Iceland Liechtenstein Norway grants

UNIVERSITY OF ICELAND

GRAVOTHERMAL COLLAPSE OF SELF-INTERACTING DARK MATTER HALOS

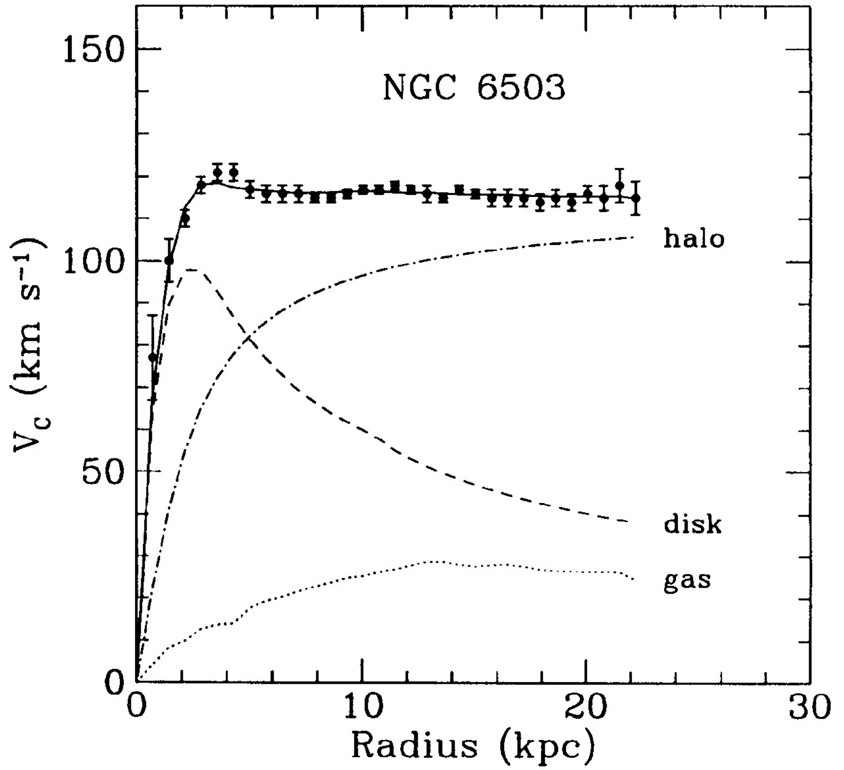
- *Tamari Meshveliani, PhD student*
- *Supervisor: Prof. Jesús Zavala Franco*

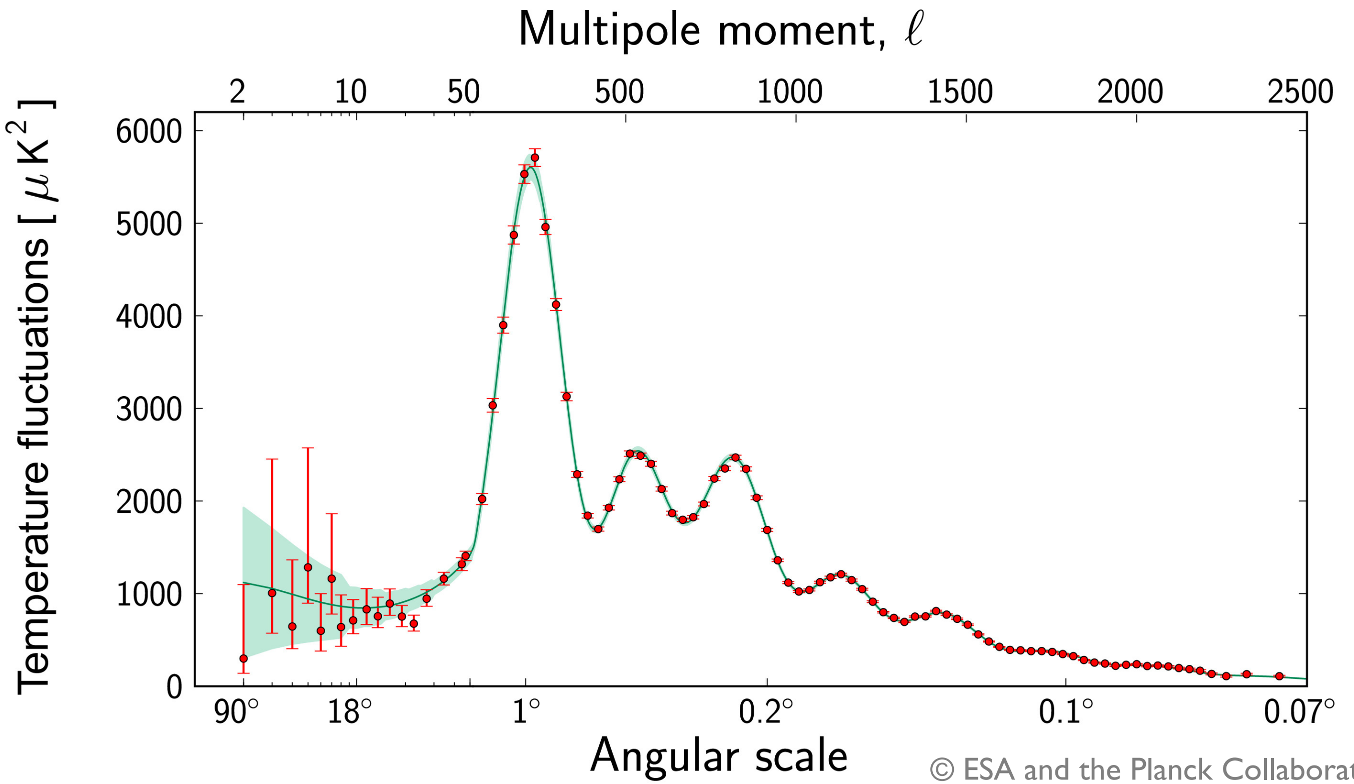
tam15@hi.is

The observational evidence of Dark Matter

Large number of independent observations support DM hypothesis:

Galaxy rotation curves, CMB, Gravitational lensing of background sources , the measured distribution of hot gas, dwarf spheroidals, the Bullet Cluster

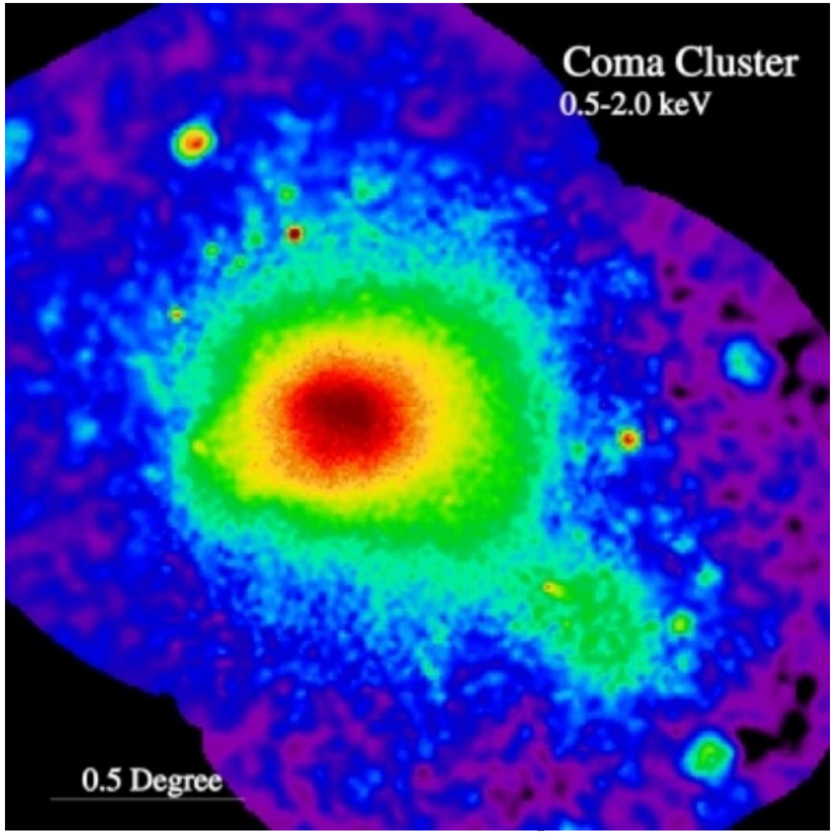




The observational evidence of Dark Matter

Large number of independent observations support DM hypothesis:

Galaxy rotation curves, CMB, Gravitational lensing of background sources , the measured distribution of hot gas, dwarf spheroidals, the Bullet Cluster



Small Scale Structure Formation Puzzles

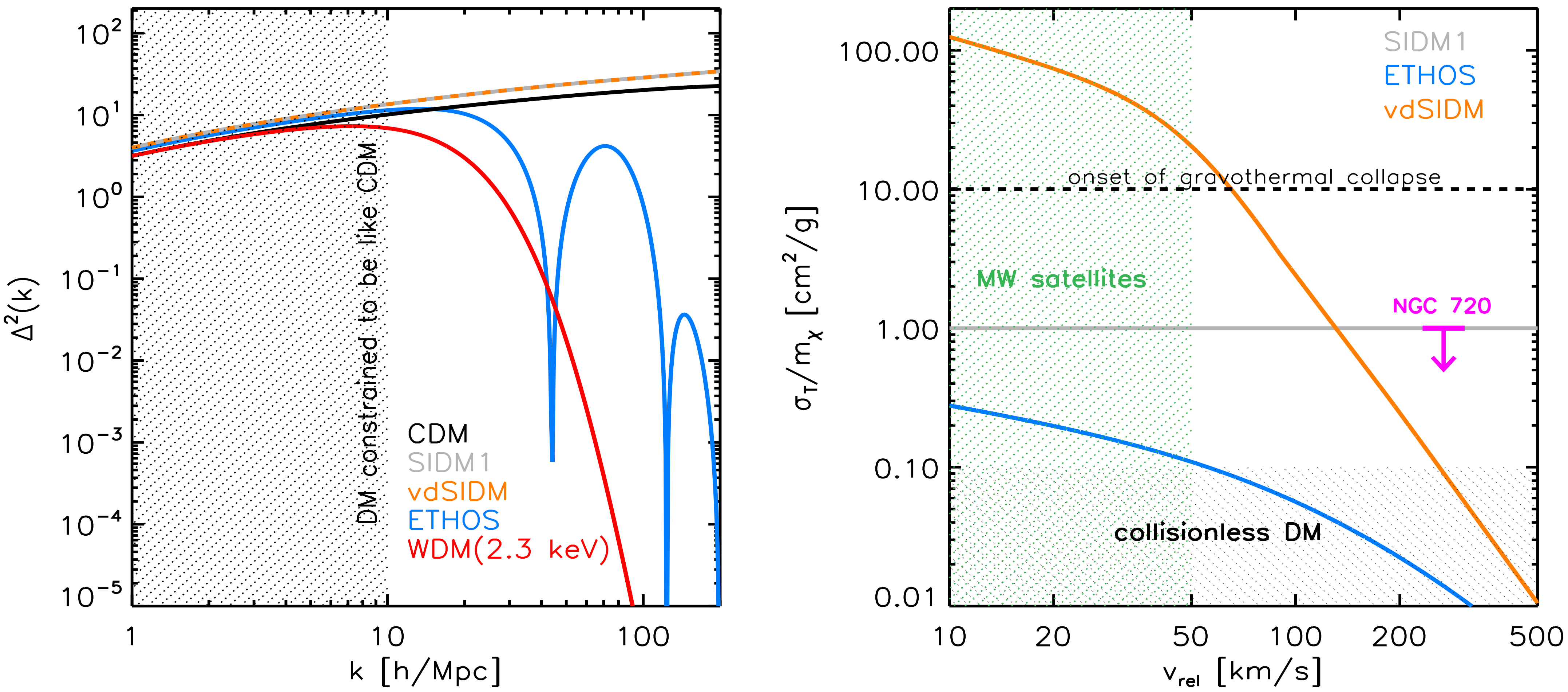
- Under-abundance of low mass galaxies
- Core-cusp problem
- Too-big-to-fail problem
- Diversity problem

Possible solutions to these problems:

1. Limitations to observations - incomplete data.
2. Uncertain baryonic physics
3. Deviations from the CDM hypothesis

Windows for alternative DM models to impact the physics of galaxies.

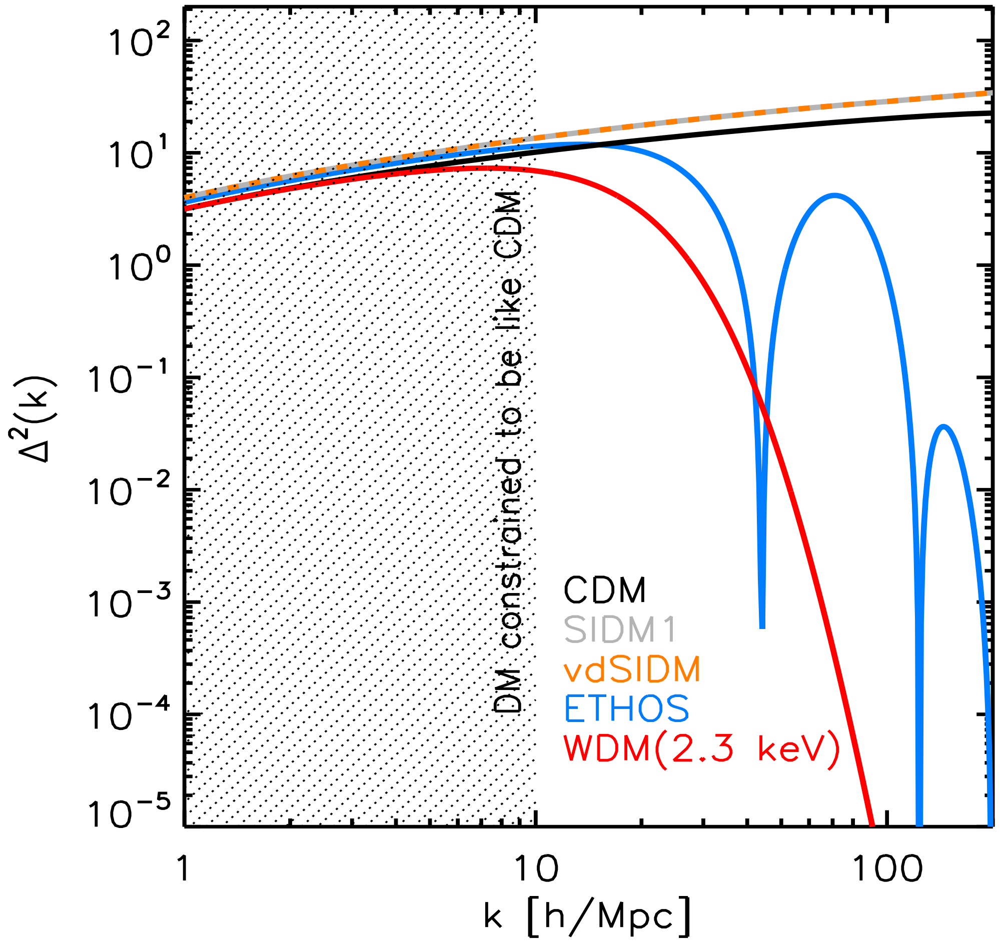
Zavala et al.2019

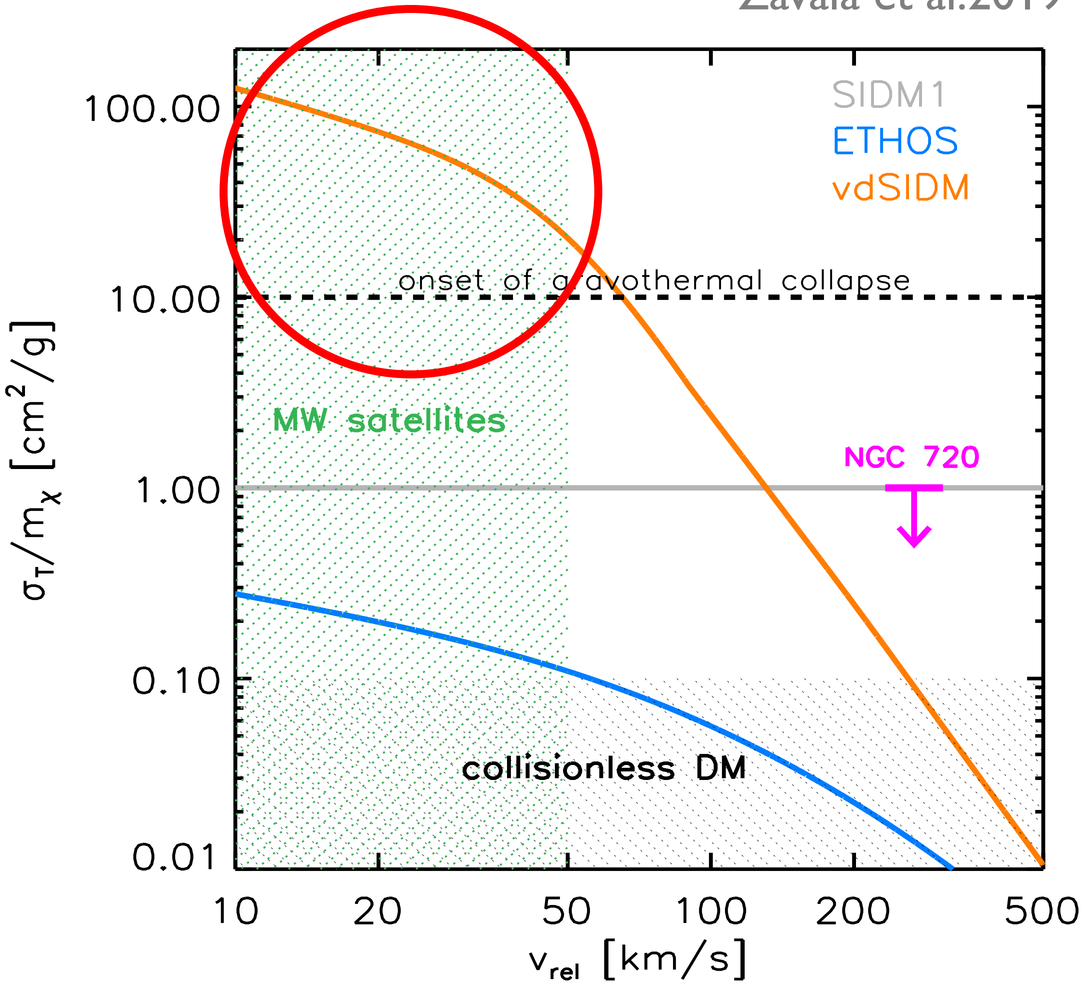


Iceland Liechtenstein Norway grants

Windows for alternative DM models to impact the physics of galaxies.

Zavala et al.2019





Concentration-Mass Relation based on Extended Press-Schecter (EPS) theory

The model (Ludlow et al. 2016) assumes that $<\rho_{-2}>$ ~ an assembly redshift z_{-2}

$$c\left(\frac{H(z_{-2})}{H(z_0)}\right)^2 = \frac{<\rho_{-2}>}{\rho_0} = 200c^3 \frac{\ln(2) - 0.5}{\ln(1+c) - c/(1+c)}$$

z_{-2} - the redshift when M_{-2} of the descendant halo was first assembled into progenitors having a mass larger than a fraction f of the descendant

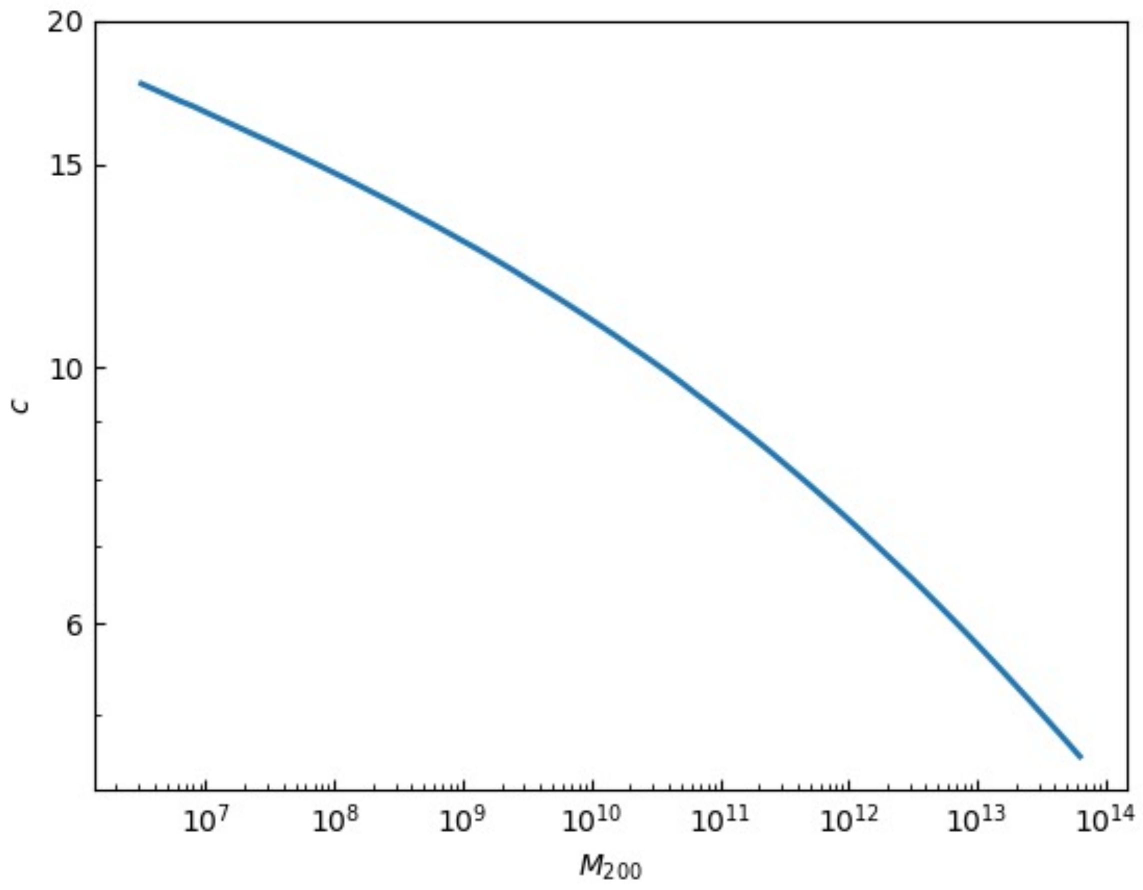
$$\mathrm{erfc}\left(\frac{\delta_c(z_{-2}) - \delta_c(z_0)}{\sqrt{2(\sigma^2(f \times M) - \sigma^2(M))}}\right) = \frac{M_{-2}}{M_0} = \frac{\ln(2) - 0.5}{\ln(1+c) - c/(1+c)}$$

Concentration-Mass Relation based on Extended Press-Schecter (EPS) theory

NFW profile:

$$\frac{\rho(r)}{\rho_s} = \frac{\delta_c}{\frac{r}{r_s}\left(1+\frac{r}{r_s}\right)^2}$$

$$\delta_c = \frac{200}{3}\frac{c^3}{\ln(1+c) - c(1+c)}$$



The timescale for the formation of a black hole within SIDM halos

The time after the Big Bang where a SIDM halo of current day mass, M_{200}, has undergone a gravothermal collapse and formed a black hole

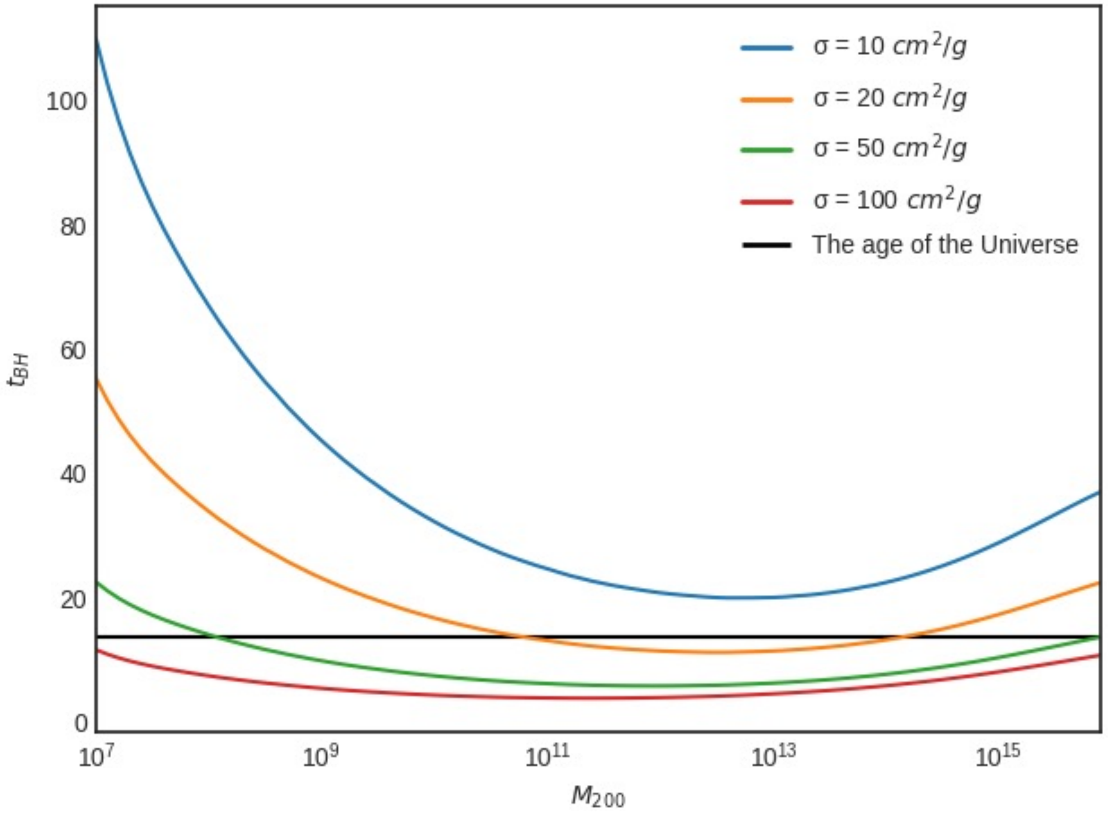
$$t_{BH}(M_{200}, \sigma) = t_{universe}(z_{start}) + t_{collapse} =$$

$$= t_{universe}(z_{start}) \; + 455.65 t_r(r_s, z_{start})$$

Where

$$t_r(r, t) = \frac{1}{a\rho\upsilon\sigma}$$

is the relaxation time - the mean time between single collisions



Late time evolution of the core

Only a small fraction of the inner core energy is transferred to the outer core and $|\zeta| \sim 0$

$$\frac{dE_c}{dt} = \zeta \frac{E_c}{M_c}\frac{dM_c}{dt}$$

$$\frac{dlogv_c^2(t)}{dlogM_c(t)} = -(1-\zeta)$$

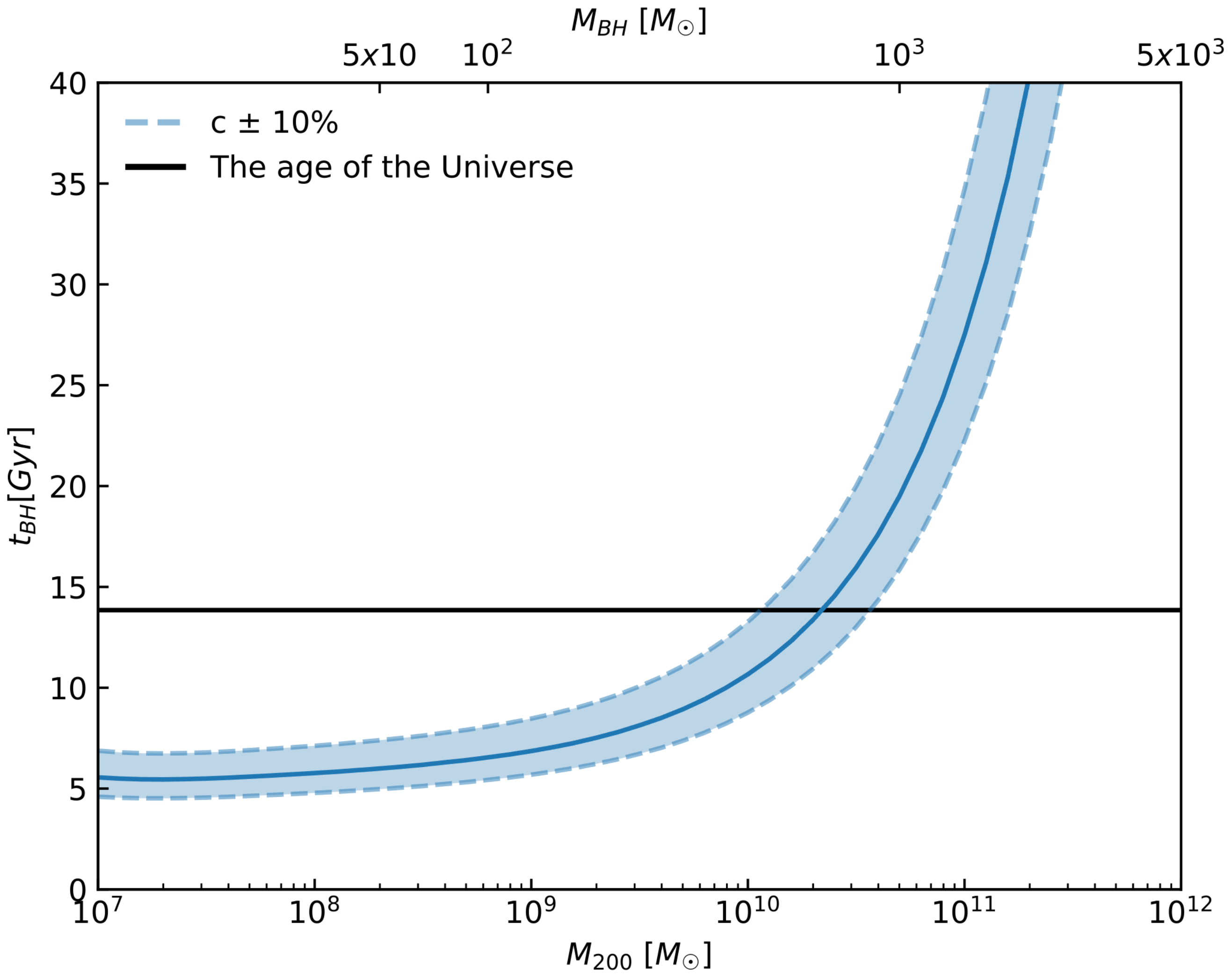
$$\frac{dlogv_c^2(t)}{dlogM_c(t)} \approx -1.1 - 1.2$$

The timescale for the formation of a black hole within SIDM halos

The local termal average of the transfer cross section

$$\langle\sigma_T\rangle(\vec{x}) = \frac{1}{2\sigma_{vel}^3(\vec{x})\sqrt{\pi}}\int \sigma_T v^2 e^{-v^2/4\sigma_{vel}^2(\vec{x})}dv$$

where $\sigma_{vel}(\vec{x})$ is the local velocity dispersion



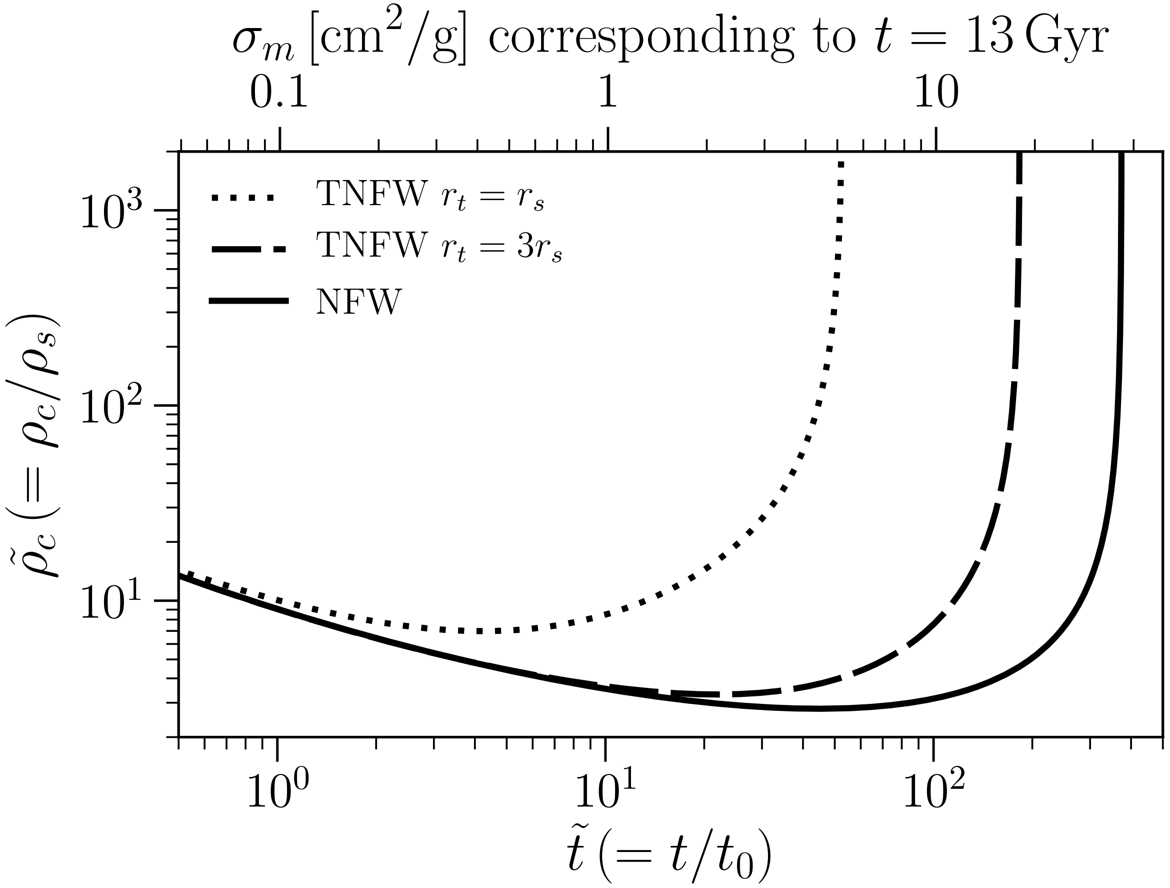
Accelerated core collapse in tidally stripped SIDM halos

Satellite galaxies with significant mass loss due to tidal stripping should have larger central densities and significantly faster core collapse compared to isolated halos.

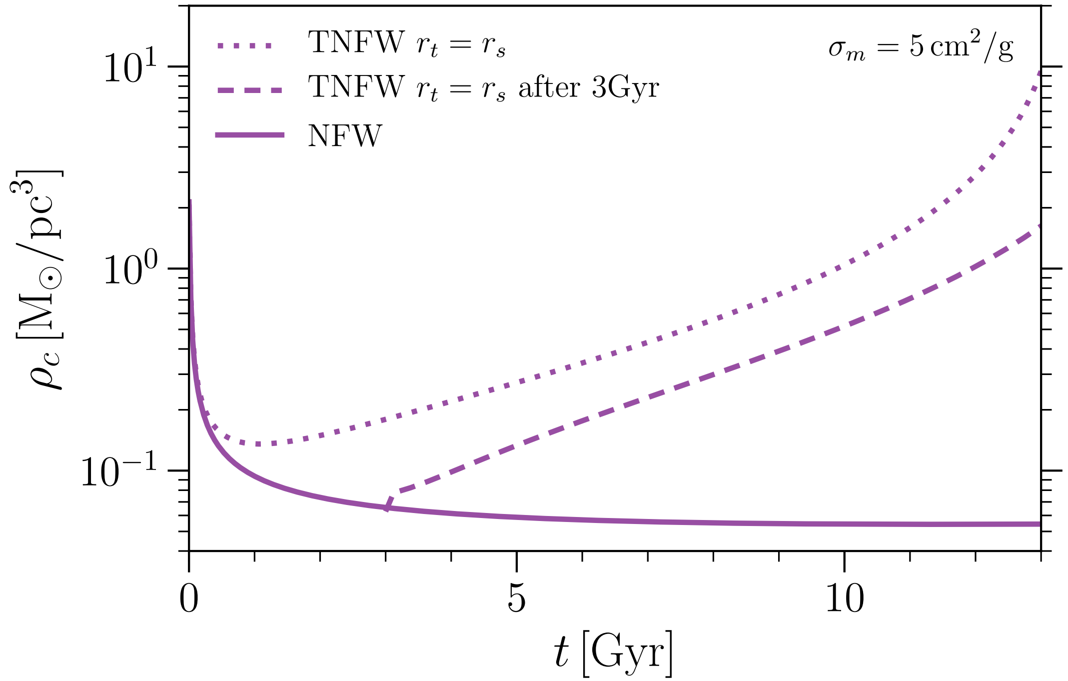
For an NFW profile, we model the tidal stripping by channging the profile for $\mathrm{r} > r_t$ to

$$\rho_{NFW}(r_t) \times (r_t/r)^{p_t}$$

Truncations at $r_t = r_s$ and $3r_s$, correspond to a halo mass loss of $\sim 90\%$ and 70% respectively, for concentration of 20.

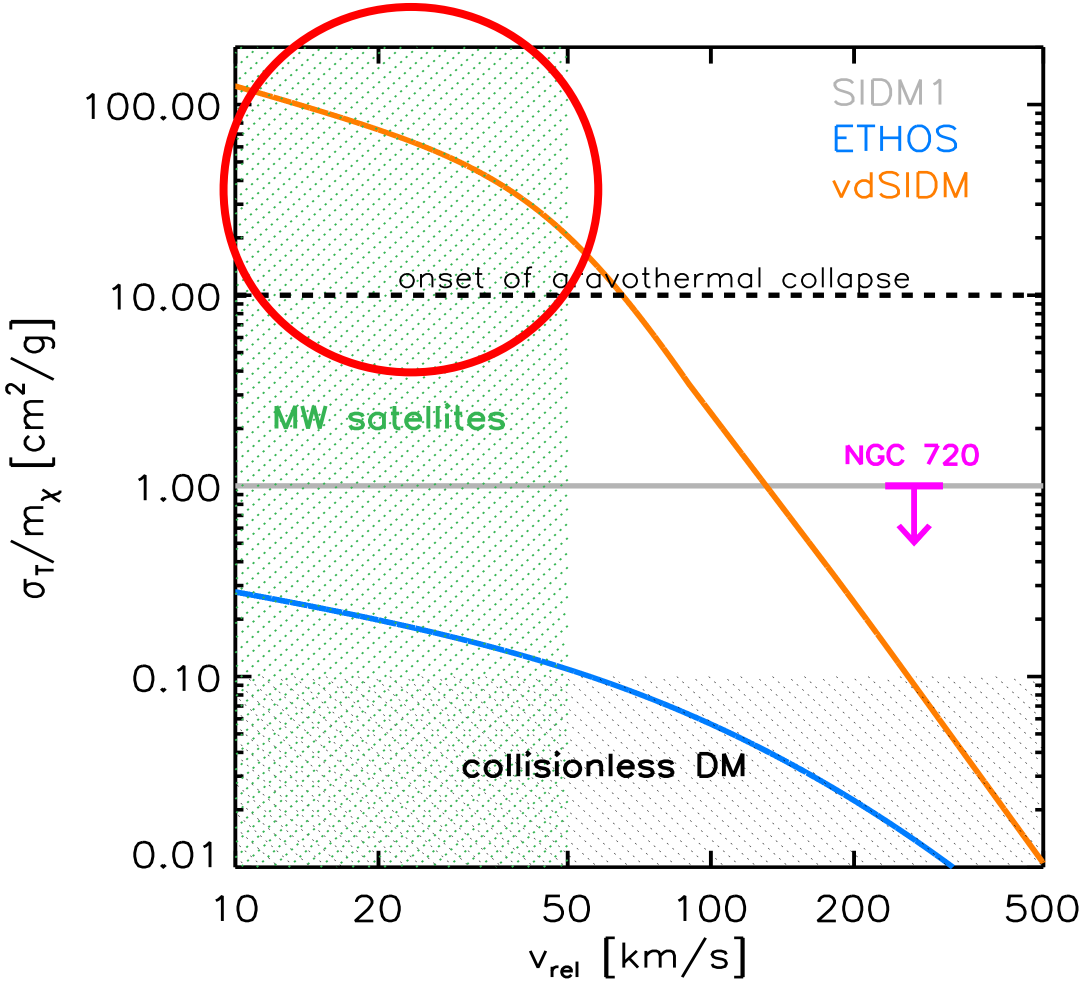


© Nishikawa et al.2019



Such a scenario could explain compact cores of dwarf galaxies in the Local Group like
Tucara (isolated from MW),
MW satellite Draco,
ultrafaint satellites

- To compare with the simulations
- Observational constraints on the masses of black holes



Iceland
Liechtenstein
Norway grants

UNIVERSITY OF ICELAND

THANK YOU FOR YOUR ATTENTION

📩 tam15@hi.is