What SKA Can Tell Us About Dark Matter

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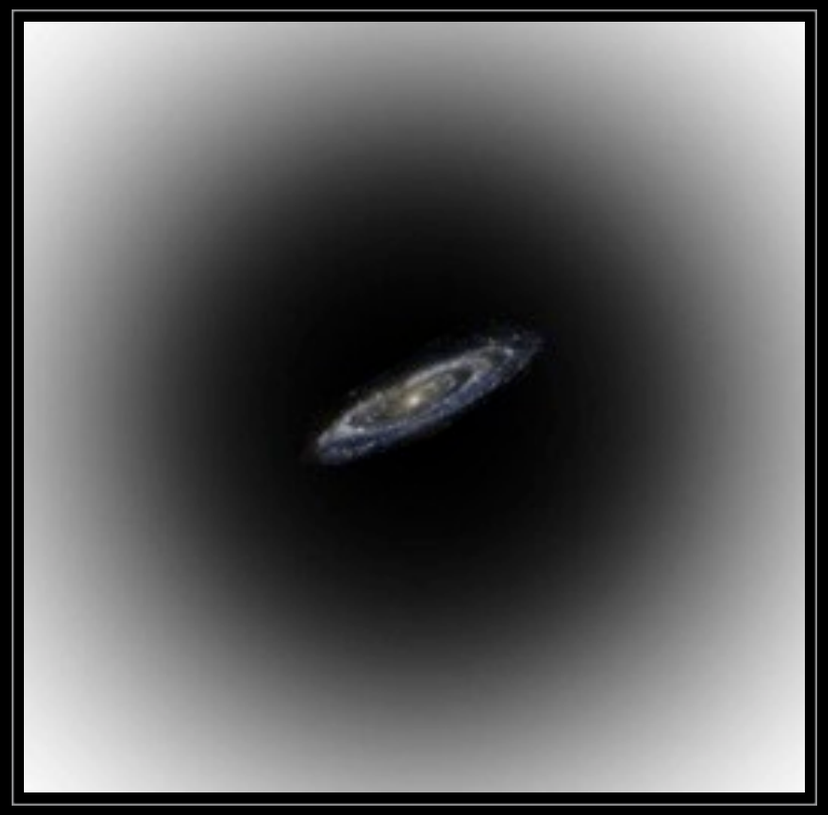
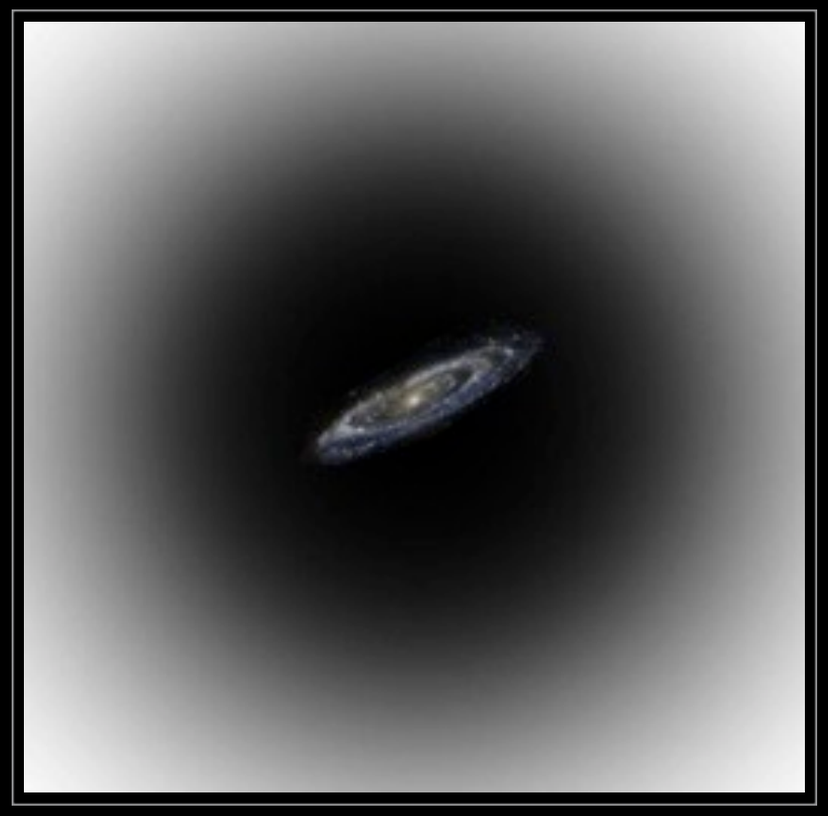
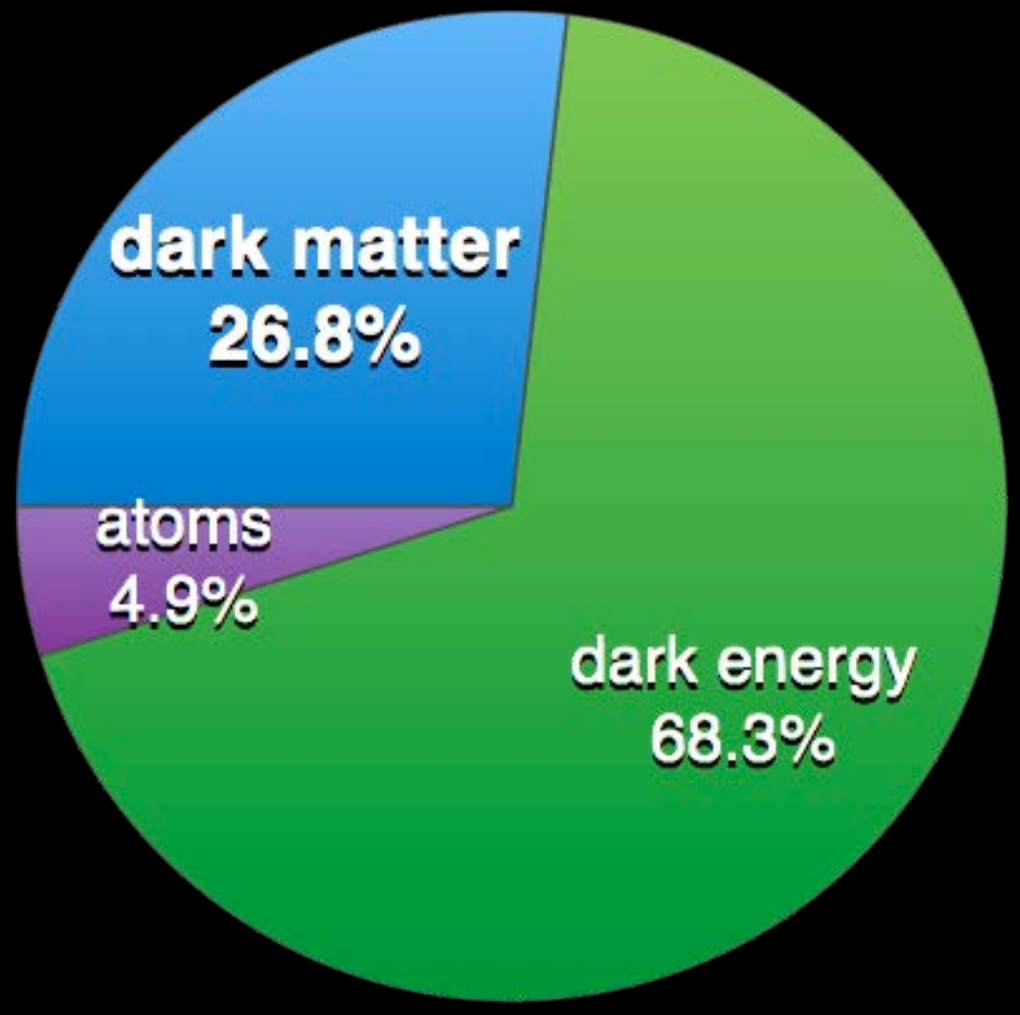


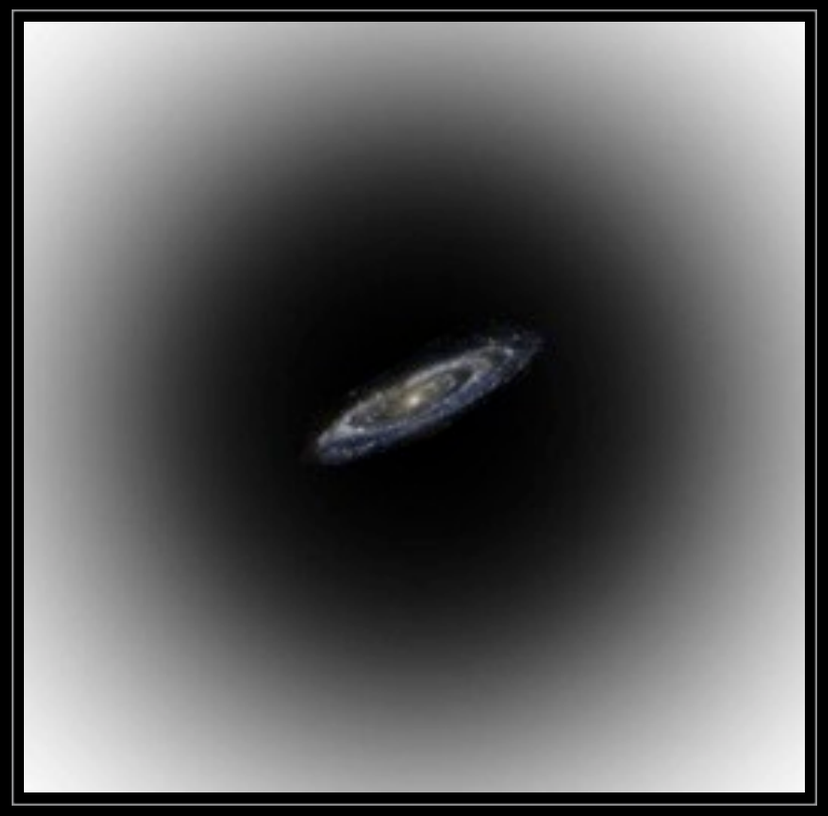
dark matter basics



dark matter basics

Dark matter is the **dominant form of matter** in the Universe





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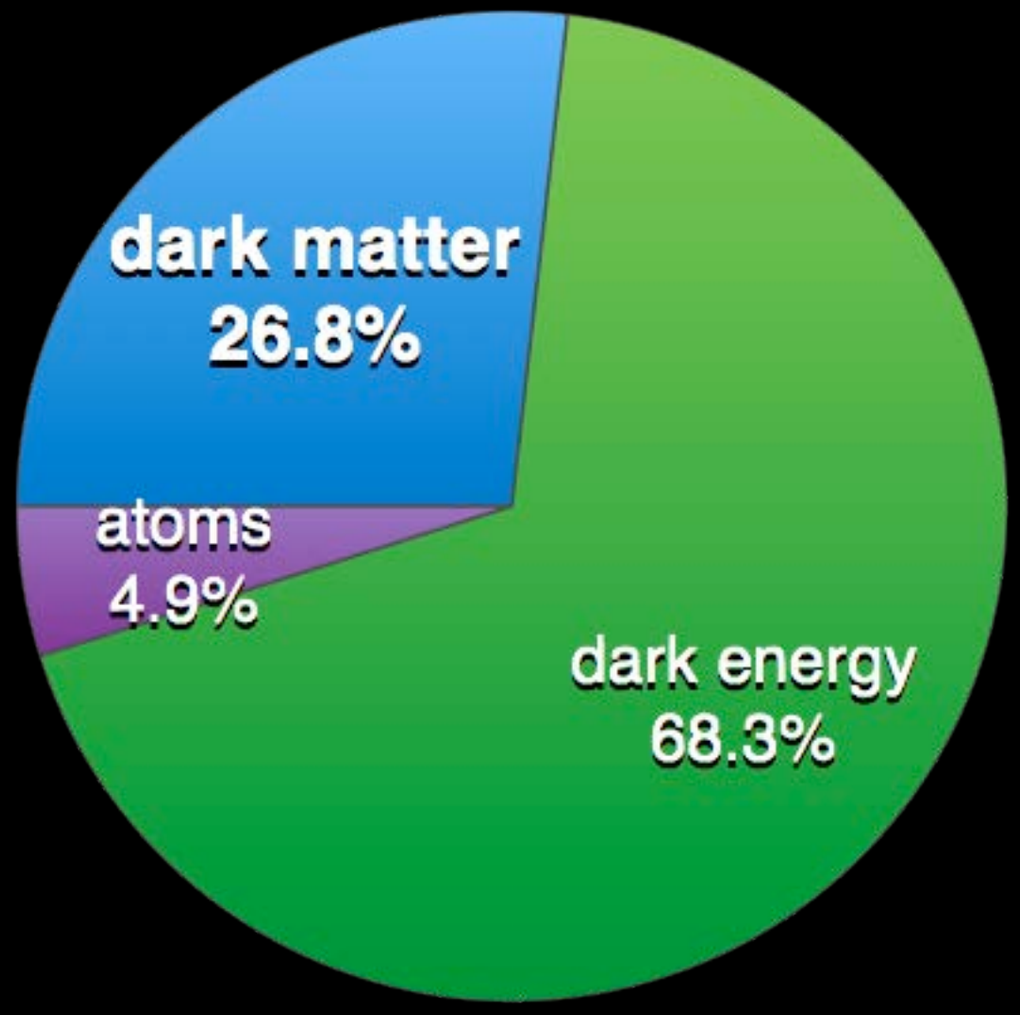

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So far, all evidence for dark matter comes from **astrophysics**

impact of dark matter

25 Mpc slice

Greg Poole, GiggleZ Simulation

impact of dark matter

- Dark matter density field
  - angular dependence of 21cm power spectrum
  - lensing convergence

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velocity offsets

Tseliakhovich & Hirata 2010
McQuinn & O'Leary 2012
Fialkov et al. 2014
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animation by Daniel Eisenstein

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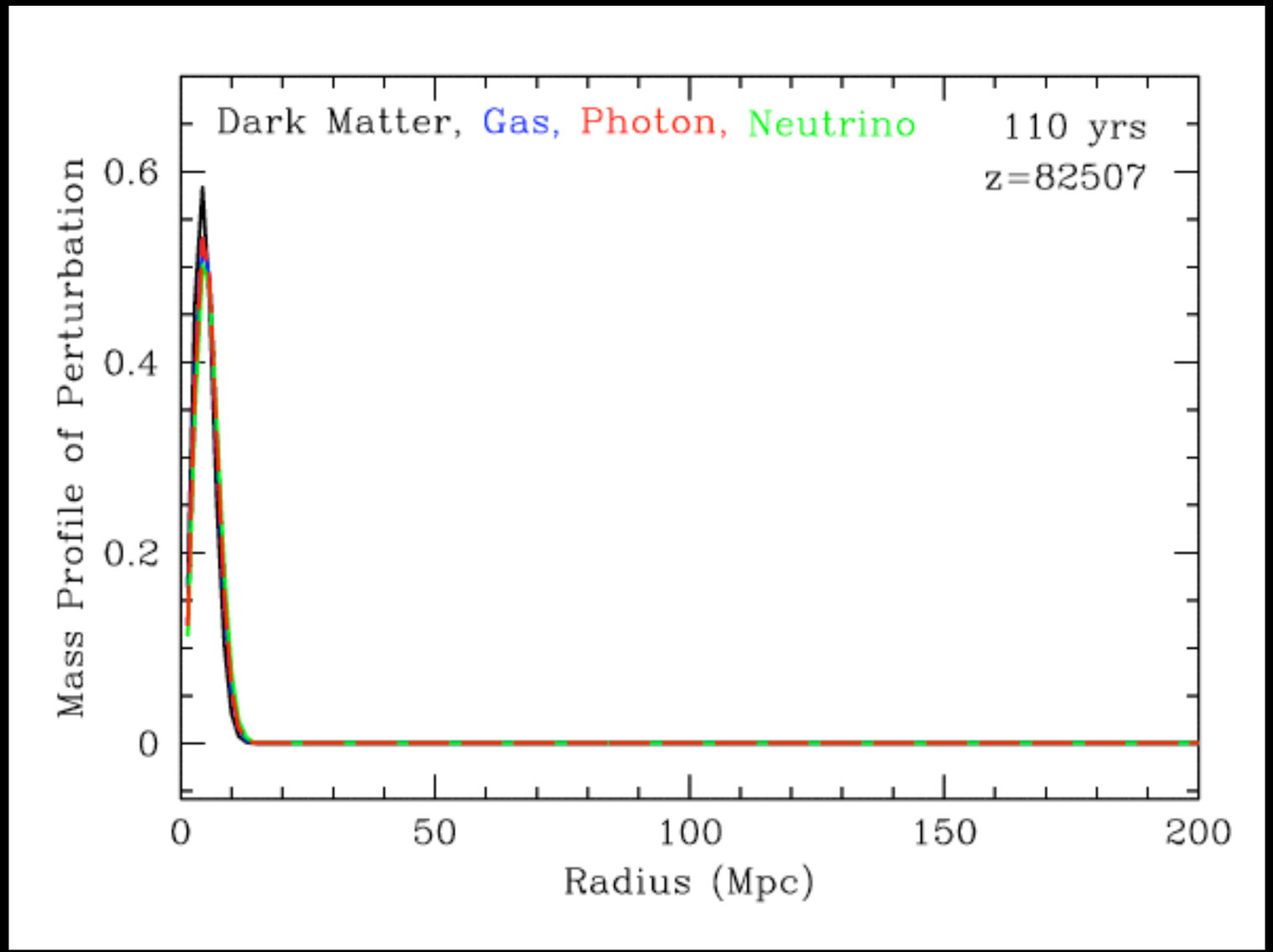

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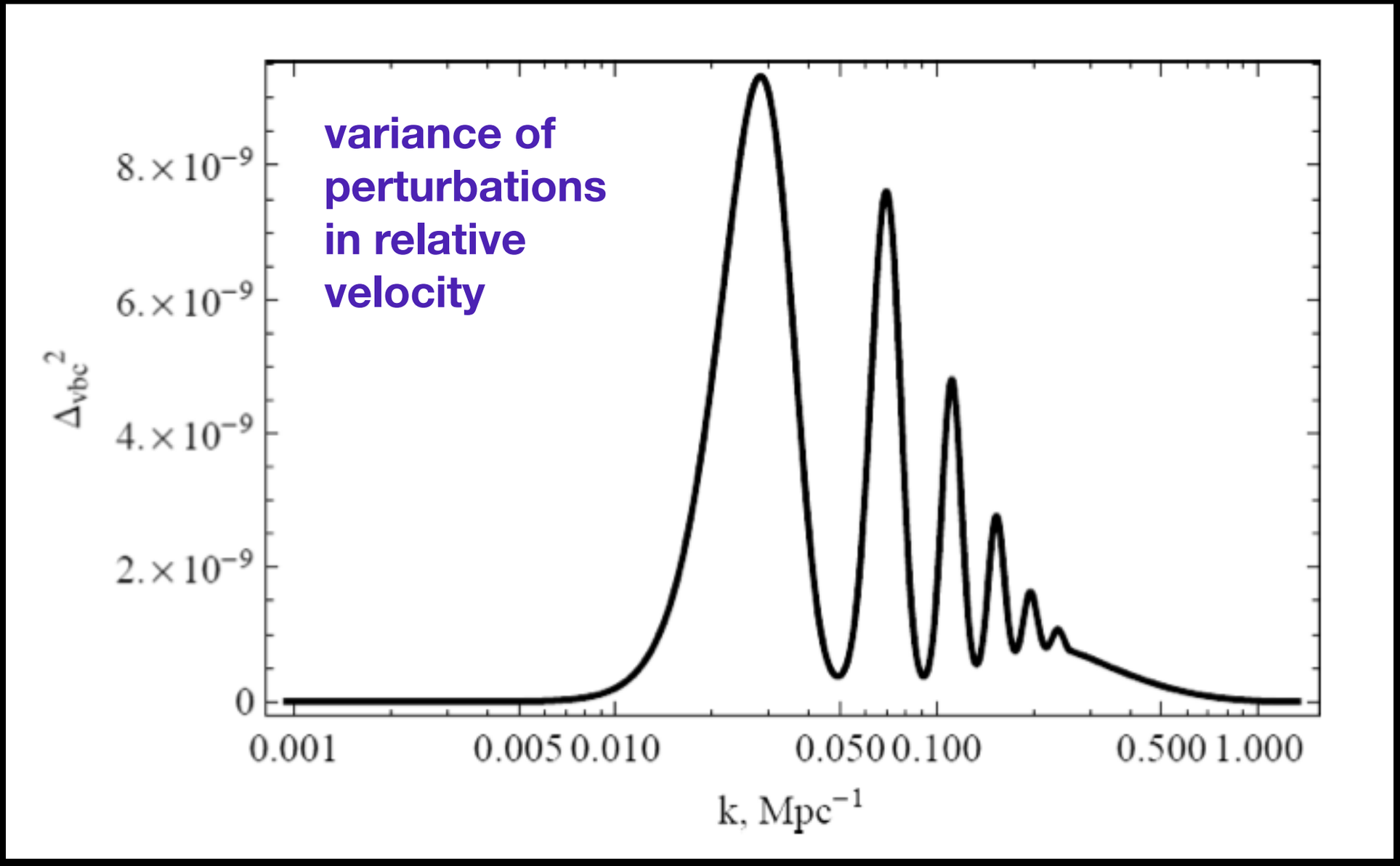

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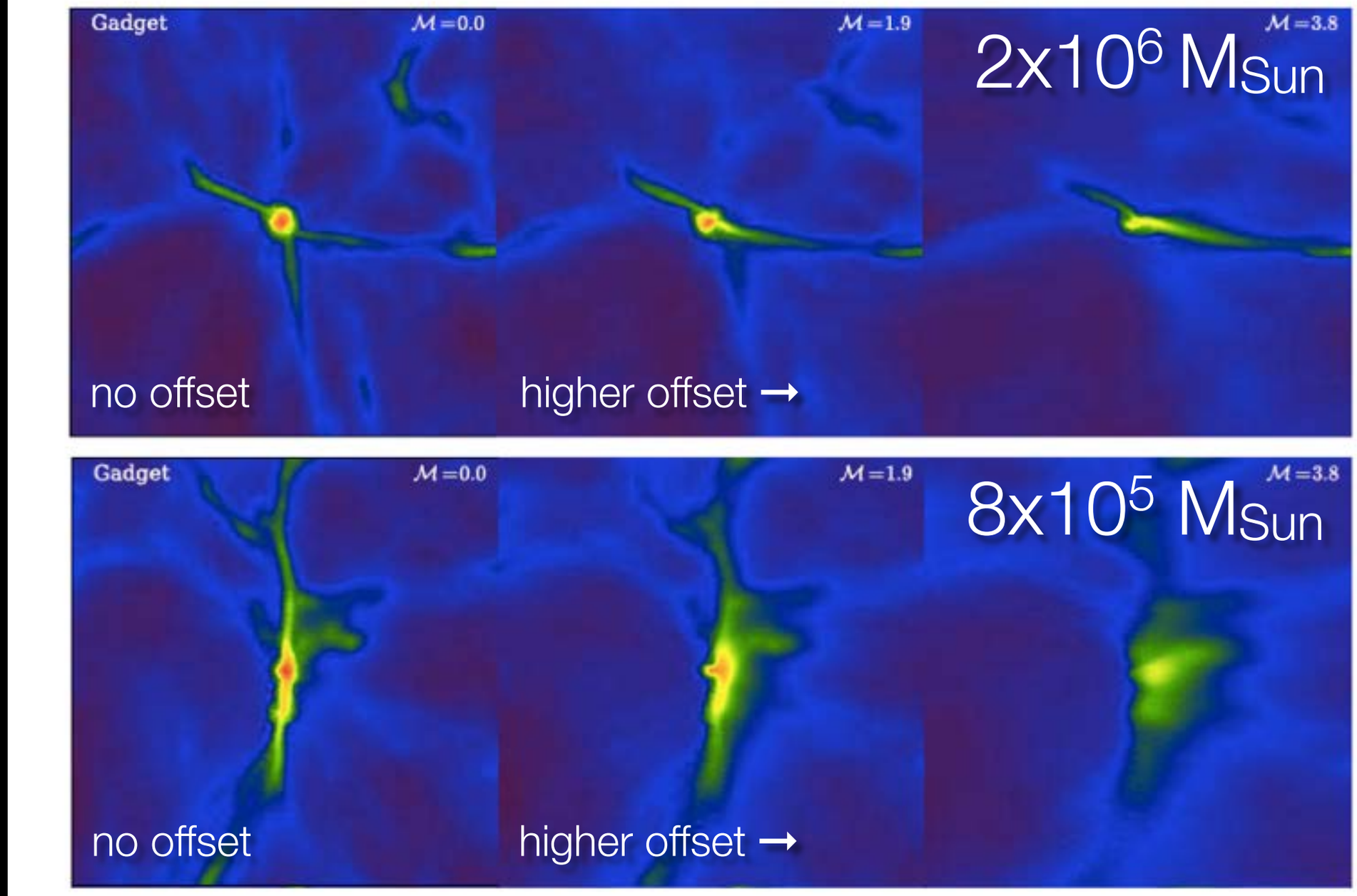

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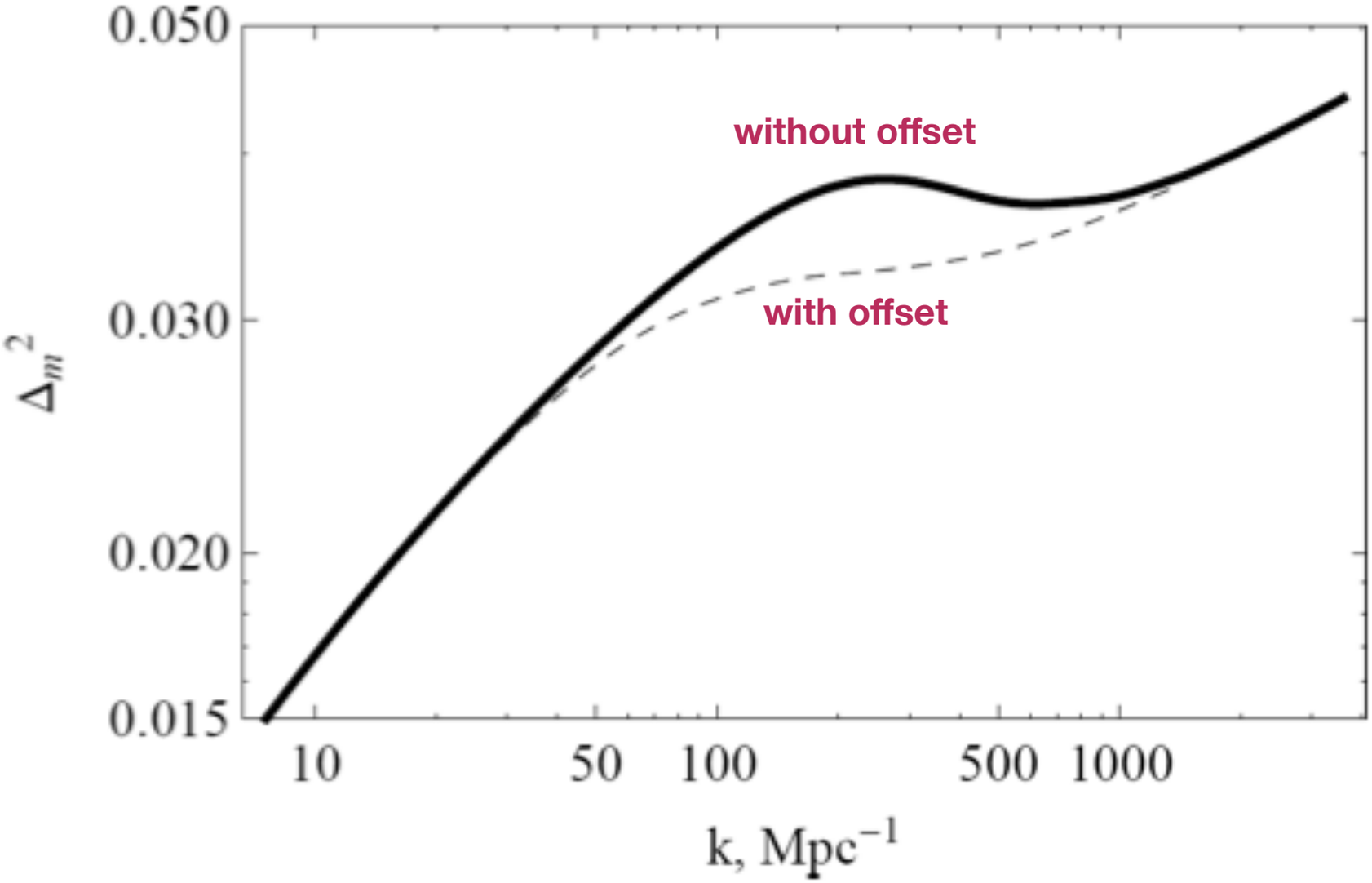

linear matter power spectrum

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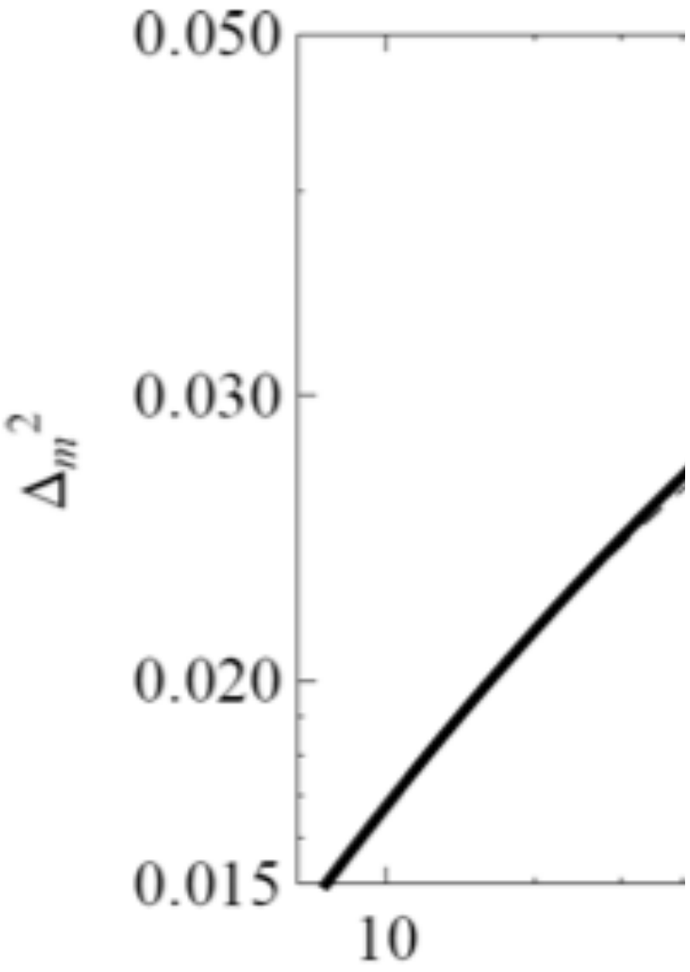
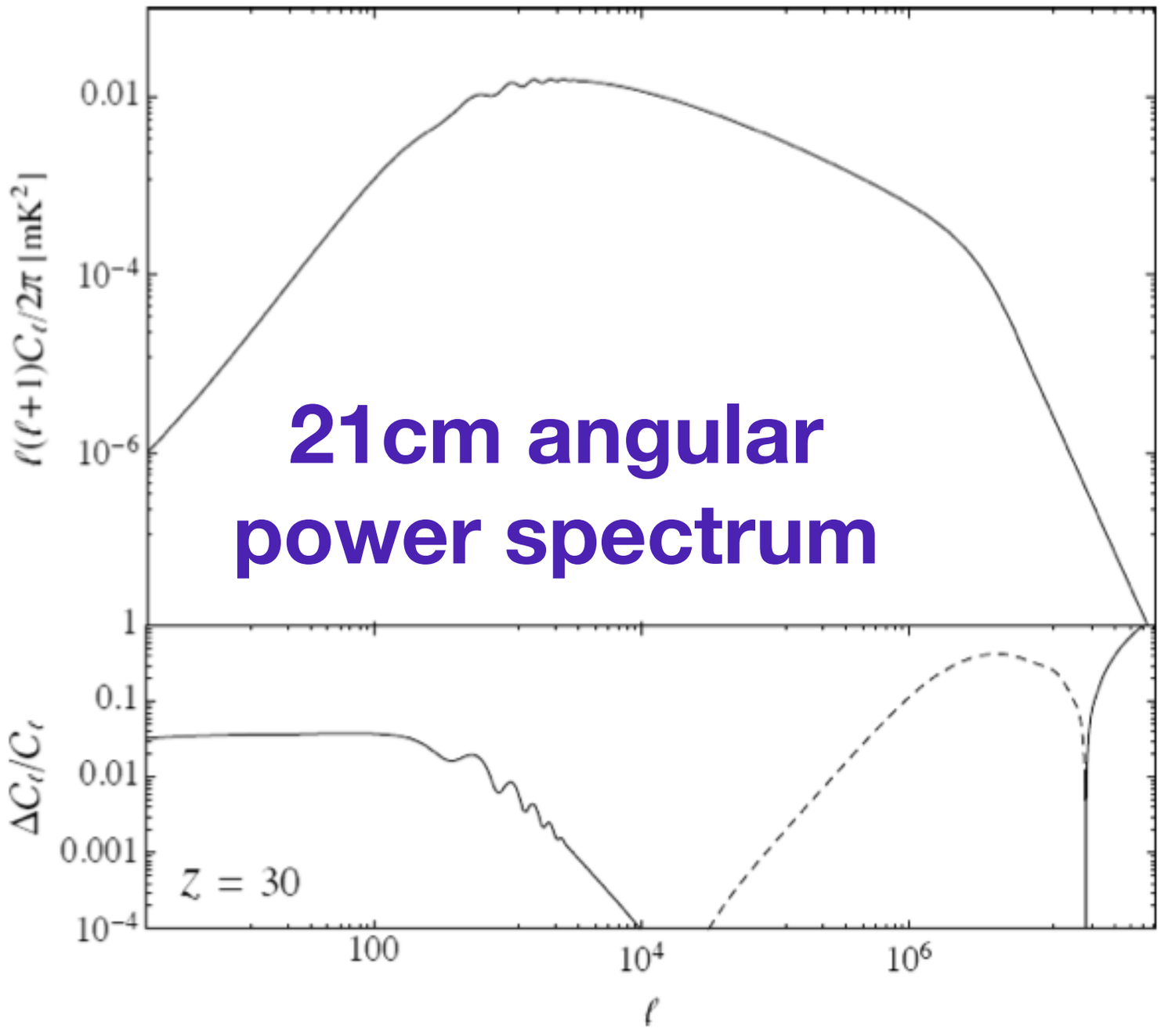


linear matter p



21cm angular power spectrum

velocity offsets

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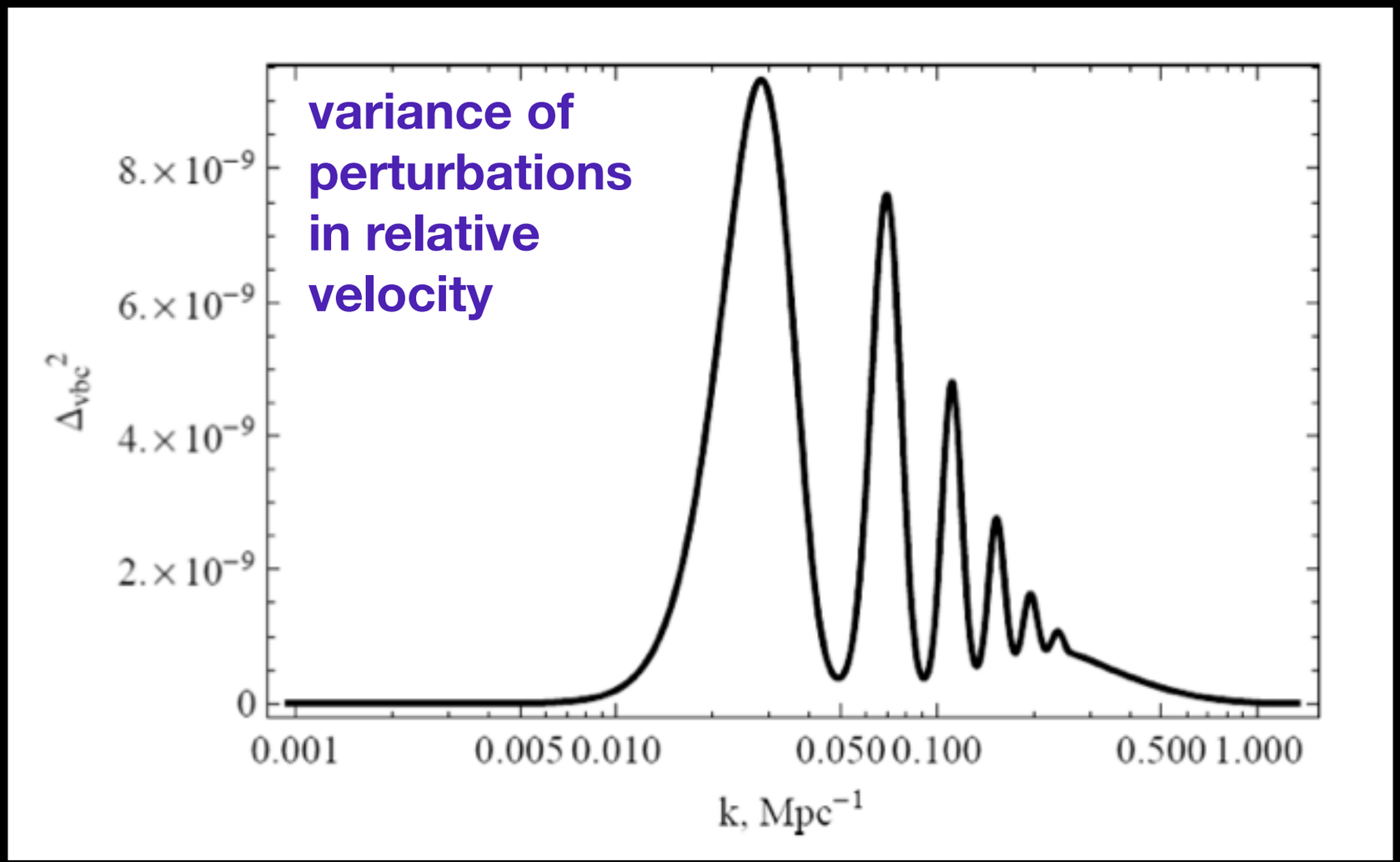
Ali-Haimoud et al. 2014
Marsh 2015



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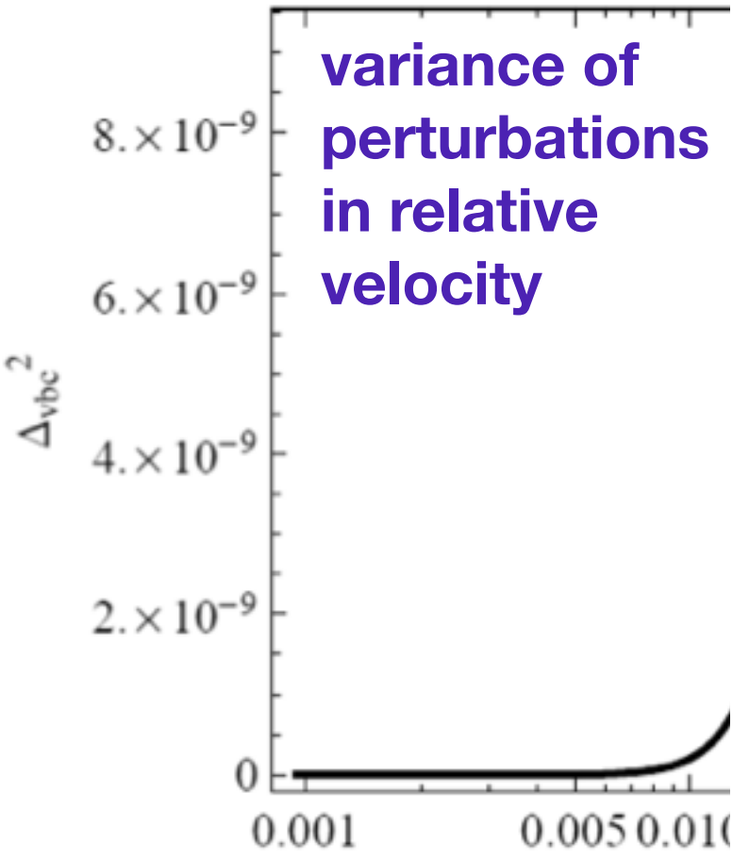
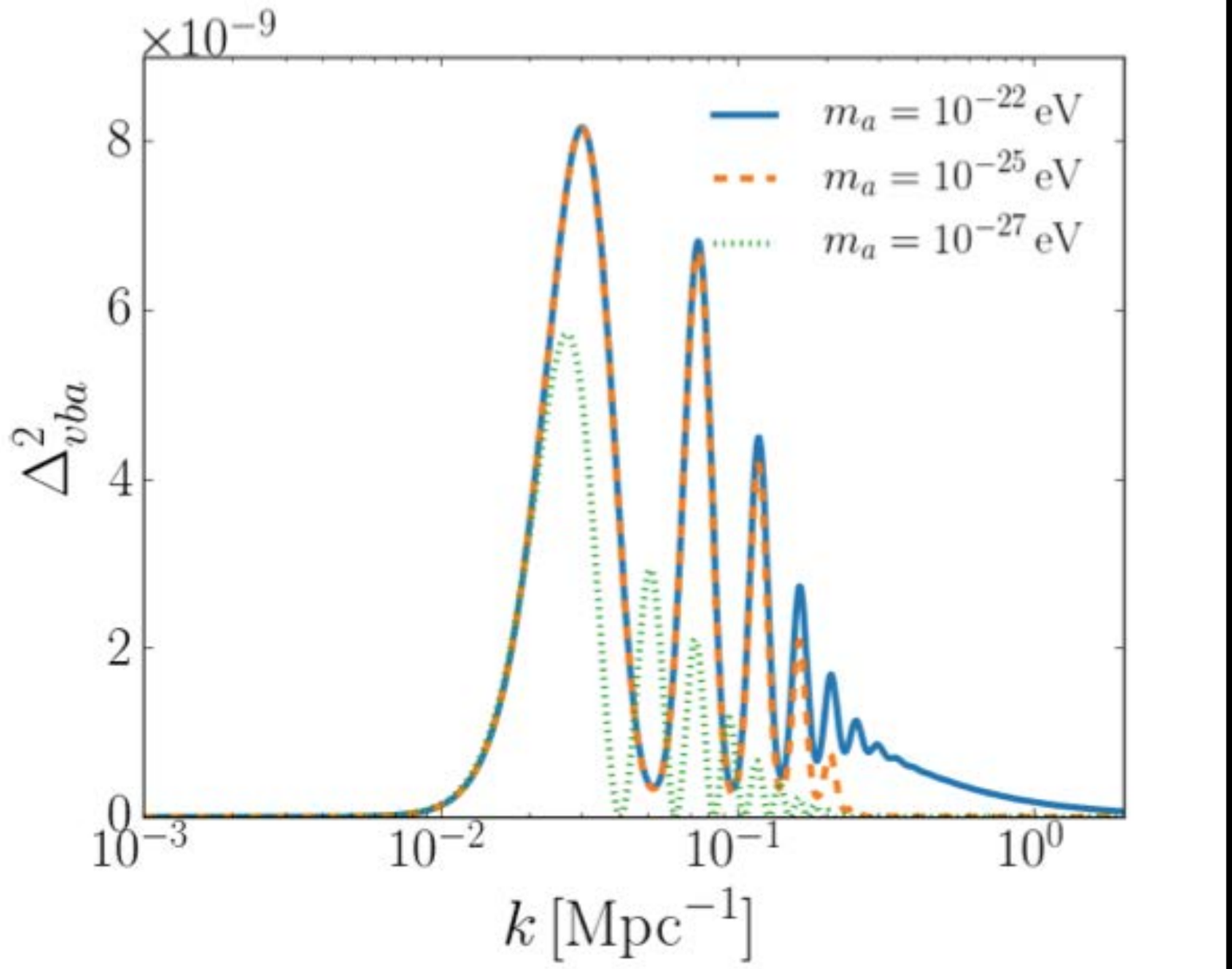
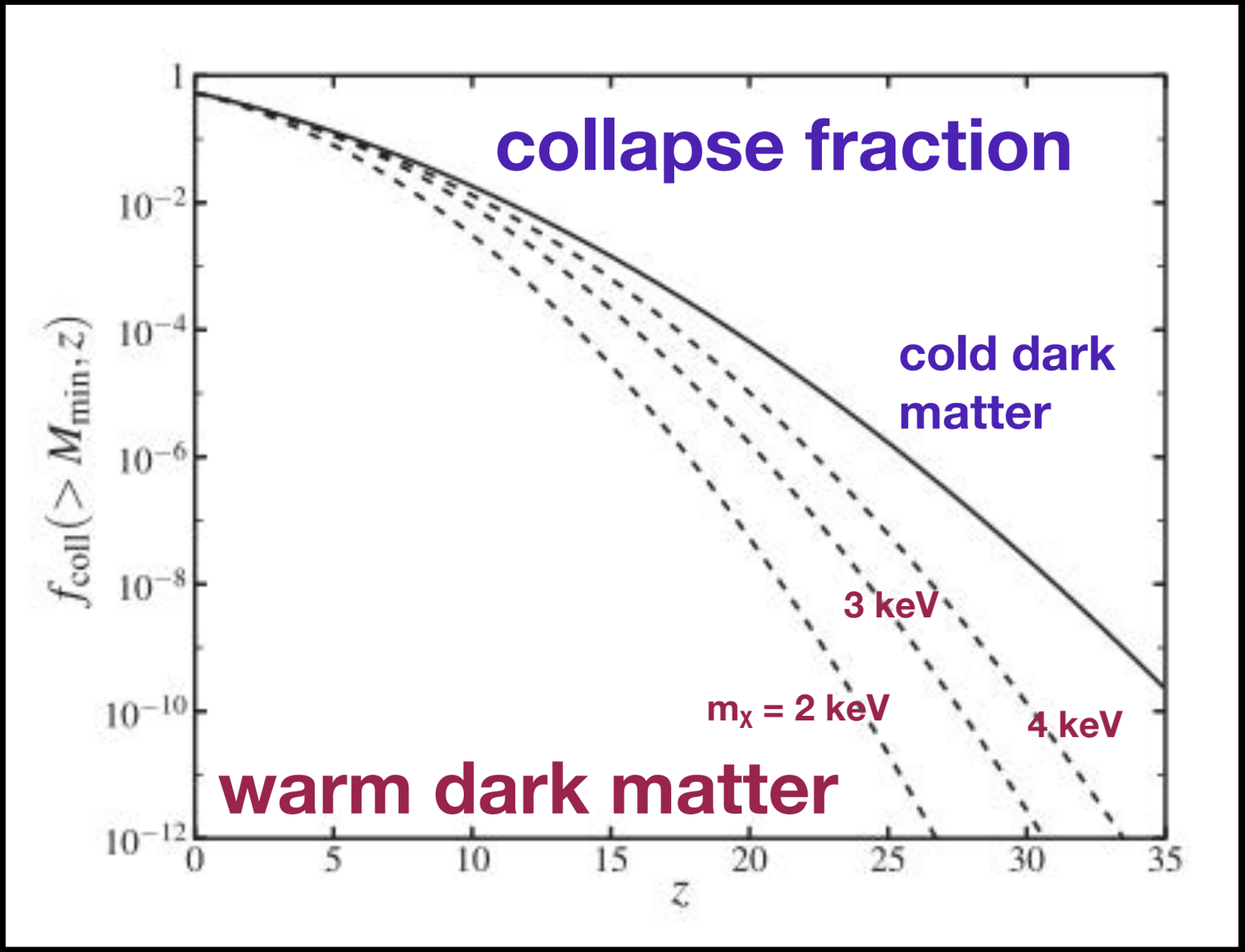




Sitwell et al. 2014

small-scale structure

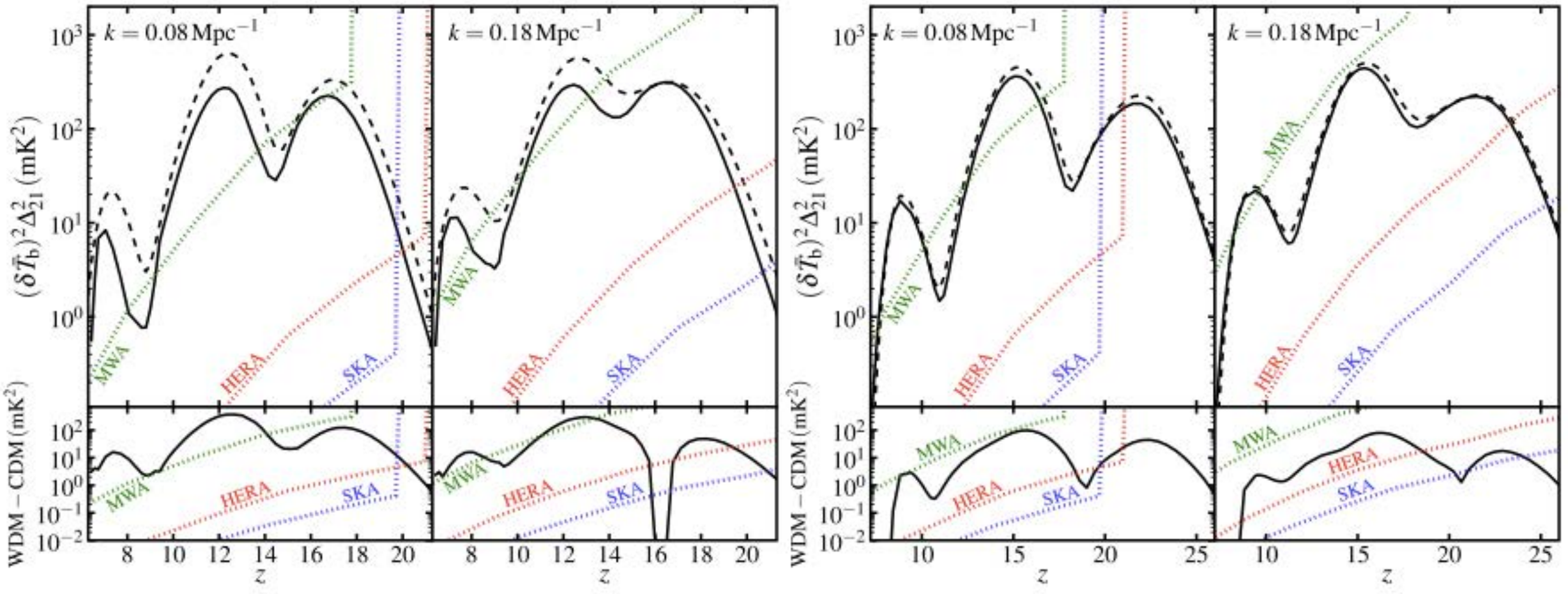


warm dark matter free-streams out of density peaks

cut-off in small-scale power spectrum

Sitwell et al. 2014

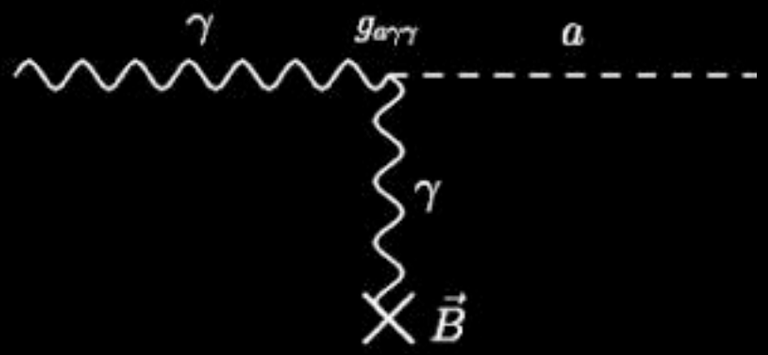
small-scale structure



m_χ = 2 keV

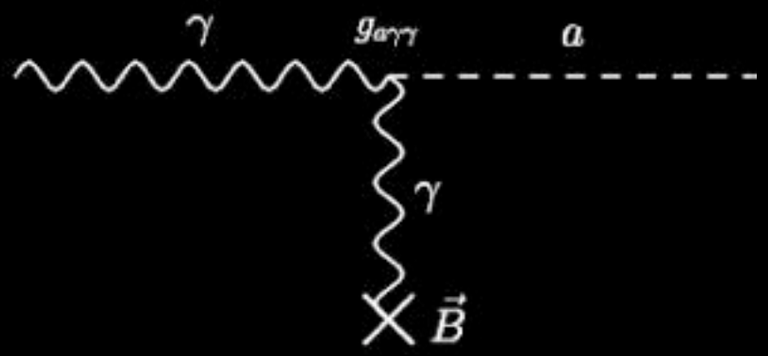
4 keV

radio counterparts: axions



axion dark matter: converts to photons in the presence of a magnetic field

radio counterparts: axions



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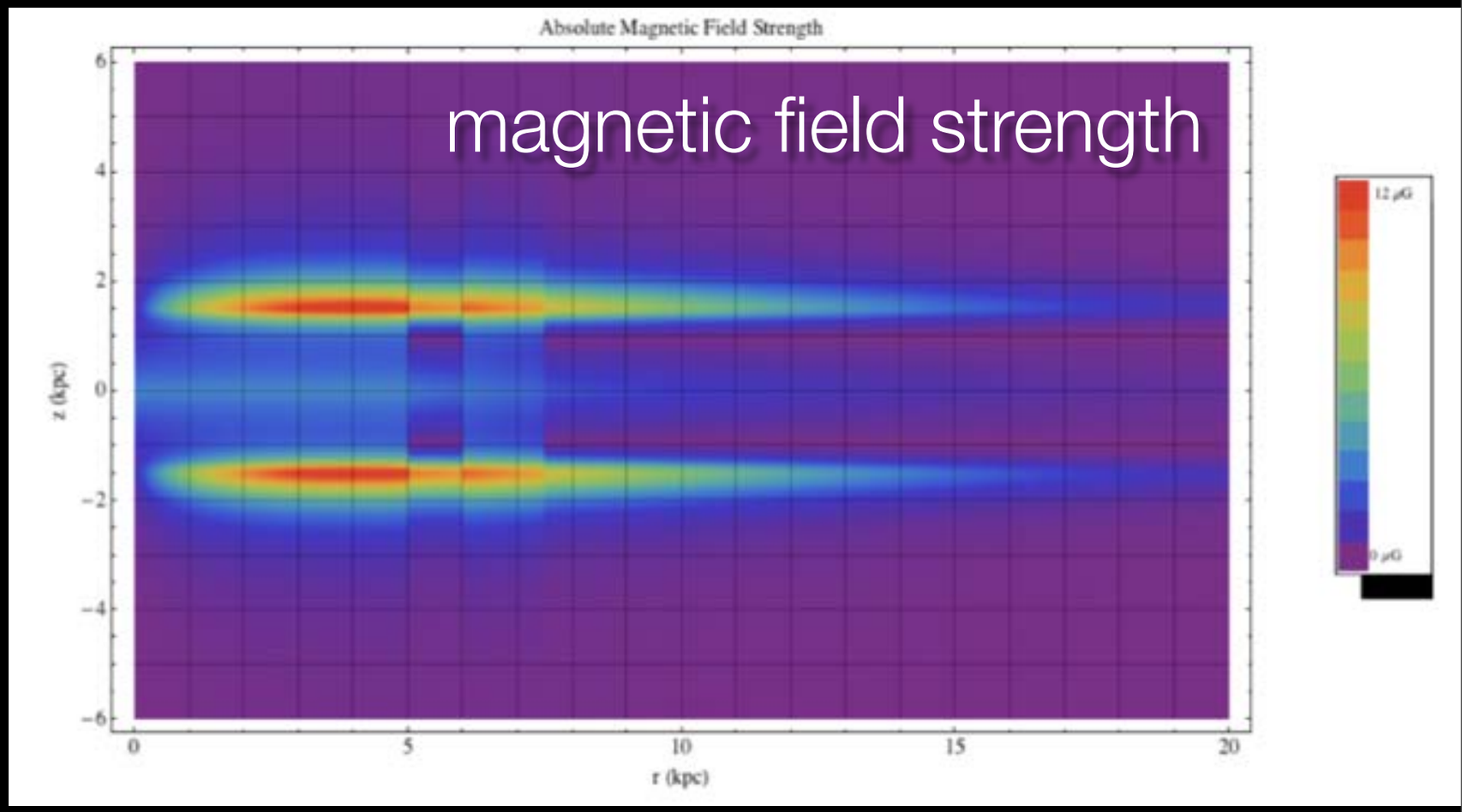
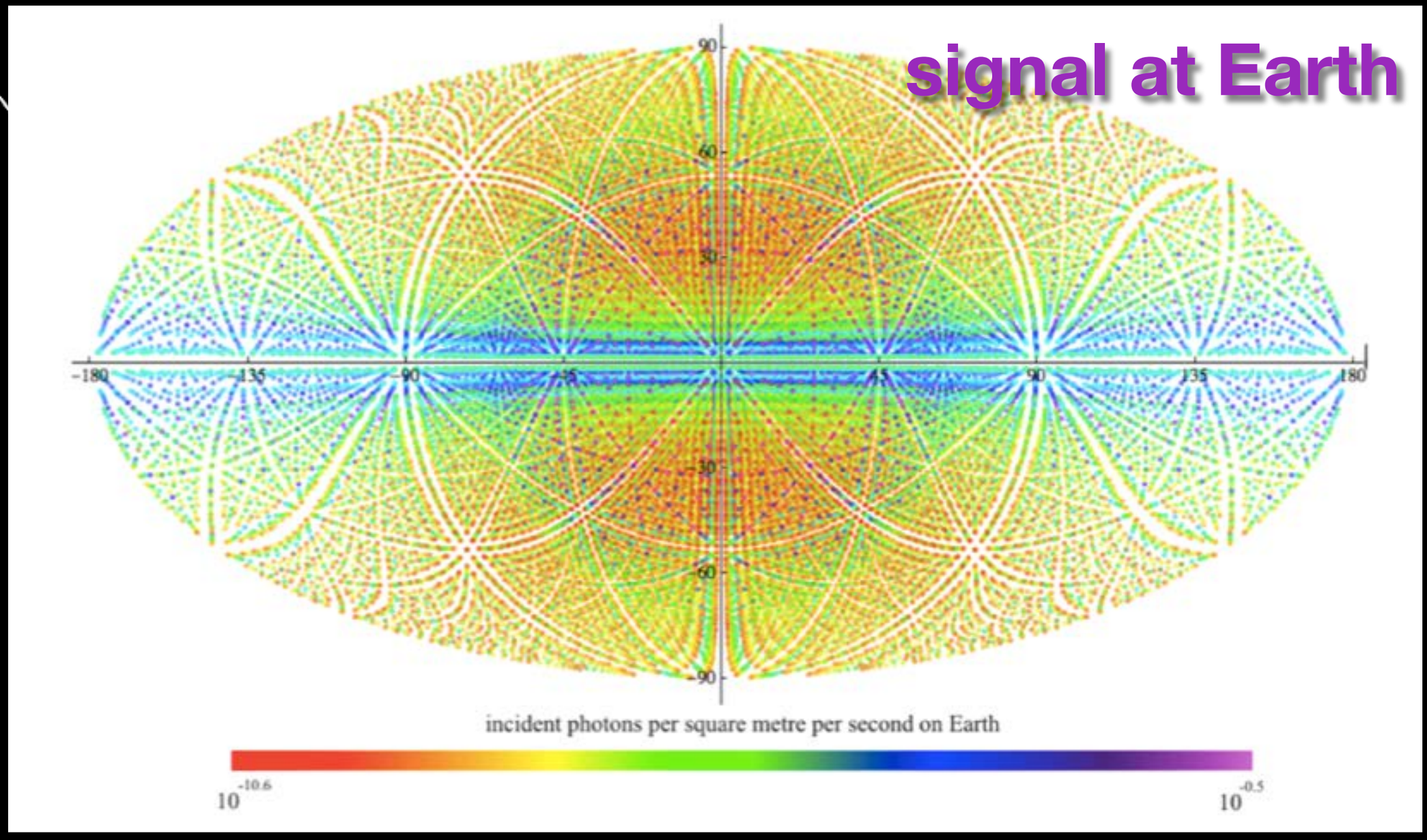


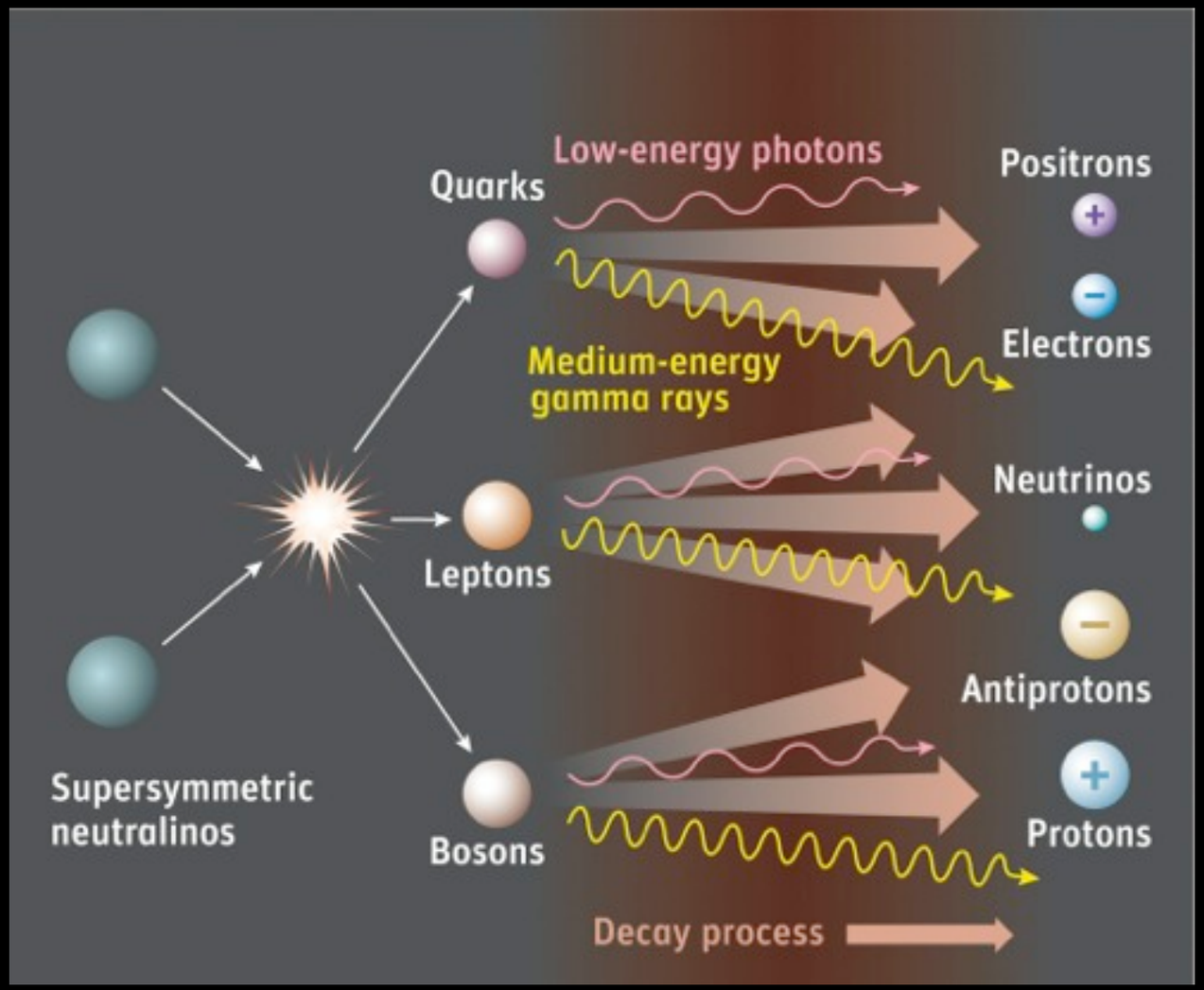
White & Quinn, Honors Thesis, 2008

radio counterparts: axions



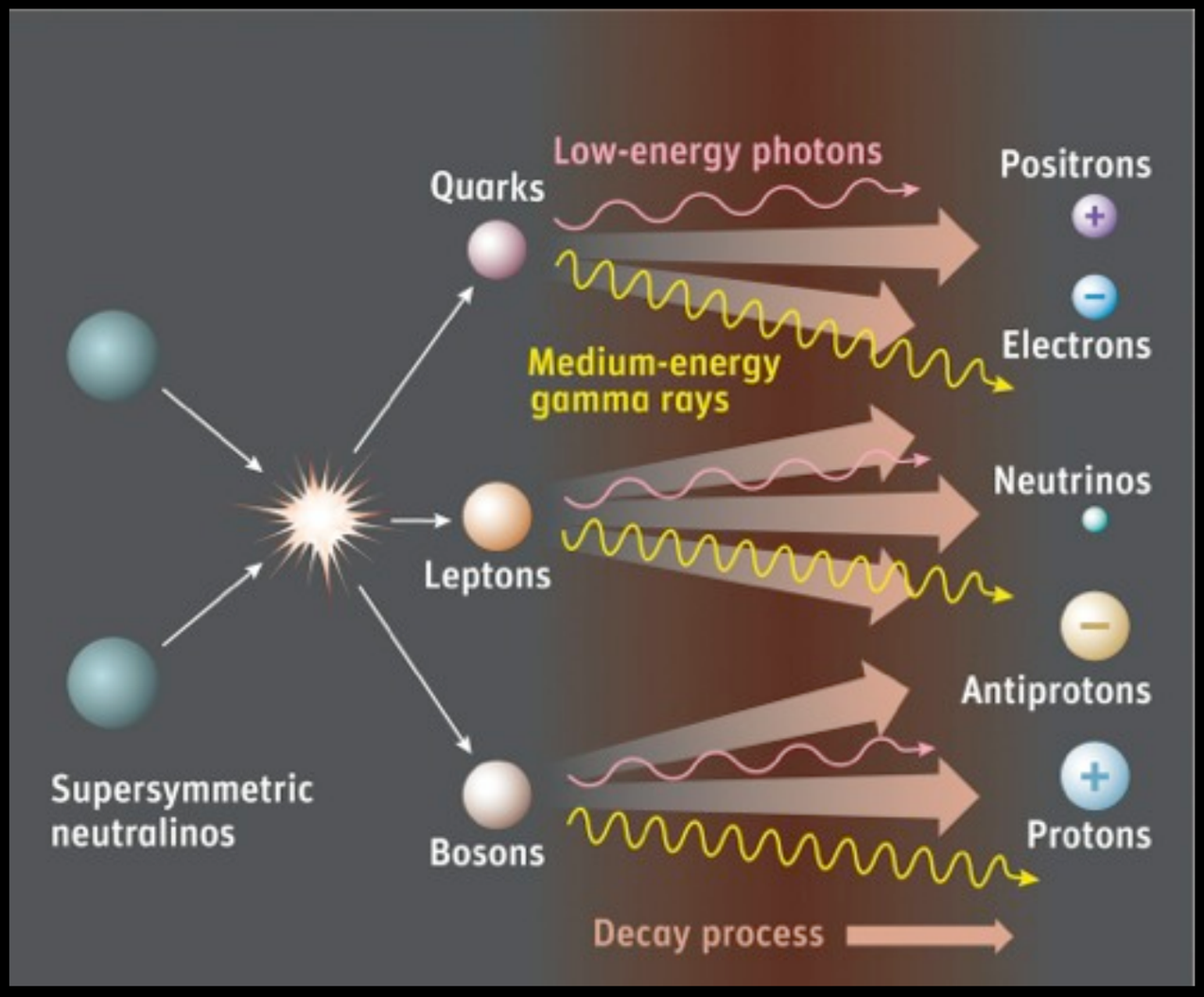
calculated all-sky signal: 20 photons/s/m^2

radio counterparts: annihilation



Credit: Sky & Telescope / Gregg Dinderman

radio counterparts: annihilation



Credit: Sky & Telescope / Gregg Dinderman

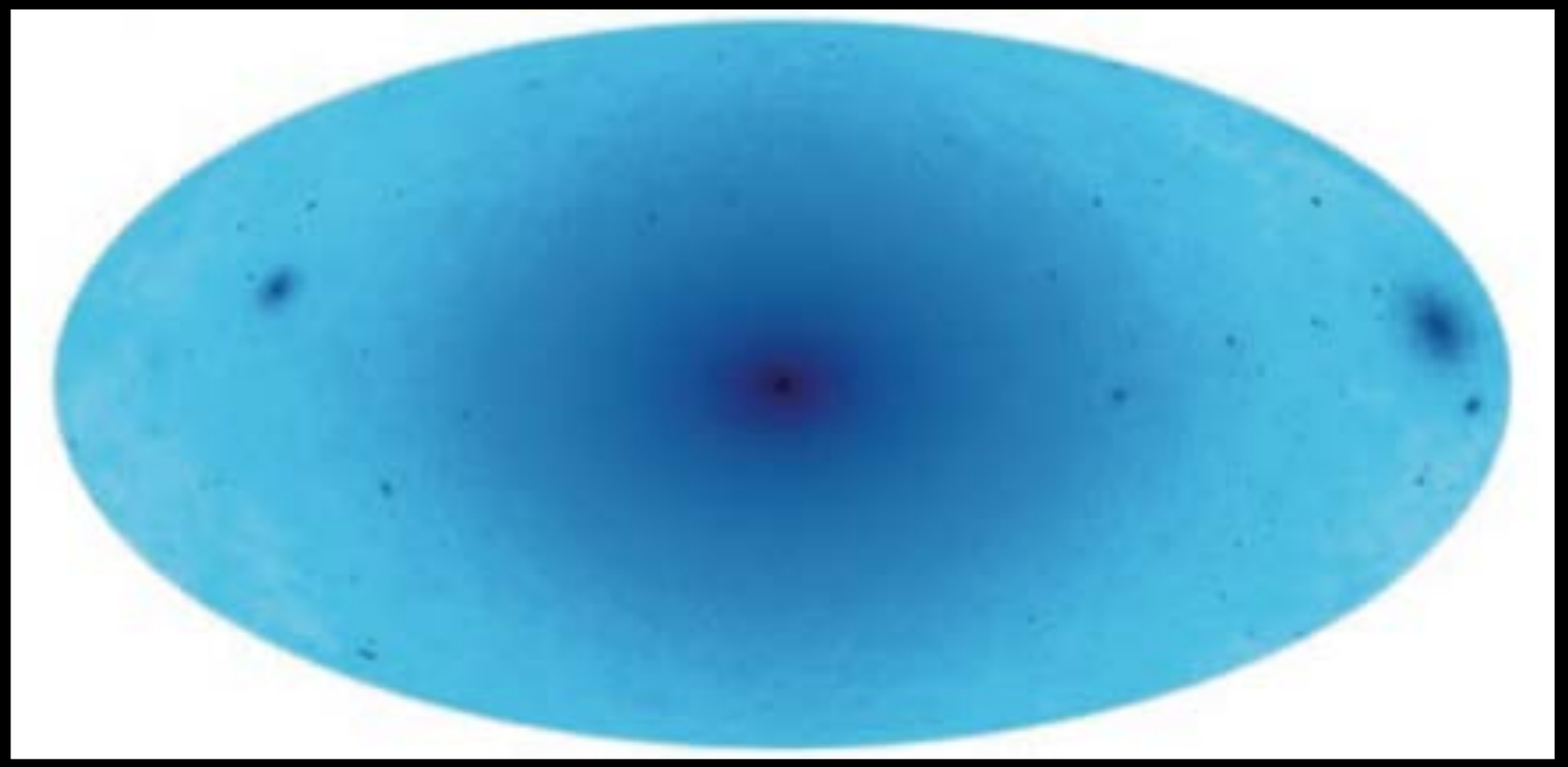
$$\frac{\text{power}}{\text{volume}} = \frac{\langle \sigma v \rangle \rho_\chi^2}{m_\chi}$$

$\langle \sigma v \rangle$ velocity-averaged self-annihilation rate

ρ_χ dark matter density

m_χ dark matter particle mass

radio counterparts: annihilation



Kuhlen, Madau & Silk 2009

- annihilation power is proportional to ρ^2
- high-density peaks produce strongest signals

radio counterparts: annihilation

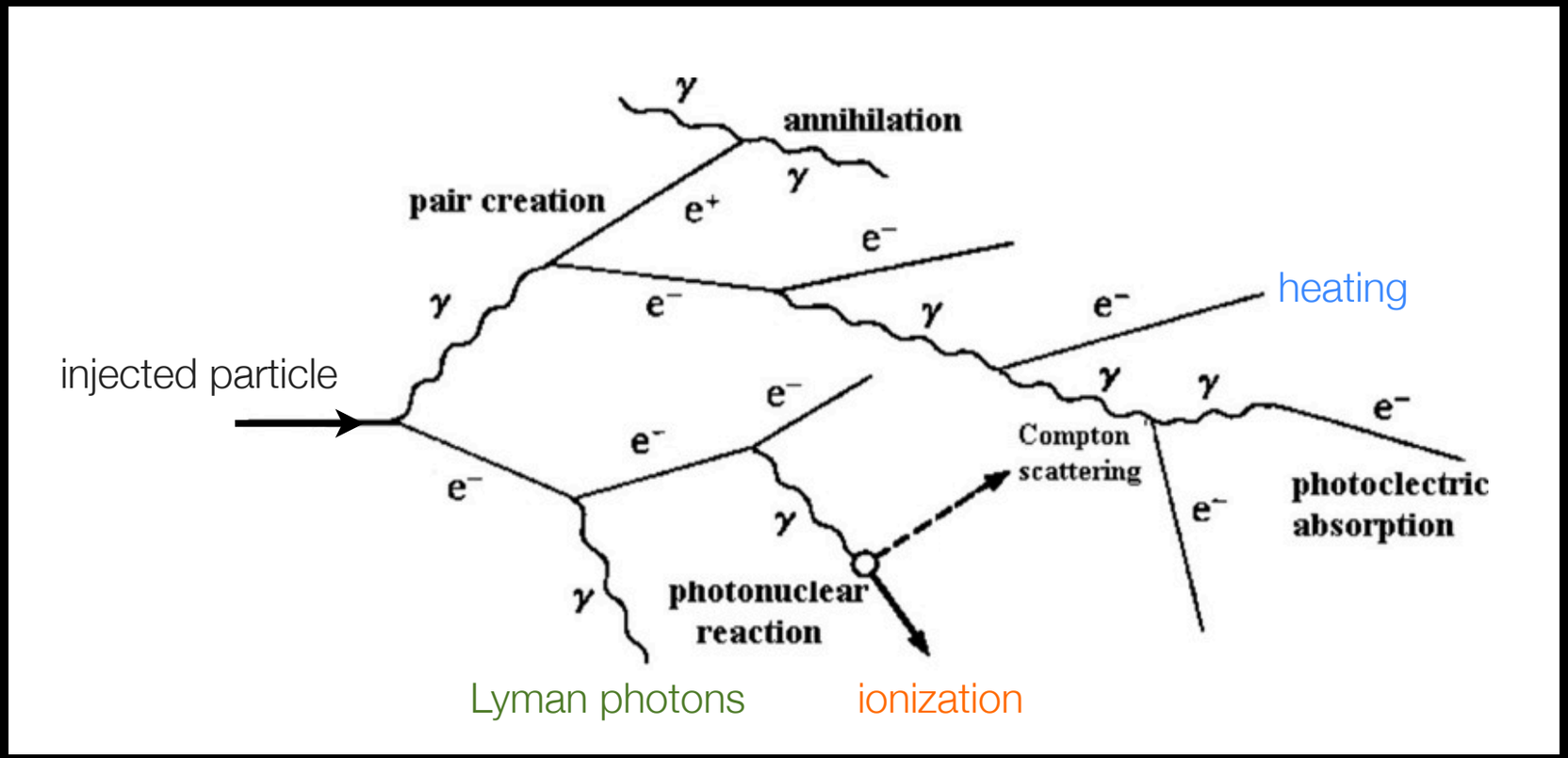
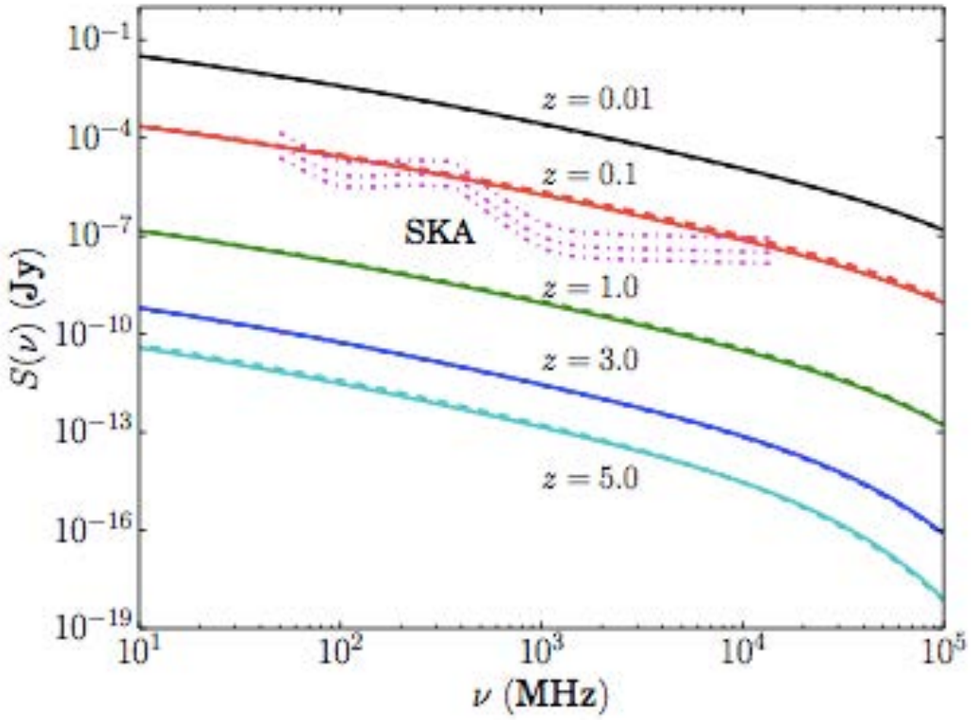


Image from talk by Carmelo Evoli

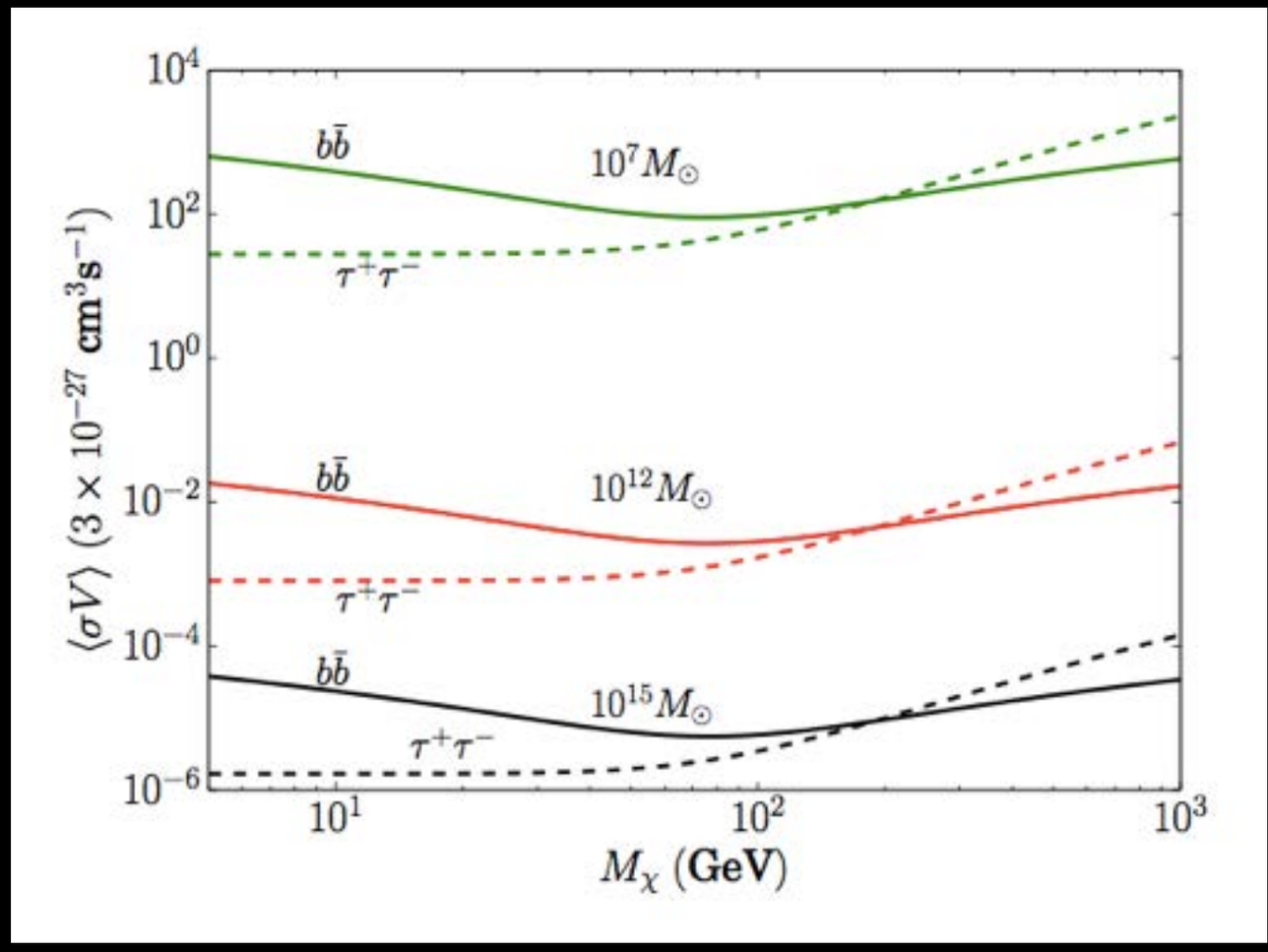
- annihilation radiation cascades through many channels
- counterparts: heating, ionization, photons
- e^+ / e^- produce radio synchrotron

radio counterparts: annihilation



galaxies with mass 10^{12} M_{Sun}
halo profile: NFW
<B> = 5 μG
WIMP mass: 60 GeV
$\langle\sigma v\rangle = 3 \times 10^{-27}$ cm^3 s^{-1}
annihilation channel: bottom quarks

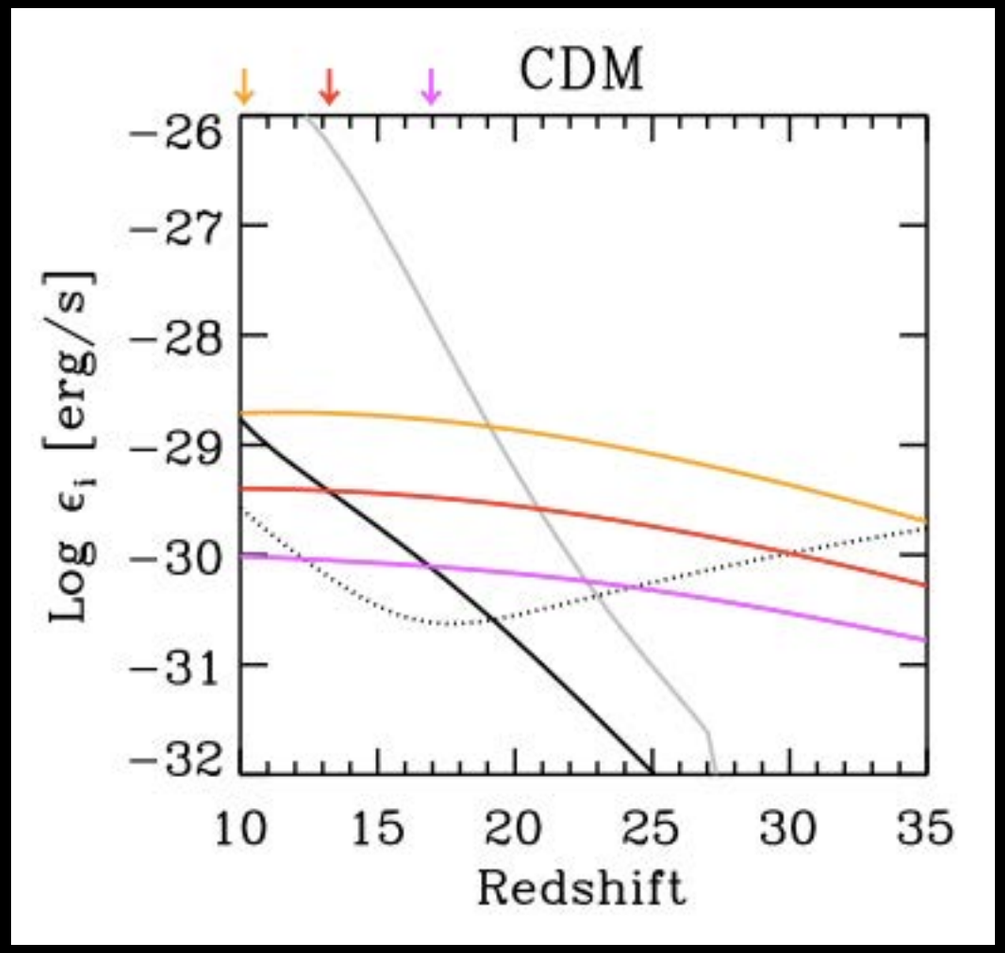
Colafrancesco et al. 2014



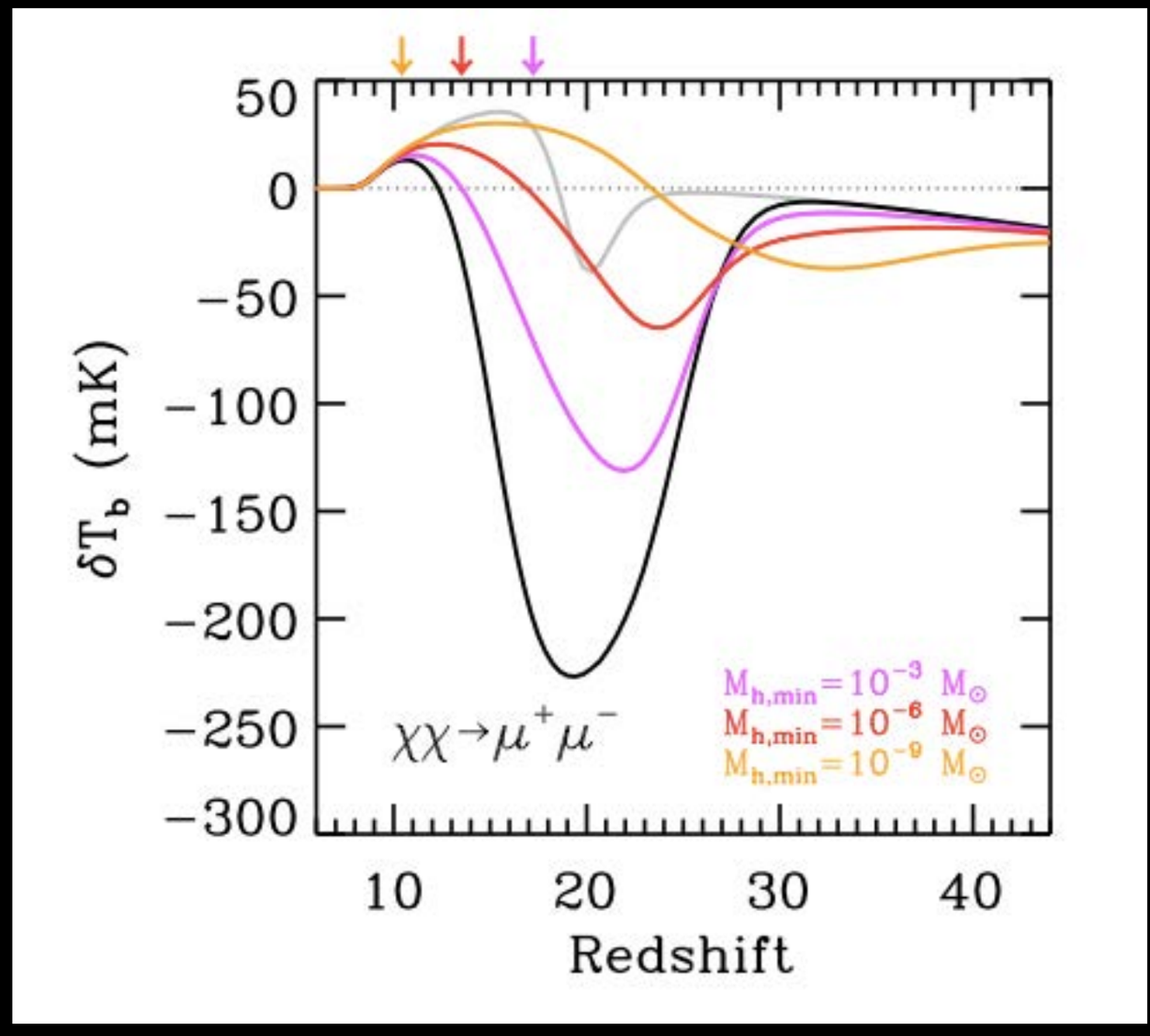
upper limits on <σv> from 30-hour SKA integration
z=0.01, 5 GHz

energy injection: global

Evoli et al. 2014



heating rate from models with different dark matter halo small-scale cut-offs; arrows indicate where dark matter heating dominates astrophysical sources

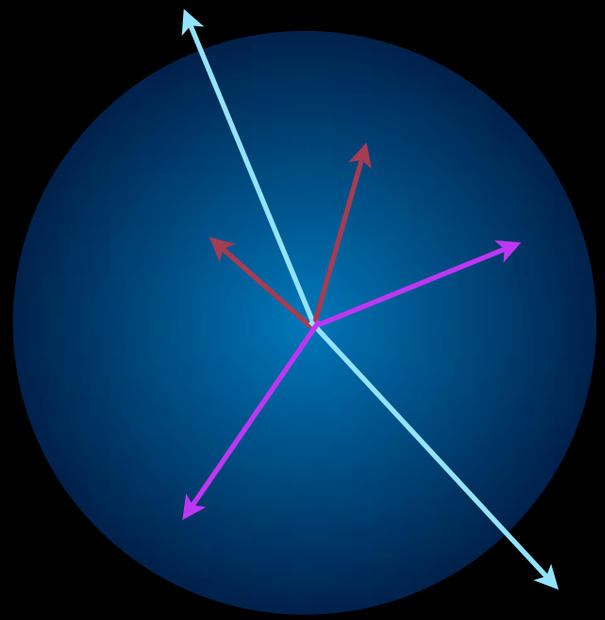


21cm all-sky signal

energy injection: local

Question:

If dark matter is annihilating **within baryonic halos**, does this constitute an effective "feedback" process?



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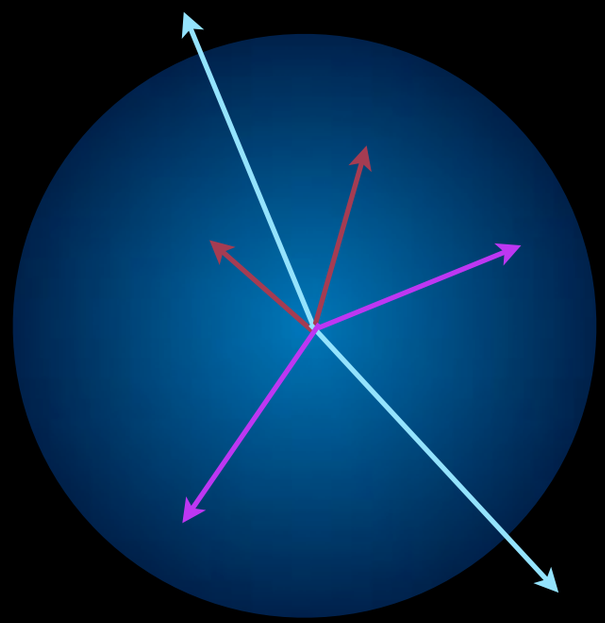


Resources:

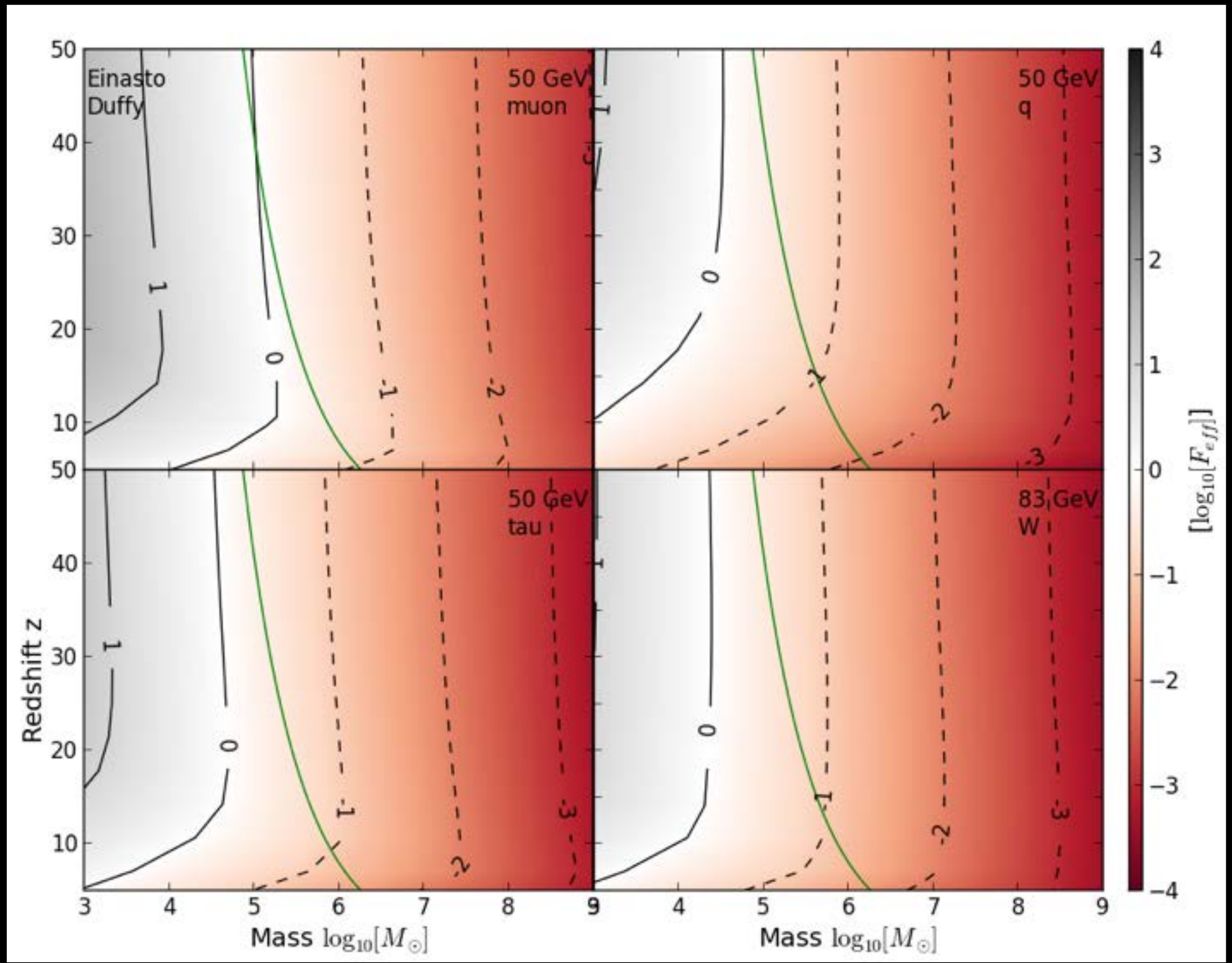
PYTHIA code: dark matter annihilation events

MEDEA2 code: energy transfer to baryons

Halo models: density profile, mass-concentration

annihilation within halos

Sarah Schon et al. 2014
arxiv:1411.3783



Ratio: dark matter annihilation energy (over Hubble time)
to gas binding energy

annihilation within halos

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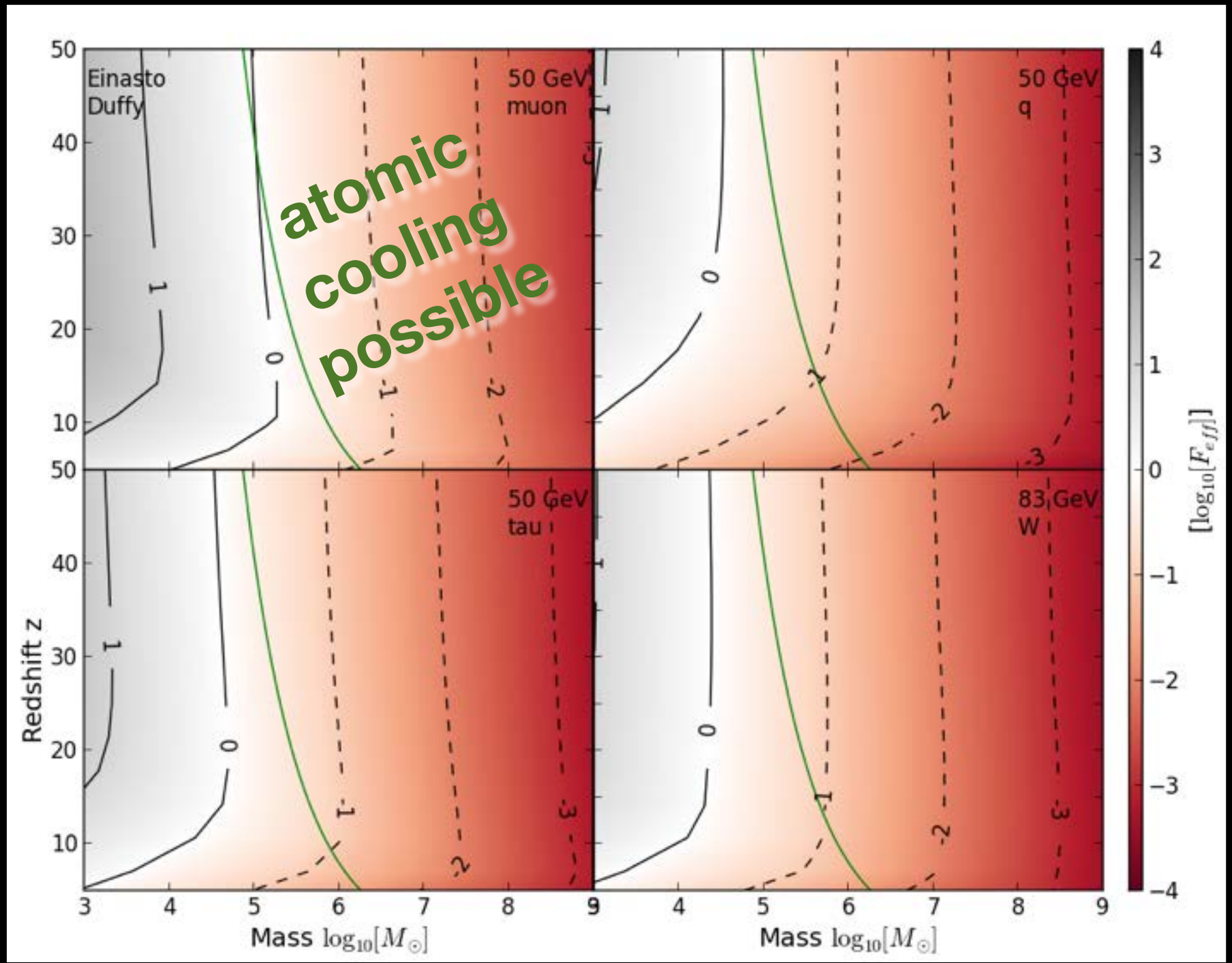

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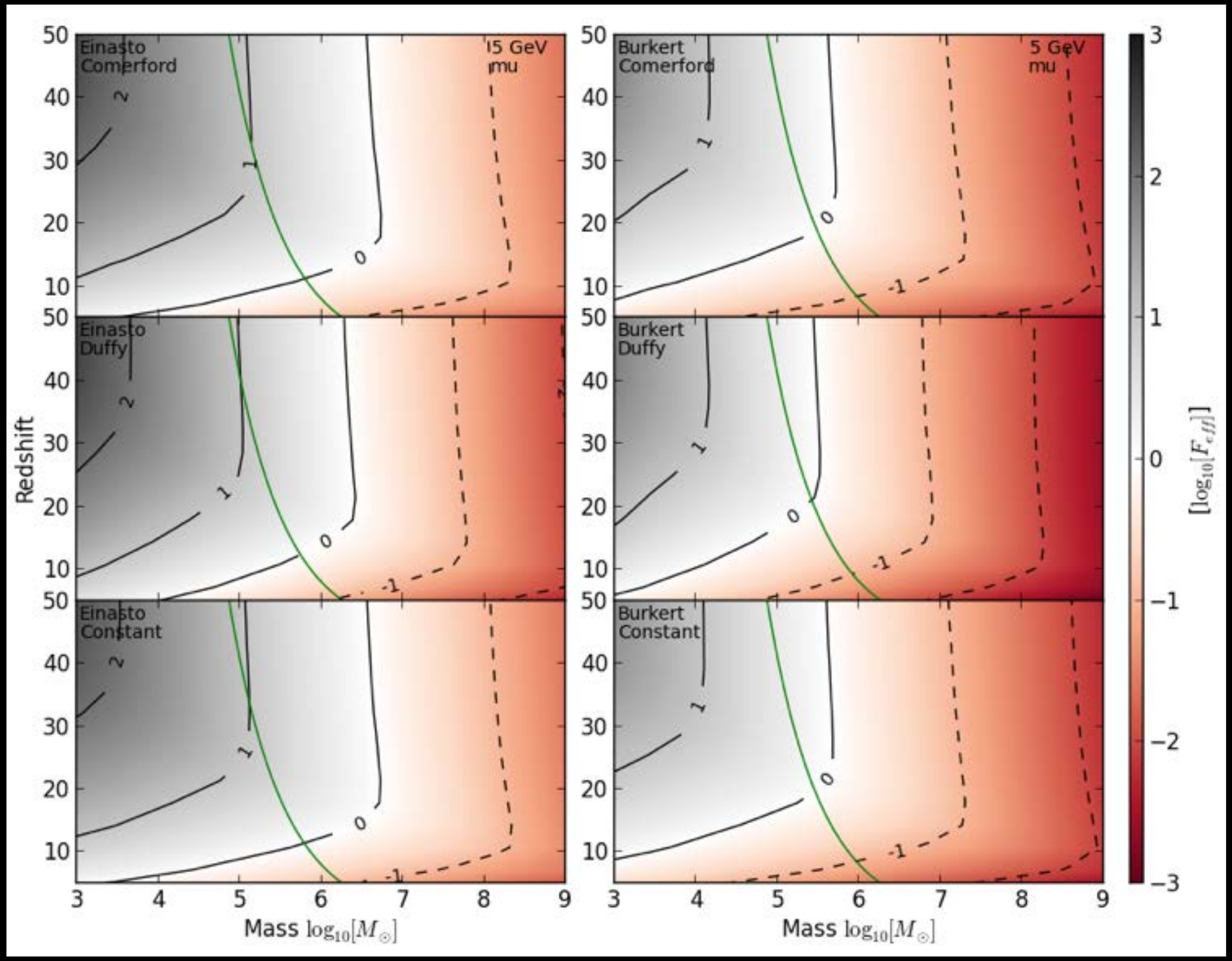

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conclusions

- SKA has the ability to probe the density field to high precision -- test ΛCDM scenario
- dark matter phenomenology can affect
  - growth of structure
  - evolution of the intergalactic medium
  - possible radio signals