UNIVERSITY OF ICELAND

# GRAVOTHERMAL COLLAPSE OF SELF-INTERACTING DARK MATTER HALOS


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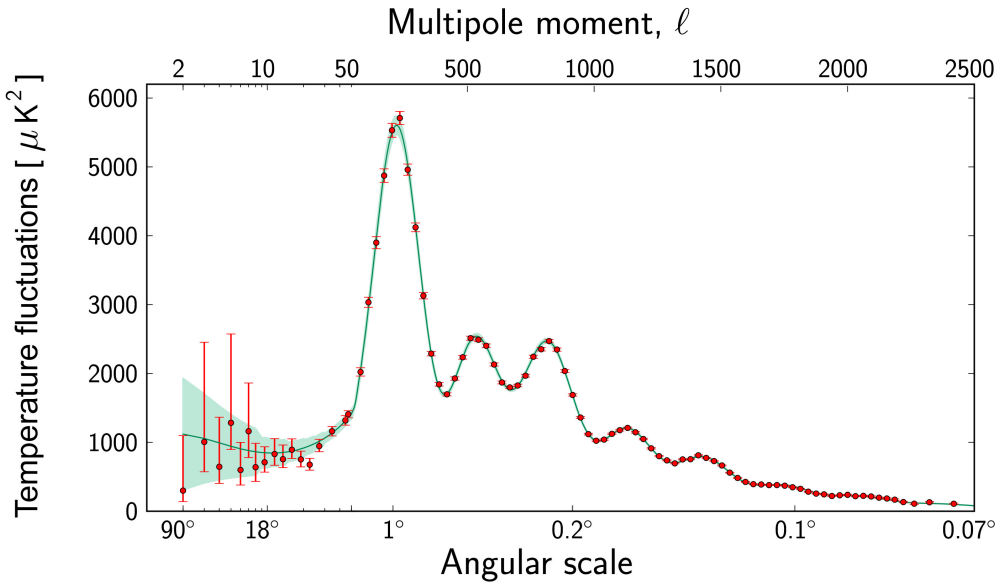
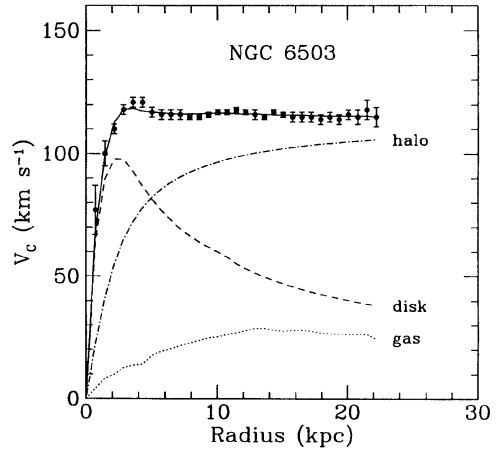
# The observational evidence of Dark Matter

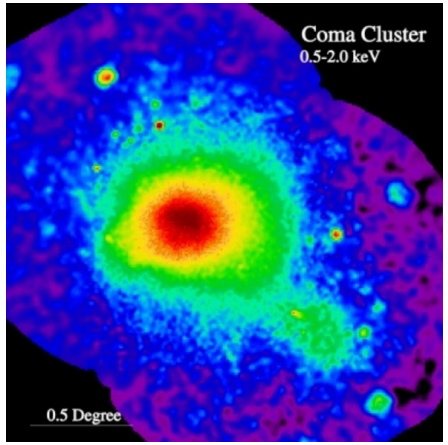
Large number of independent observations support DM hypothesis:

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






# Small Scale Structure Formation Puzzles

Lambda–CDM model has challenges matching observations on small scales.

Too-big-to-fail problem

Core-cusp problem

↓

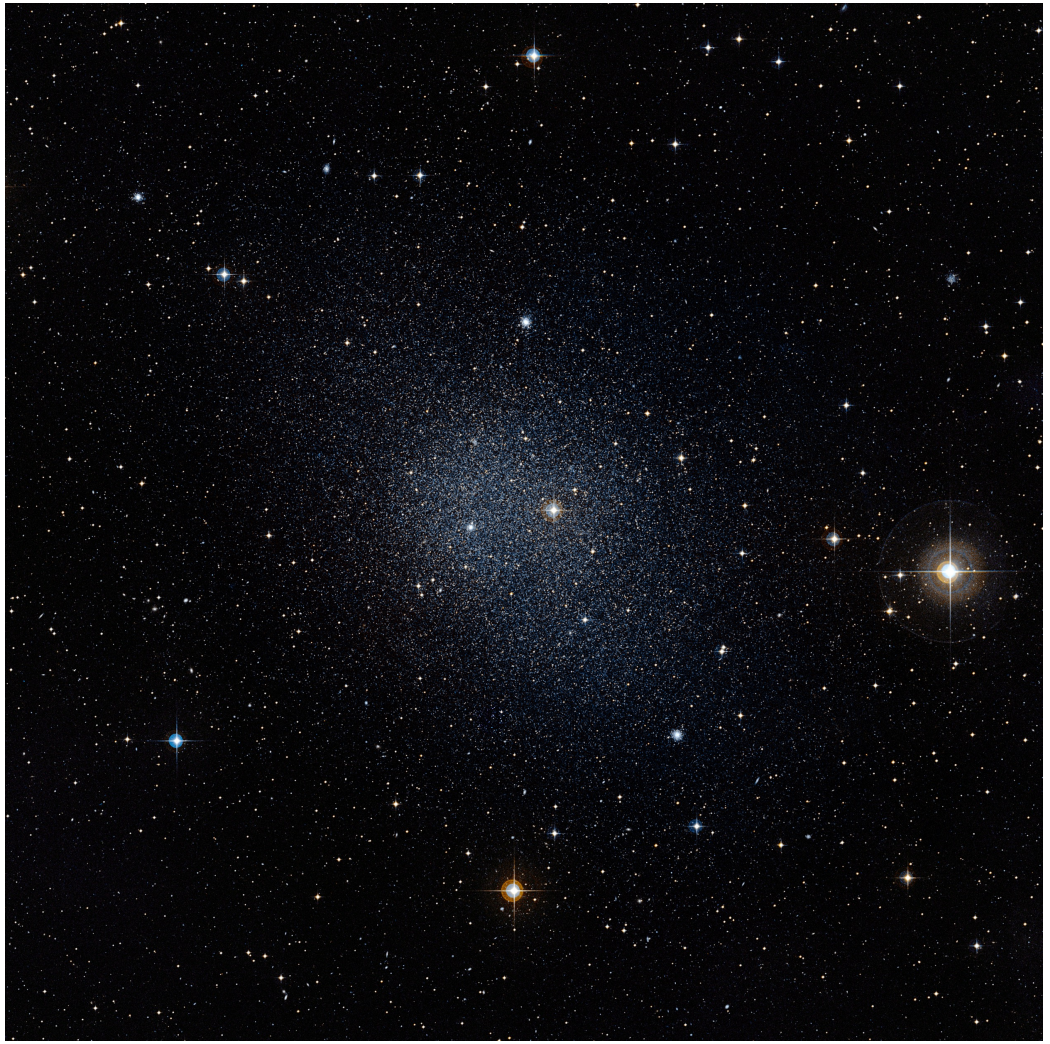
Diversity problem

ESO/Digitized Sky Survey 2

# Small Scale Structure Formation Puzzles

**Possible solutions to these problems:**

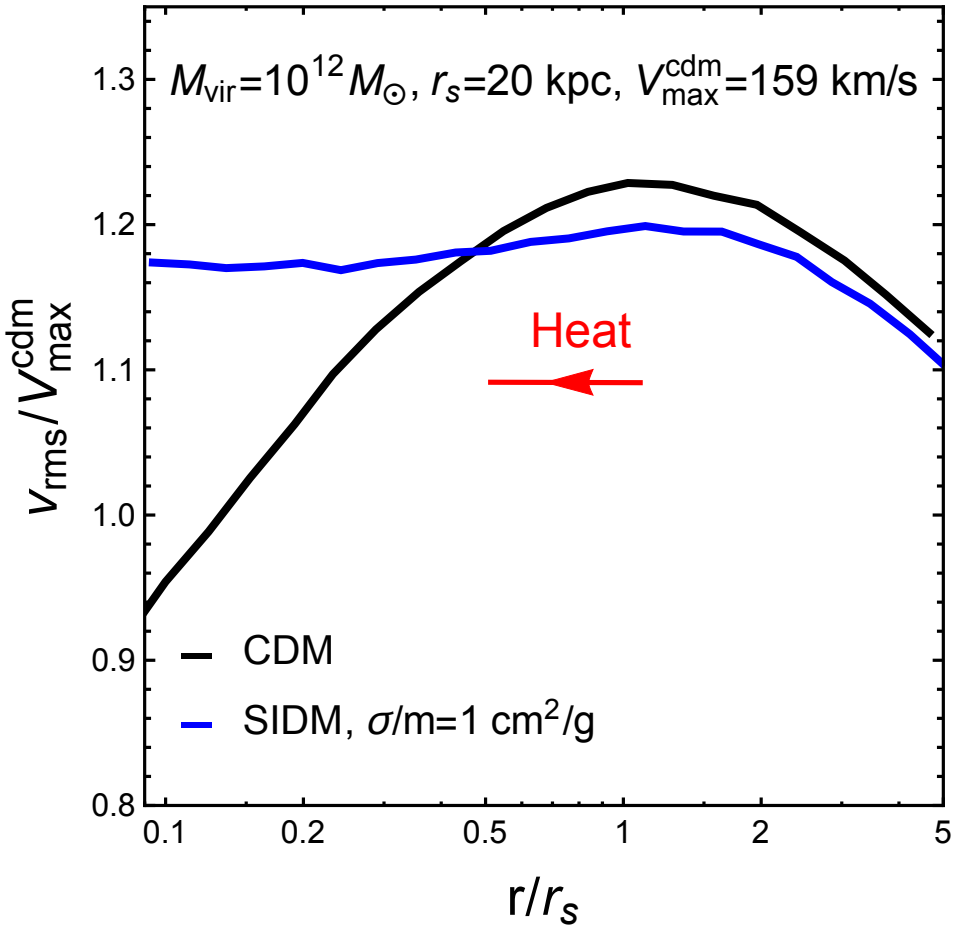
- Limitations to observations – incomplete data.
- Uncertain baryonic physics
- Deviations from the CDM hypothesis

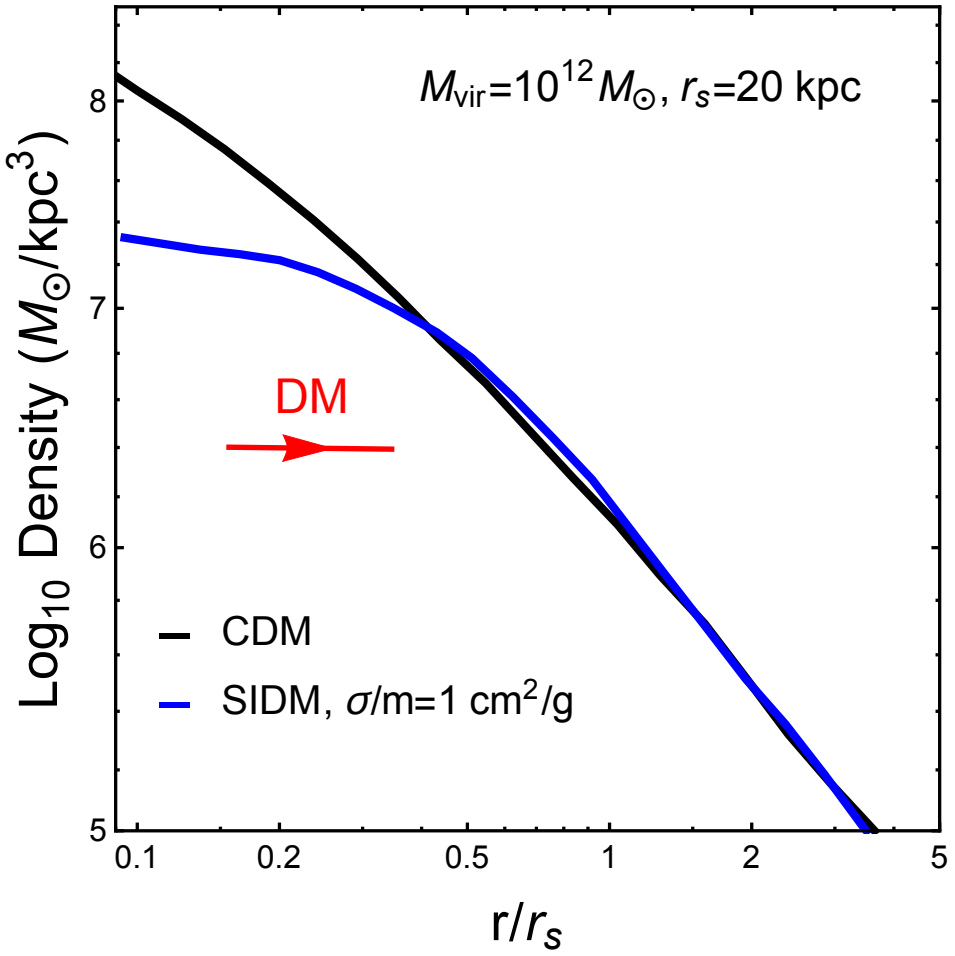


ESO/Digitized Sky Survey 2

# Velocity dispersion and density profiles of CDM and SIDM halo

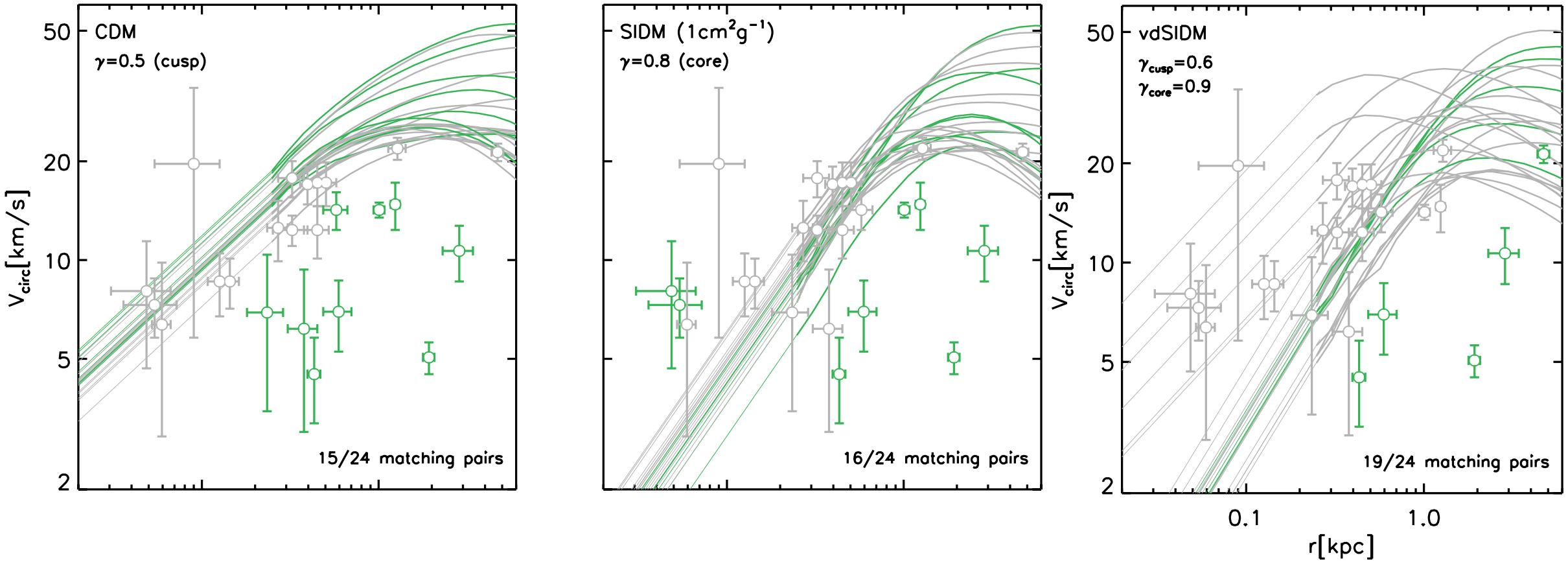
Tulin et al.2017



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

Zavala et al.2019

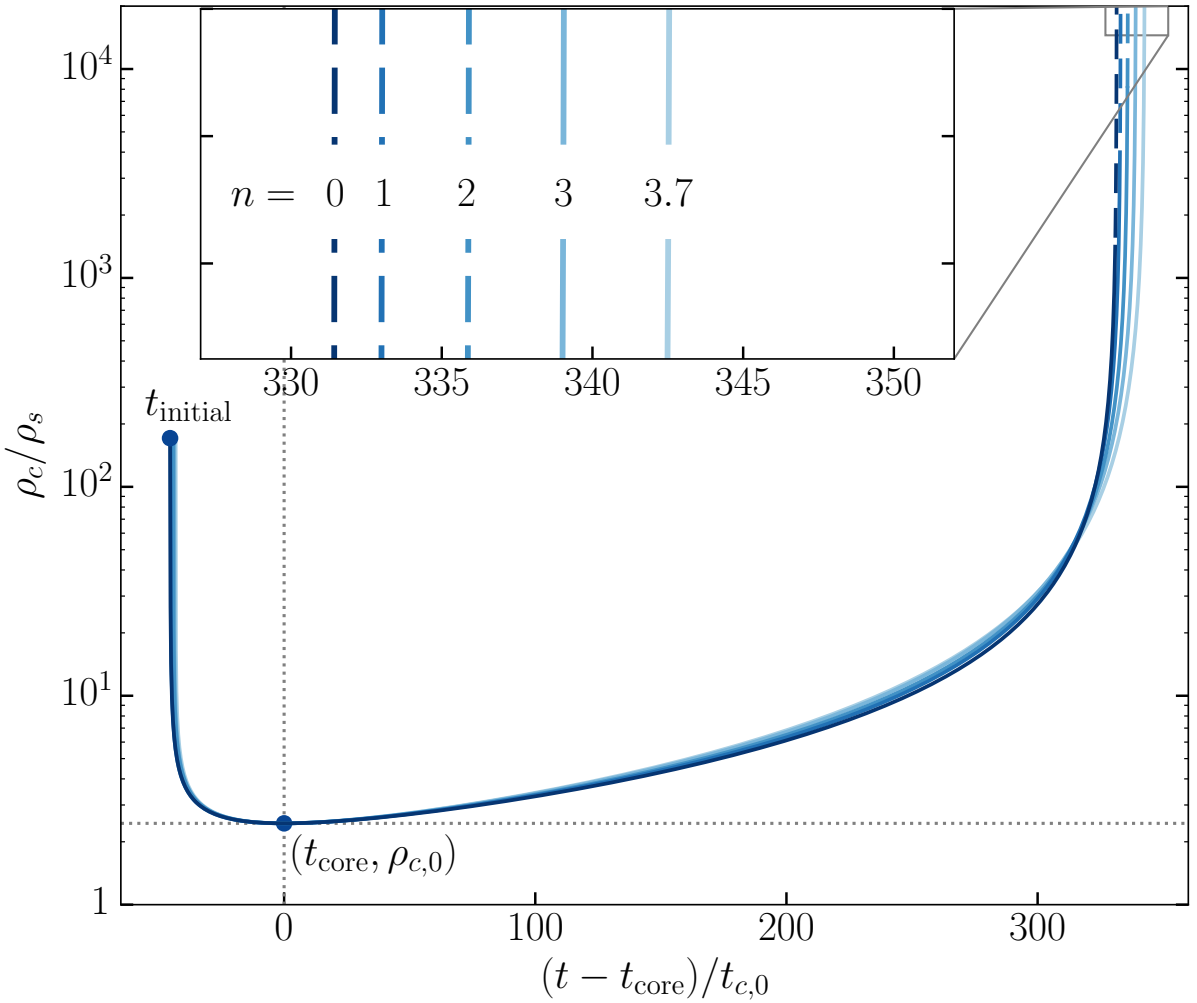


# Cosmic evolution of an SIDM halo

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

$$t_{BH}(M_{200}, \sigma) = t_{universe}(z) + t_{collapse} =$$
$$= t_{universe}(z) \ + 382 t_r(r_s, z)$$

Outmezguine et al. 2022



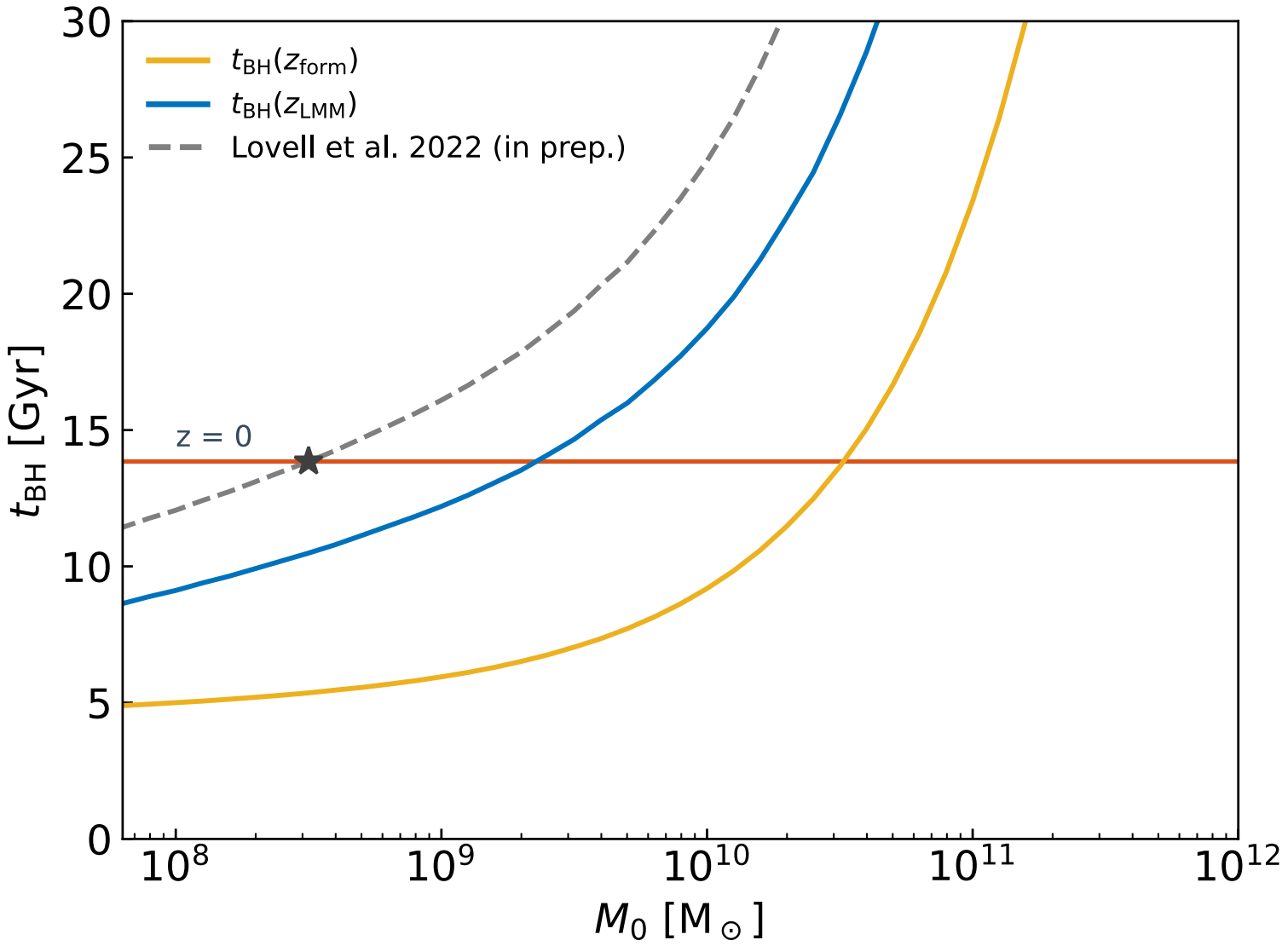
# Two limits for starting the cusp-core-collapse stage

Earliest possible time:

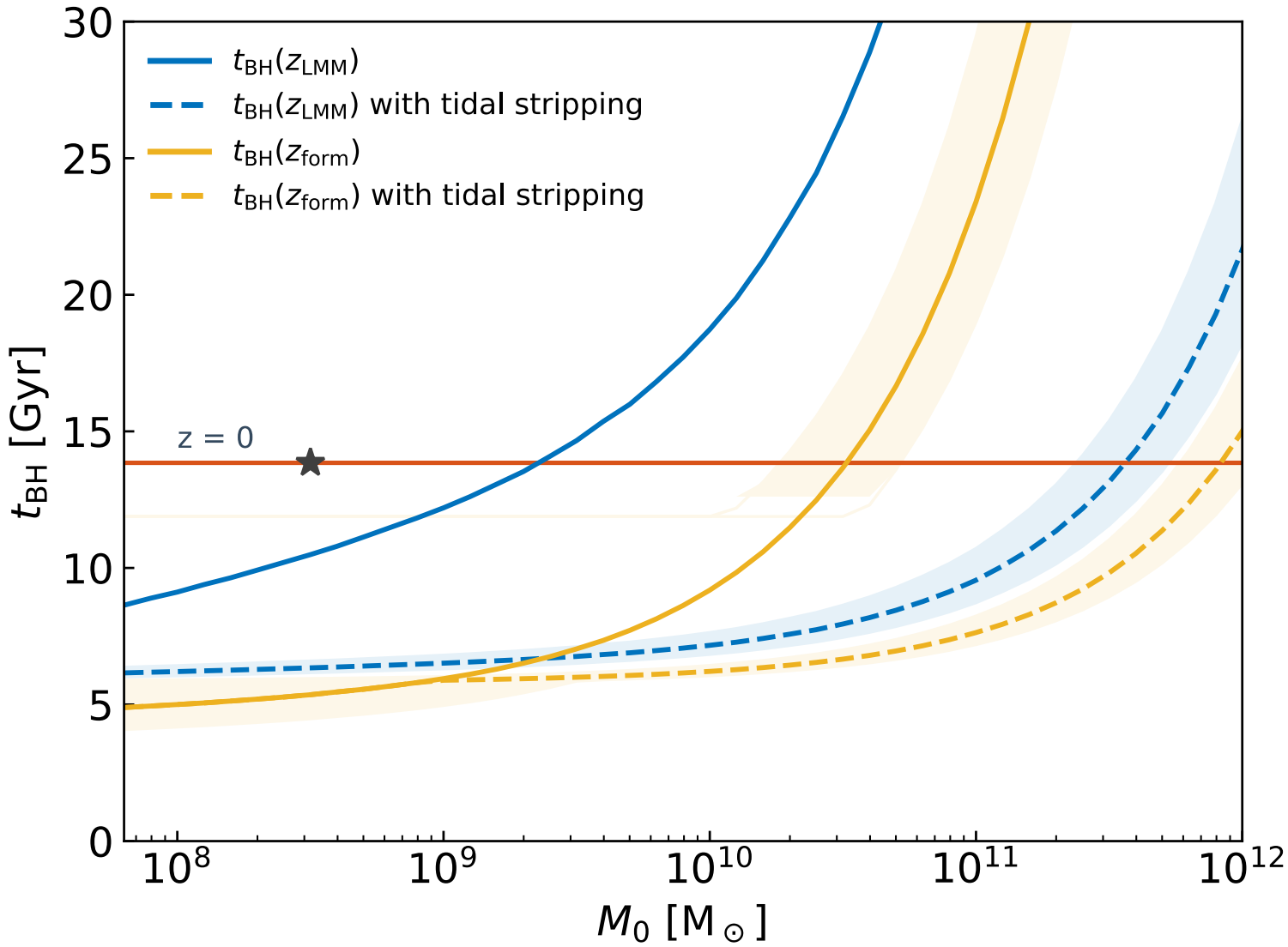
$$z_{cc} = z_{form}$$

Latest possible time:

$$z_{cc} = z_{LMM}$$



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



# Late time evolution of the core

When the inner core is sufficiently dense, mass is continuously lost from its surface as outer layers cool and expand to join the outer core. Once the energy transfer is almost zero,

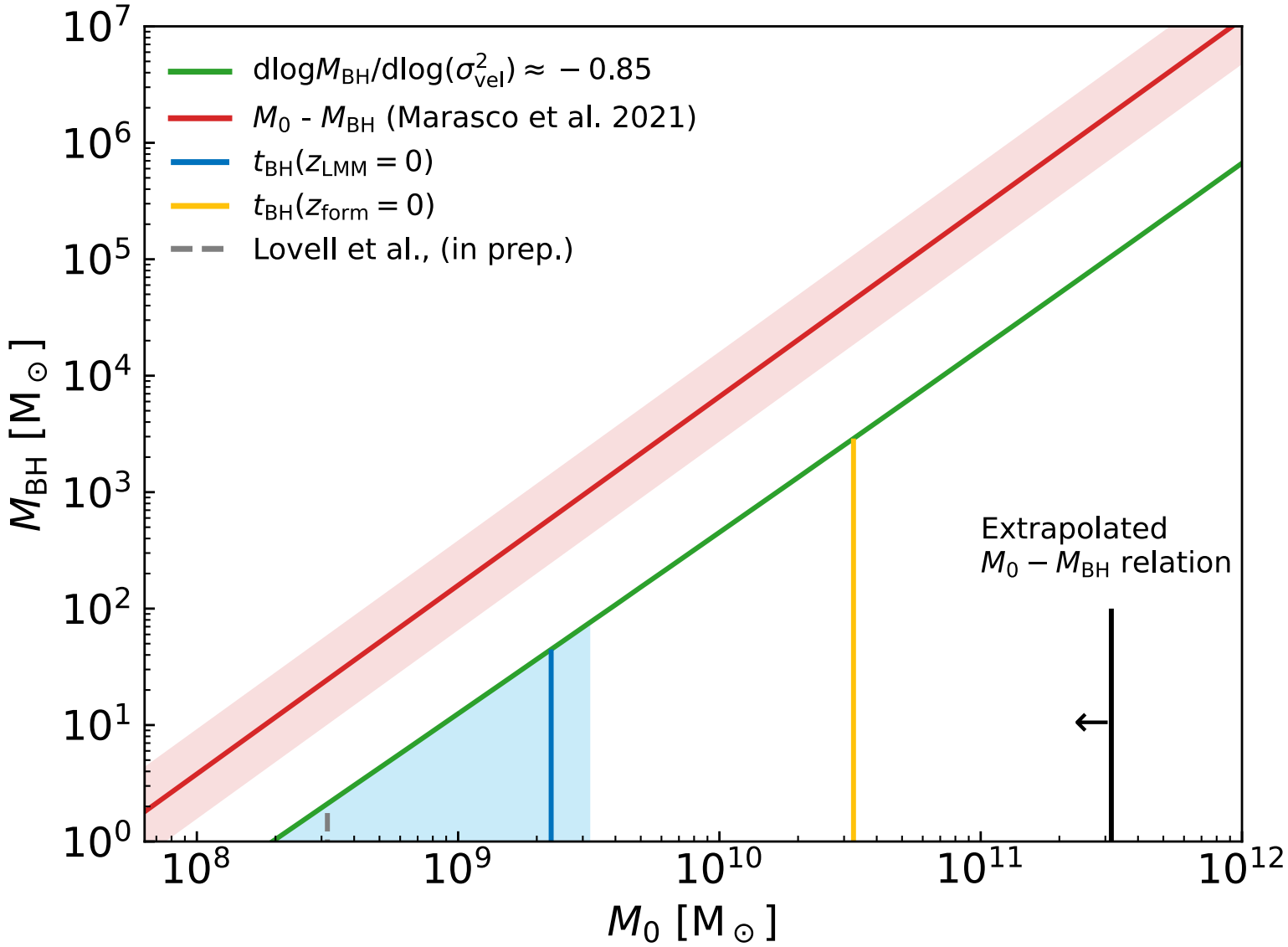
$M_{core} - \sigma_{vel}$ relation settles to

$$\mathrm{d}\log \mathrm{M_{core}}/\mathrm{d}\log(\sigma_{\mathrm{vel}}^2) \approx -0.85$$

The seed black hole mass is predicted to be:

$$M_{\mathrm{BH}} = M_0 \left( \frac{\sigma_{\mathrm{vel}}^2}{(c/3)^2 \mathrm{km}^2 \mathrm{s}^{-2}} \right)^{0.85}$$

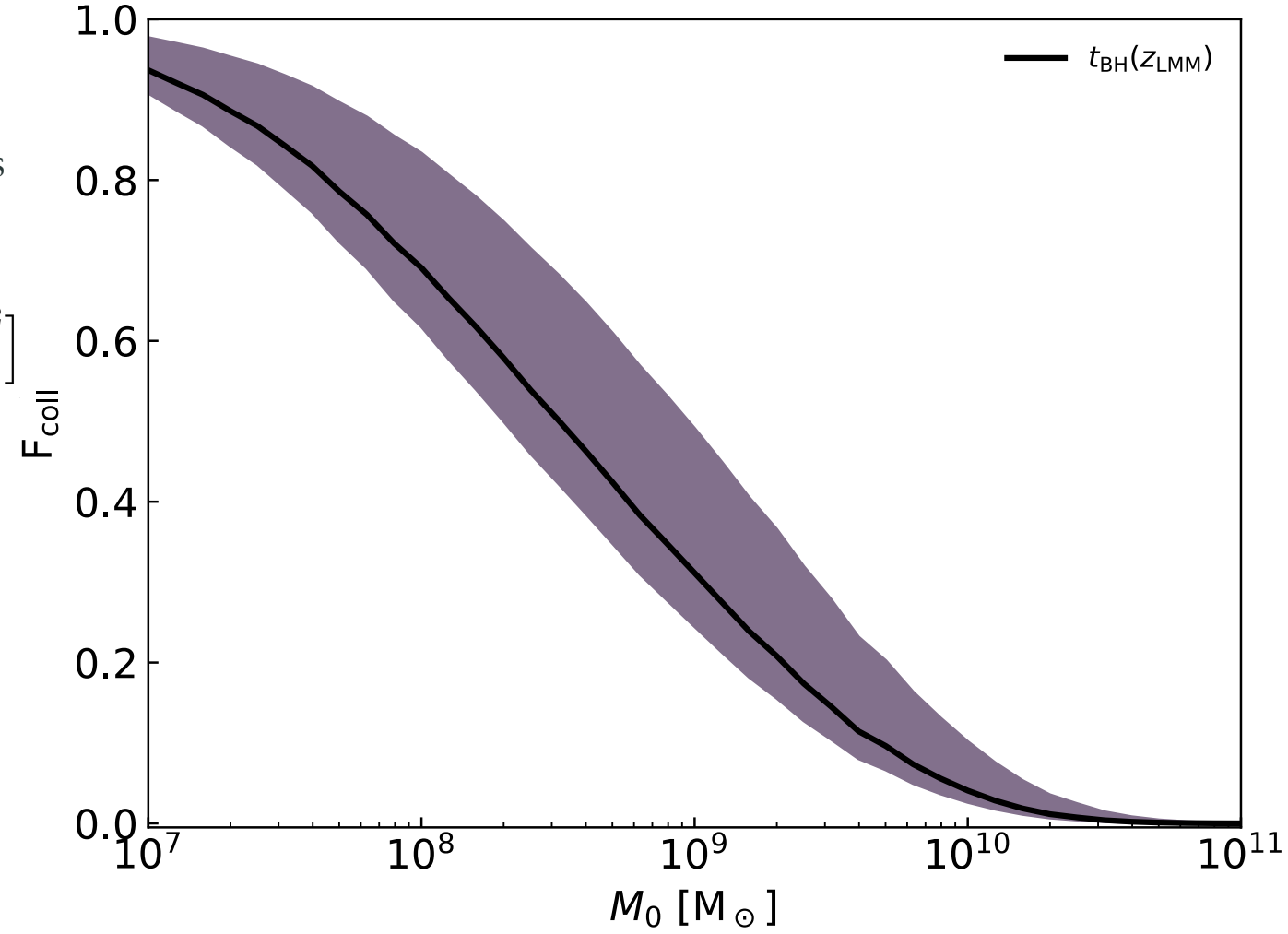
# Black hole mass - halo mass relation



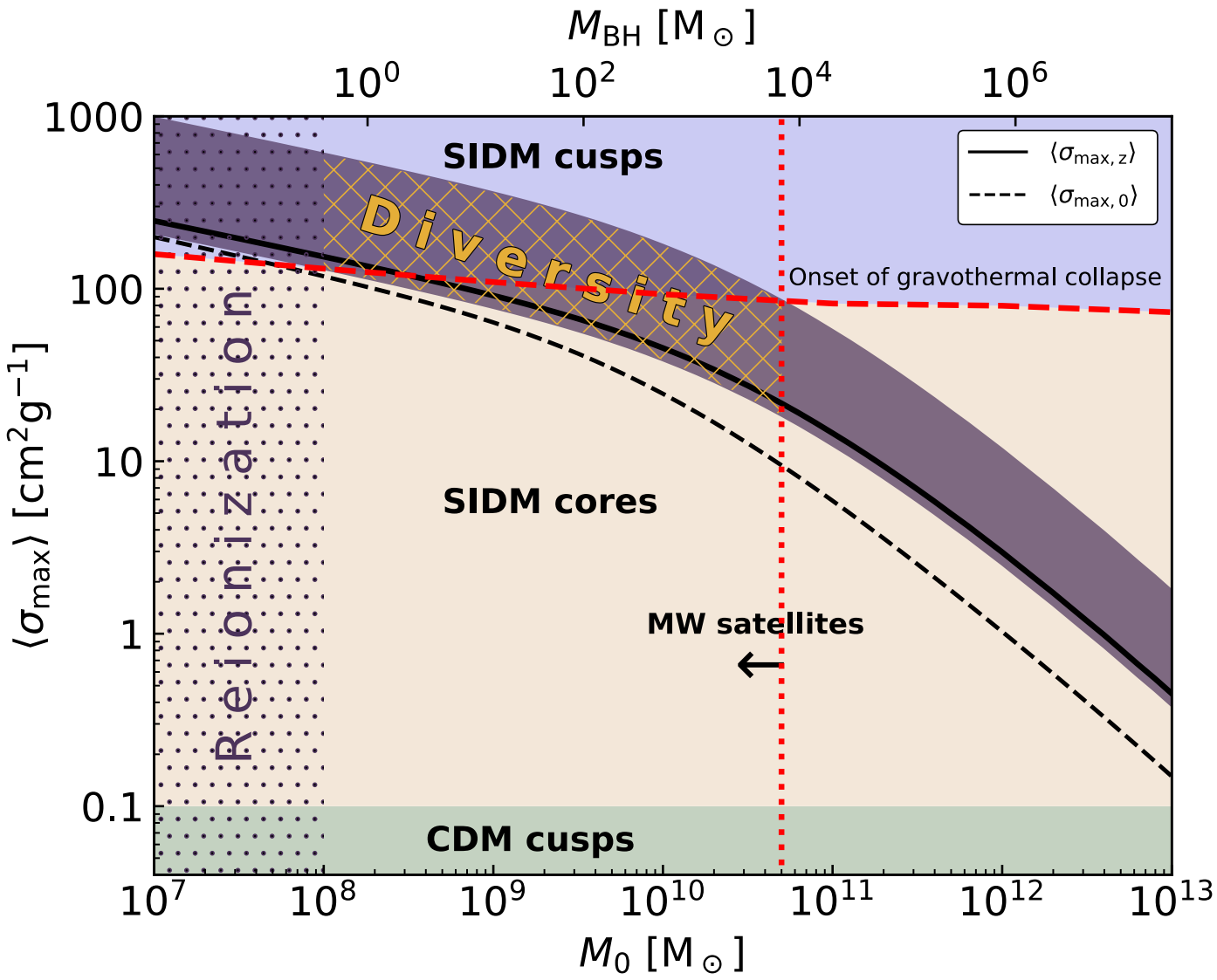
# Collapsed fraction of halos as a function of present-day halo mass

The lognormal distribution of concentrations is given by:

$$P(\log_{10} c) = \frac{1}{\sigma\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\log_{10} c - \langle \log_{10} c \rangle}{\sigma}\right)^2\right]$$



# Effective cross section parameter space

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# THANK YOU FOR YOUR ATTENTION

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