Constraints On Dark Matter Self-Interaction From Galactic Core Size

Sambo Sarkar

Department of Physics, Indian Institute of Technology Kharagpur.

arXiv: **2202.12247** with T.S. Ray and A.K. Shaw

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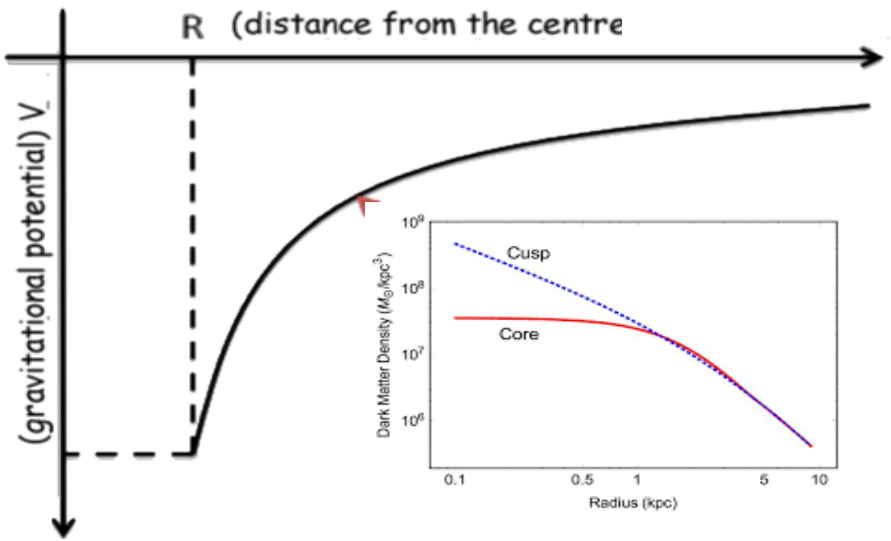
Objective

We study the feasibility of constraining DM self-interactions (σ/m) utilizing the observed and simulated distribution of core radius.

Impact of self-interaction on core formation

- Energy gets transferred from warmer periphery to inner cooler regions of the halo
- Thermalizes the central region
- Thermally cool CDM cusps are transformed to cores
- Reduces central density
- Can wash away structures below a certain scale (MSP)

Sean Tulin & Hai-Bo Yu (2017)



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cusp-like matter distribution
(Initial condition)

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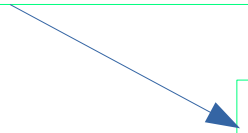

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Snapshots generated

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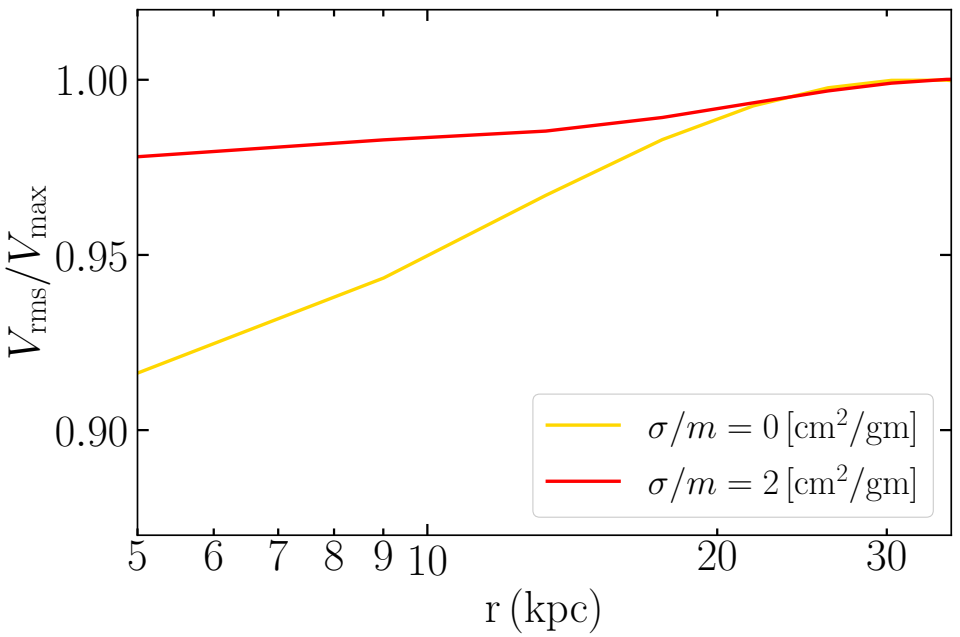
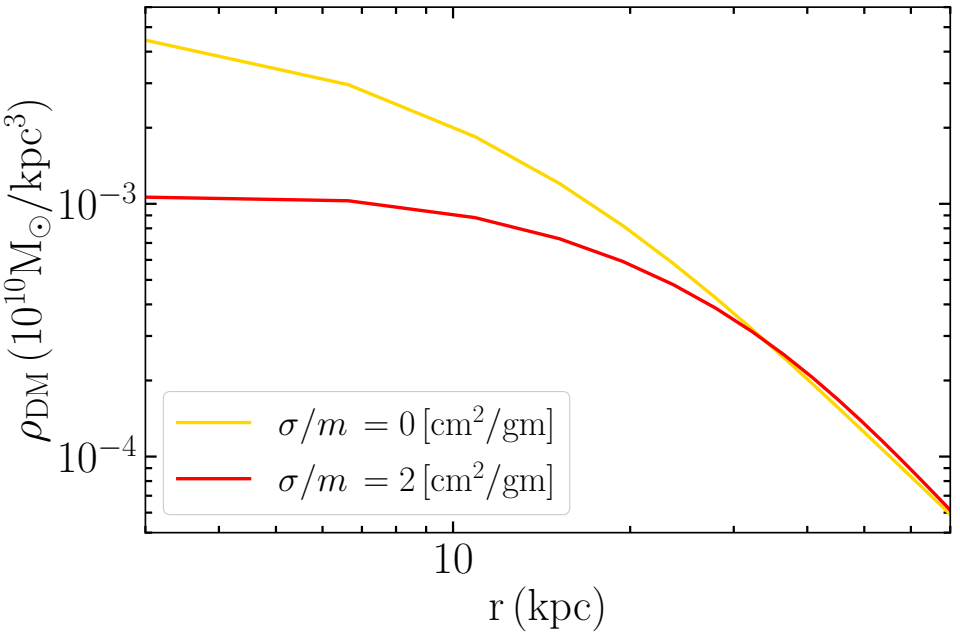
Snapshots generated

Velocity dispersion profiles

Density distribution profiles

Results from simulated haloes





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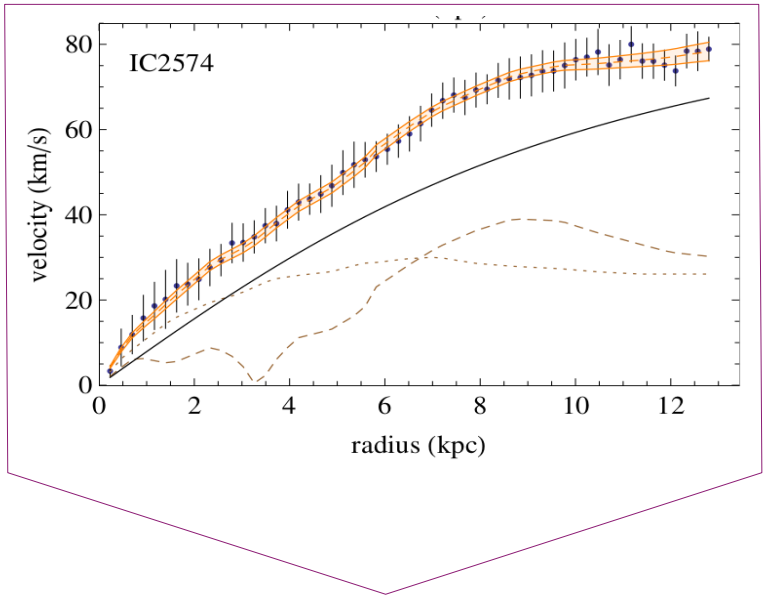
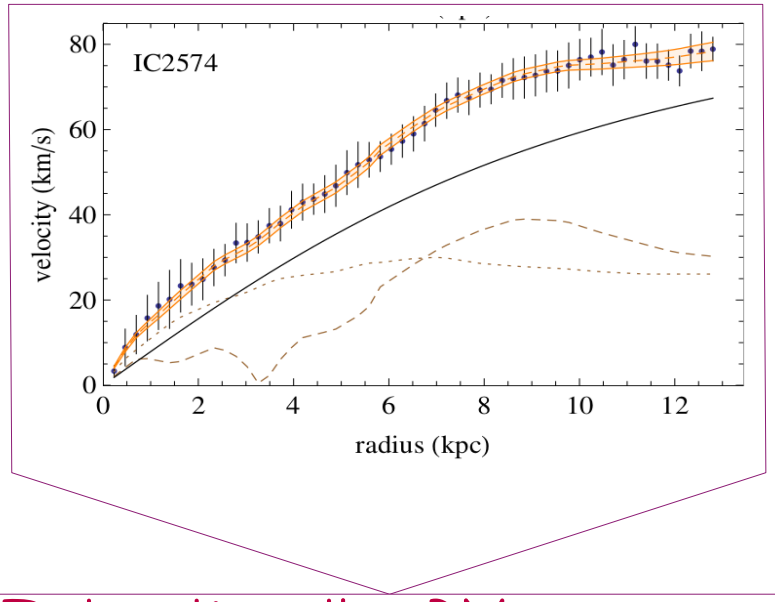
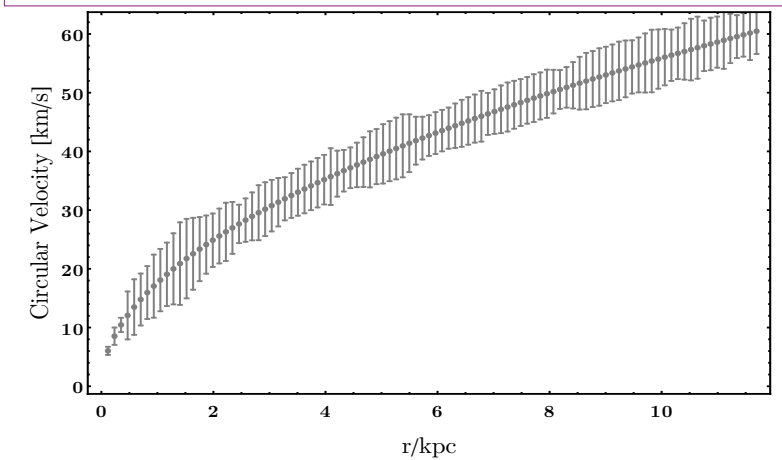
Observations from Galaxies and Clusters

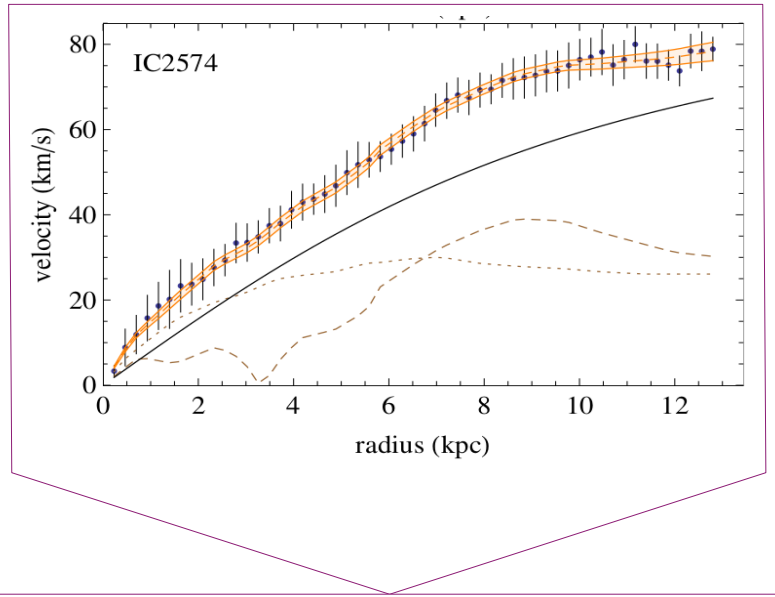
Galaxy Type	Galaxy Name	Halo mass ($10^{10}\,M_{\odot}$)	
Dwarf Spheroidal	NGC-2366	0.43	[W.J.G. de Blok et.al. (2008)]
	DD0-154	0.54	[S.H. Oh et.al. (2011)]
	IC-2754	1.46	
L.S.B	F-568-3	2.54	[Kuzio de Naray et.al. (2008)]
	F563-V2	1.65	[A. Gusev et. al. (2002)]
	F563-1	2.8	[M. Crăciun & T. Harko (2020)]
	NGC-3726	20.7	[R. Bottema and M. A. W.]
	NGC-3992	37.2	[Verheijen (2002)]
	Malin-1	82	[F. Lelli et. al. (2011)
			[Junais et. al. (2020)]
Cluster	MS-2137	36307	
	A-611	83176	[A. B. Newman et. al. (2013)]
	A-2537	218776	


IC2574
velocity (km/s)
radius (kpc)
0
20
40
60
80
0
2
4
6
8
10
12



Extracting the DM component





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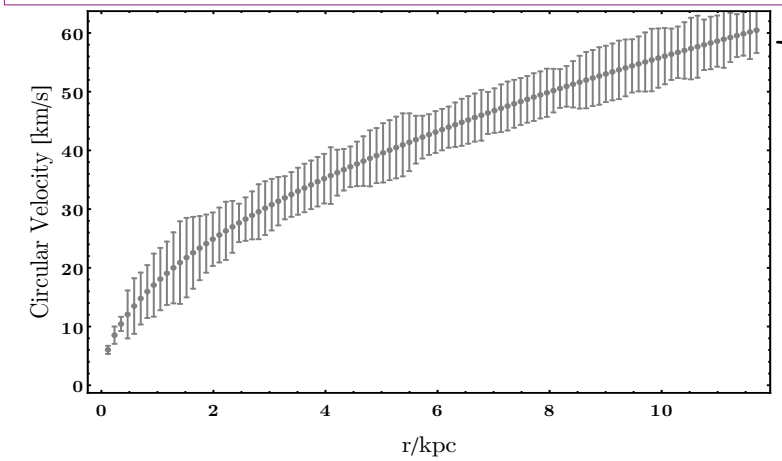
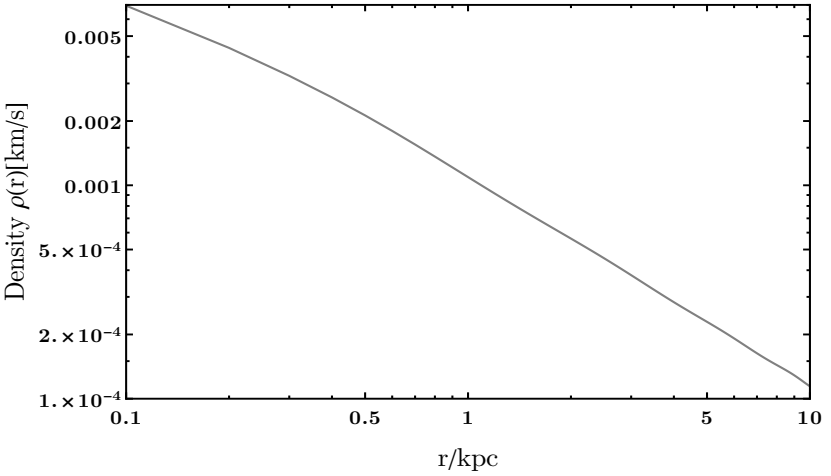
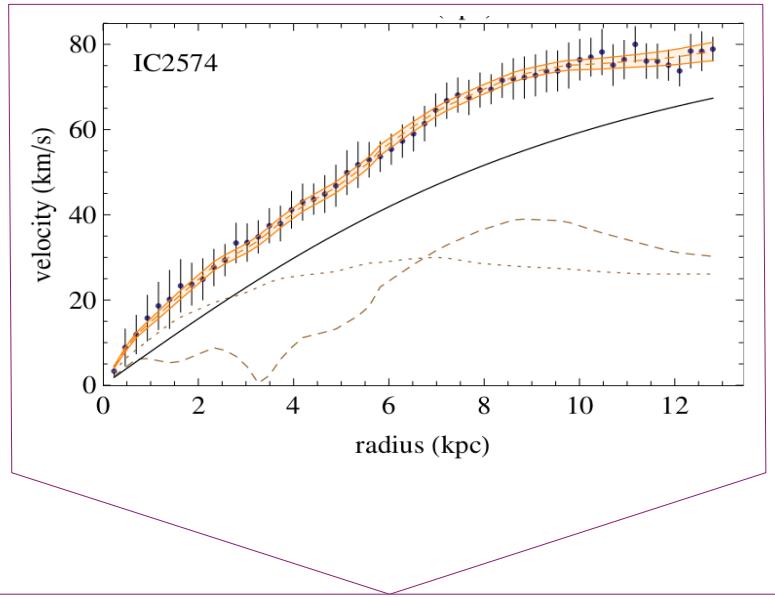


$V_{\mathrm{cir}}(r)$

$\rho_{\mathrm{DM}}(r)$



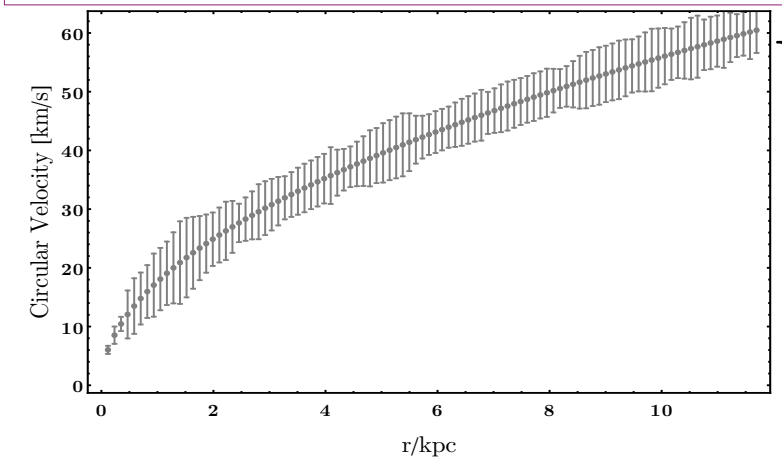


Compare: The end product from simulations & observed data.

Assumption : DM distribution in haloes.

Objective : Extract the core radius.

Extracting the DM component



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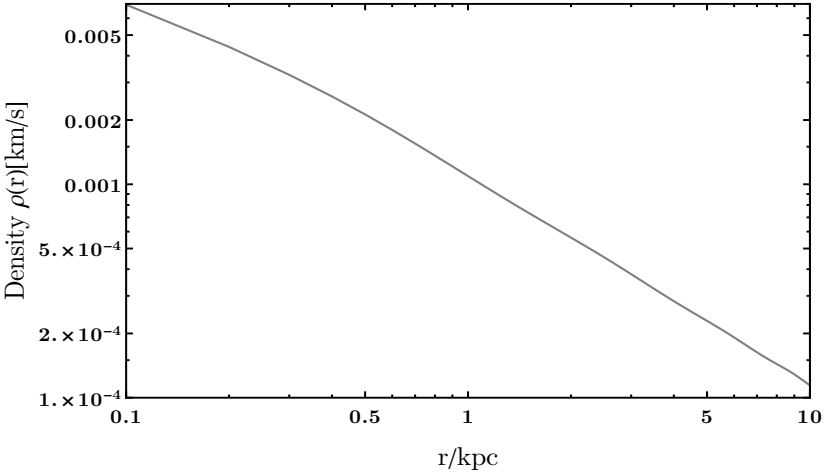


Extracting the core radius

- Jeans semi-analytic model

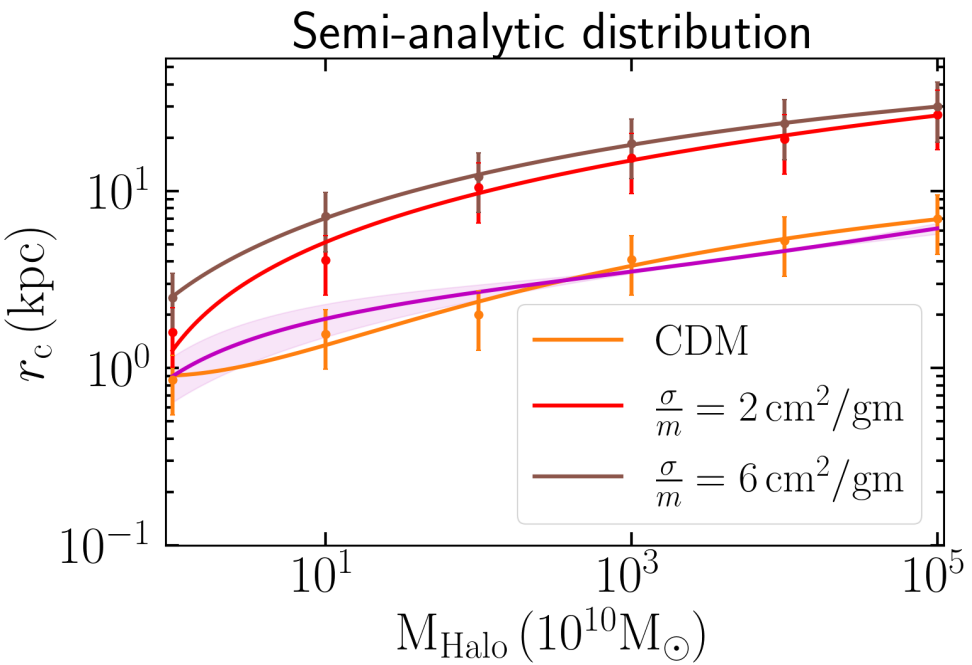
$$\rho(r) = \begin{cases} \rho_{\rm iso}(r) = \rho_o e^{-h(r/r_o)} & r \le r_1 \\ \rho_{\rm NFW}(r) = \frac{\rho_s}{\frac{r}{r_s}(1+\frac{r}{r_s})^2} & r > r_1 \end{cases}$$

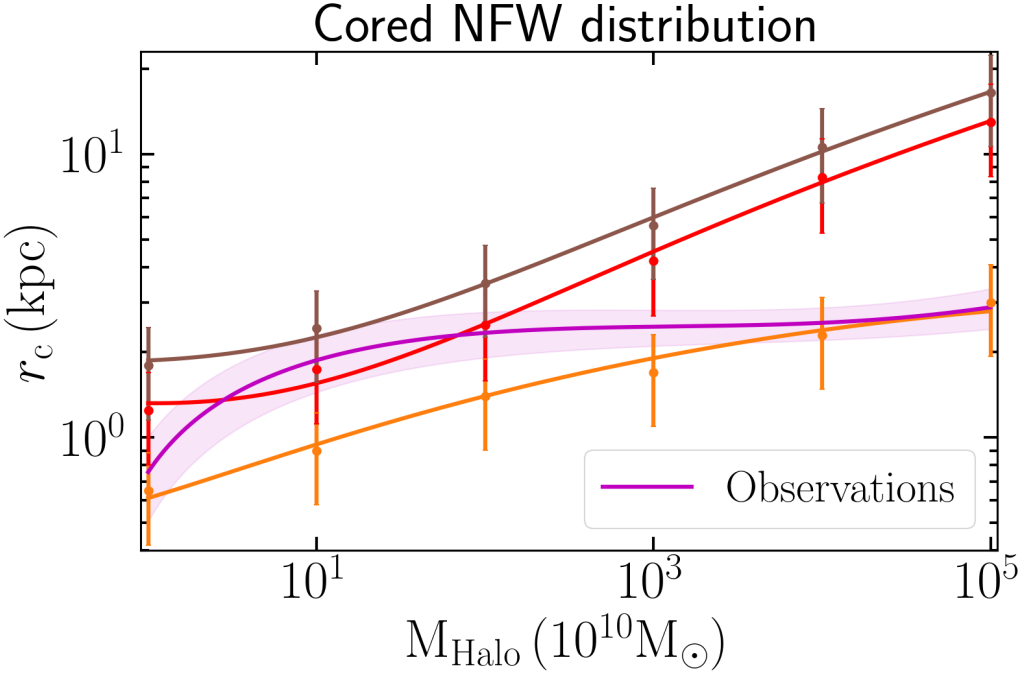
- Cored-NFW

$$\rho_{\rm cNFW}(r) = \frac{r_s \rho_s}{r_c(1+\frac{r}{r_s})^2(1+\frac{r}{r_c})}$$

[Kaplinghat et. al (2015), A. B. Newman et. al (2013)]

Core radius as a function of Halo mass





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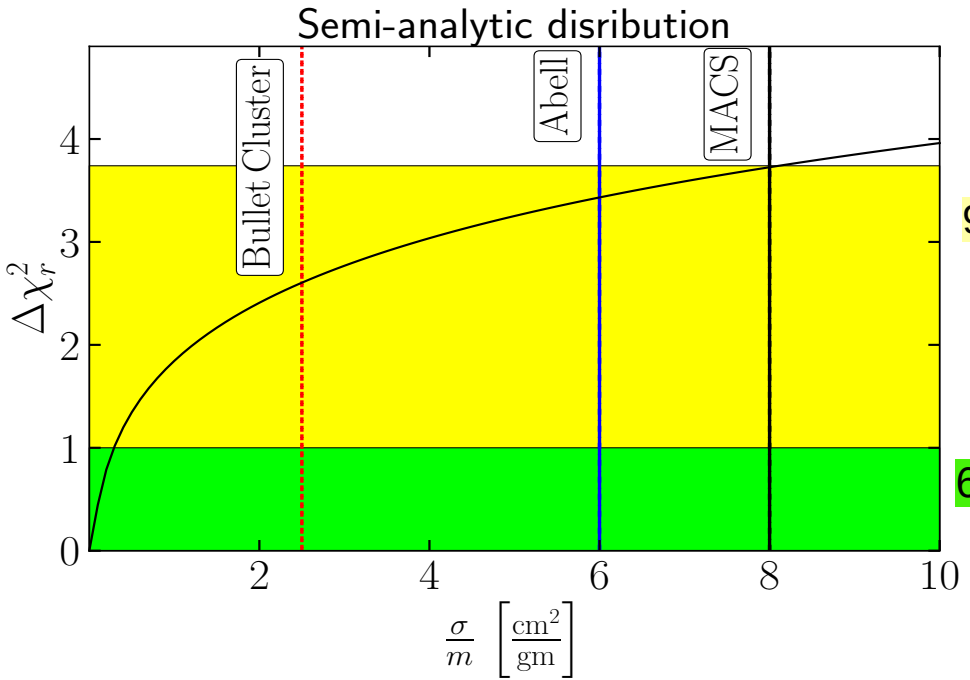
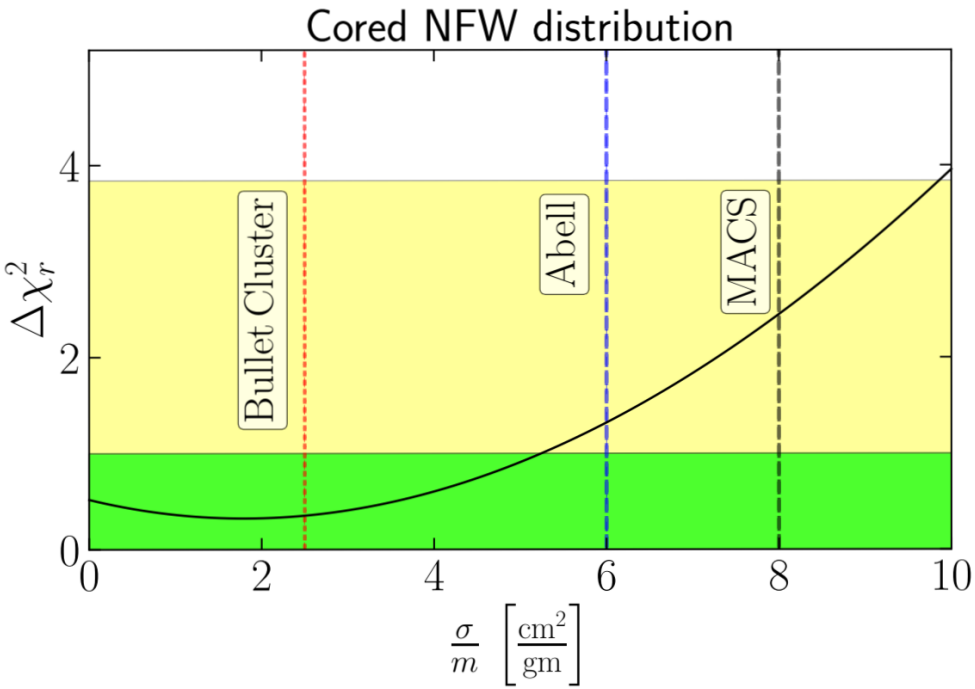
Limits on self-interaction

We perform a reduced chi-square estimation to determine the limit of DM self-interaction strength





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Significant dependence of the derived bounds on the density distribution.

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A more model independent definition of core radius
is a need of the hour

Thank you for your presence

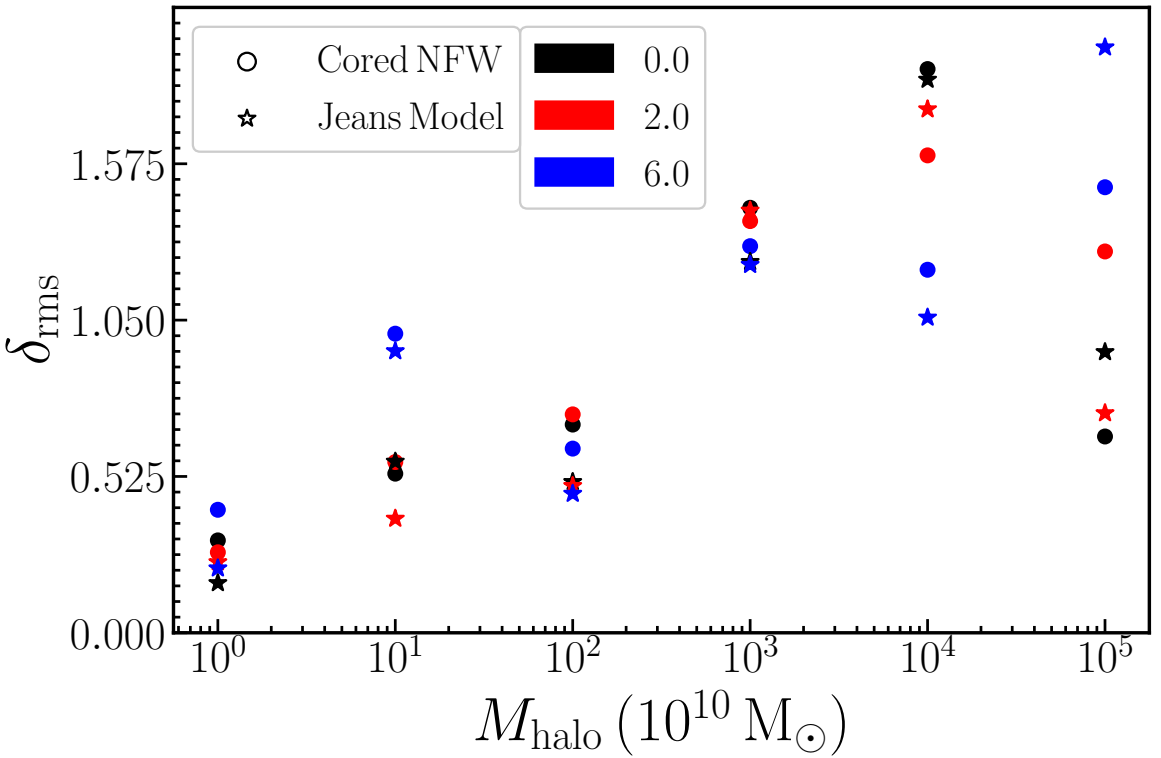
stay safe

Financial assistance:
ICHEP 2022, Organizing committee
University Grants Commission, India

Goodness of fit

$$\delta^2_{\rm rms} \equiv \frac{1}{N_{\rm bin}} \sum_{\rm i=1}^{\rm N_{bin}} \left[\log_{10} \frac{\rho_{\rm data}(\rm r_i)}{\rho_{\rm mod}(\rm r_i)} \right]^2$$

[1810.10024]



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