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The dwarf galaxy dark-matter halo occupancy

In the ΛCDM cosmology the universe consists of matter, both luminous and dark, and dark energy which is responsible for the accelerating expansion of the universe. Galaxies form when gas collapses in dark matter halos. Baryons, in the form of gas, dust or stars, are the most accessible form of matter, emitting radiation over the whole electromagnetic spectrum. Dark matter (DM), on the other hand, as it only interacts gravitationally, is more difficult to "observe".

Guo et al. (2010) determined a **M_{star}-M_{halo} relation** for a large sample of galaxies using a statistical analysis of the Sloan Digital Sky Survey, which yields the stellar masses, and the Millenium Simulation, which yield the dark-matter masses.

Observations

- Gravitational lensing. Mandelbaum (2006), Liesenborgs (2009)
- Dynamical modelling of the observed properties of a kinematical tracer. Kronawitter (2000), De Rijcke (2006), Napolitano (2011), Barabè (2009)

Simulations

Valcke (2008), Stinson (2007,2009), Governato (2010), Mashchenko (2008), Sawala (2011), Schroyen (2011)

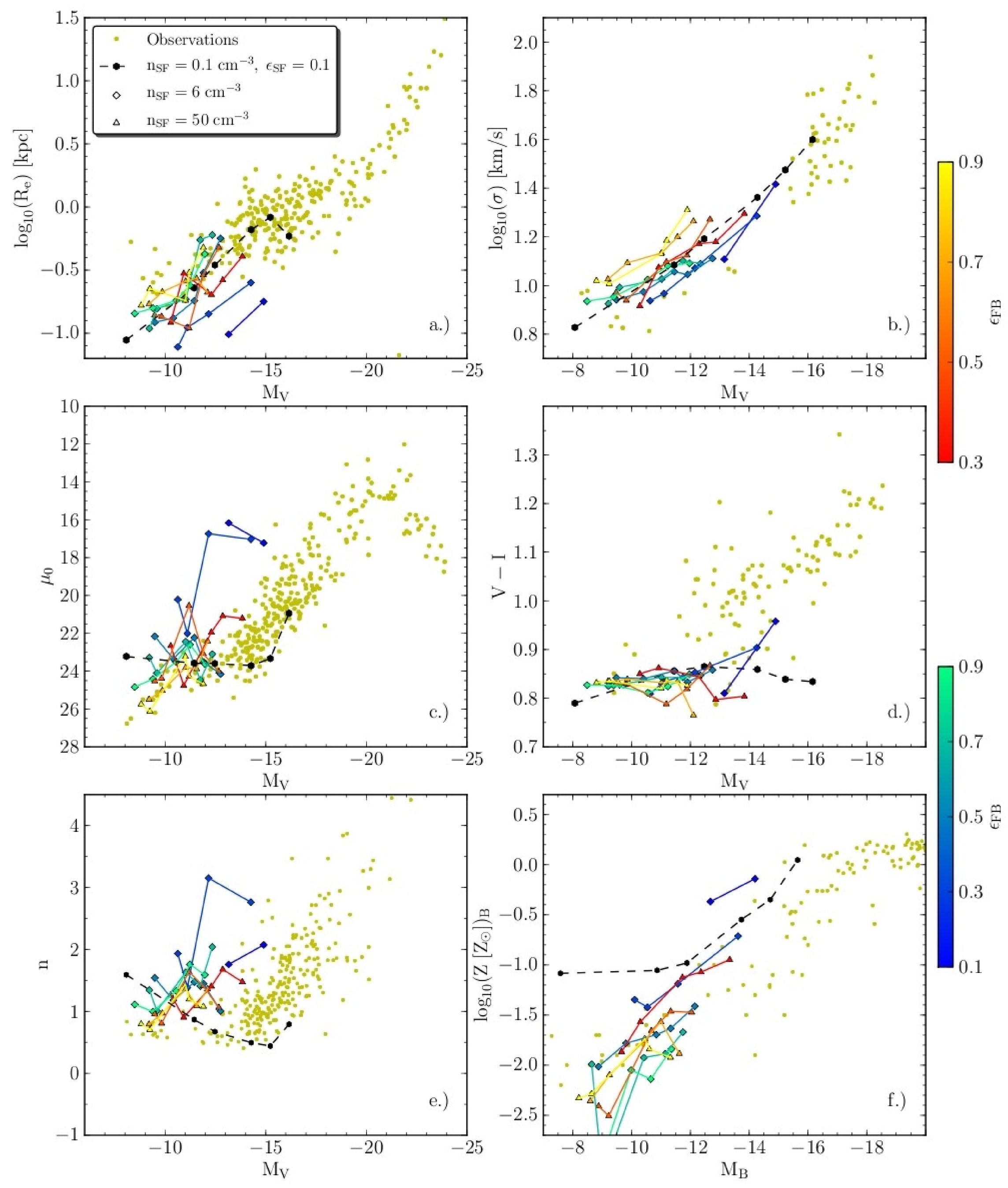
Simulations show an efficiency of converting baryons into stars which is too large by an order of magnitude to produce the M_*-M_{halo} relation

The star-formation efficiency can be lowered:

- Increasing the density threshold of star formation (n_{SF})
- Increasing the feedback efficiency (ε_{FB})

Simulations

We performed a parameter survey in which dwarf galaxy models, starting from a dark matter halo with a NFW density profile and a homogeneous gas cloud, are simulated with a range of values for the density threshold and the feedback efficiency. All simulations were performed with a modified Gadget2 code, which includes star formation and feedback (Gadget2: Springel et al. 2005)



Degeneracy between n_{SF} and ε_{FB}:

When increasing both n_{SF} and ε_{FB} the models shift along the scaling relations.

The higher the density threshold, the more concentrated the gas density will be and the higher the feedback efficiency should be to make the star formation self-regulated. So certain combinations of n_{SF} and ε_{FB} will produce galaxies with properties analogous with observed galaxies.

Constrain the ε_{FB}/n_{SF}-combinations:

By evaluating the simulated dwarf galaxies in terms of the observed photometric and kinematic scaling relations.

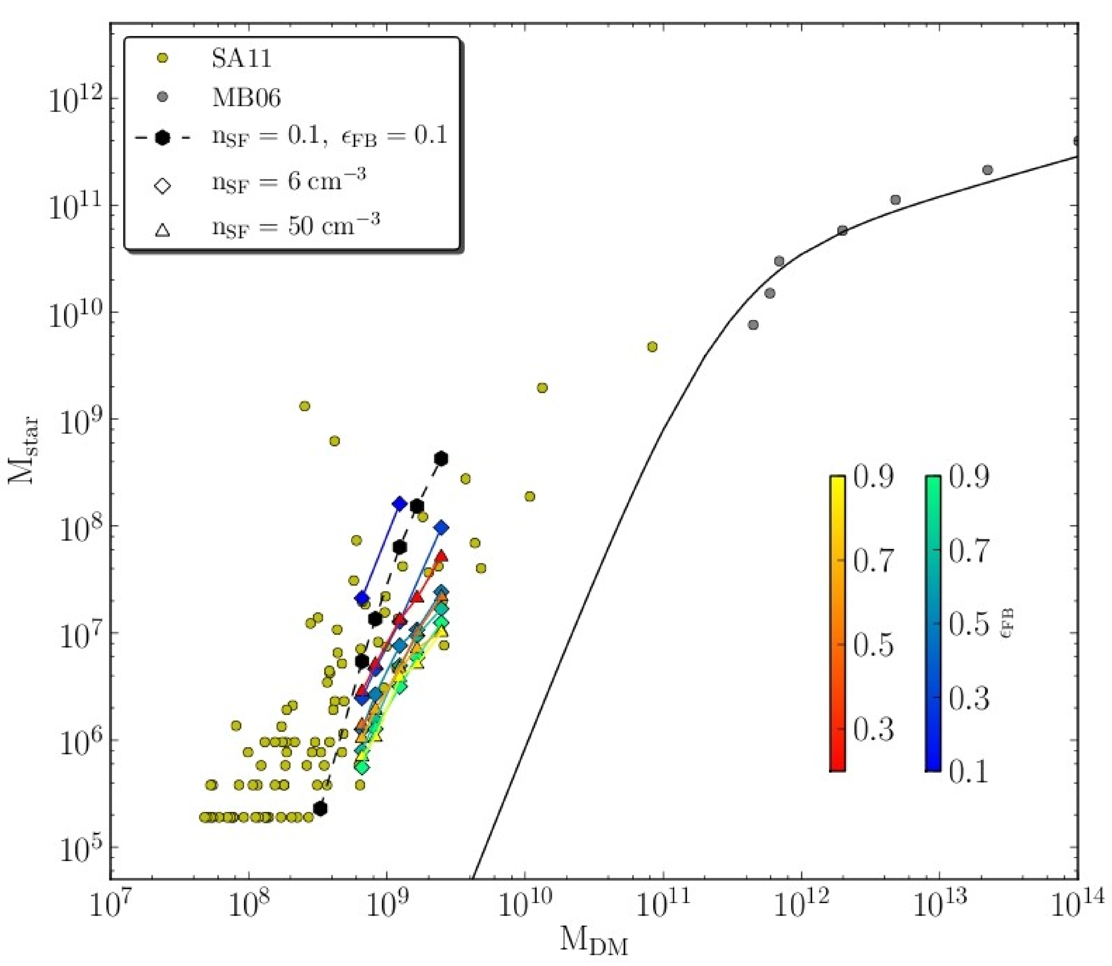
- **Lower limit** of ε_{FB} is determined from the **R_e-M_v relation:**

  The supernova feedback should be high enough to sufficiently expel/heat the gas, otherwise the produced galaxies are too concentrated (= very small effective radii)

- **Upper limit** of ε_{FB} is determined from the **Z-M_B relation:**

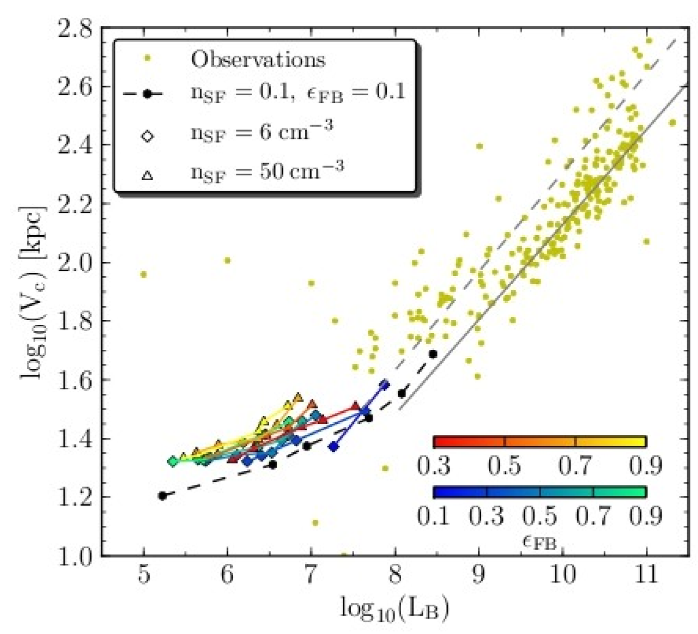
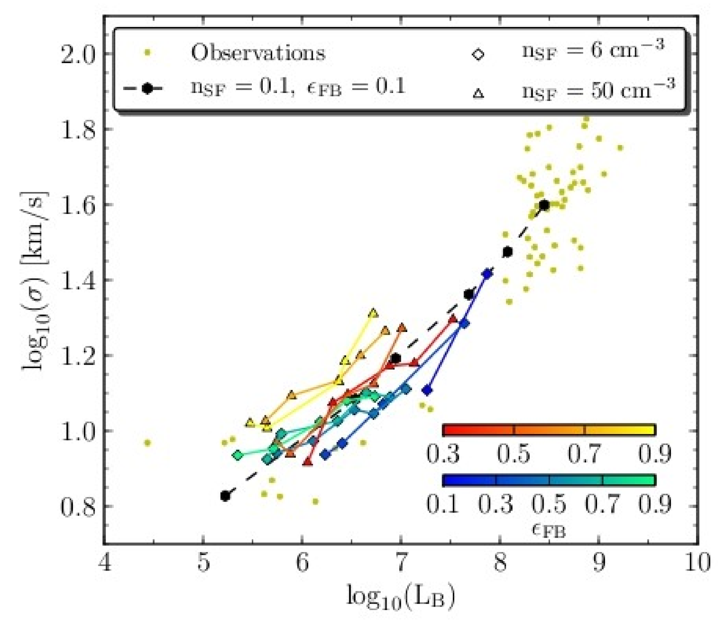
  If the feedback is very high, star formation is immediately extinguished and newly produced metals are dispersed over a large volume, causing new stars to have metallicities which are too low.

$$\rightarrow \quad n_{SF} = 6\ cm^{-3} \quad \Rightarrow \quad \varepsilon_{FB} = 0.5$$
$$\rightarrow \quad n_{SF} = 50\ cm^{-3} \quad \Rightarrow \quad \varepsilon_{FB} = 0.7$$



M_{star}-M_{halo} relation:

We are not able to reproduce the relation obtained by Guo et al. (2010), but we do reproduce the slope of the relation and our simulations are in good agreement with the results of the Aquila Simulation (Sawala et al. 2011, to be published) and other simulations.

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