

Nonlinear modelling and constraints from dark matter decays and implications on S_8 tension

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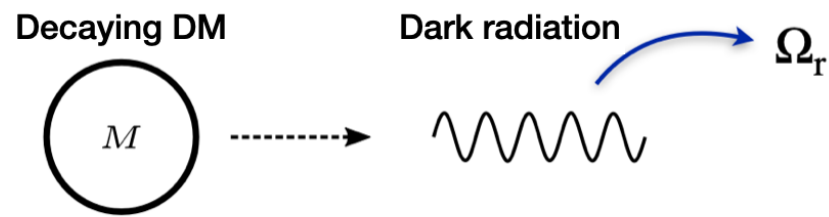
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One-body (late-time) decays of dark matter

[Bucko et al. 2023a](#)



→ suppression of matter $P(k)$

Model parameters

- $\Gamma \equiv 1/\tau$ - decay rate of DM particles or lifetime
- f - fraction of decaying DM

Fitting formula from N -body simulations

$$P_{\text{DDM}}(k, z)/P_{\Lambda\text{CDM}}(k, z) = 1 - \epsilon_{\text{nonlin}}(k, z)$$

$$\frac{\epsilon_{\text{nonlin}}(k, z)}{\epsilon_{\text{lin}}} = \frac{1 + a(k/\text{Mpc}^{-1})^p}{1 + b(k/\text{Mpc}^{-1})^q} f,$$

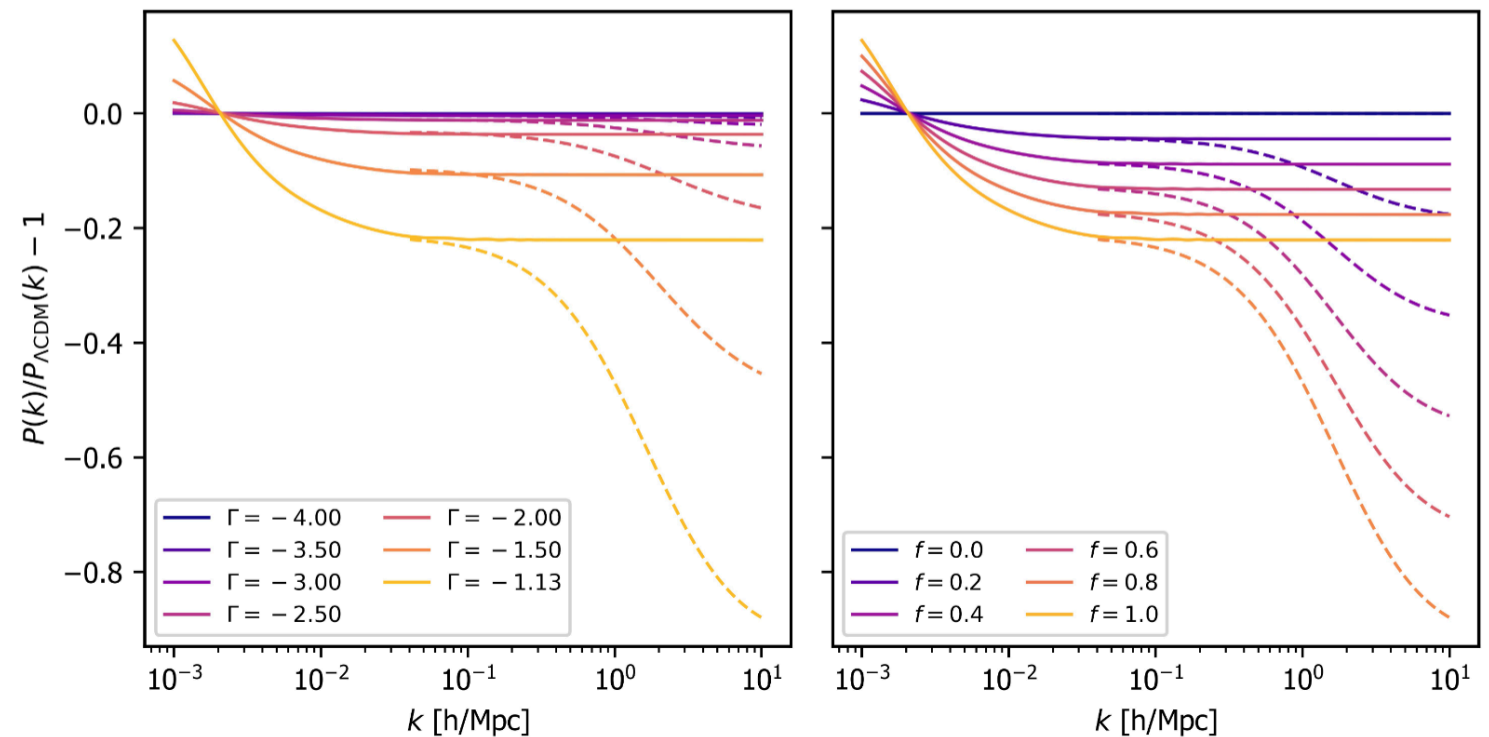
with the factors a , b , p , and q given by

$$a(\tau, z) = 0.7208 + 2.027 \left(\frac{\text{Gyr}}{\tau} \right) + 3.031 \left(\frac{1}{1 + 1.1z} \right) - 0.18,$$

$$b(\tau, z) = 0.0120 + 2.786 \left(\frac{\text{Gyr}}{\tau} \right) + 0.6699 \left(\frac{1}{1 + 1.1z} \right) - 0.09,$$

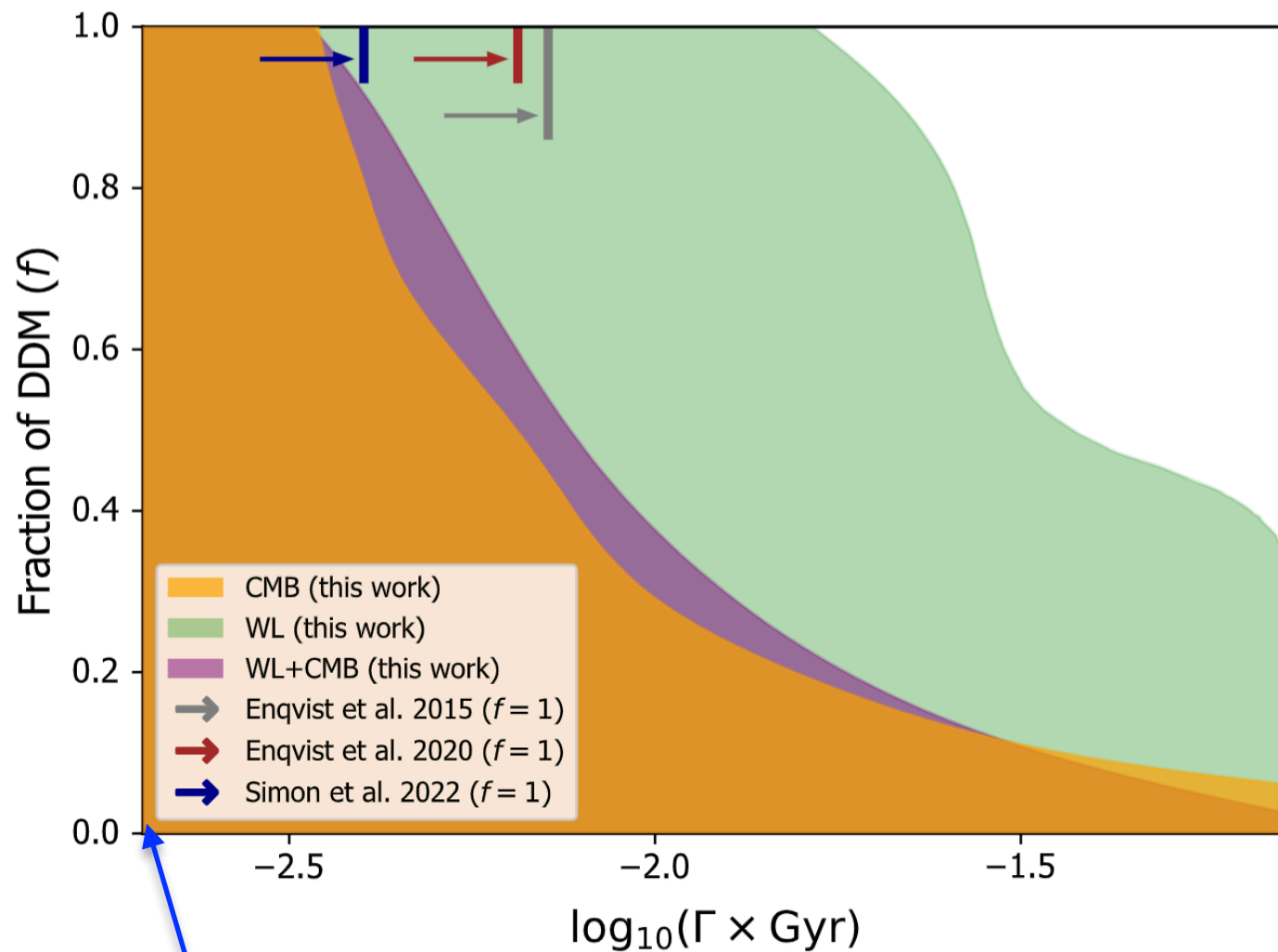
$$p(\tau, z) = 1.045 + 1.225 \left(\frac{\text{Gyr}}{\tau} \right) + 0.2207 \left(\frac{1}{1 + 1.1z} \right) - 0.099,$$

$$q(\tau, z) = 0.992 + 1.735 \left(\frac{\text{Gyr}}{\tau} \right) + 0.2154 \left(\frac{1}{1 + 1.1z} \right) - 0.056.$$

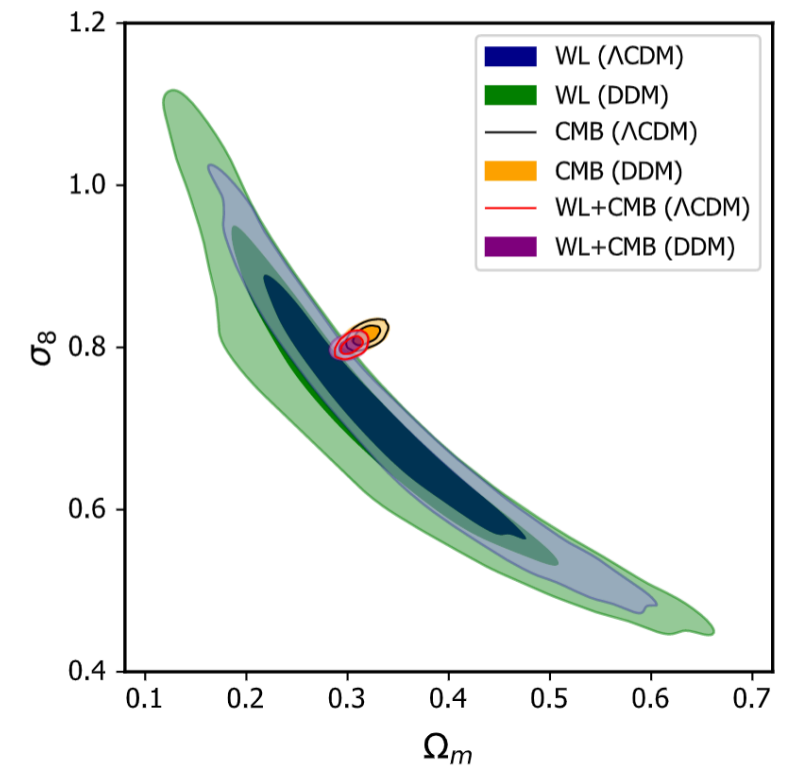


One-body decays of dark matter

- Cosmic shear (*KiDS-1000*) and CMB (*Planck 2018*)
- Nonlinear alignment, baryonic feedback ([BCemu](#))



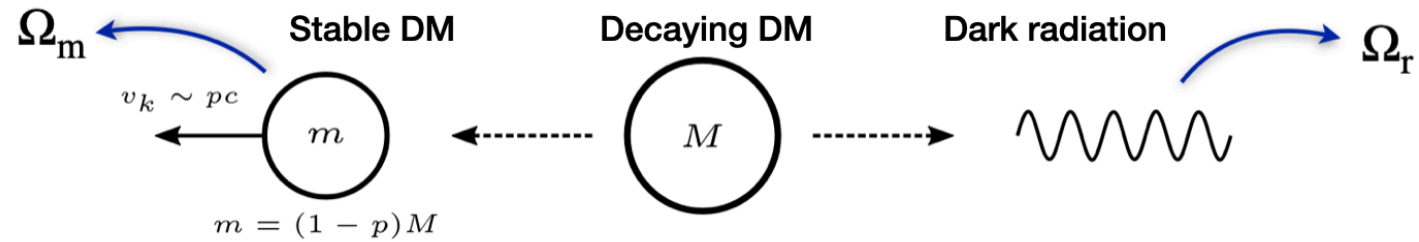
Λ CDM



Takeaway:

- One-body decays strongly constrained by *Planck* data (ISW effect), not that much by weak lensing from KiDS
- Constraints in **agreement with Λ CDM**
- Strongest constraints up-to-date for decay rate Γ and fraction of decaying dark matter f
- One-body decays **cannot explain S_8 tension**

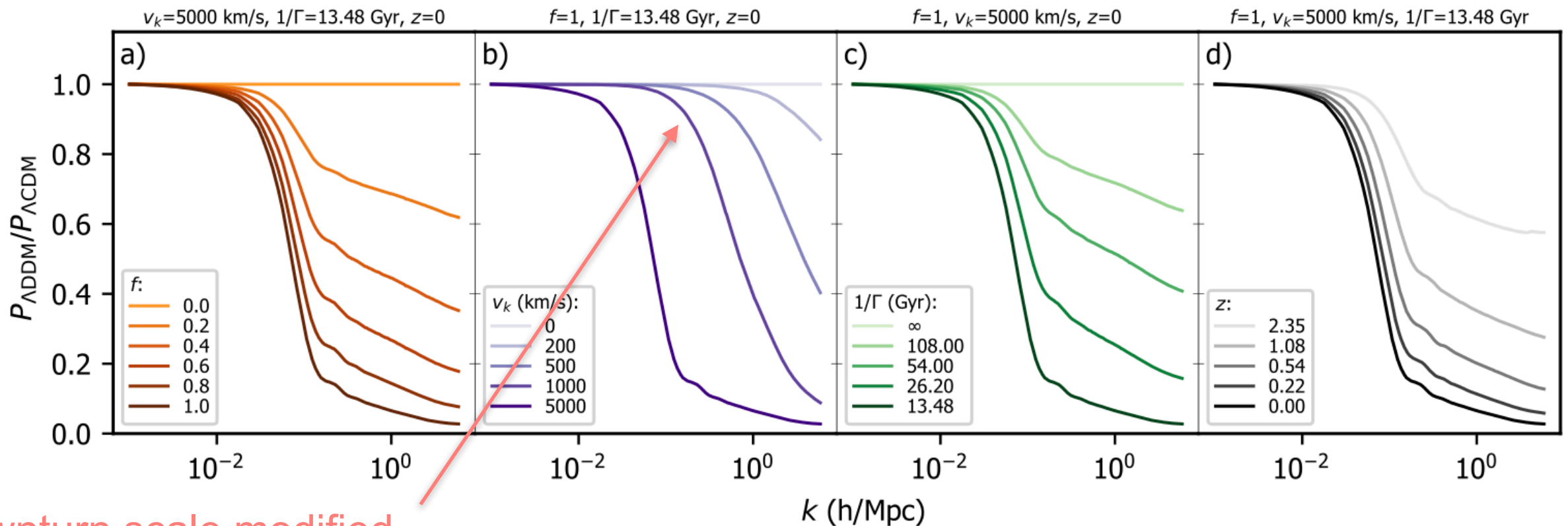
Two-body (late-time) decays of dark matter [Bucko et al. 2023b \(in prep.\)](#)



- Model parameters

 - $\Gamma \equiv 1/\tau$ - decay rate of DM particles or lifetime
 - v_k - velocity kick magnitude
 - f - fraction of decaying DM

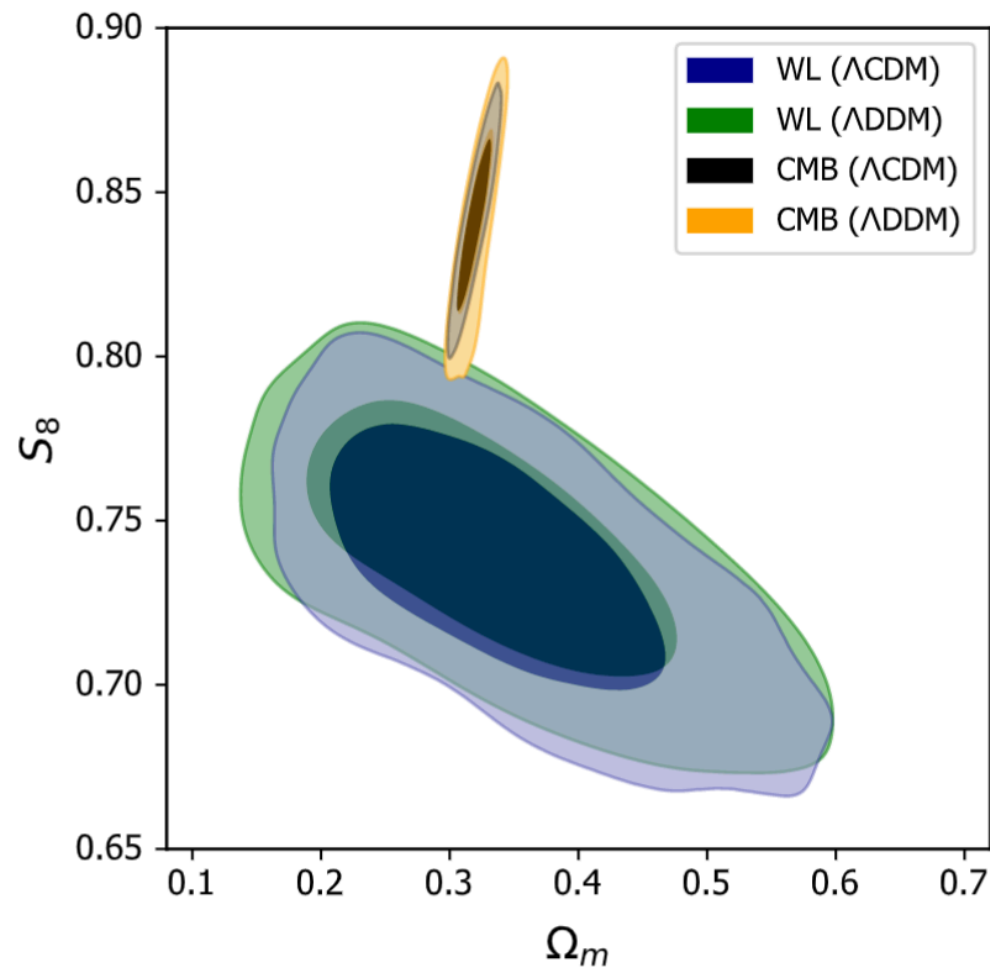
Effects on nonlinear matter $P(k)$ from N -body simulations



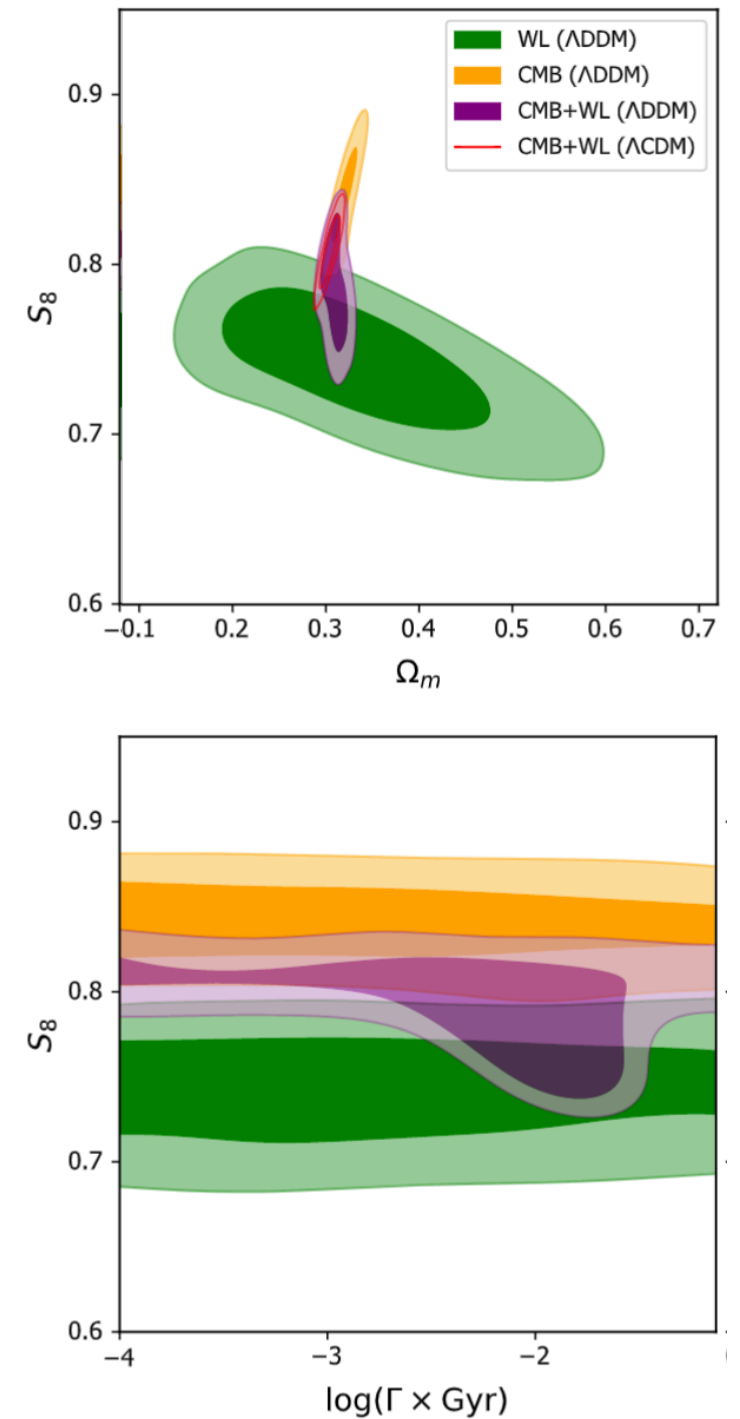
Downturn scale modified

Two-body decays of dark matter

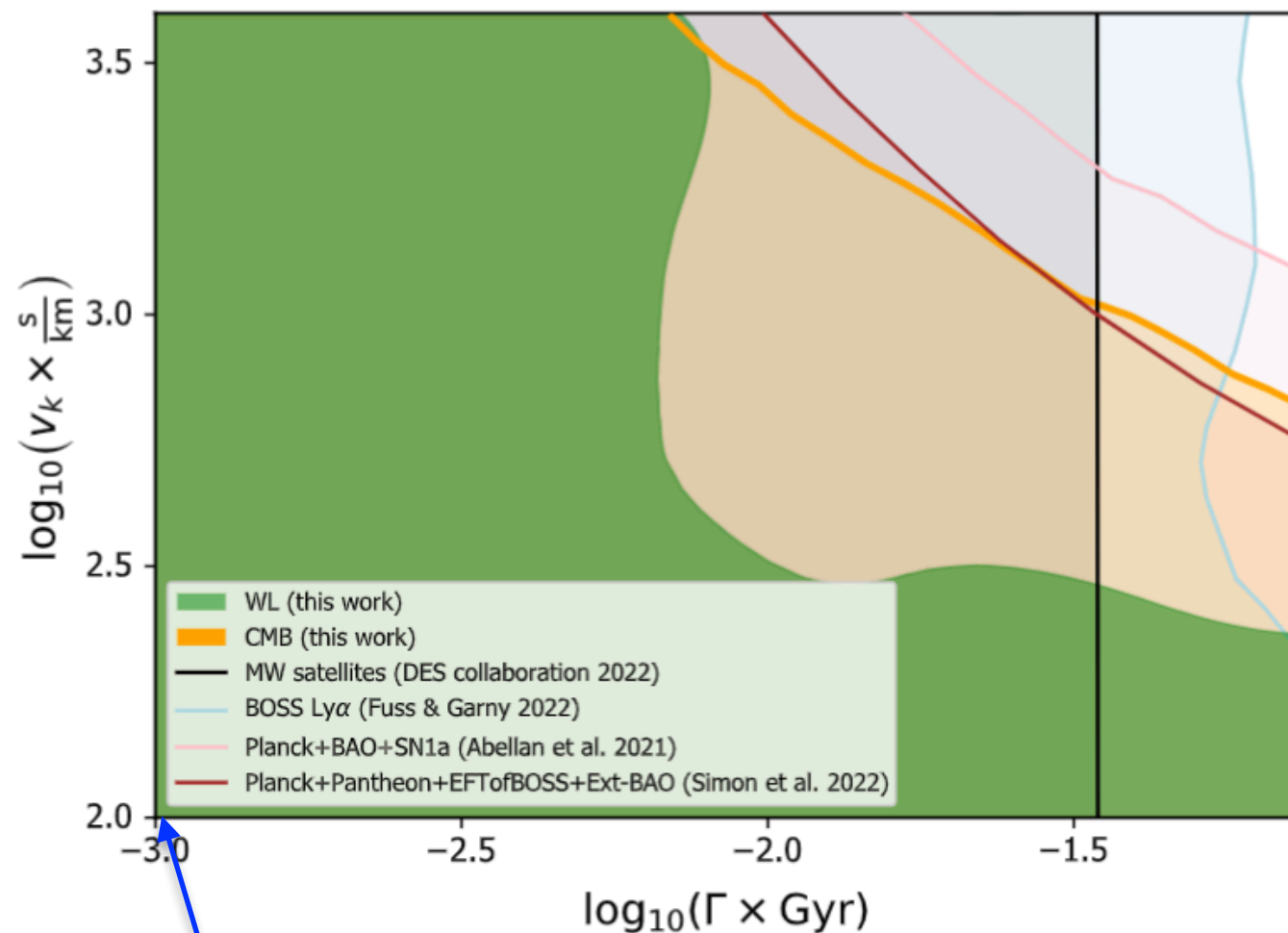
- Λ CDM cosmology preferred
- Negligible modification of (low) S_8 value



When combined with *Planck 2018 TTTEEE*



Two-body decays of dark matter



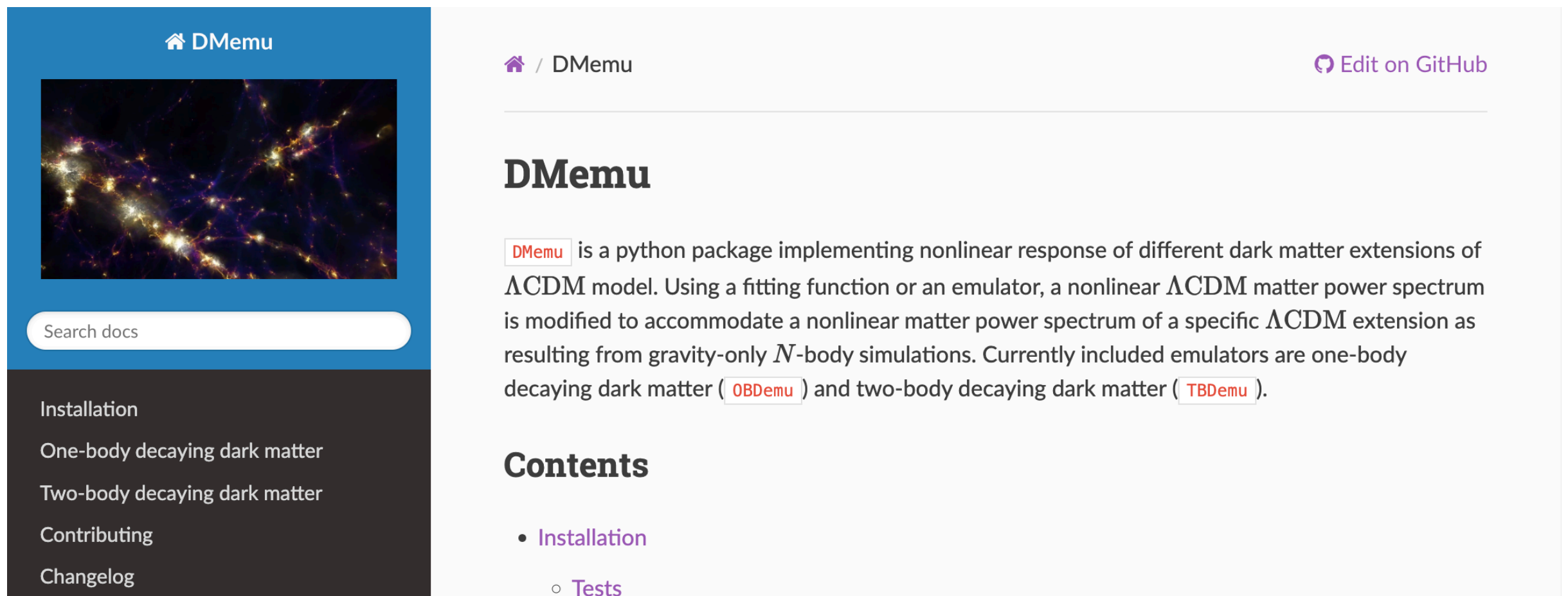
Λ CDM

Takeaway:

- Emulator of nonlinear effects built
- Two-body decays can be strongly constrained by weak lensing from *KiDS*
- Constraints in **agreement with Λ CDM**
- Strongest constraints up-to-date for decay rate Γ and velocity kick magnitude v_k
- Two-body decays **cannot naturally explain S_8 tension**

One & two-body decays of dark matter

- [DMemu](#) - a package for fast emulation of late-time dark matter decays effects of matter $P(k)$
- For different dark matter models and S_8 tension, see also [Hervas Peters et al. 2023](#) (in prep.)



The image shows a screenshot of the DMemu GitHub repository page. On the left, there is a dark blue sidebar with the DMemu logo at the top, a search bar for documentation, and a list of navigation links: Installation, One-body decaying dark matter, Two-body decaying dark matter, Contributing, and Changelog. The main content area has a light blue header with a home icon and the text 'DMemu', and a purple link to 'Edit on GitHub'. Below the header, the title 'DMemu' is displayed in large bold letters. The description states that DMemu is a Python package implementing the nonlinear response of different dark matter extensions of the Λ CDM model, using fitting functions or emulators to modify the nonlinear matter power spectrum. It mentions that currently included emulators are one-body decaying dark matter (OBDemu) and two-body decaying dark matter (TBDemu). A 'Contents' section lists 'Installation' and 'Tests' as sub-topics.

www.dmemu.readthedocs.io



Thank you...

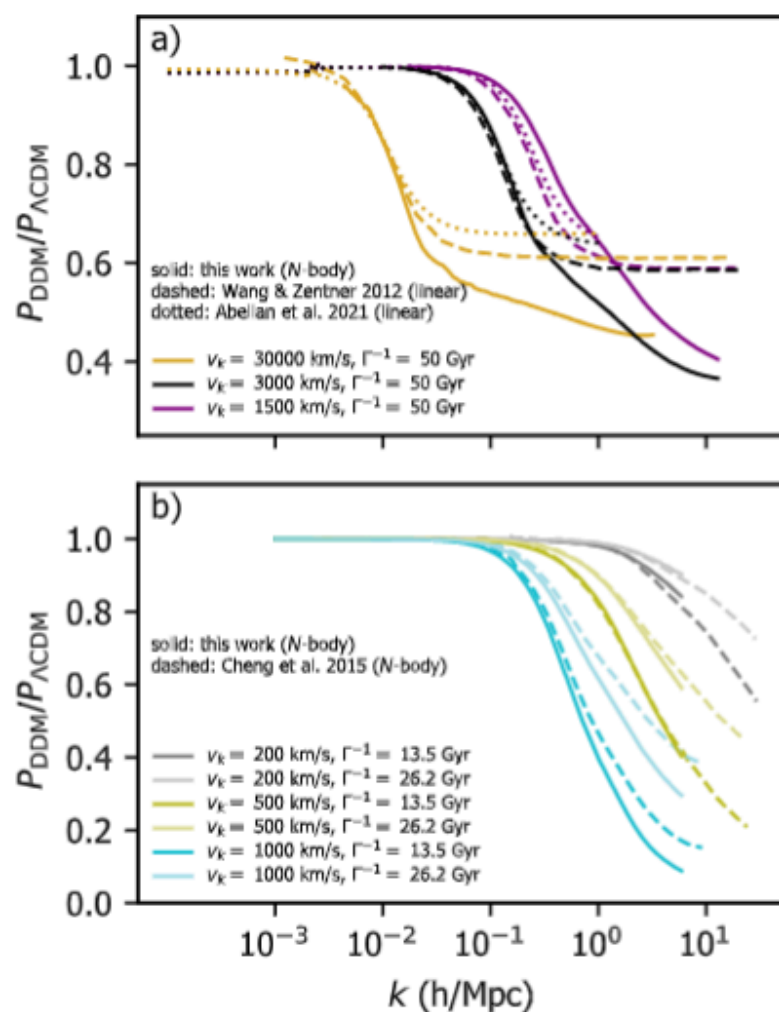
...and enjoy the conference dinner!



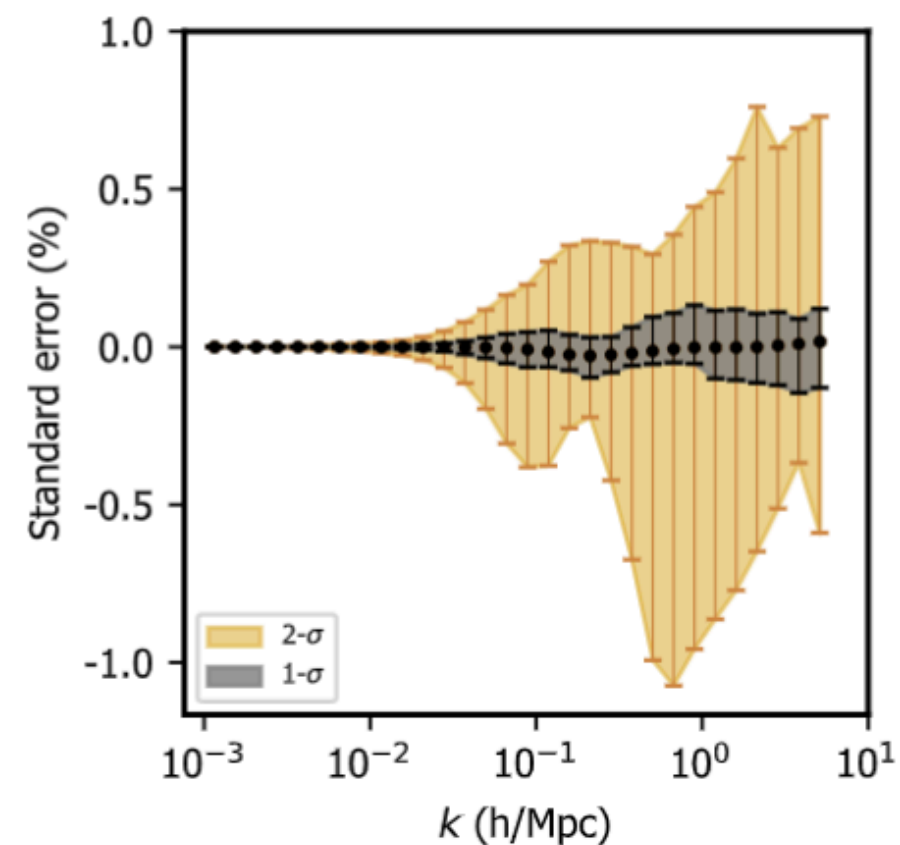
DALL-E: “cosmology barbecue party”

Two-body decays -

N -body simulations of warm DM decays compared to past N -body implementation and to predictions of Boltzmann code



Warm DM emulator's performance



Two-body late-time decays of dark matter: effects on observables

