Easing the σ_8-tension with neutrino-dark matter interactions

MARKUS R. MOSBECH

THE UNIVERSITY OF SYDNEY

Based on the work by

Markus R. Mosbech,[a] Celine Boehm,[a] Steen Hannestad,[b] Olga Mena,[c] Julia Stadler,[d] and Yvonne Y. Y. Wong[e]

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Motivations

Neutrino masses

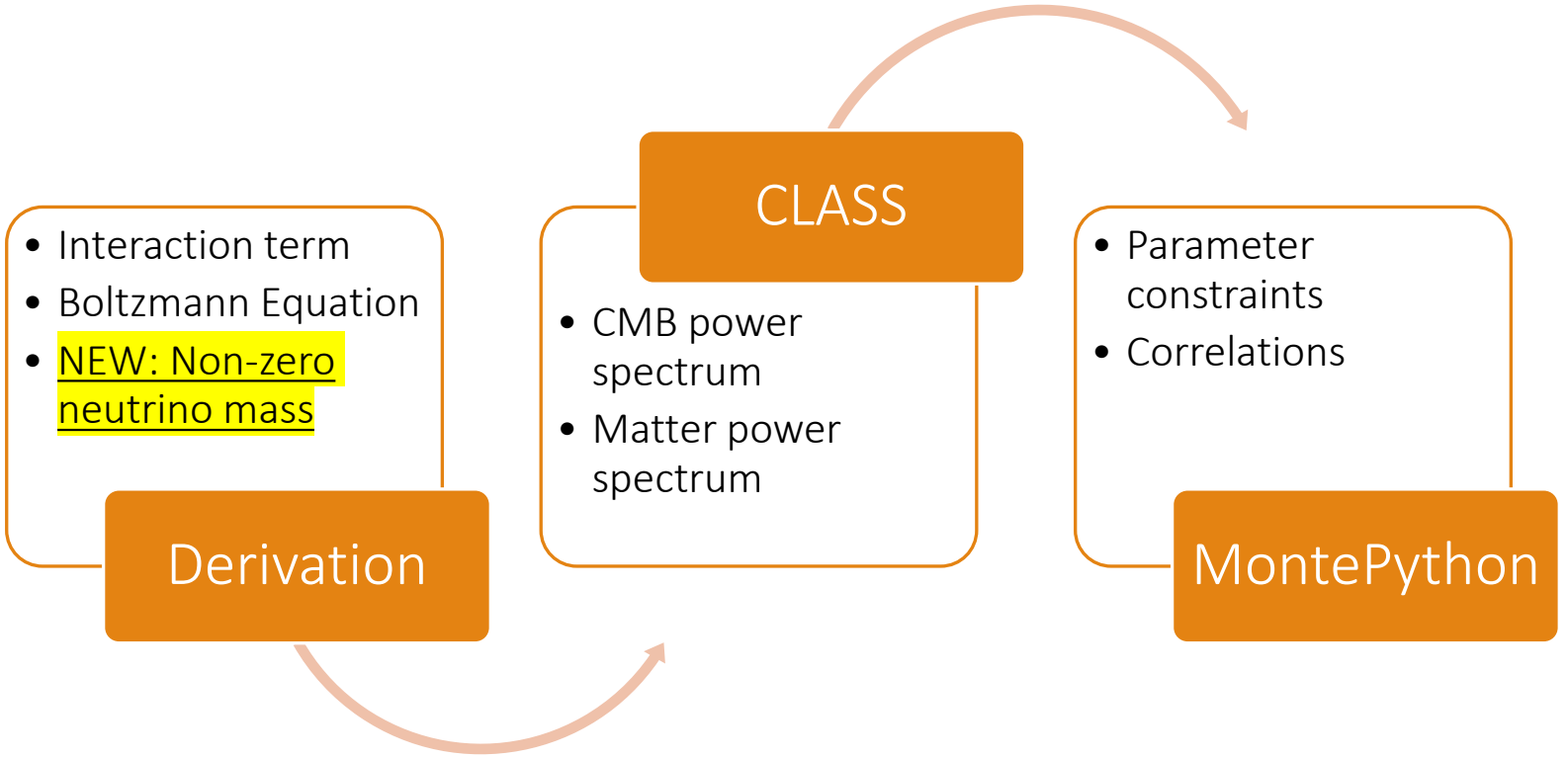
- Evidence from oscillation experiments, but not previously accounted for in this type of DM interaction study.

H_0 tension

- Planck vs. local measurements (e.g. SH0ES)

σ_8 tension

- Planck vs. local measurements (e.g. KiDS-1000)


Interaction term
Boltzmann Equation
NEW: Non-zero neutrino mass
Derivation
CLASS
CMB power spectrum
Matter power spectrum
Parameter constraints
Correlations
MontePython

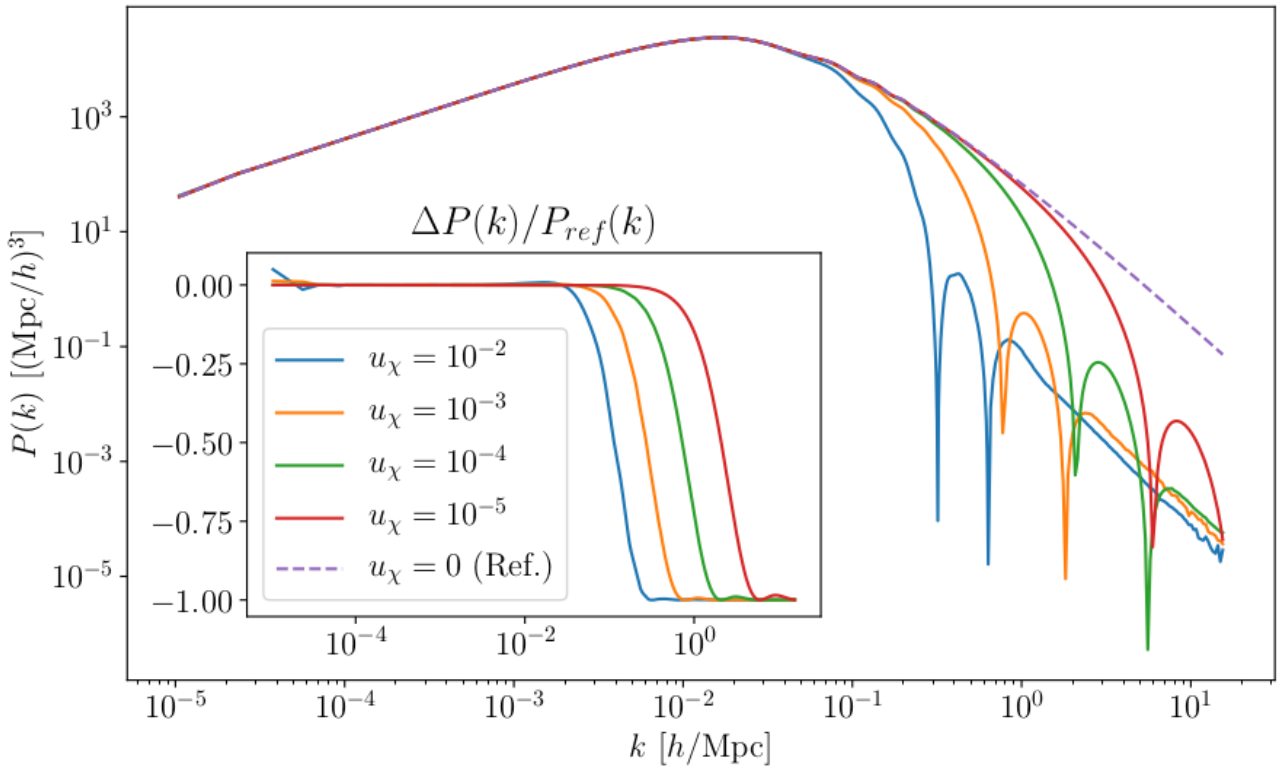
The Boltzmann equation slide

- Describes the evolution of the distribution function
- The early universe is fairly homogeneous → perturbation theory
- Fourier transform → scales decouple

$$P^\alpha \frac{\partial f}{\partial x^\alpha} - \Gamma^\gamma_{\alpha\beta} P^\alpha P^\beta \frac{\partial f}{\partial P^\gamma} = m \left(\frac{\partial f}{\partial \tau}\right)_C$$

$$\dot{\delta}_{\rm cdm} = -\theta_{\rm cdm} + 3\dot{\phi}\,,$$
$$\dot{\theta}_{\rm cdm} = -\frac{\dot{a}}{a}\theta_{\rm cdm} + k^2\psi$$

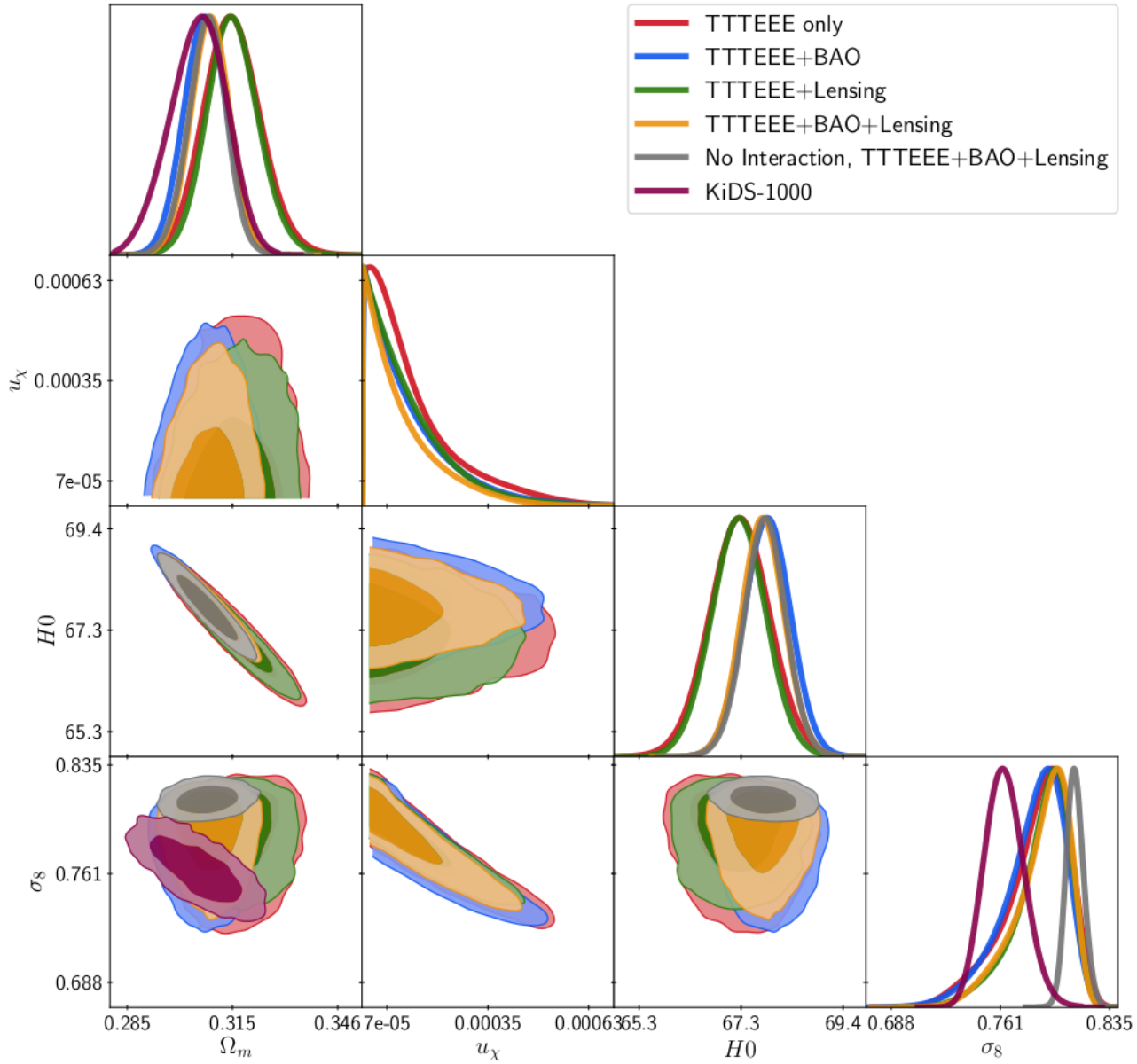
$$\frac{\partial \Psi_0}{\partial \tau} = -\frac{pk}{E_\nu(p)}\Psi_1 - \dot{\phi}\frac{d\ln f^{(0)}(p)}{d\ln p}\,,$$
$$\frac{\partial \Psi_1}{\partial \tau} = \frac{1}{3}\frac{pk}{E_\nu(p)}\left(\Psi_0 - 2\Psi_2\right) - \frac{E_\nu(p)\,k}{3p}\psi\frac{d\ln f^{(0)}(p)}{d\ln p}$$
$$\frac{\partial \Psi_l}{\partial \tau} = \frac{1}{2l+1}\frac{pk}{E_\nu(p)}\left(l\Psi_{l-1} - (l+1)\Psi_{l+1}\right), \quad l \geq 2$$



$$u_{\nu\chi} = \frac{\sigma_0}{\sigma_{\rm Th}} \left(\frac{m_\chi}{100\,{\rm GeV}}\right)^{-1}$$

- Suppression similar to WDM
- 'Peaks' shifted to slightly higher *k* compared to massless neutrino case (Same *u* yields smaller effect)
  For comparison see arXiv:1903.00540
- Matches expectation from new p^2/E^2 dependence

$$C_\chi = a\, u_{\nu\chi}\, \frac{\sigma_{\rm Th}\rho_\chi}{100\,{\rm GeV}} \frac{p^2}{E_\nu^2}$$



- No significant impact on H_0
- Stronger interaction → lower σ_8