Structure of subhalos around Milky Way-mass galaxies in CDM and SIDM universes

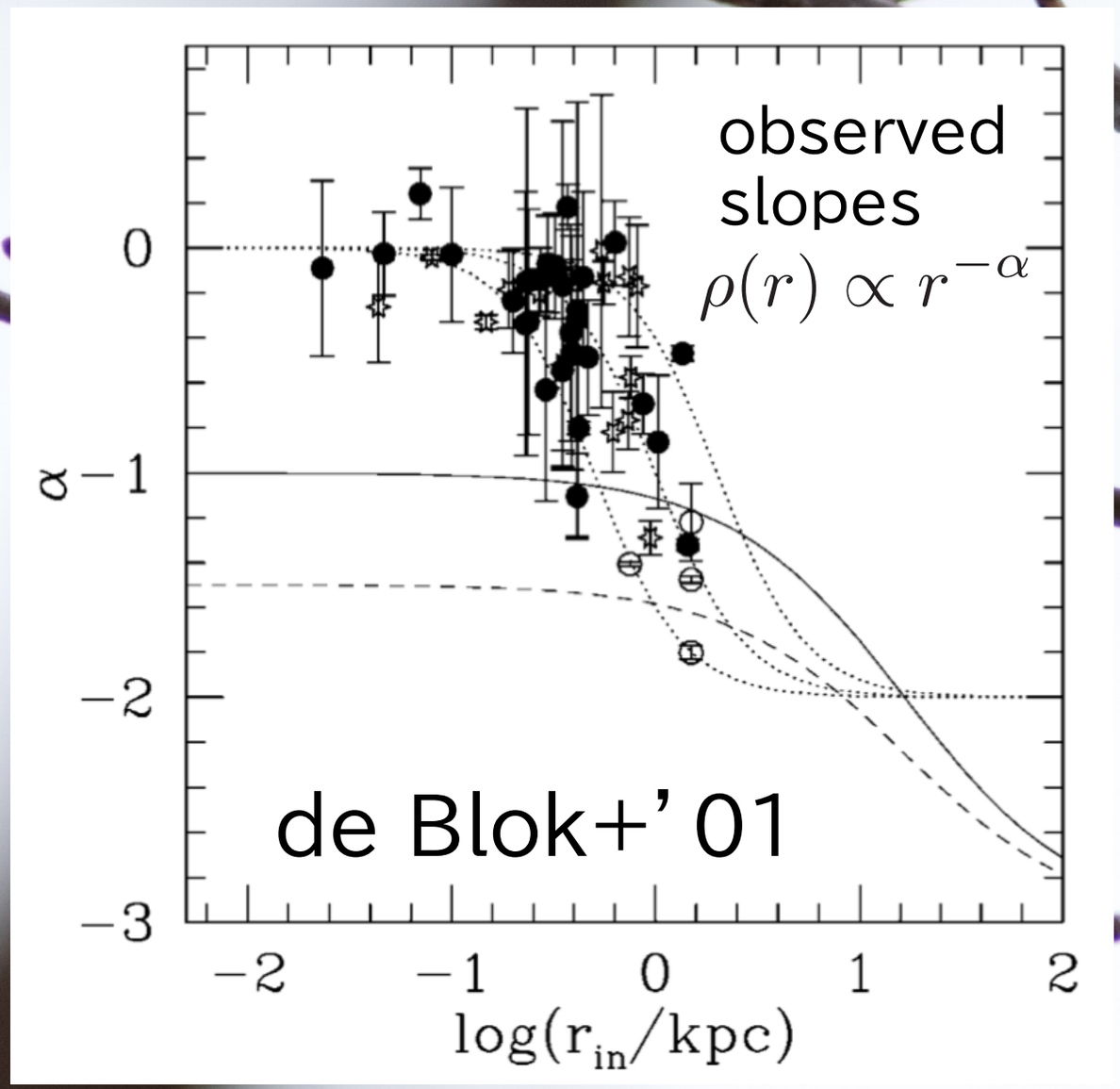
Takashi Okamoto (Hokkaido University)

Kobo Research（18H04333）

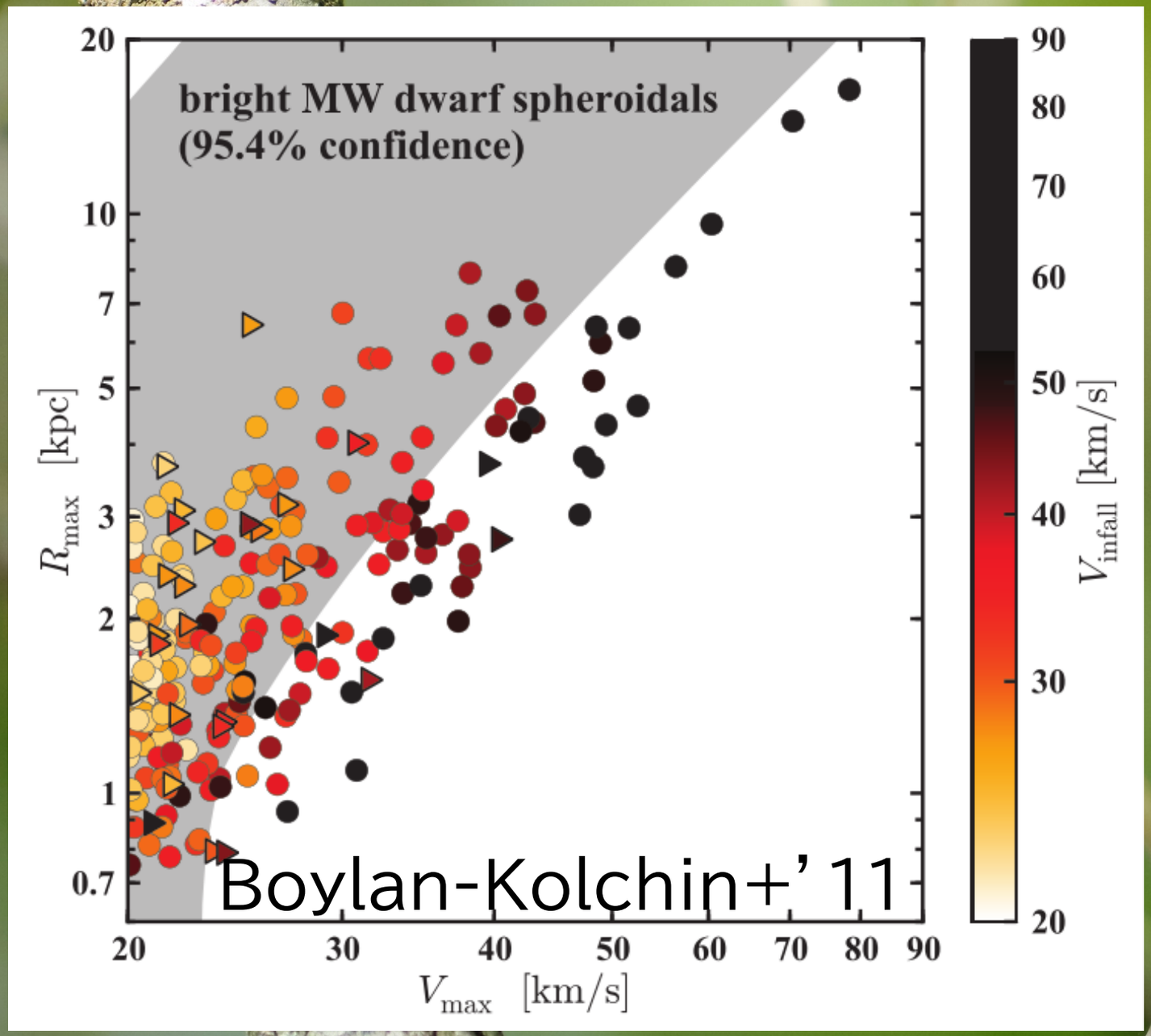
Small-scale crisis of CDM?

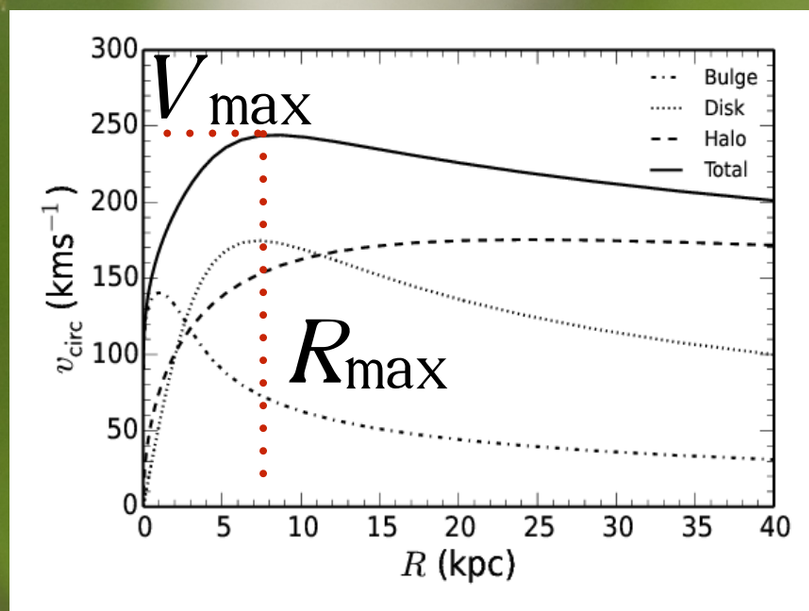
- Missing satellite problem
- Core-cusp problem
- Too-big-to-fail problem
  - These problems are mainly about the Local Group satellite galaxies
  - Most of the problems can be solved by galaxy formation processes

Central DM halo density profile of low surface brightness galaxies



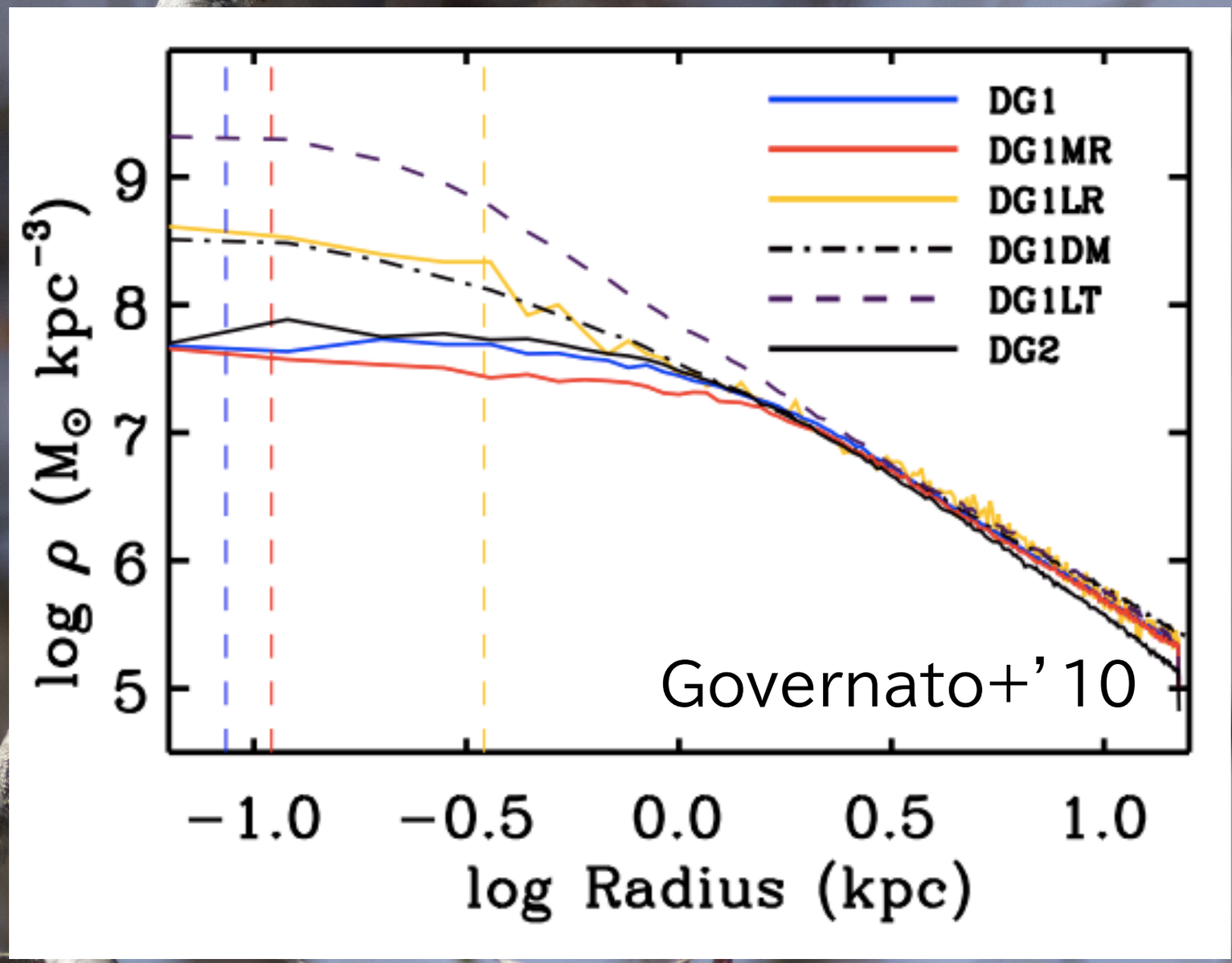
Too-Big-To-Fail





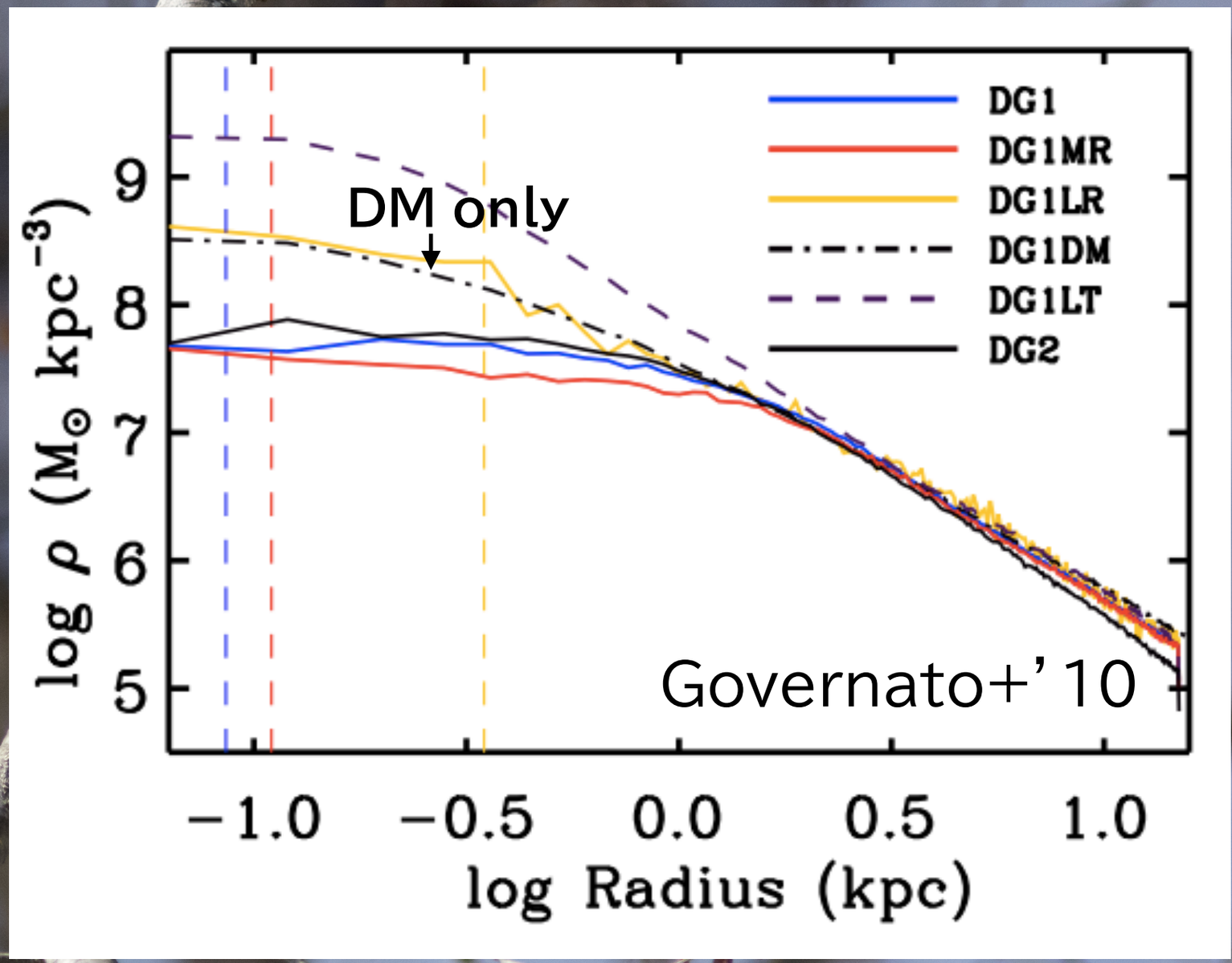
Core creation by stellar feedback

DM halo profile



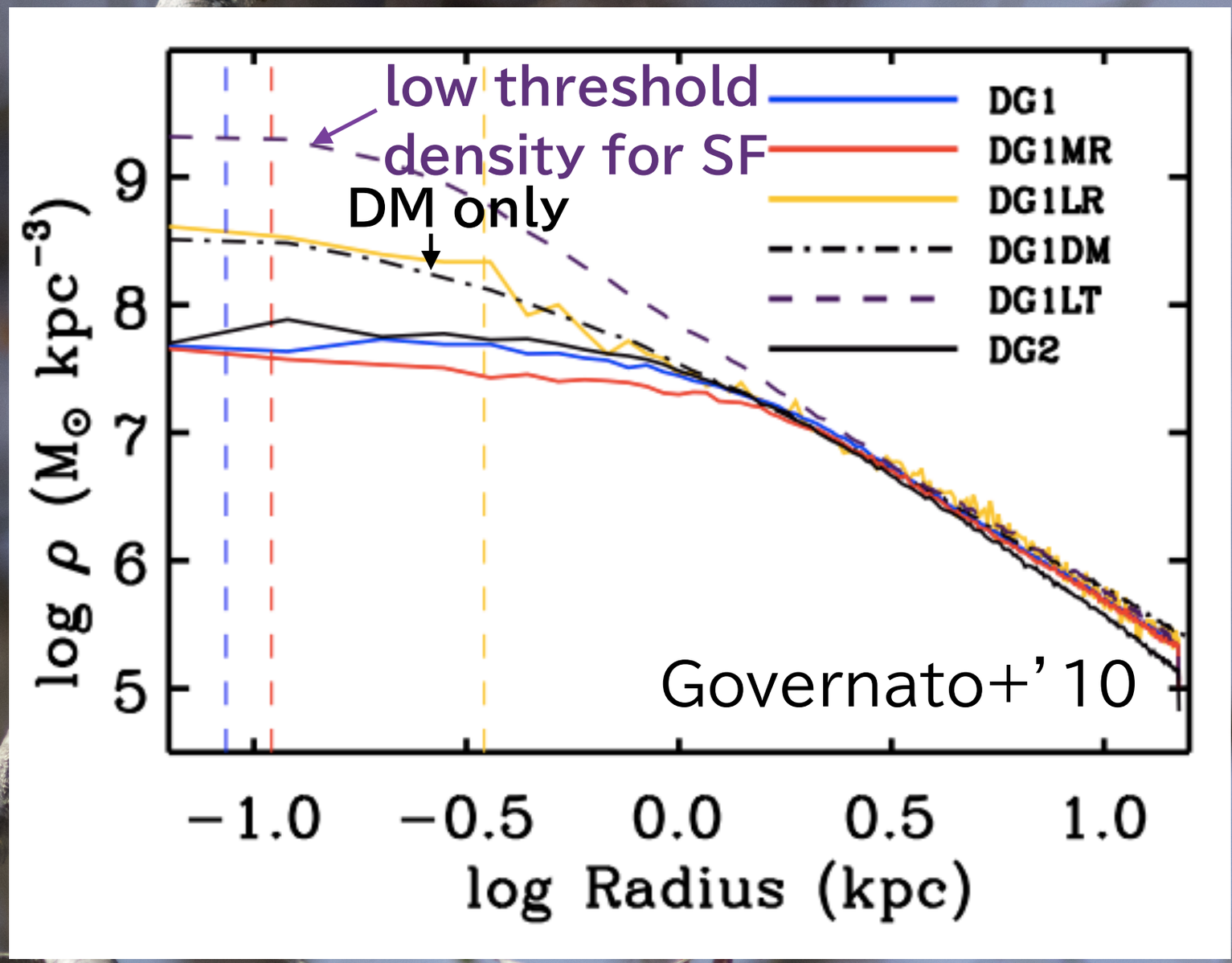
Core creation by stellar feedback

DM halo profile



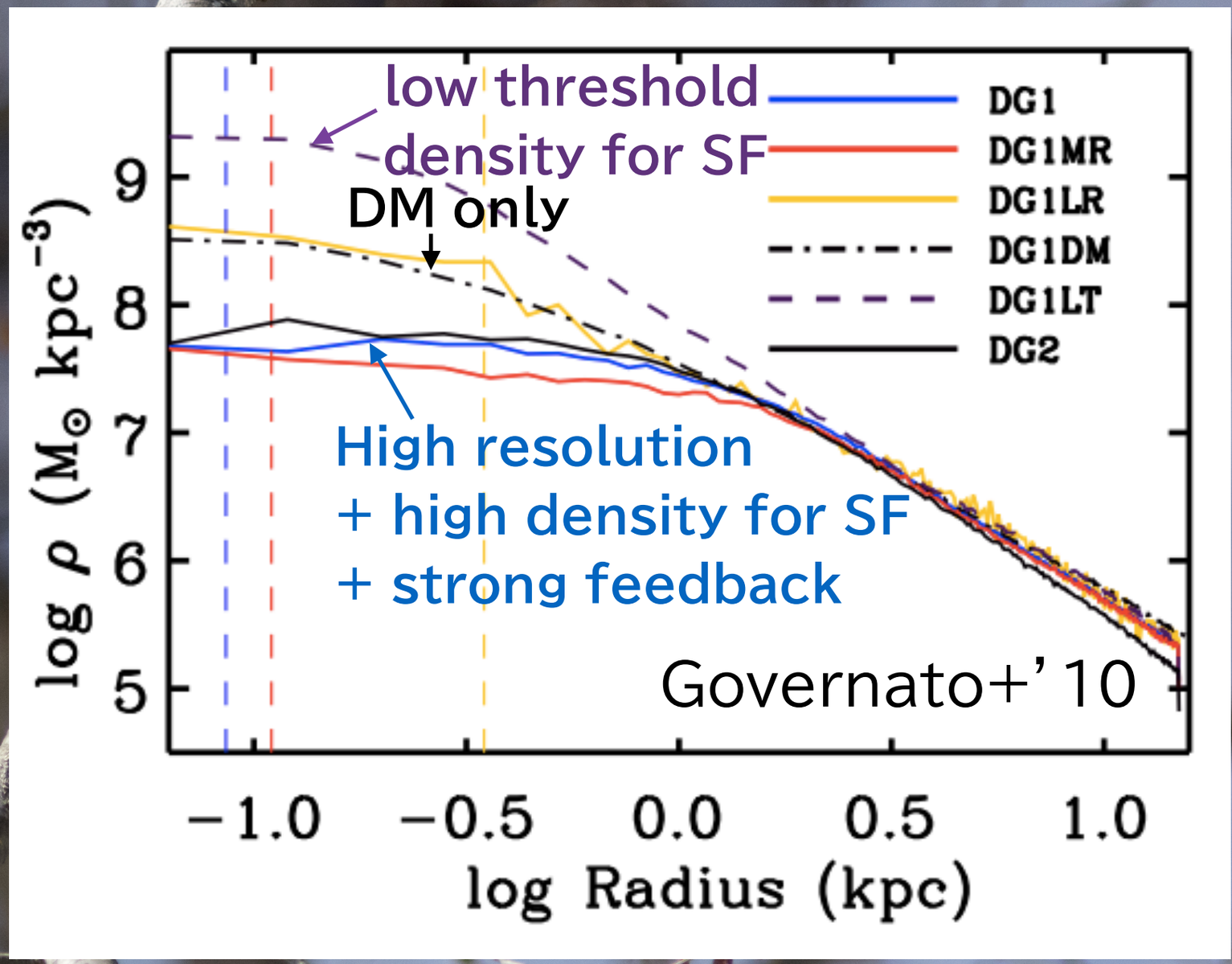
Core creation by stellar feedback

DM halo profile

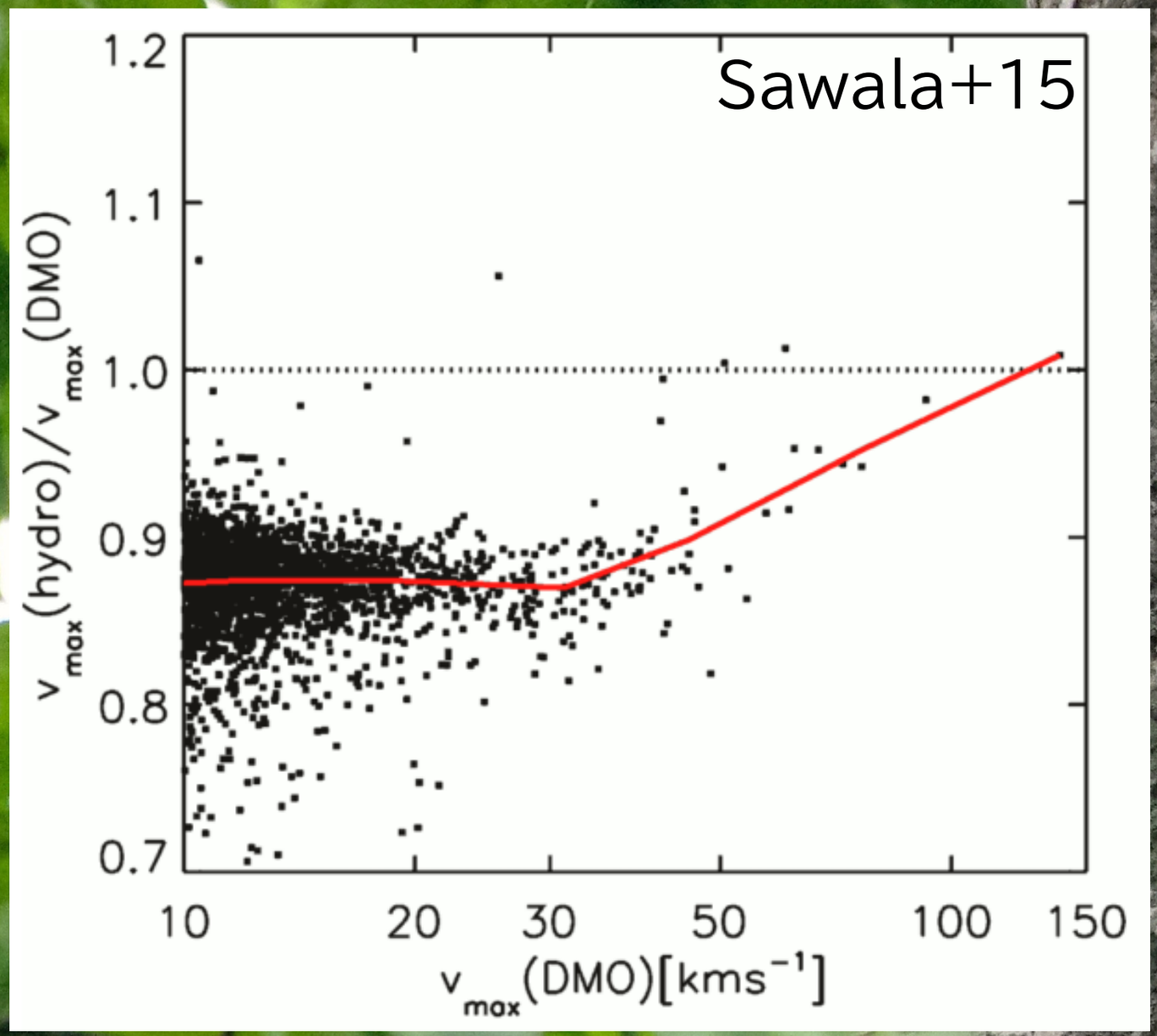


Core creation by stellar feedback

DM halo profile

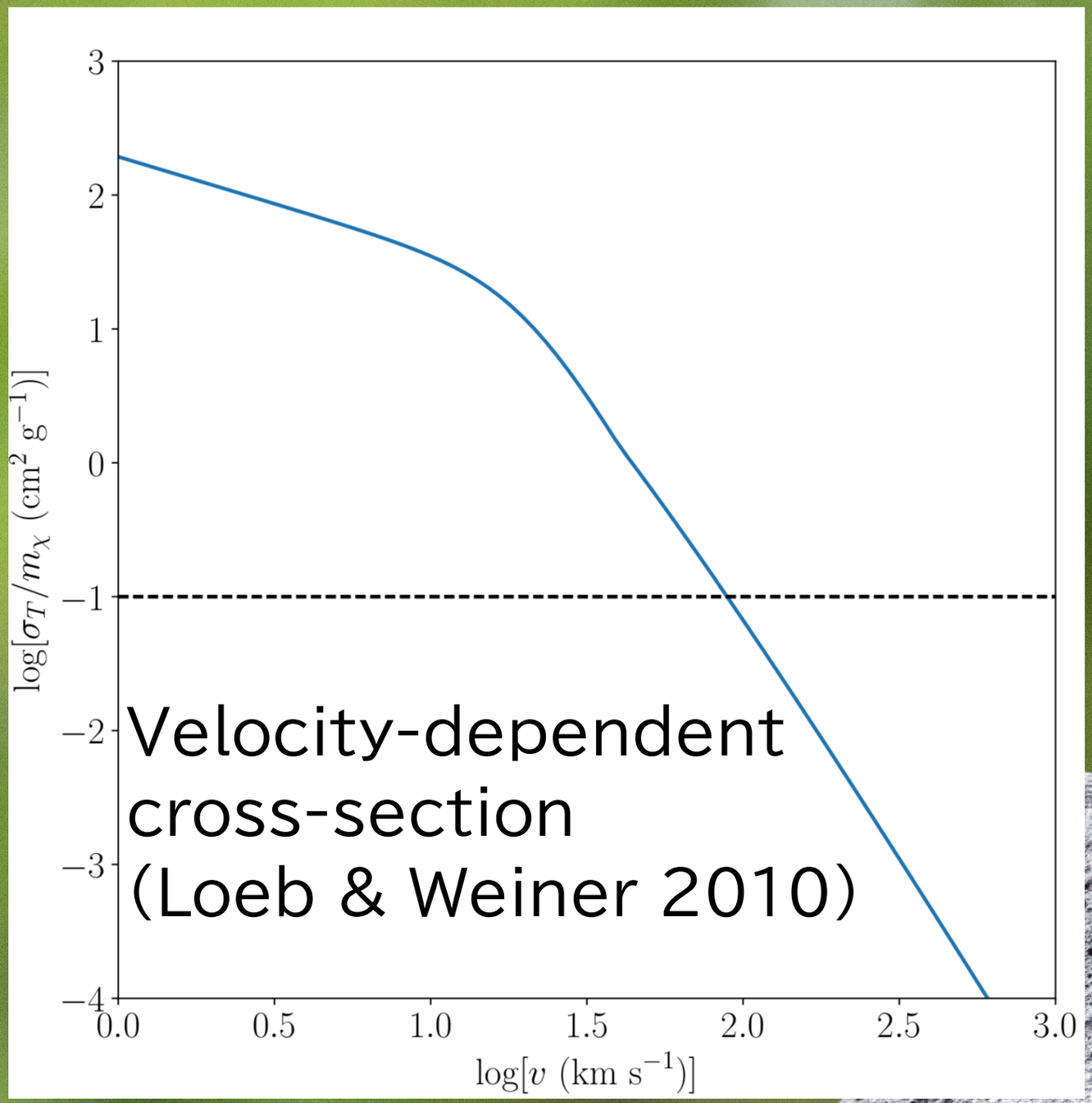


Reduction of V_{max} by Feedback



Can we distinguish SIDM, which has large cross-section on dwarf scale, from CDM after we take the galaxy formation into account by looking at satellite galaxies?

Self-interacting dark matter (SIDM)

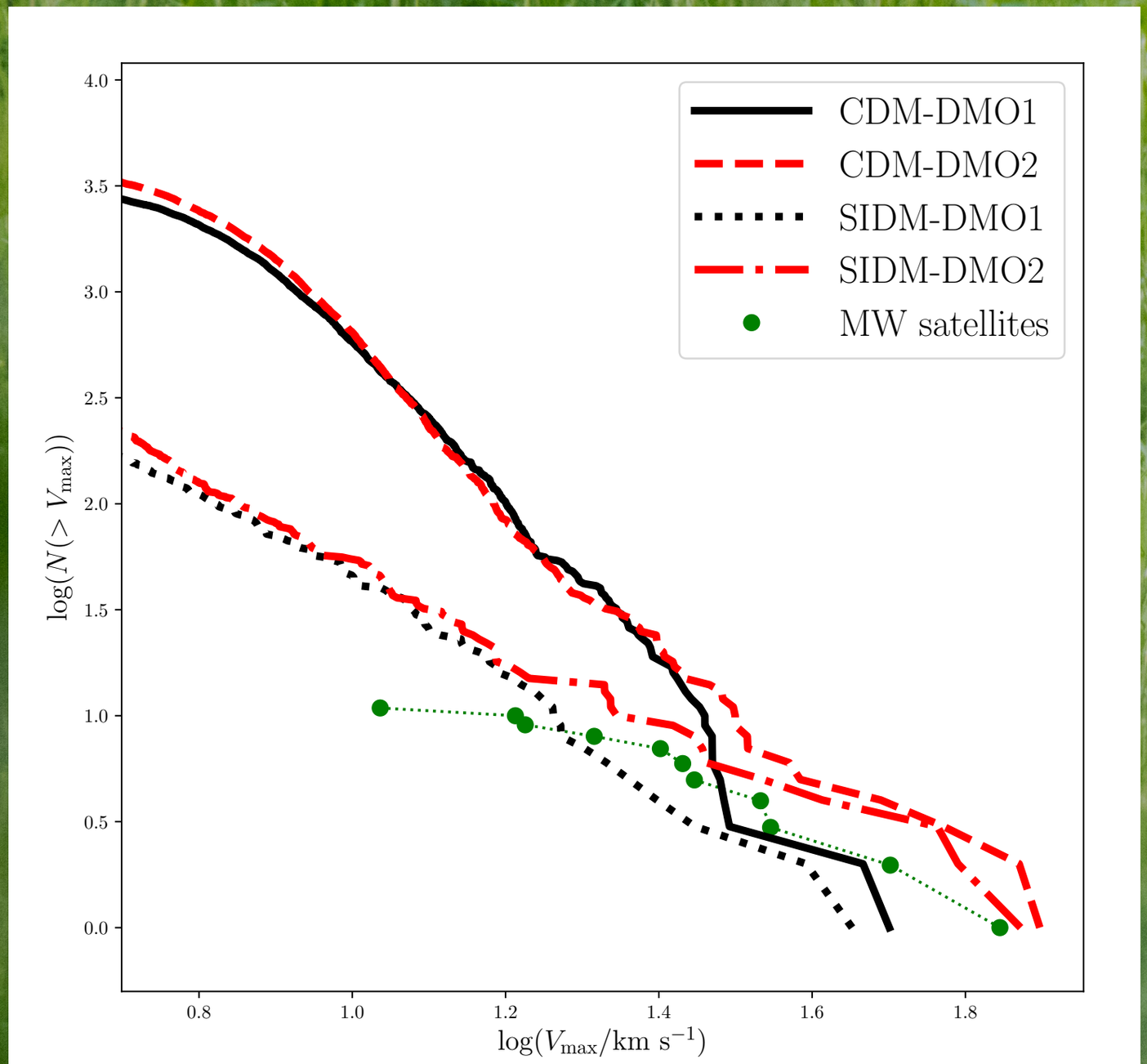




Simulations

- 2 MW-mass halos
  - Halo 1
    - $M_{\rm vir} = 1.79 \times 10^{12}\ {\rm M}_\odot$
  - Halo 2
    - $M_{\rm vir} = 1.97 \times 10^{12}\ {\rm M}_\odot$
- Resolution
  - $m_{\rm gas} = 1.12 \times 10^{4}\ {\rm M}_\odot$
  - $m_{\rm DM} = 6.02 \times 10^{4}\ {\rm M}_\odot$

Velocity functions (Dark matter only)

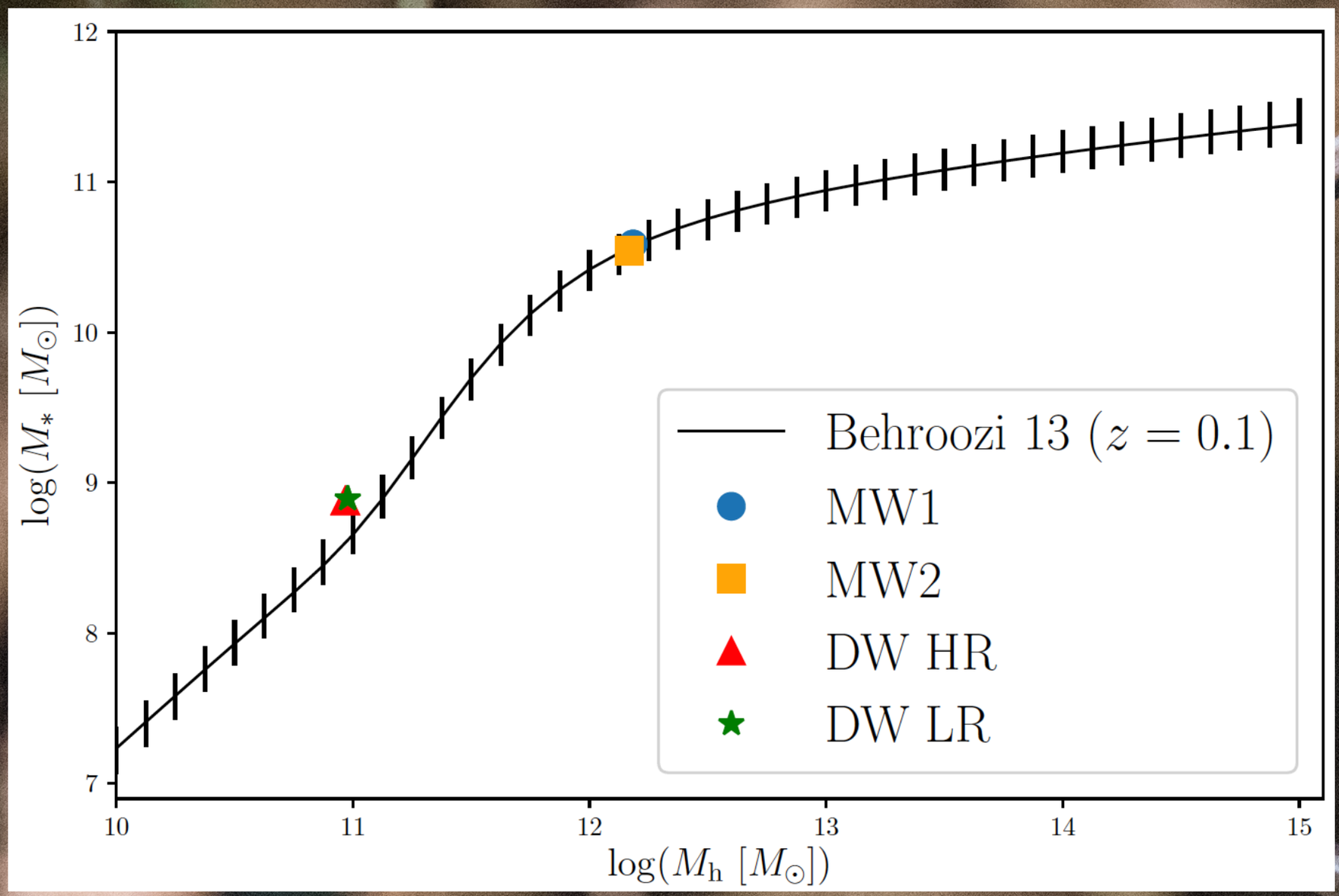


- Halo 2 has more massive subhalos.
- Almost impossible to explain the data by SIDM-H1.

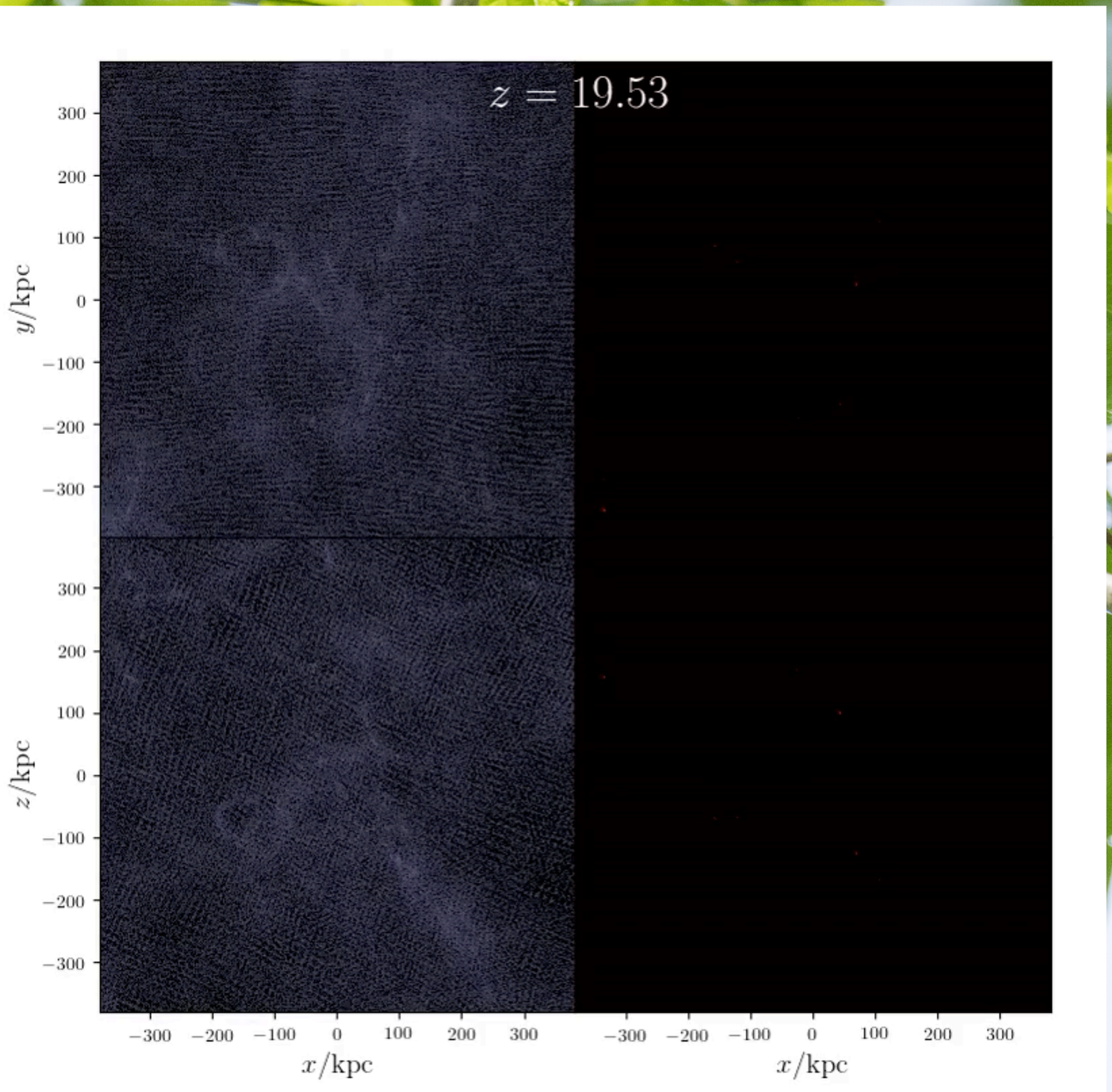
Simulations of galaxy formation

- CDM
  - Halo 1
- SIDM
  - Halo 2 (← substructure rich)

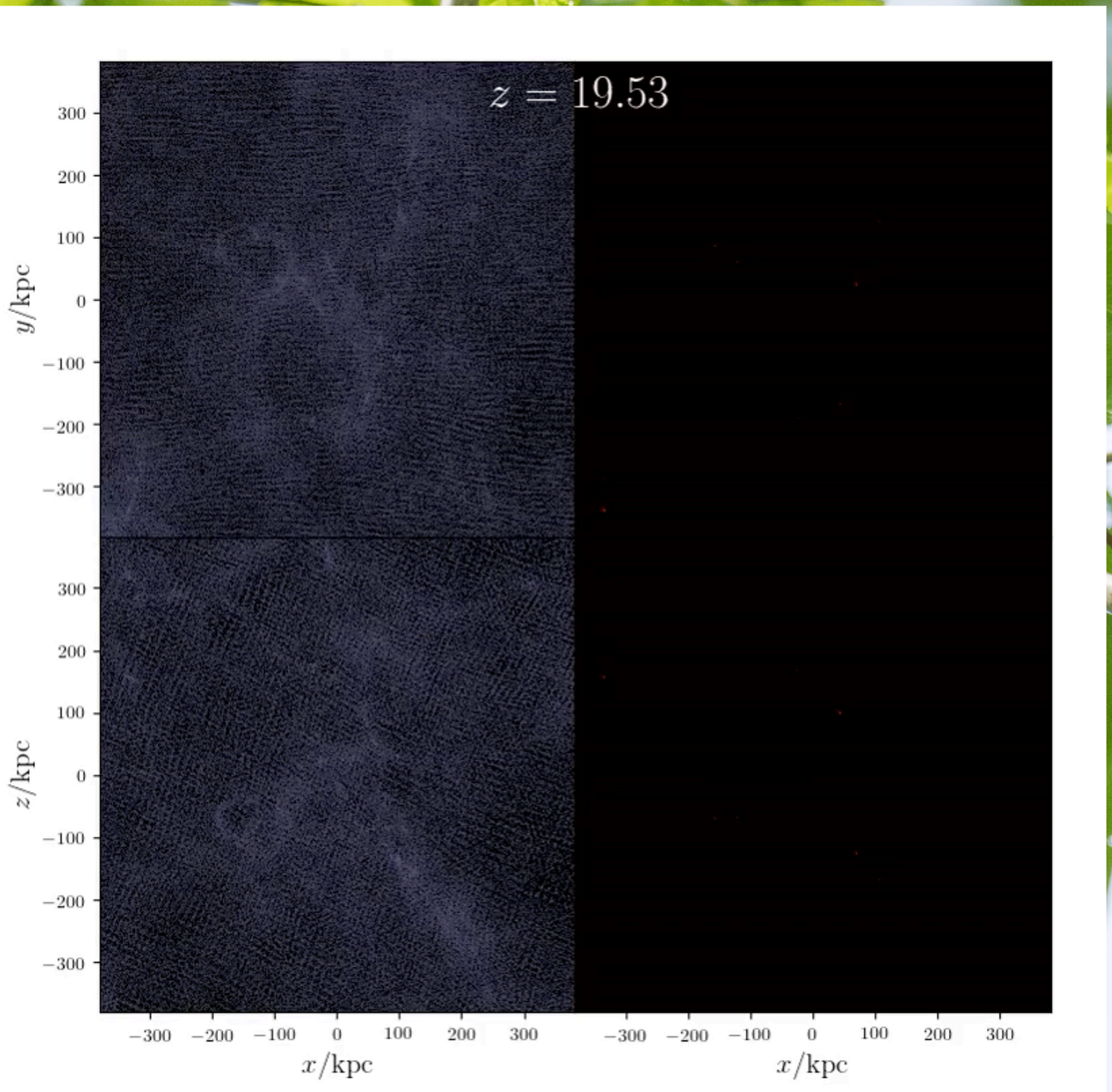
Our simulations form a right amount of stars and are resolution independent.



Formation of a MW-mass galaxy

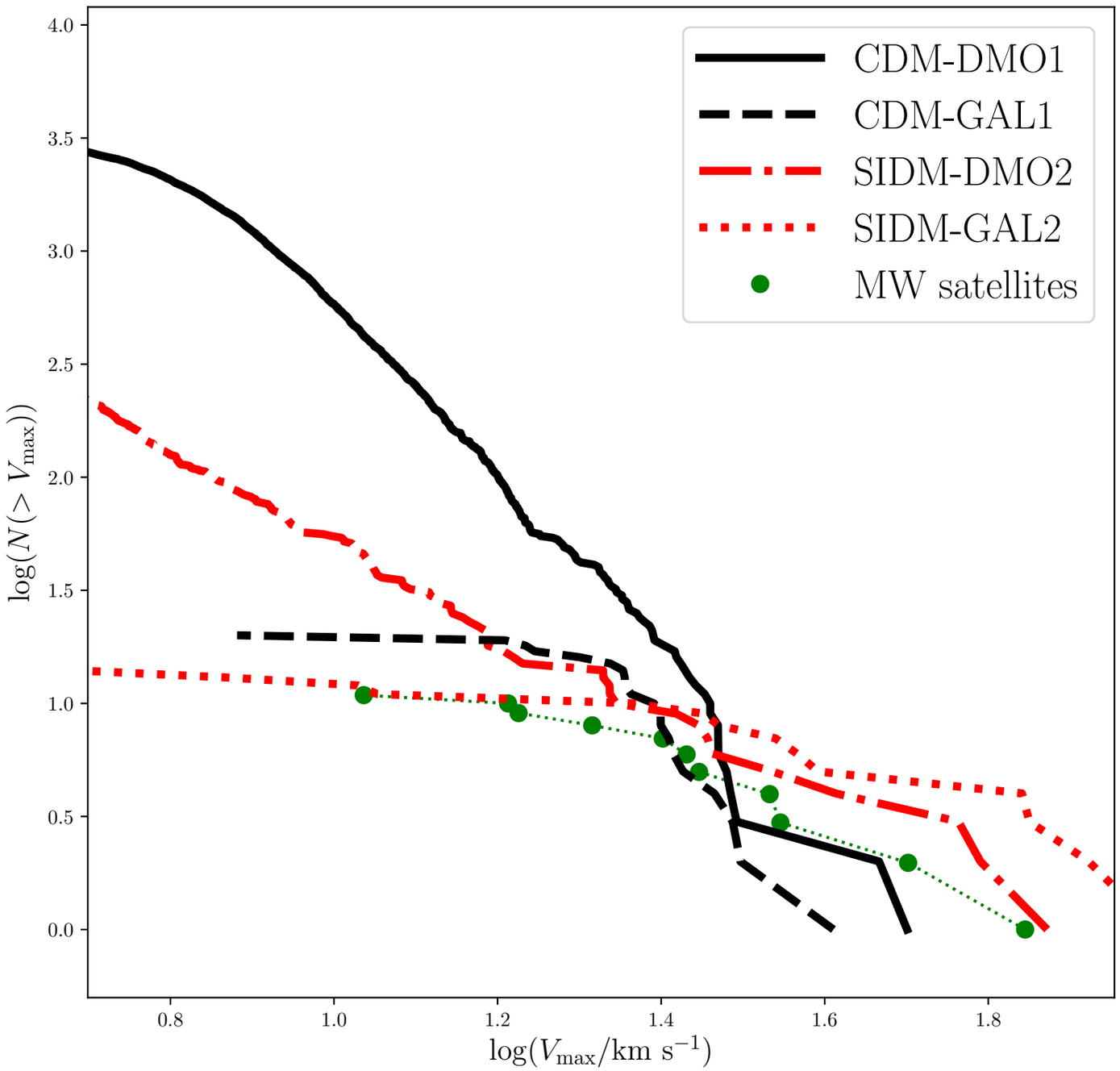


Formation of a MW-mass galaxy

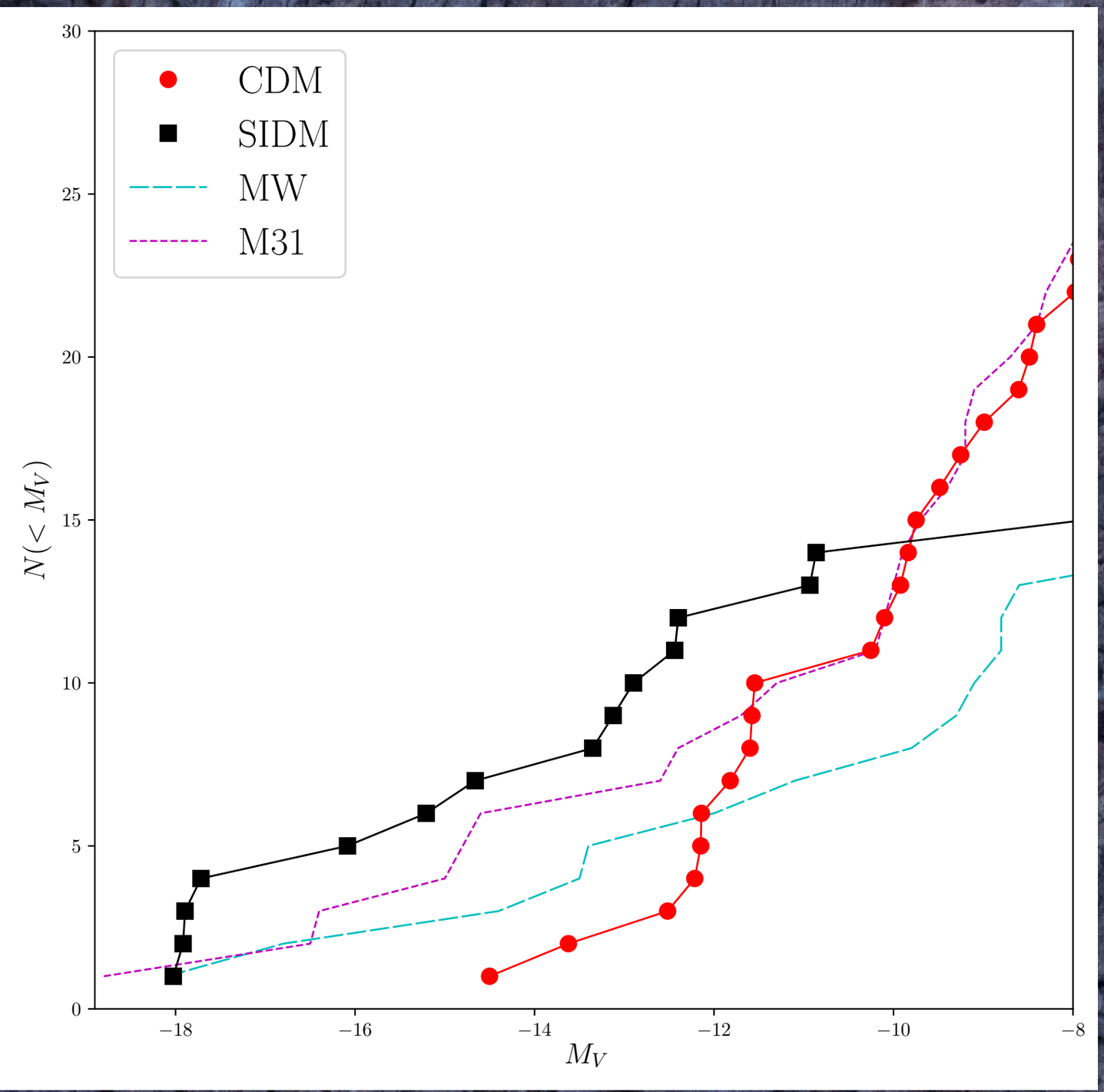


Velocity Functions





Luminosity functions

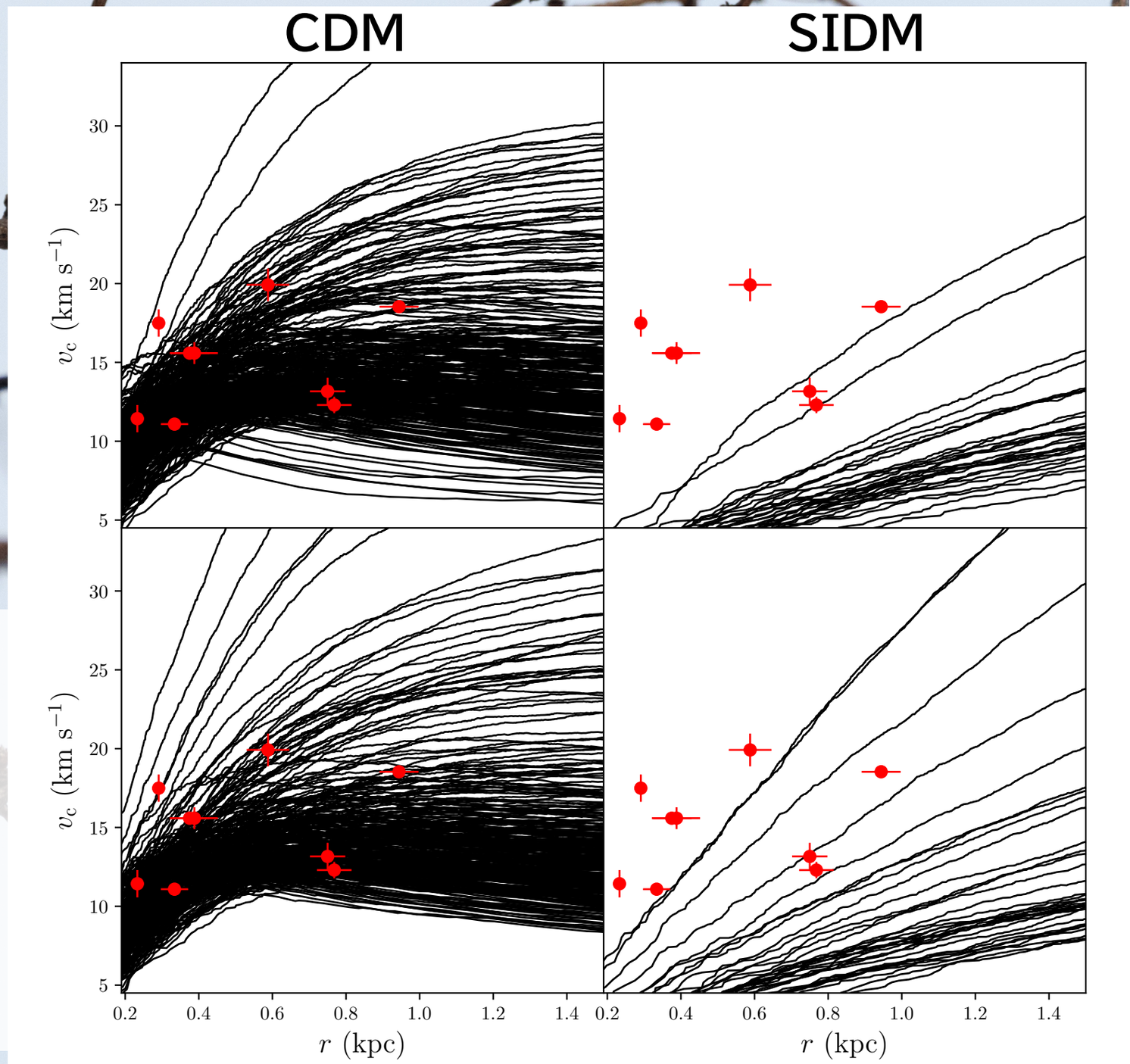


- Both are broadly consistent with data
- SIDM may have a difficulty explaining the faint end.

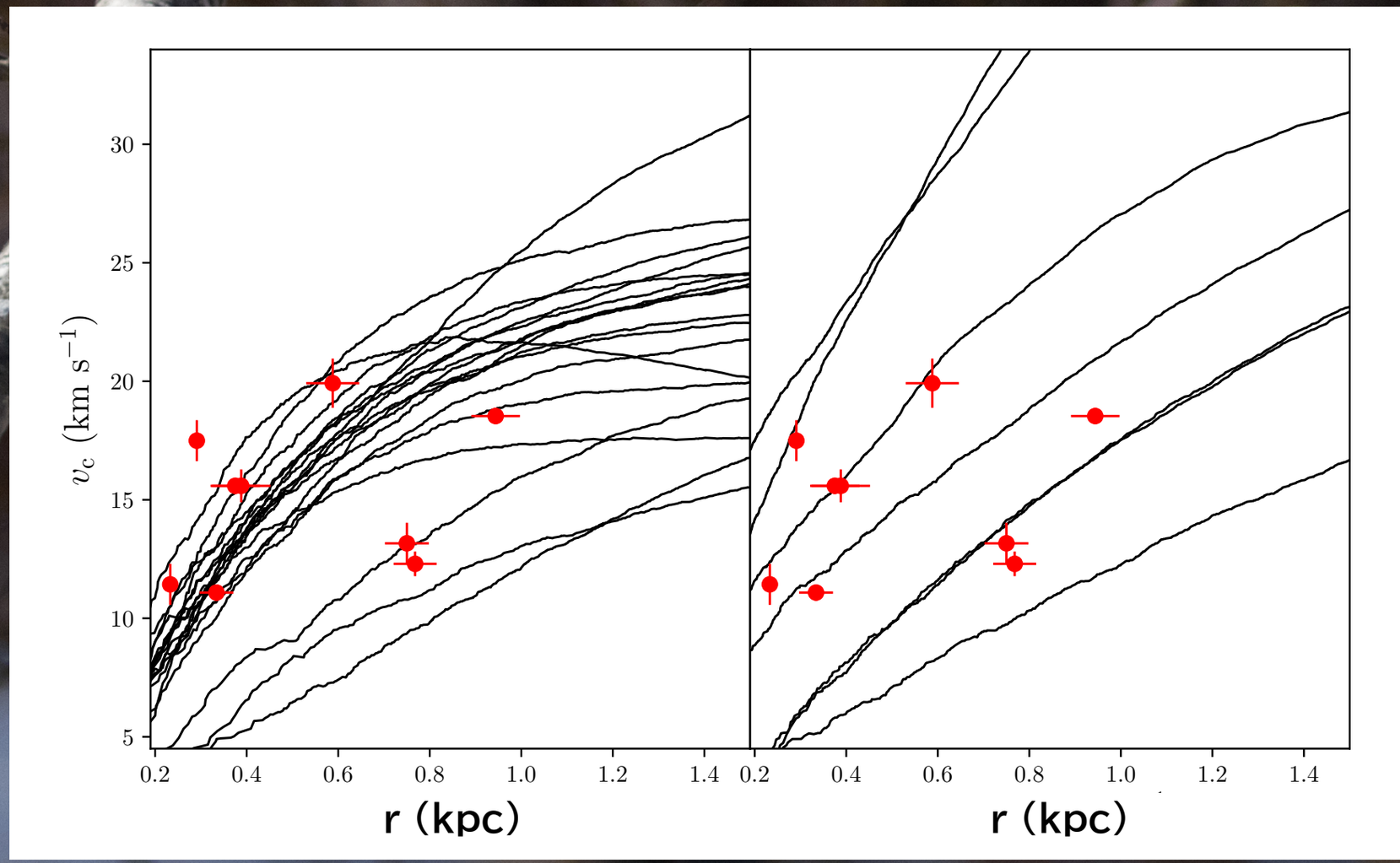
V_c profiles (DMO)



- CDM subhalos do not show TBTF problem. They are just too many.
- Central density of SIDM subhalos are too low.

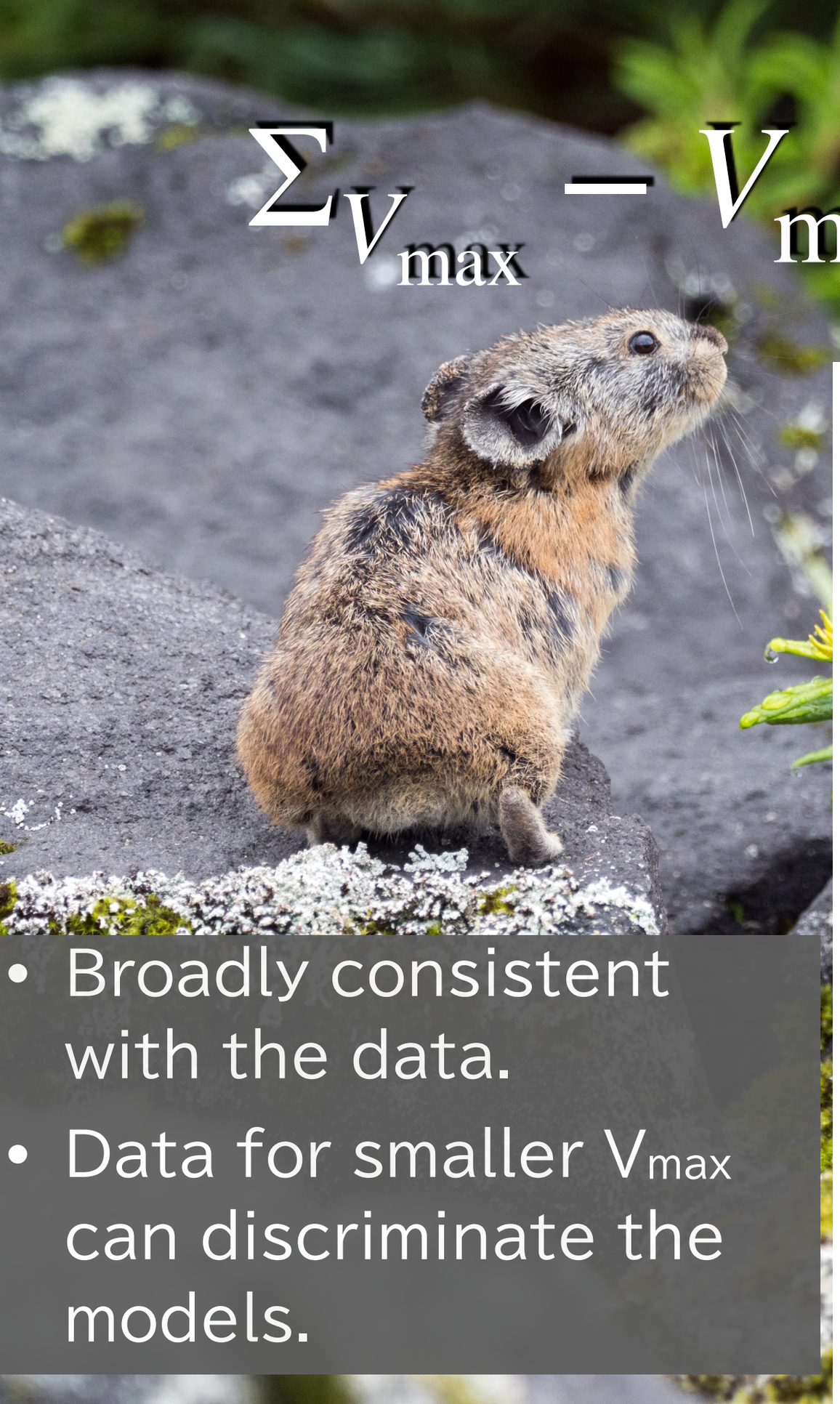


V_c profiles (GAL)

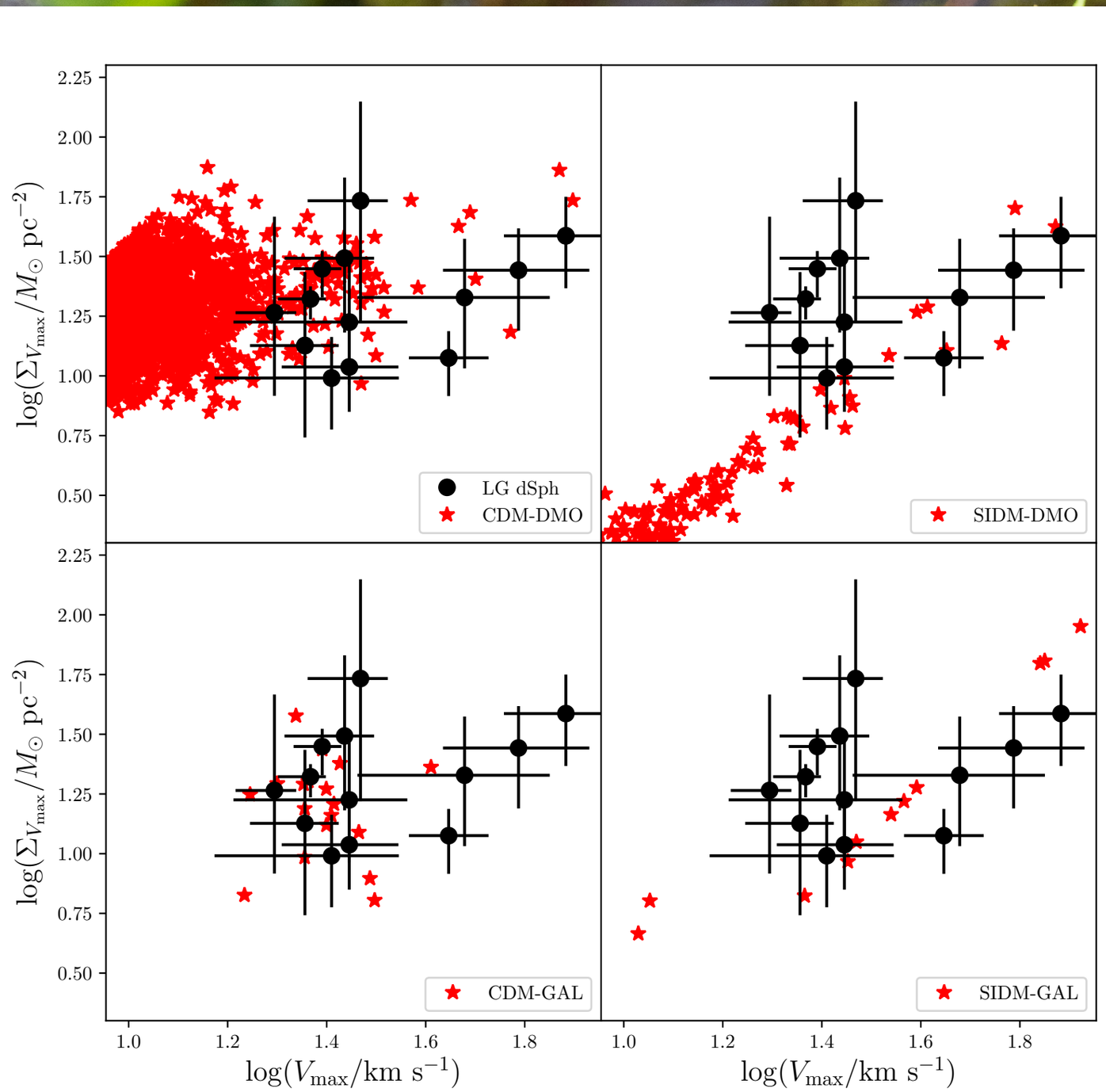


- Simulated satellites are broadly consistent with data.

$\Sigma_{V_{\rm max}} - V_{\rm max}$ relation



- Broadly consistent with the data.
- Data for smaller V_{max} can discriminate the models.



Conclusion

- We carry out simulations of MW-mass galaxies with SIDM whose cross-section is large on dwarf scales($\sim 10\ \mathrm{cm}^2/\mathrm{g}$).
- We can reproduce observed properties of satellites.
- Surface mass density for $V_{\mathrm{max}} \lesssim 10\ \mathrm{km/s}$ or the luminosity function for $M_V > -8$ can be used to distinguish such SIDM from CDM.