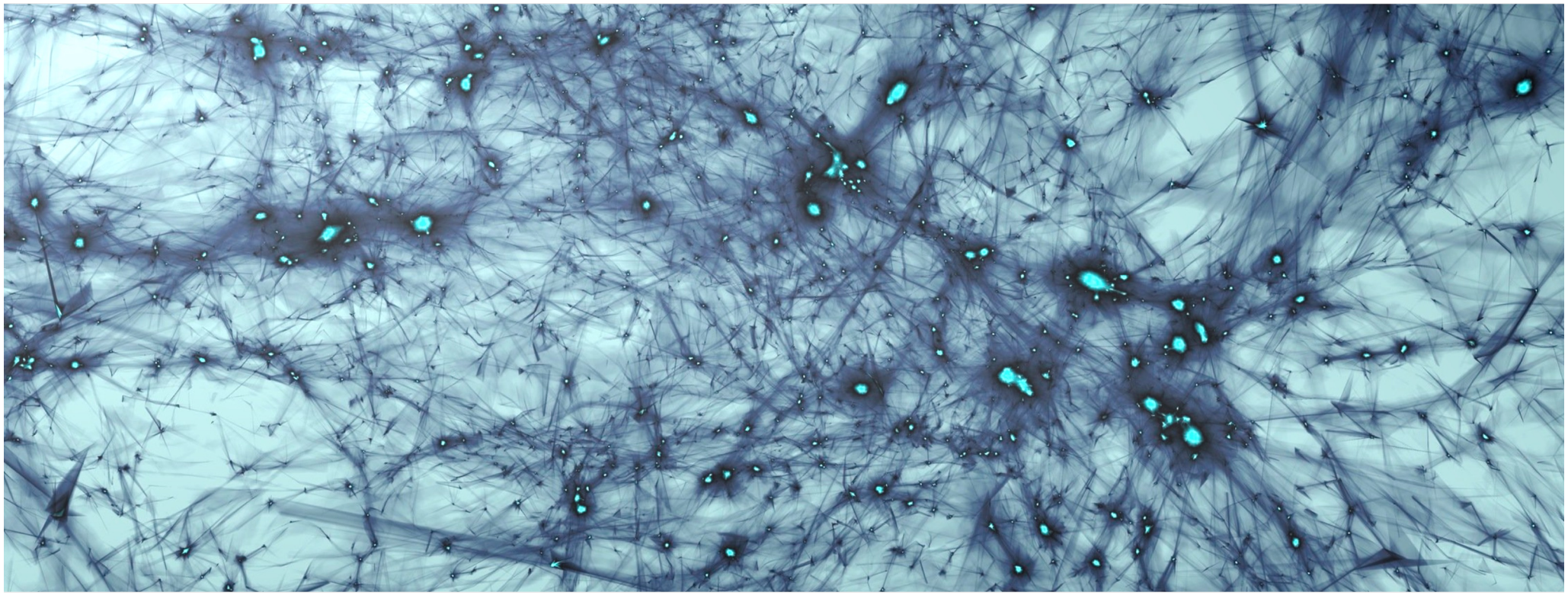
Cosmological probes of DM physics

Mass, interactions, thermal history

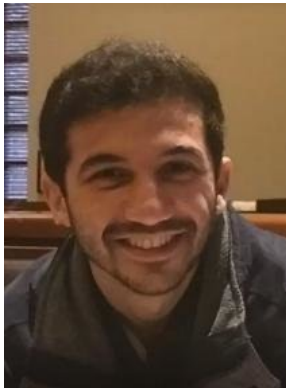


Vera Gluscevic

University of Southern California

Cosmological probes of DM physics

arxiv
2301.08299
2301.08260
2209.04499
2010.02936
2008.00022
1904.10000


Karime Maamari


Adam He

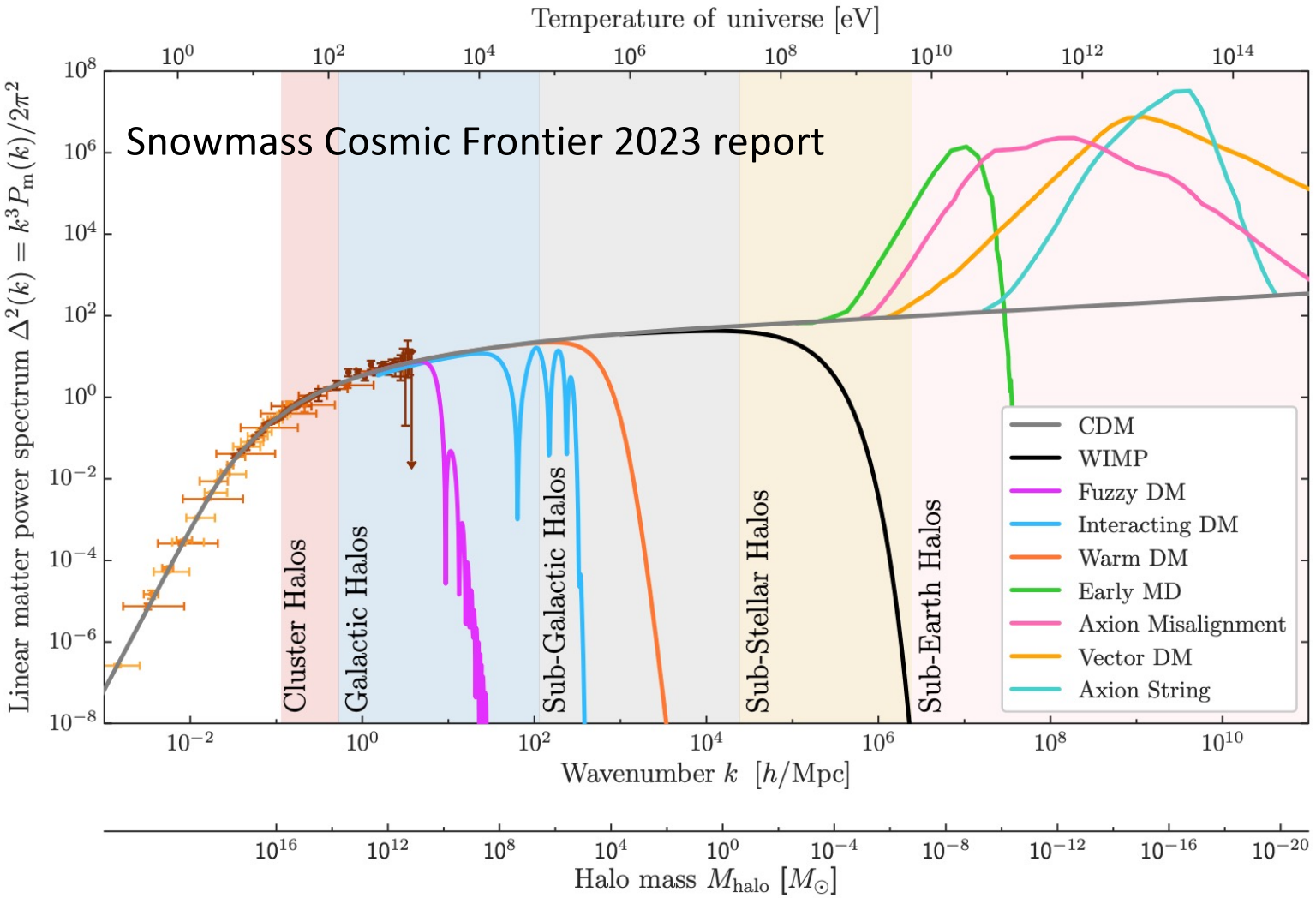

Trey Driskell


Rui An


Ethan Nadler

Also: Mikhail Ivanov, Jordan Mirocha, Yue Zhang, Kim Boddy, Andrew Benson, Risa Wechsler, +DES and ACT Collaborations.

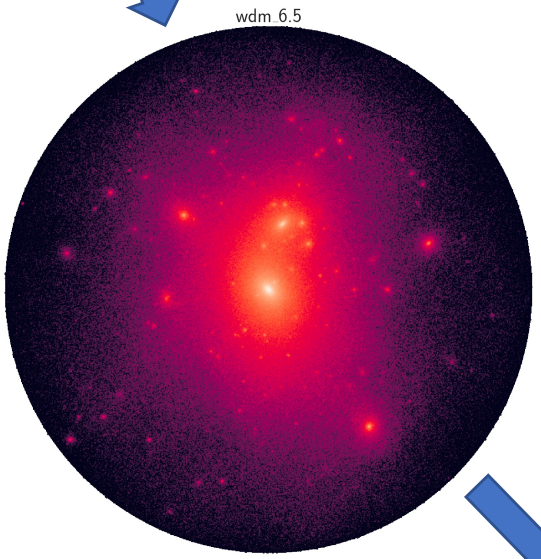
DM microphysics at the small-scale frontier



Lyman-alpha forest, dwarf galaxies, stellar streams, galaxy clustering, strong and weak lensing, intensity mapping, etc.

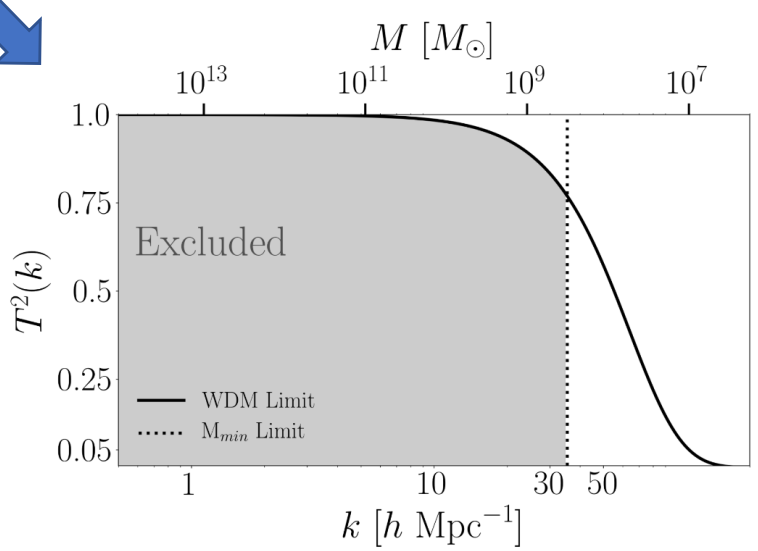
Near-field Cosmology (Milky Way satellites)

Known MW satellites from DES + PanSTARRS + SDSS



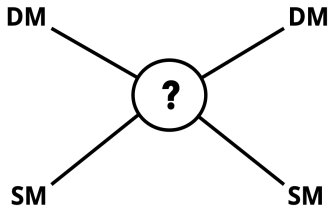
galaxy-halo connection model
(Nadler+ 2018)
+
mock observations

>6.5keV

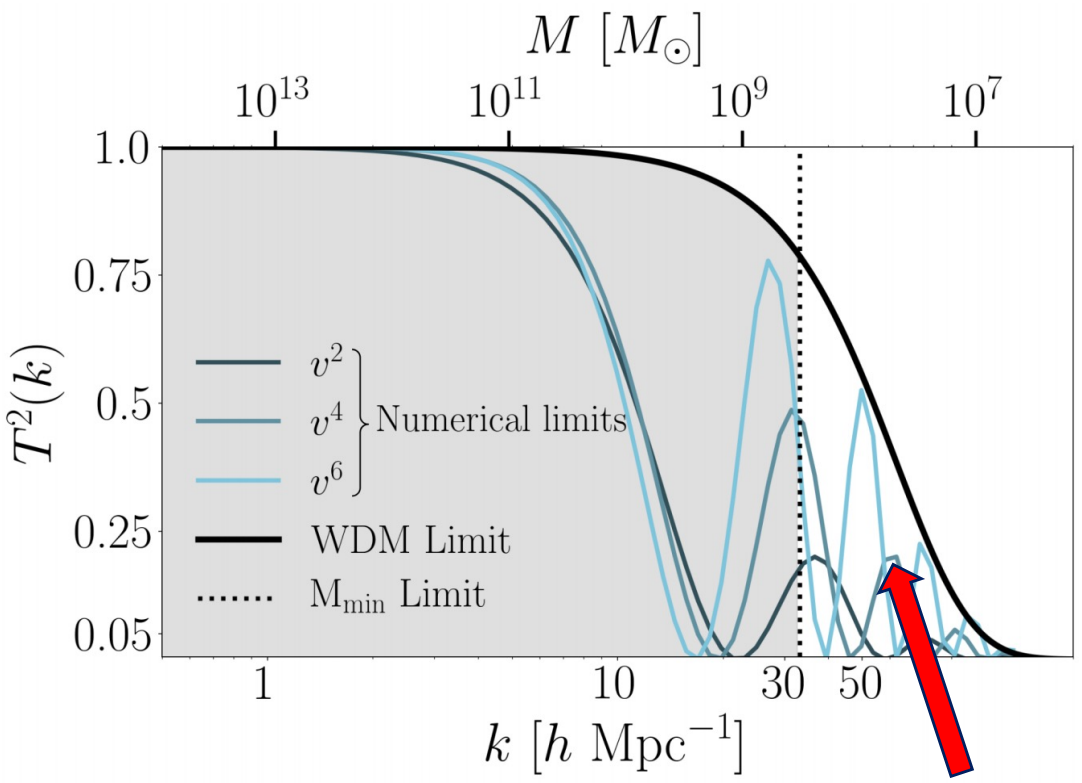


Nadler, Gluscevic, Boddy, Wechsler (2019)
DES+ (2020)

Interactions of sub-GeV DM with the Standard Model



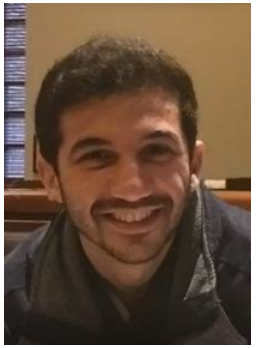
$$\sigma_{MT} = \sigma_0 v^n$$



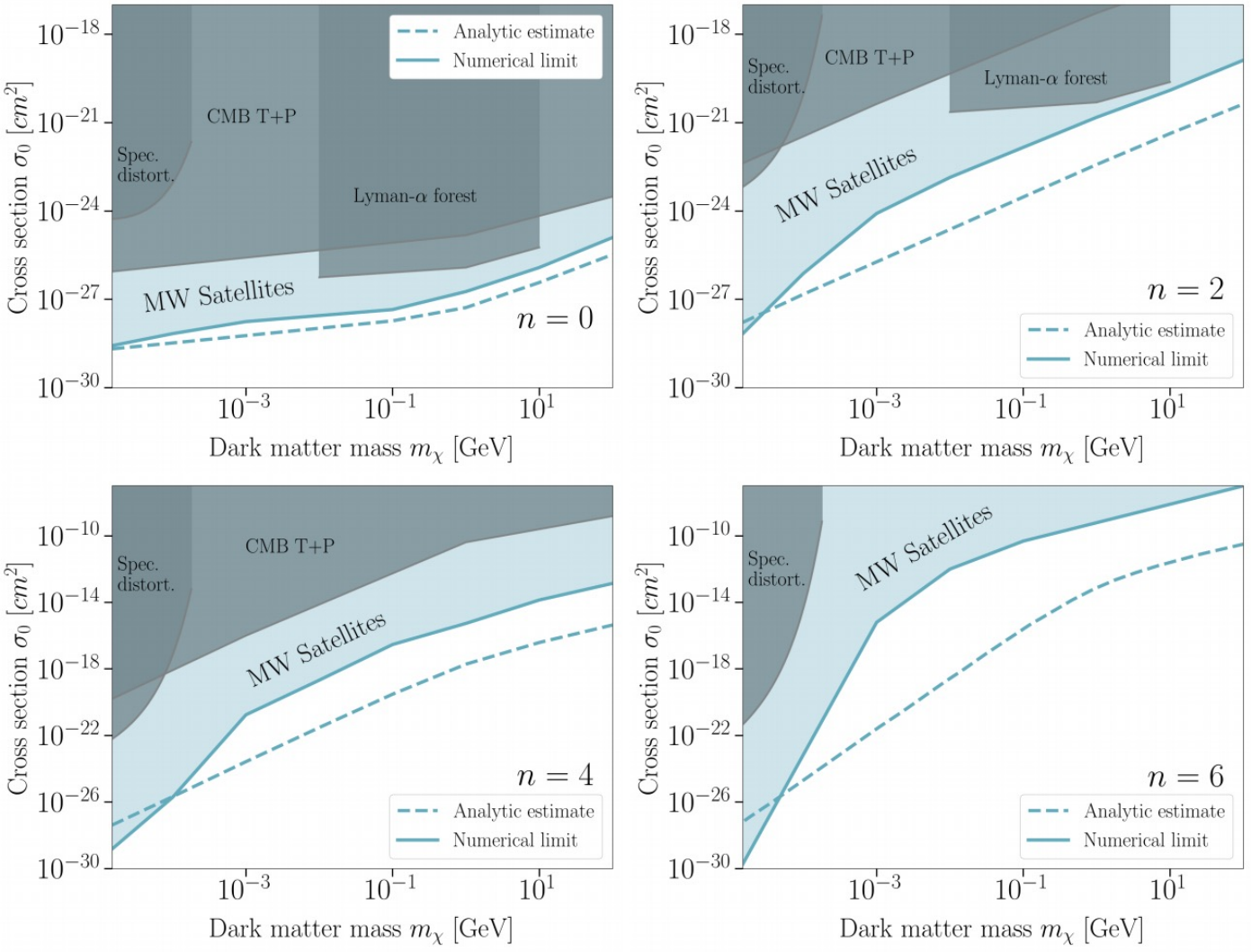
inconsistent

Maamari, Gluscevic,+ (2021), arXiv:2010.02936

DM-proton scattering bounds



Karime Maamari
(USC)

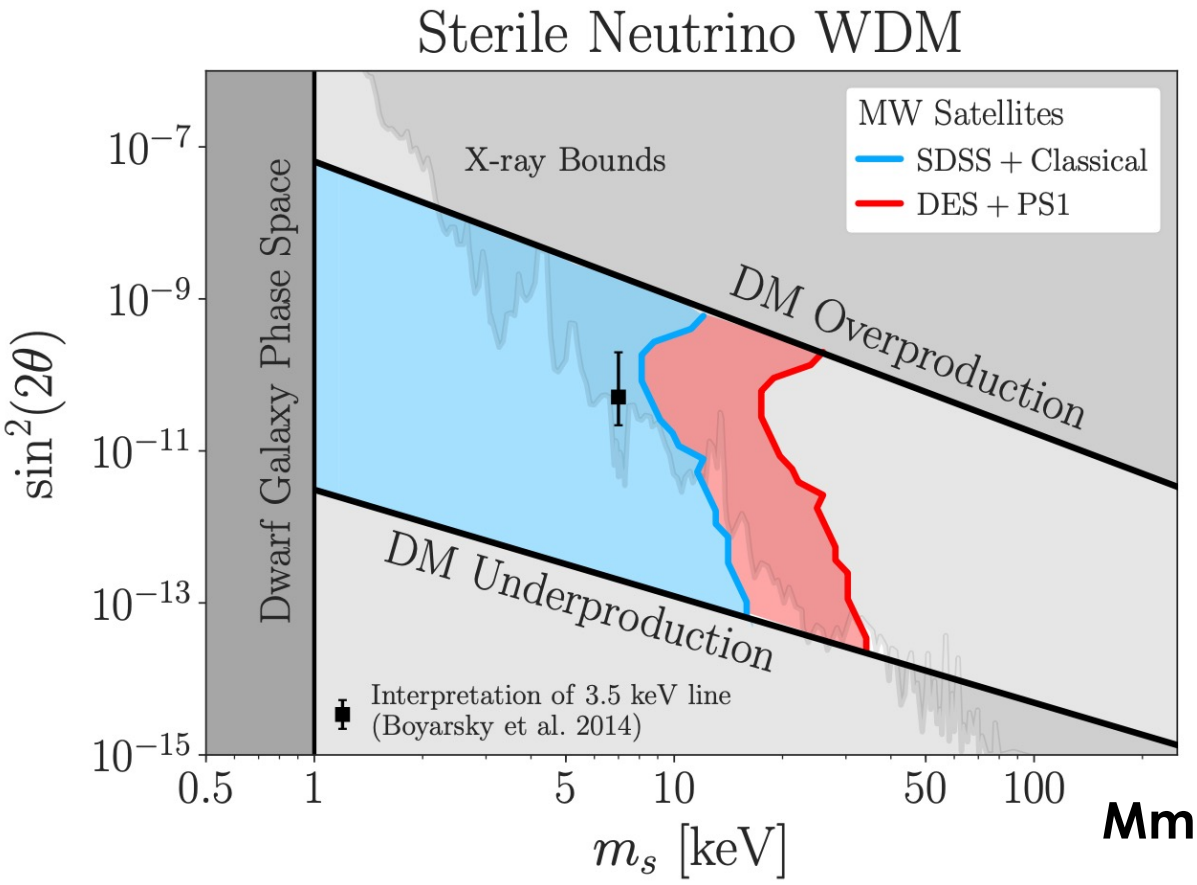


=> **3-5 OOM improvement.**

Maamari, Gluscevic,+ (2021), arXiv:2010.02936

Shi-Fuller mechanism is ruled out (for 100% DM)

Ethan Nadler
(USC/Carnegie)



Mmin < 10^8 Msun

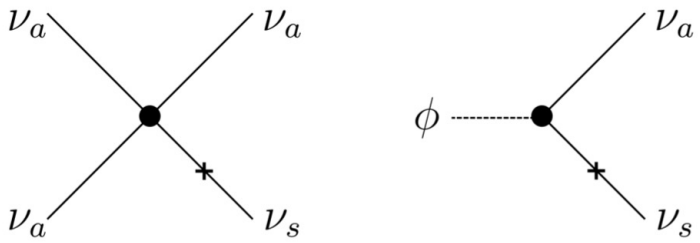
Nadler, DES+ (2020)
2008.00022

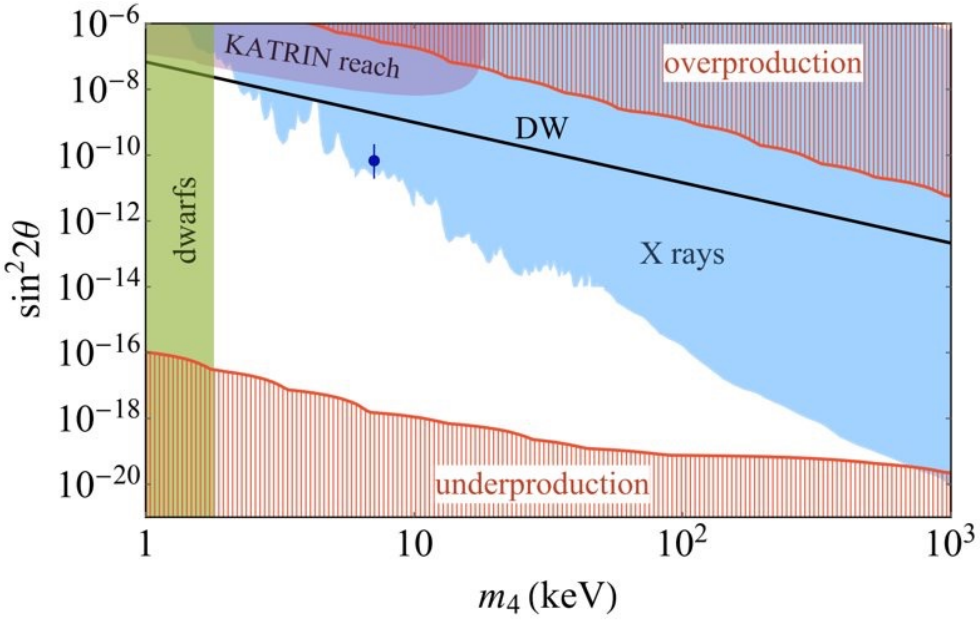
***Including:** realistic modeling of galaxy-halo connection (incl. disruption of subhalos by the Milky Way disk) and mock observations of the satellite abundance (luminosity, size, and radial distribution).

Neutrino self-interactions save sterile neutrino DM?

Sterile neutrinos + **neutrino self-interactions**

$$\mathcal{L} \supset \frac{\lambda_\phi}{2} \nu_a \nu_a \phi + \text{h.c.}$$

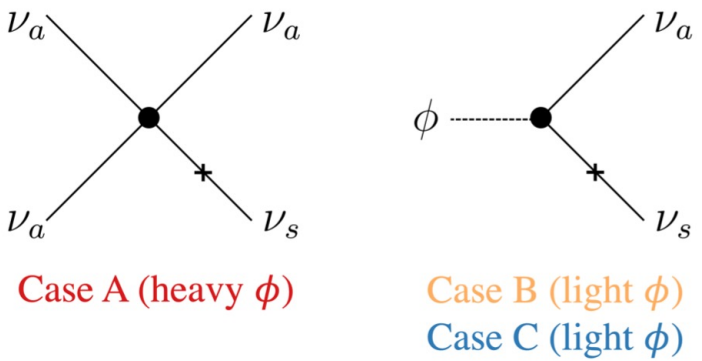


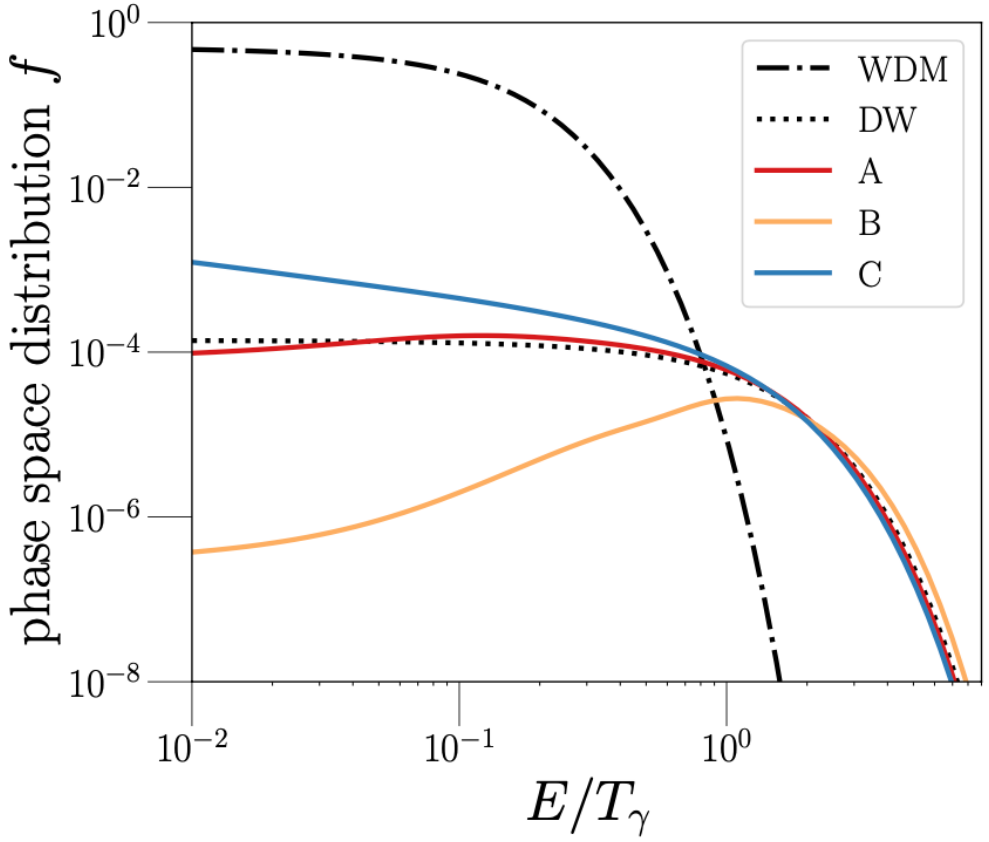


de Gouvea + (2019), etc.

Sterile neutrinos + **neutrino self-interactions**

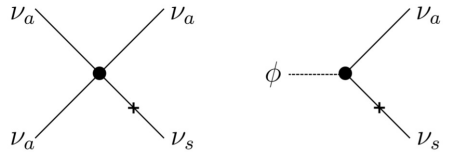
Rui An





Power suppression from sterile neutrino free streaming:

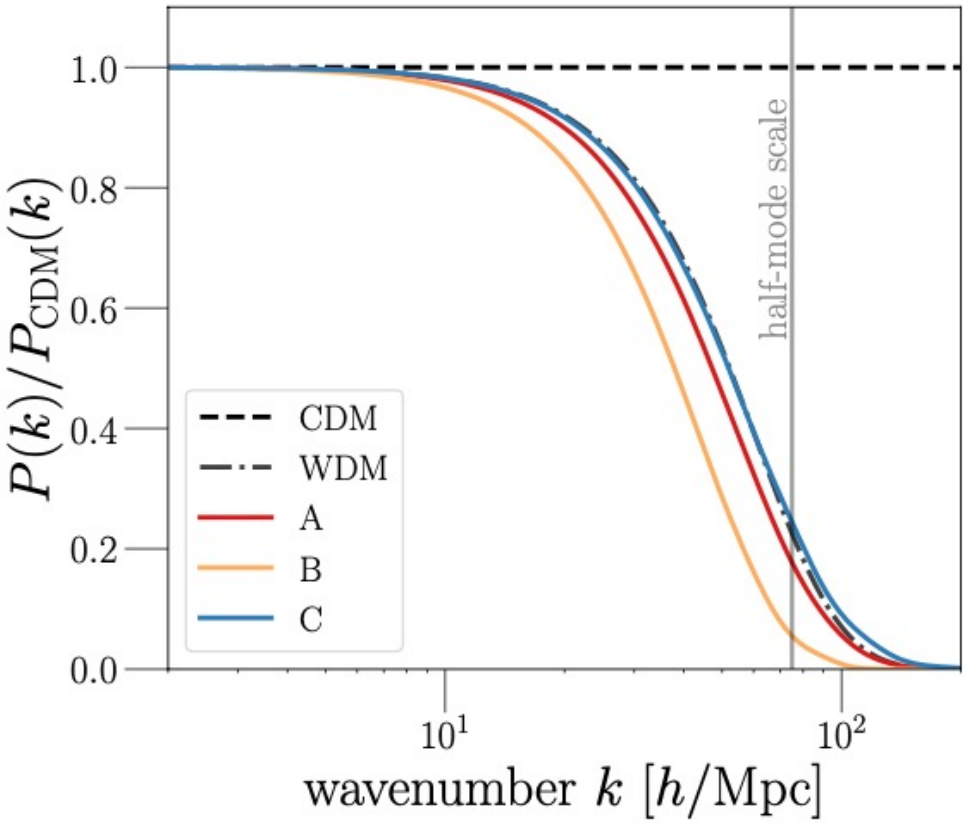
Rui An



Case A (heavy ϕ)

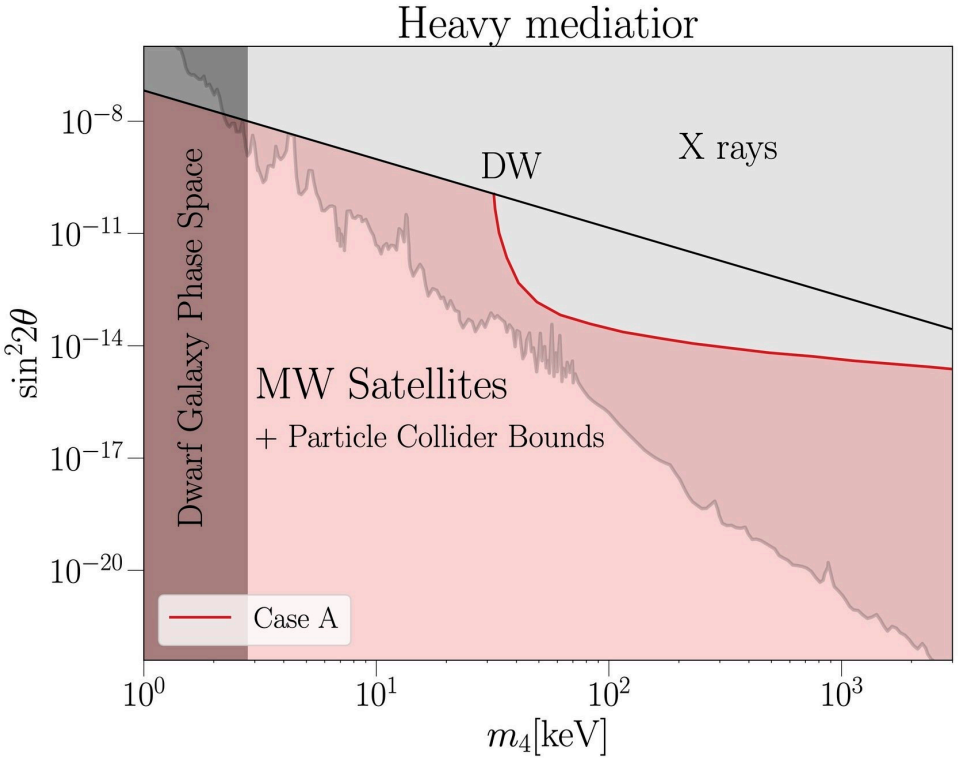
Case B (light ϕ)

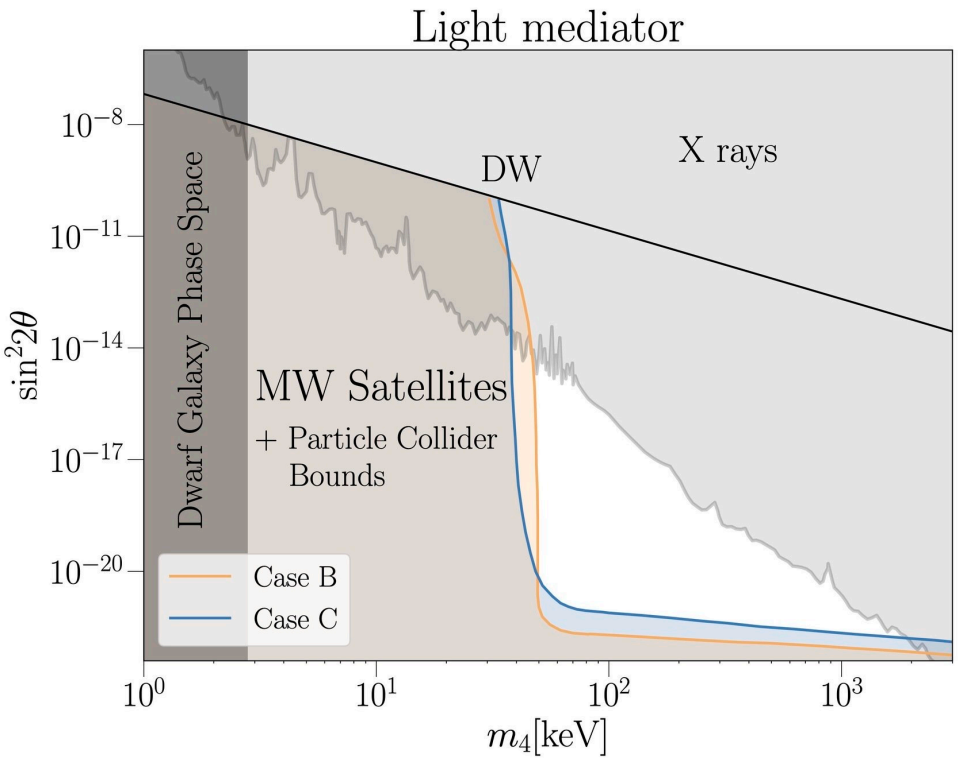
Case C (light ϕ)



Mediators > 1GeV are ruled out.

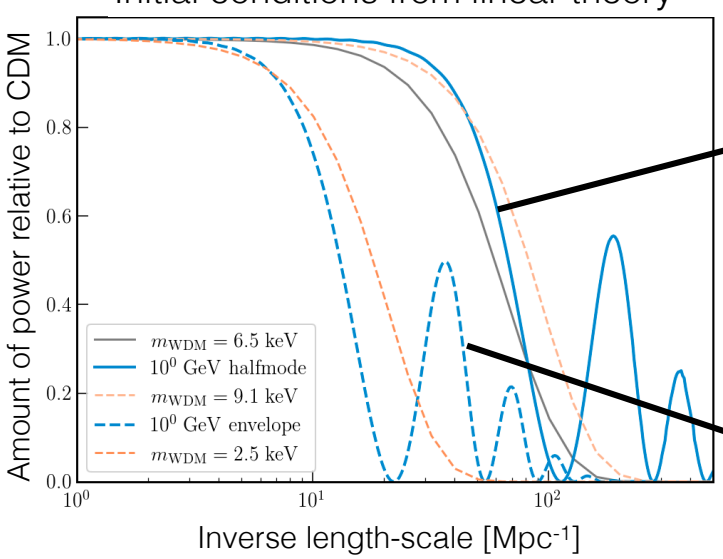
Rui An

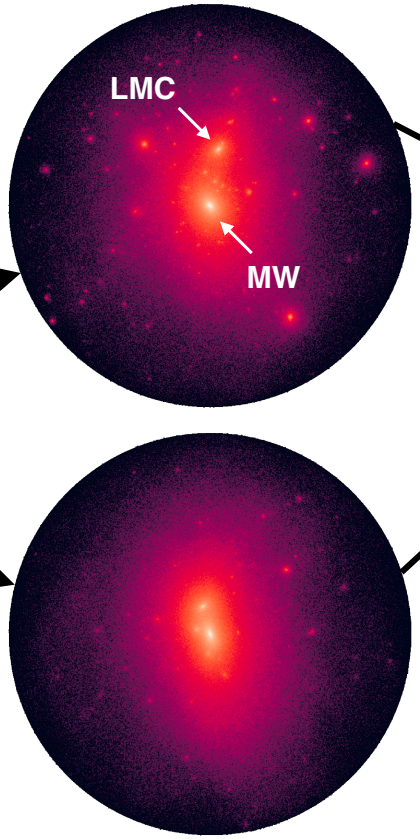




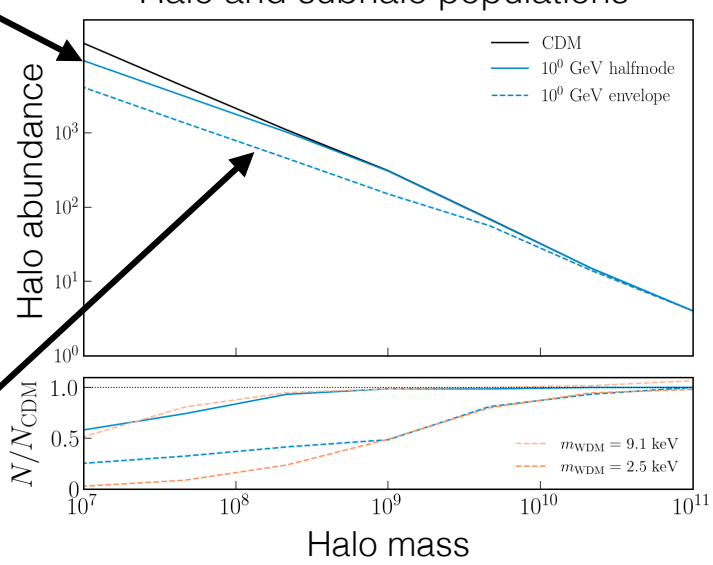
An, Gluscevic, Nadler, Zhang (2023)

IDM transfer + N-body simulations + galaxy-halo model





PRELIMINARY



72 cosmological simulations of Milky Way-like systems in various dark matter models: warm, ultra-light, interacting

Ethan Nadler

Rui An

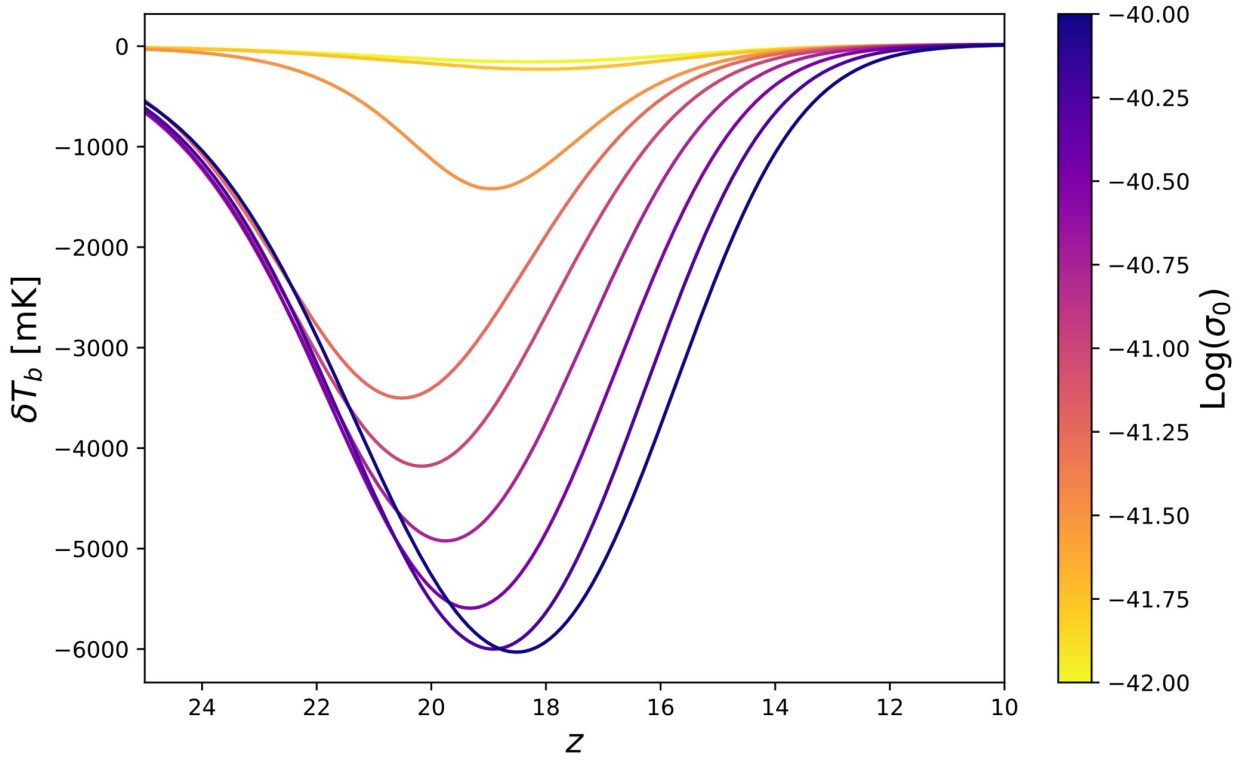
Andrew Benson

Talk by Ethan Nadler @ 10.30

21- cm intensity mapping

Global 21-cm signal with IDM

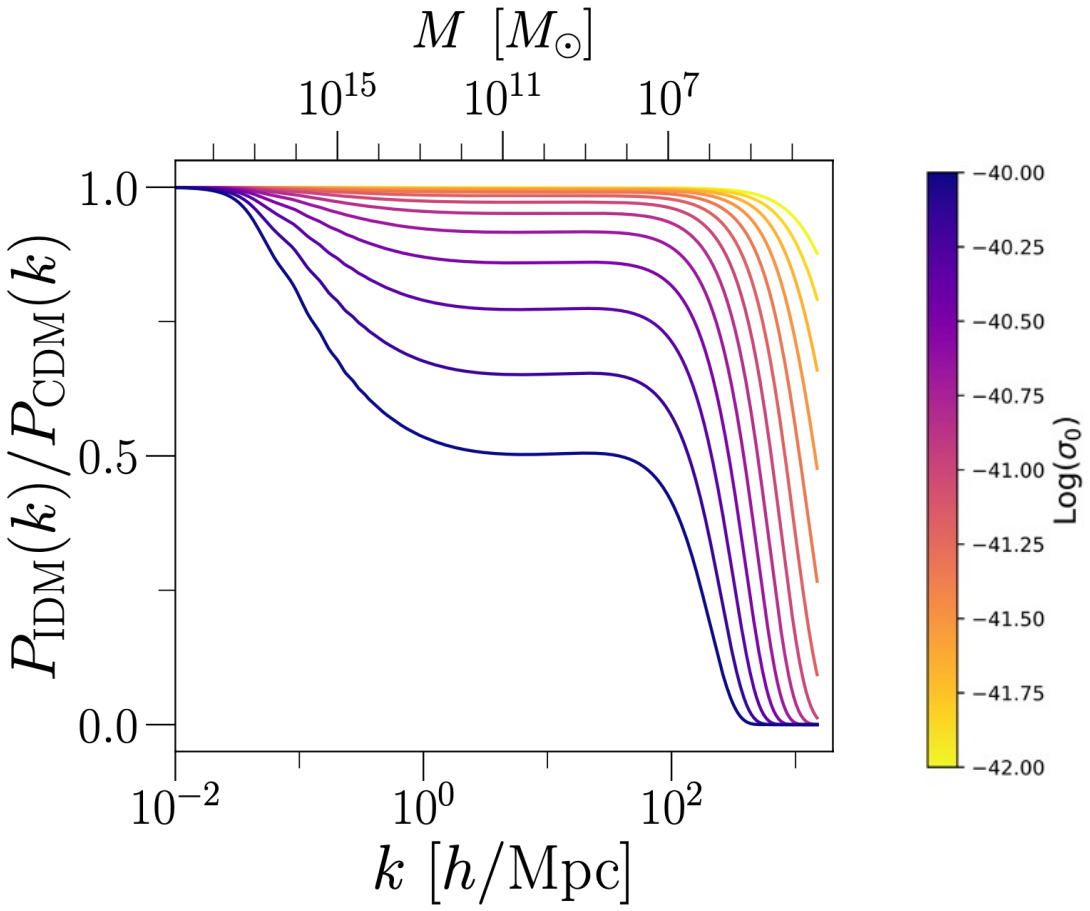
Altered thermal history:



Driskell + (2022)
Munoz+ (2016)
EDGES collab. (2018)

Global 21-cm signal with IDM

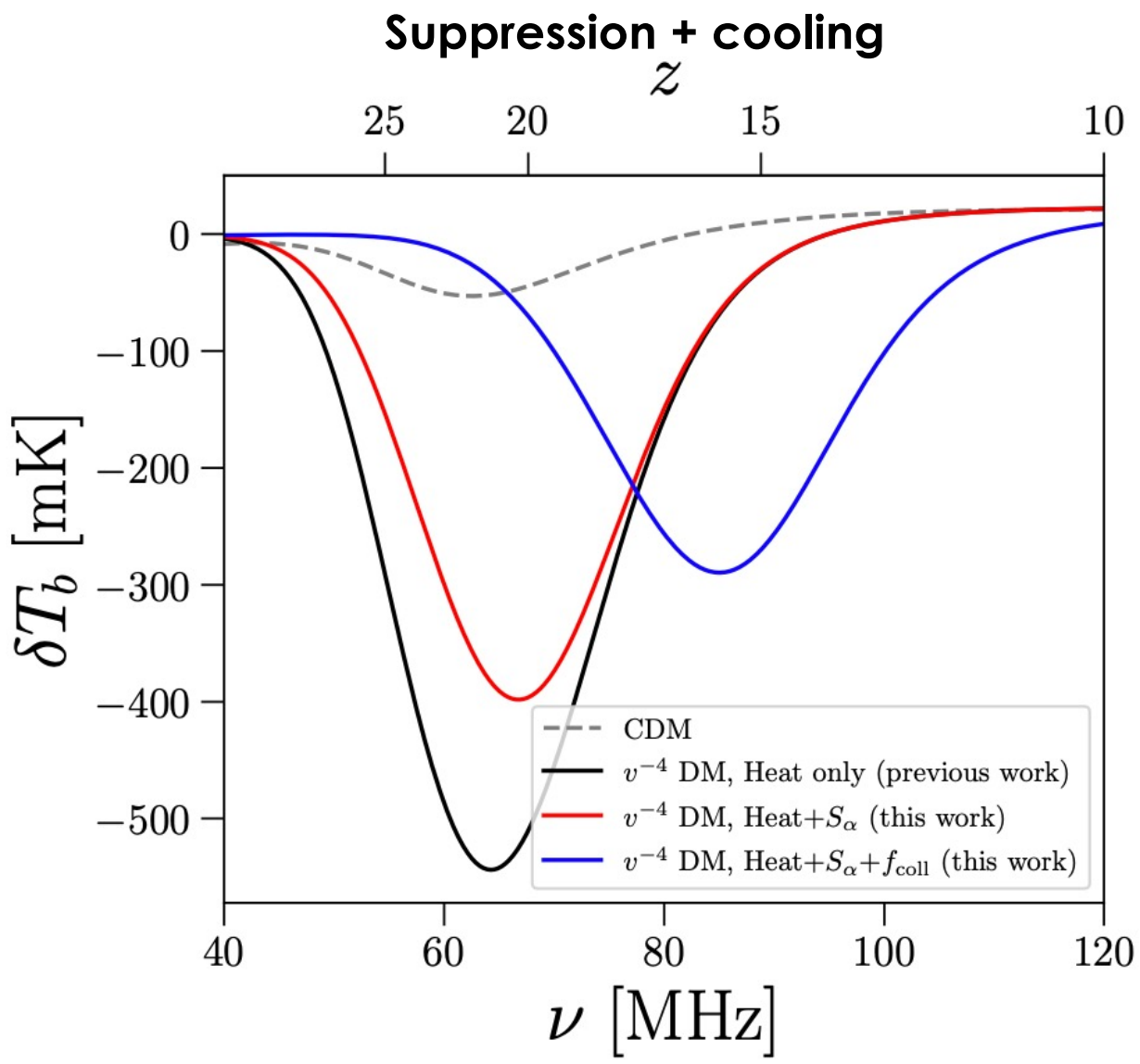
Suppression of structure:
(Not included in previous modeling)



Driskell + (2022)

Global 21-cm signal with IDM

Trey Driskell

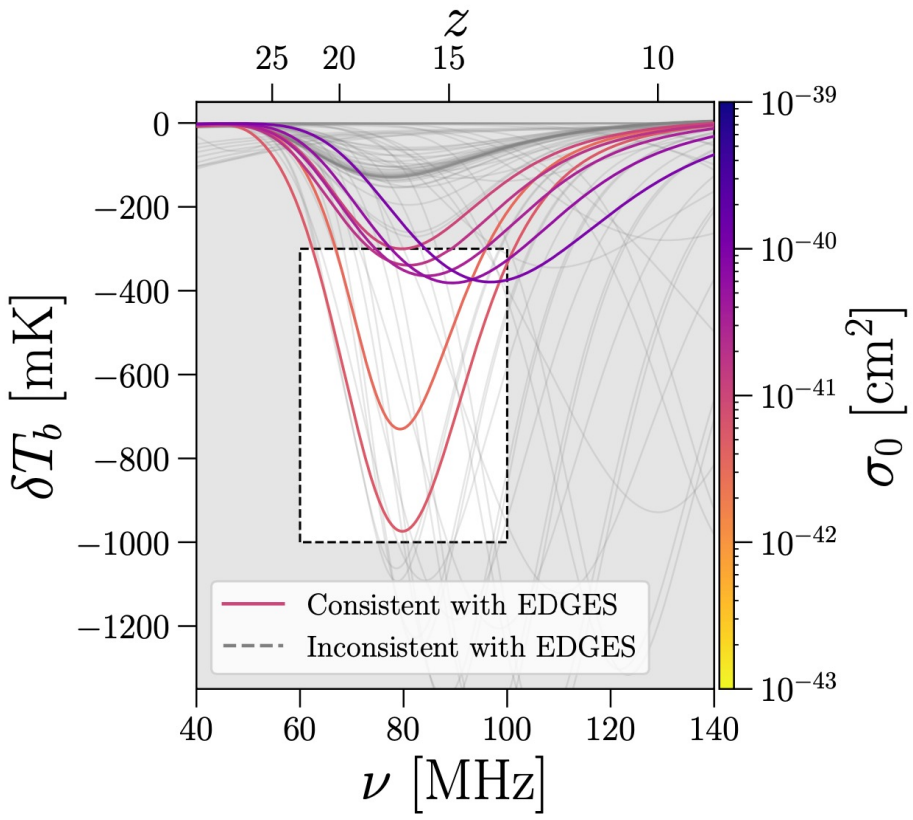


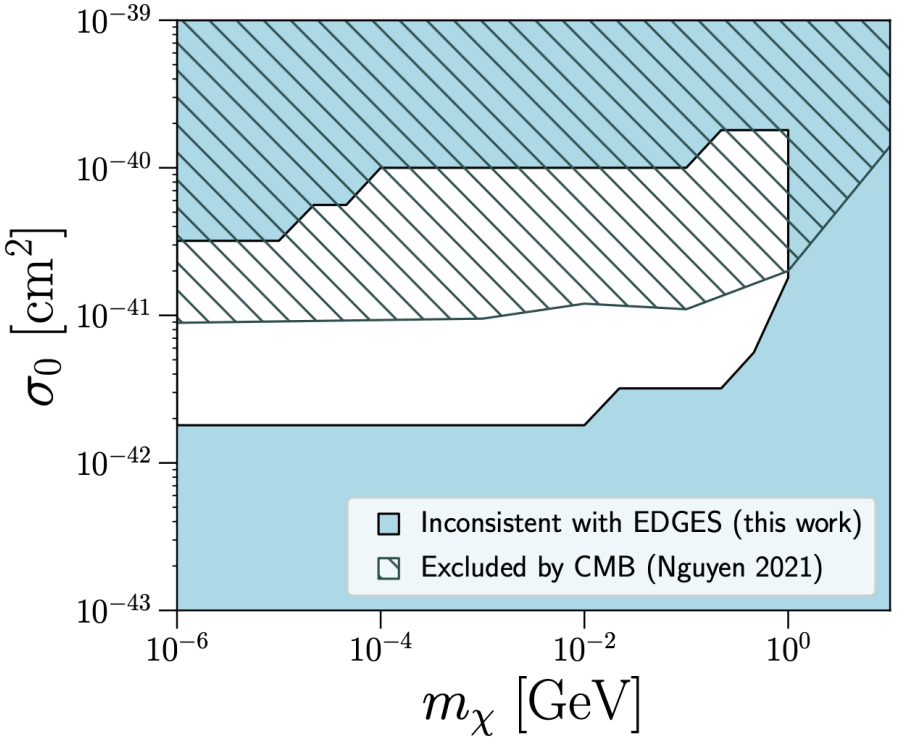
Driskell + (2022)

Global 21-cm signal with IDM

Millicharge cannot explain the EDGES signal.
V^−4 Coulomb-like scattering is further constrained by the timing of the signal.

Trey Driskell



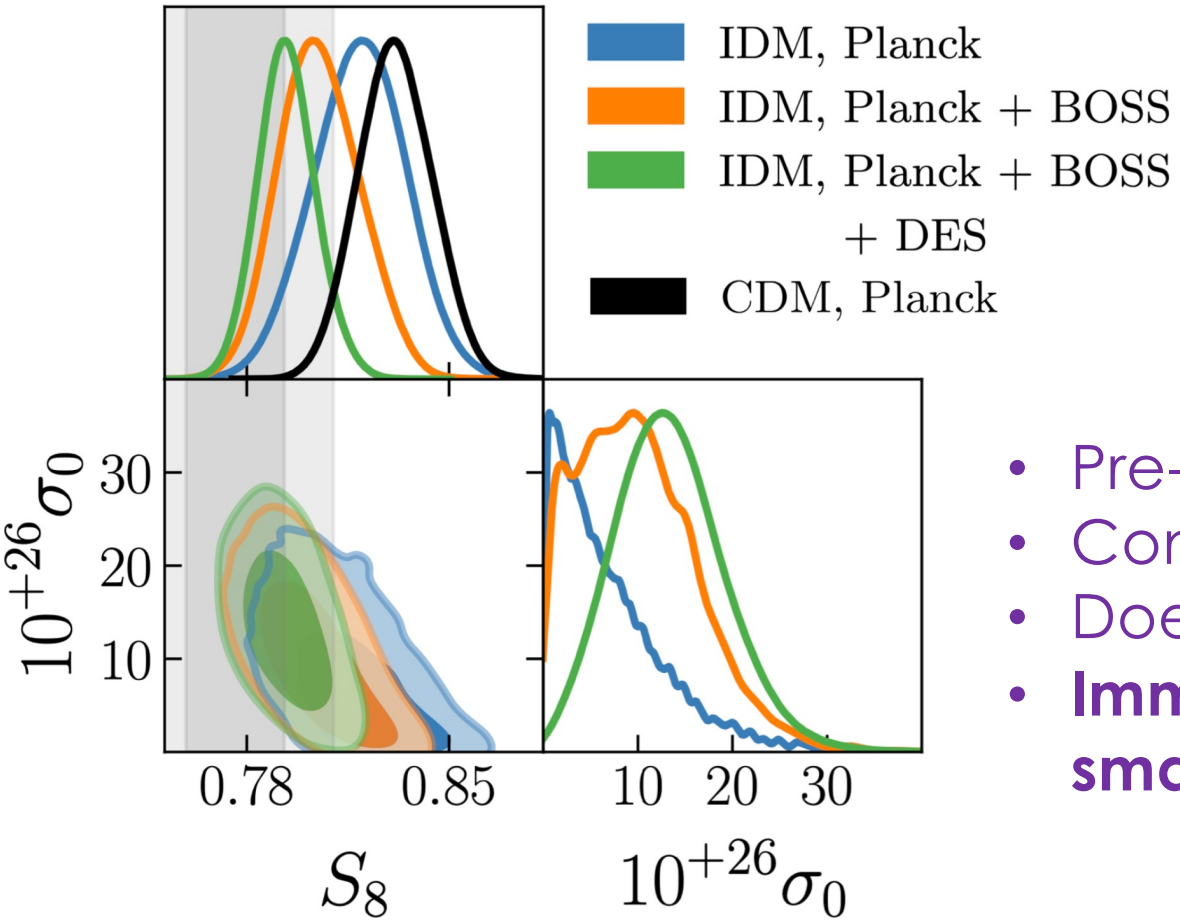


Driskell + (2022)

LSS and tensions

Does IDM alleviate S8 tension?

Adam He

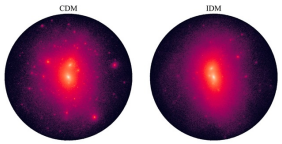


- Pre-tension physics
- Consistent across data
- Does not mess up H0
- **Imminently falsifiable – with small scale structure!**

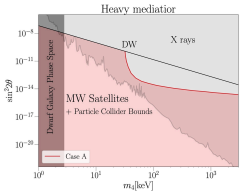
Model	ΛCDM, *Planck* + BOSS + DES	IDM, *Planck* + BOSS + DES
σ_0 $[10^{-26}$ cm$^2]$	–	$13.23\ (5.163)^{+5.2}_{-6.5}$
S_8	$0.813\ (0.813) \pm 0.009$	$0.794\ (0.804)^{+0.009}_{-0.01}$
$\Delta\chi^2_{\rm min}$	–	-6.7

He, Ivanov, An, Gluscevic (2023)

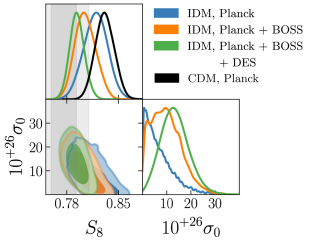
Key Points



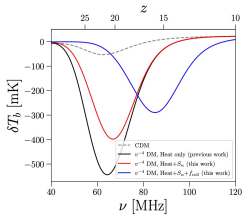
- Small scale structure is sensitive to DM physics. **MW satellites** drive a non-CDM frontier.



- **Sterile neutrino** DM is heavily constrained by small scale structure, regardless of the particle spectra.



- **DM-baryon scattering** alleviates S8 tension, through scale-dependent power suppression.



- **21cm signal** requires accurate modeling of structure formation + thermal history.