII feedback, black hole seed mass, strength of AGN feedback

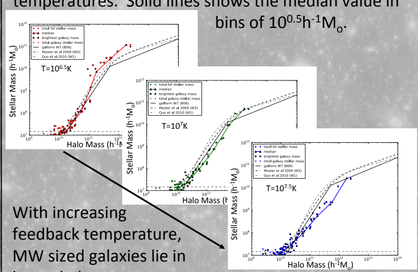
Methodology

- Building on GIMIC (Crain et al 2009) and OWLs (Schaye et al 2010) projects
- Use variety of box sizes to test physics, including zooms

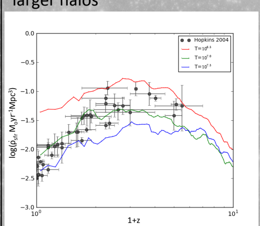


- Small boxes to tune SNII feedback parameters and larger boxes combined with zooms to tune AGN feedback parameters
- Some preliminary results from small boxes

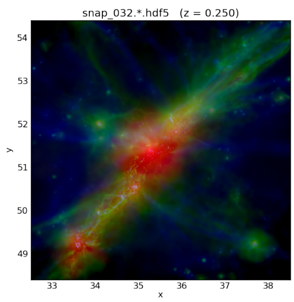
Below is the stellar mass against halo mass for three simulations with different SNII feedback heating temperatures. Solid lines shows the median value in bins of $10^{0.5}h^{-1}M_o$.



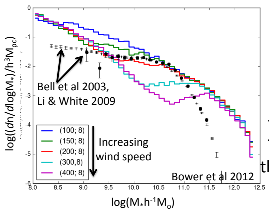
With increasing feedback temperature, MW sized galaxies lie in larger halos



The Madau diagram shows the star formation rate density against redshift. The effectiveness of the feedback in shutting down star formation with increasing temperature is clear.



Combining SPH simulations with semi-analytic philosophy



From semi analytic models we know the galaxy stellar mass function is very sensitive to the feedback parameters. The figure shows how the effect of varying the SNII wind (coloured lines) on the shape of the SMF

Subgrid Physics

- Cooling (Wiersma et al 2009a)

Cooling rates are calculated element by element for the 9 elements followed in the simulation. The CMB and UV and X-ray background from quasars and galaxies are considered in the cooling tables.

- Star Formation (Schaye & Dalla Vecchia 2008)

For n_H>0.1cm^{-3} an effective equation of state is imposed, where $P \propto \rho^{\gamma_{eff}}$. The SFR is then given by

$$m_* = m_g A (1 M_o pc^{-2})^{-n} \left(\frac{\gamma}{G} f_g P\right)^{\frac{n-1}{2}}$$

- Metal Enrichment (Wiersma et al 2009b)

Timed release of metals from SNII, SNIa and AGB stars are followed for the 9 elements considered in the cooling rates. Metals are distributed over gas neighbours using the smoothed density.

- Supernova II Feedback (Dalla Vecchia & Schaye, submitted to MNRAS)

After 30Myr a star particle injects the energy from massive stars that end in core collapse SN. Energy is injected stochastically to gas neighbours through increasing their internal energy.

- Black Holes and AGN (Booth & Schaye 2010)

Black holes are formed, accrete mass and eject a fraction of their energy back into their surrounds. See see 'The Role of the AGN in the Evolution of Eagle Galaxies Groups' poster by Yetli Rosas-Guevara for more details.

Computing Requirements

- **Cosma4** : 2700 cores, 5Gb Ram per core, 12 cores per node
- Tuning runs take ~ week to run, full simulation will take up to 6 months

Particles/ dimension	Length/ dimension	RAM req (Gb)	Tota CPU Time (days)	Cores	Time (days)
128	9Mpc	2.6375	175	4	44
256	17Mpc	21.1	1398	12	117
512	36Mpc	168.8	11185	75	149
1024	71Mpc	1350.4	89478	593	151
1536	100Mpc	4557.6	301990	2000	151

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