Starless low-mass dark matter halos

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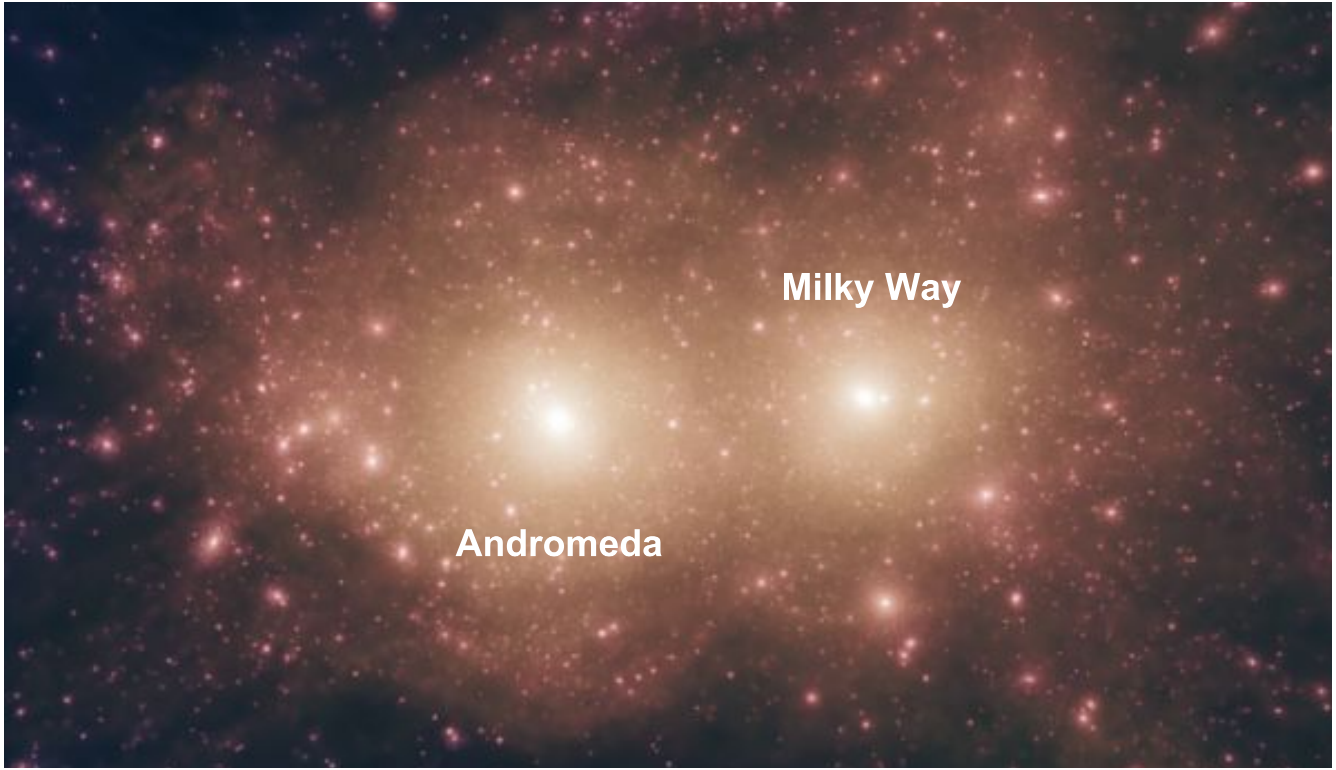
Based on Benitez-Llambay et al. 2017

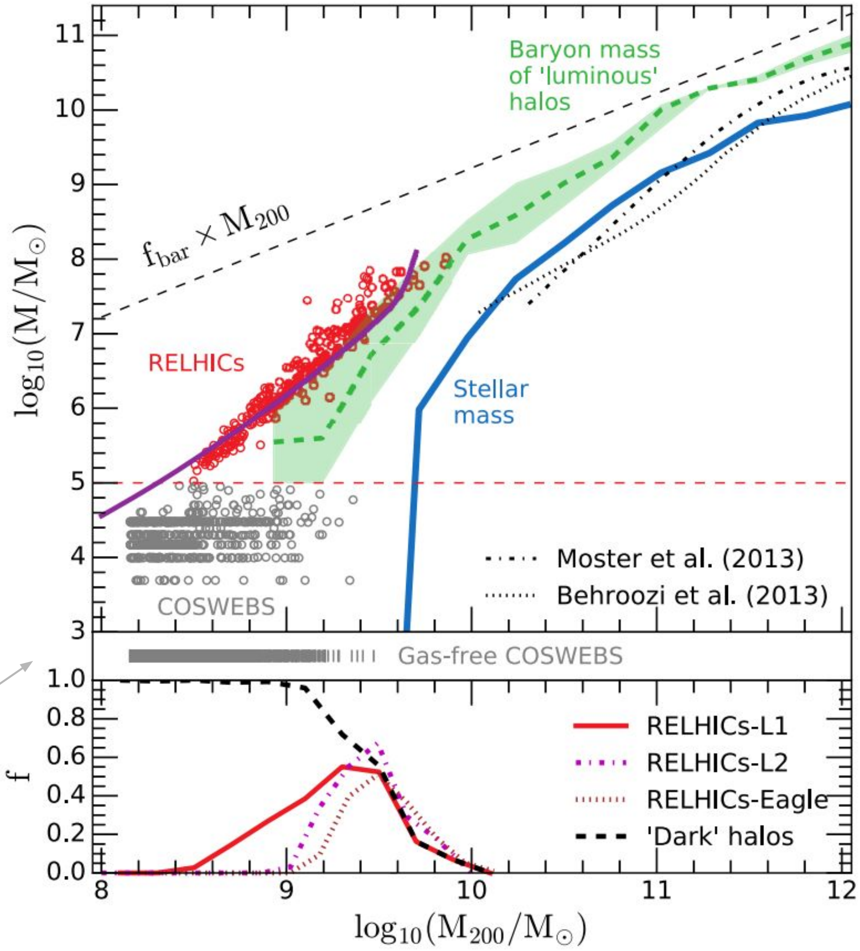
Dark matter substructures surrounding the Local Group



Gas content of starless low-mass dark matter haloes

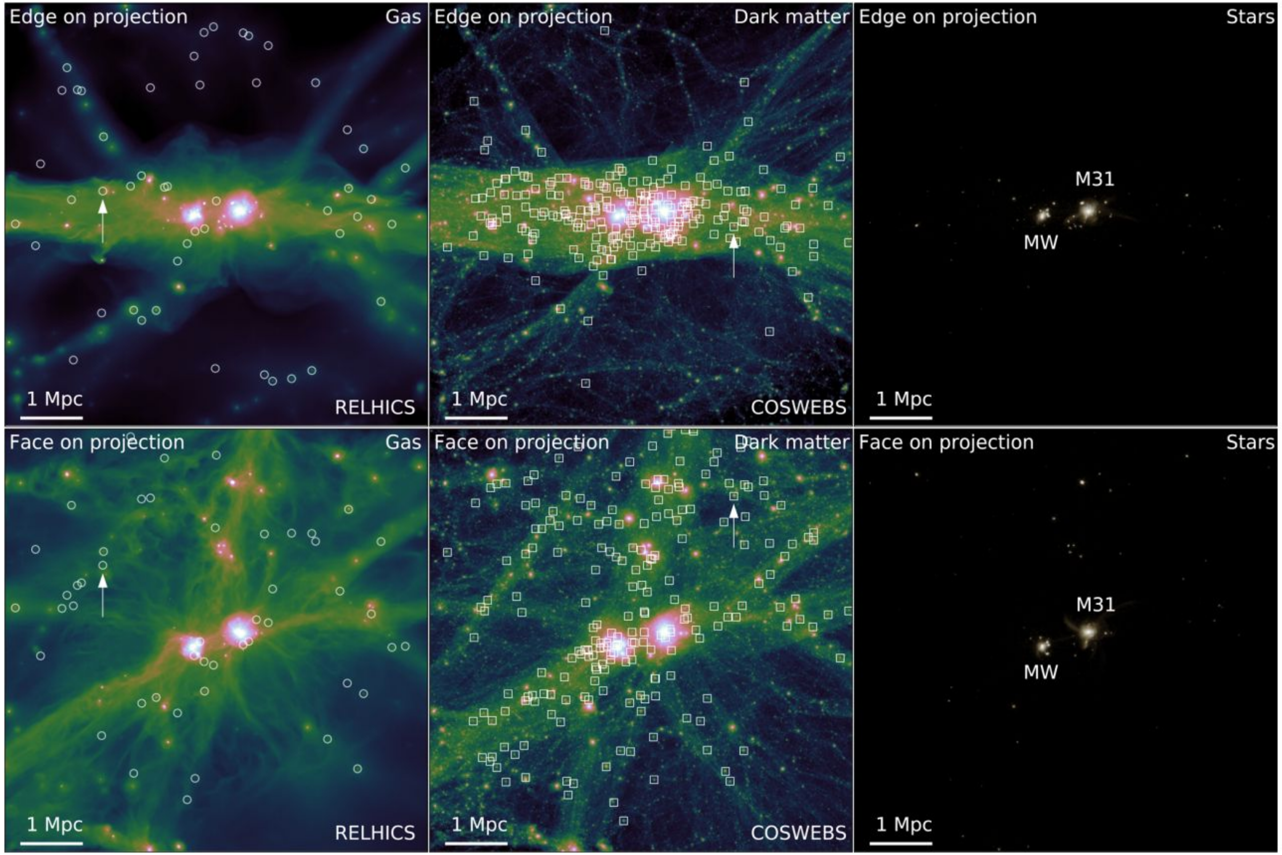
- Gas mass of starless halos - as measured in cosmological hydrodynamical simulations - agrees well with simple analytic expectations.
- Baryonic mass of of luminous galaxies reduced (Supernova feedback).
- Sharp cut-off in galaxy formation below 10^{10} solar masses.

High fraction of starless and gas free dark matter halos!



Clustering of starless halos

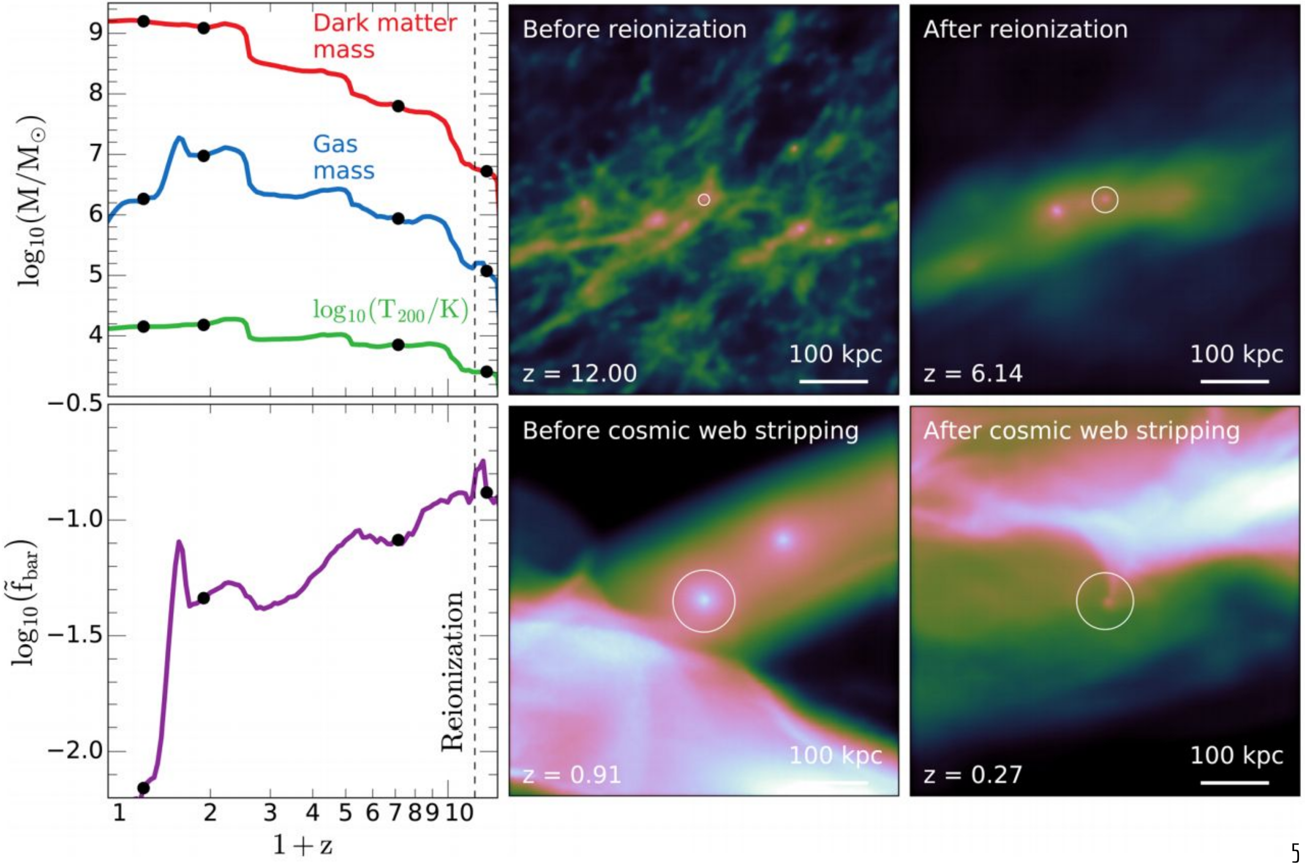
- The origin of gas-free starless dark matter halos is clearly environmental.



Cosmological hydrodynamical simulation from the APOSTLE project.

Gas-free starless halo

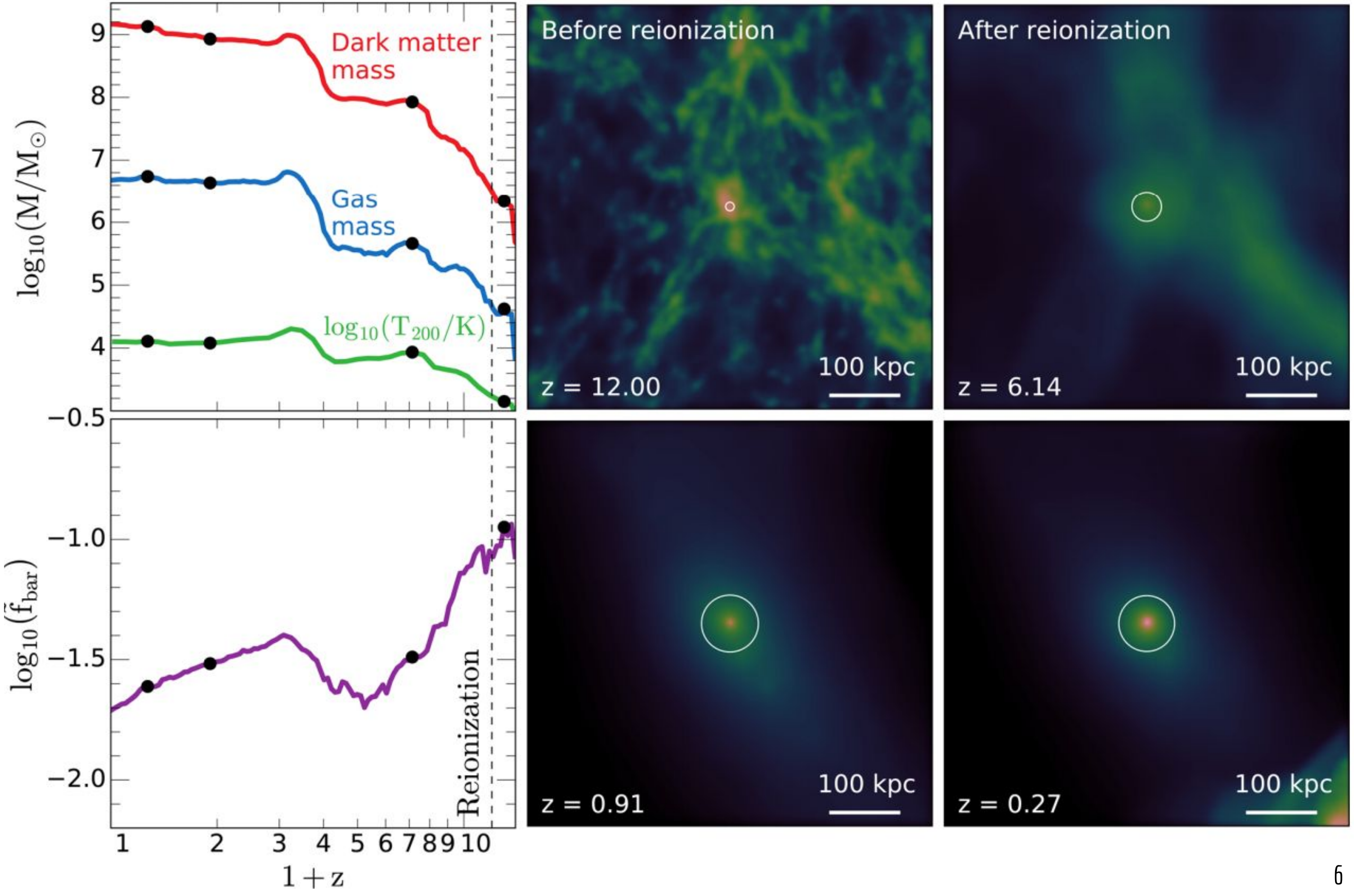
- Circular velocity smaller than 30 km/s, and very low density.
- Ram pressure stripping with overdense filaments is expected to be very efficient at removing baryons



RELHICs (Reionization Limite HI Clouds)

- If there are not interactions with the environment, the gas is stuck in hydrostatic equilirium.

- The amount of gas is essentially set by reionization (Photoheating UV background)



Thermal state of gas in starless dark matter halos

- Cooling rate is proportional to ρ^2
- Photoheating rate is proportional to ρ

Cooling dominates over heating at high densities.
Heating dominates over cooling at low densities.

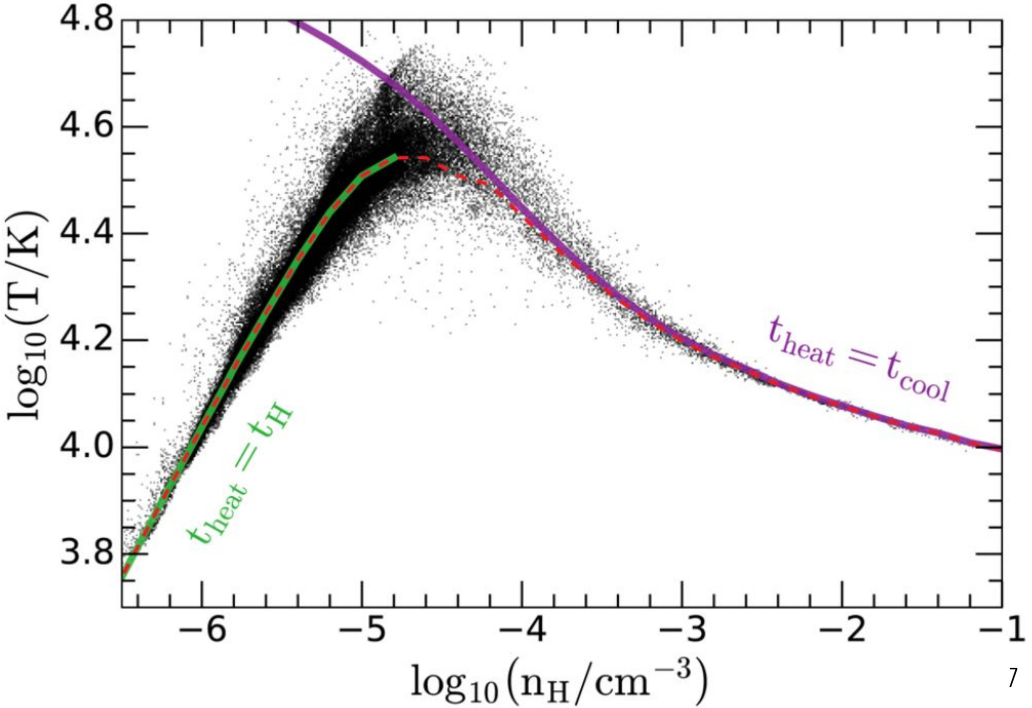
(However)

If cooling and heating timescales are much smaller than the Hubble time, gas will reach an equilibrium temperature (for each density).

Otherwise, the temperature will be the maximum (minimum), given the time available to heat (cool) the gas

$$\left(\frac{T}{\rho} + \frac{\mathrm{d}T}{\mathrm{d}\rho}\right)\mathrm{d}\rho = -2T_{200}\frac{\tilde{M}(\tilde{r})}{\tilde{r}^2}\mathrm{d}\tilde{r}$$

Effective equation of state - T(ρ)

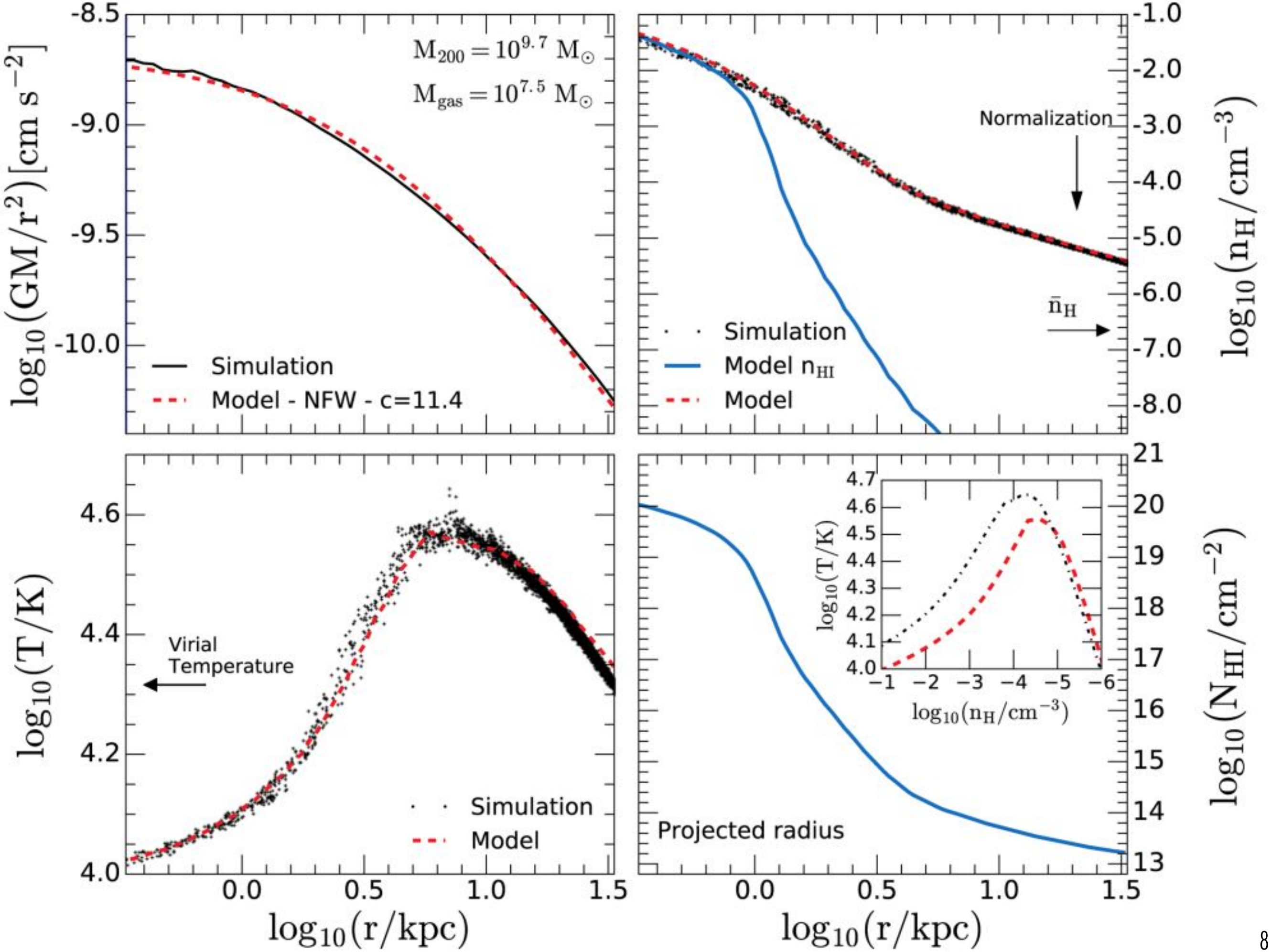


The model works in detail

- Determine the best fit NFW acceleration profile for a given dark matter halo.

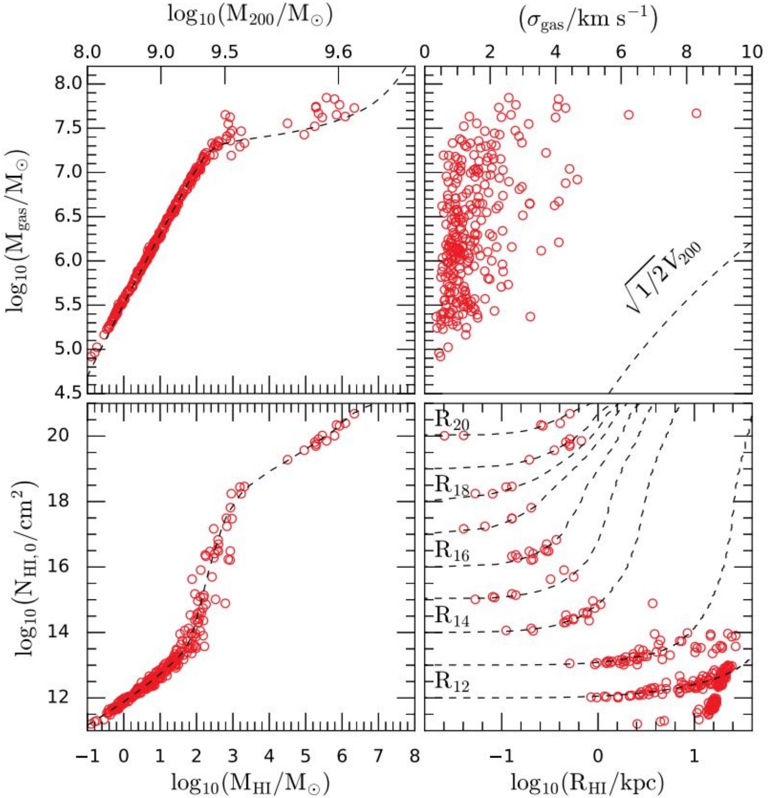
- Assume the equation of state given by previous arguments.

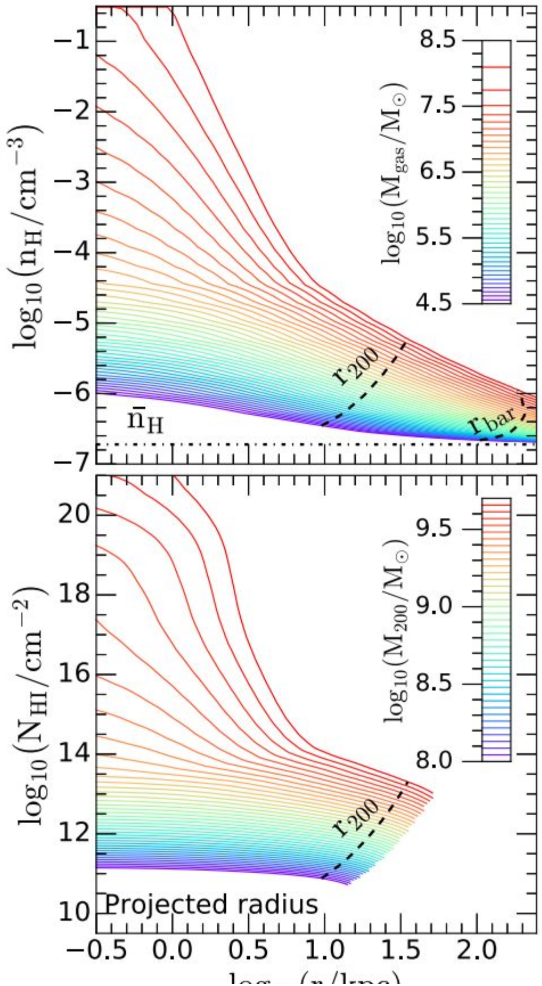
- Solve the equations numerically.



We can describe this objects very accurately

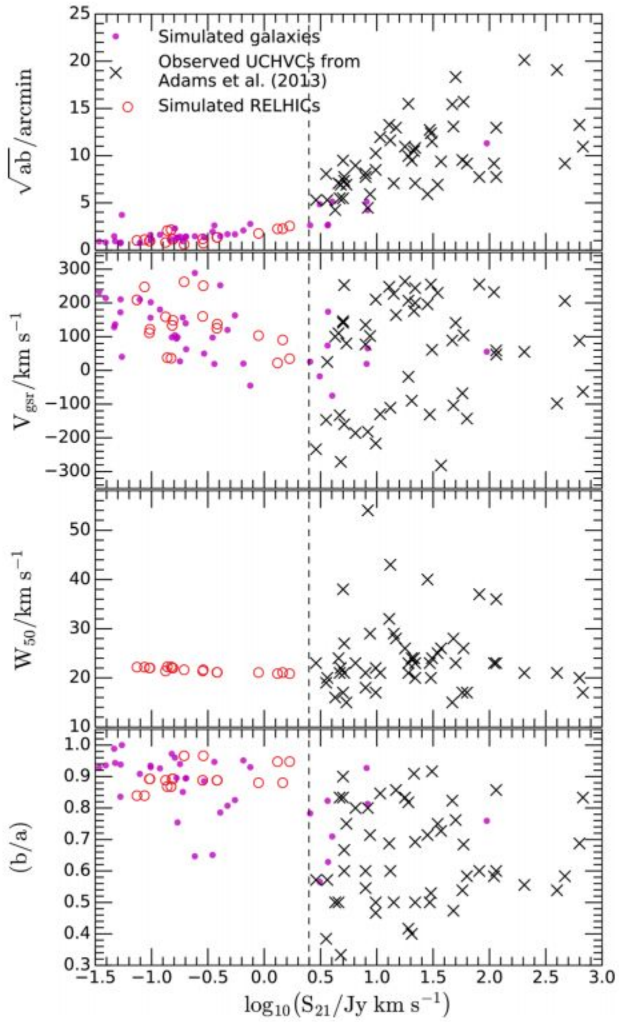
Dark matter haloes are fully specified (on average) with a single parameter (M200)





Observational signatures

- We compared the properties of simulated RELHICs to those of UCHVCs from ALFALFA (Adams et al. 2013)
- All RELHICs fall below the detection limit of ALFALFA, are rounder, have mostly positive galactocentric distances and have a well-defined thermal broadening.
- However, simulated low-mass galaxies have properties compatible with some UCHVCs. After all, Leo P was discovered as an UCHVCs.



Conclusions

★ LCDM + reionization predicts that the Local Group should be teemed by low-mass halos that failed to form a galaxy in their centres ($M_{vir} < 3x10^9\ M_{\odot}$).

★ Analytic calculations to predict their thermodynamics properties in detail can be done, and our model has proven to be successful in describing the properties of simulated RELHICs.

★ We predict that RELCHIs should have **(i) positive galactocentric velocities, (ii) be round (a/b > 0.8) , (iii) low HI fluxes, (iv) very small angular diameter and (v) a well-defined thermal broadening.**

★ UCHVCs observed by ALFALFA seem inconsistent with the properties expected for “dark” RELHICs.

★ More work to characterize the clustering of RELHICs is needed (high resolution numerical simulations to resolve the interactions with the environment, perhaps semianalytic calculations).