Non-thermal Hot Dark matter in Light of S_8 Tension

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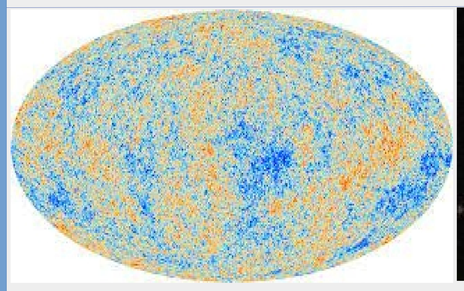
What is S8 Tension

Defined as $S_8 = \sigma_8 \sqrt{\frac{\Omega_m}{3}}$

Where σ_8 is the root mean square of matter fluctuations on a 8Mpc/h scale

Ω_m is matter density parameter



Planck CMB

$S_8 = 0.832 \pm 0.013$

KIDS/VIKING+DES

$S_8 = 0.755^{+0.019}_{-0.021}$

Tension of 3σ

Solution

Just a massive thermal neutrino not enough

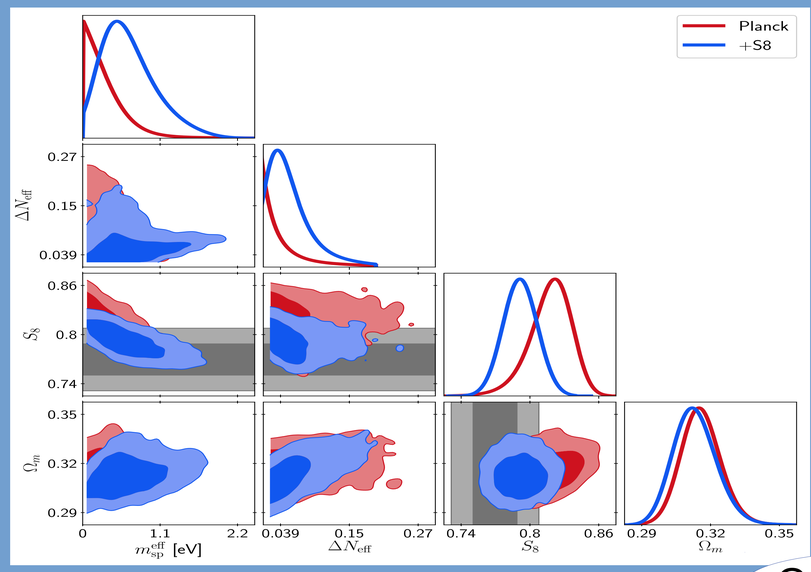
Nonthermal Dark Matter

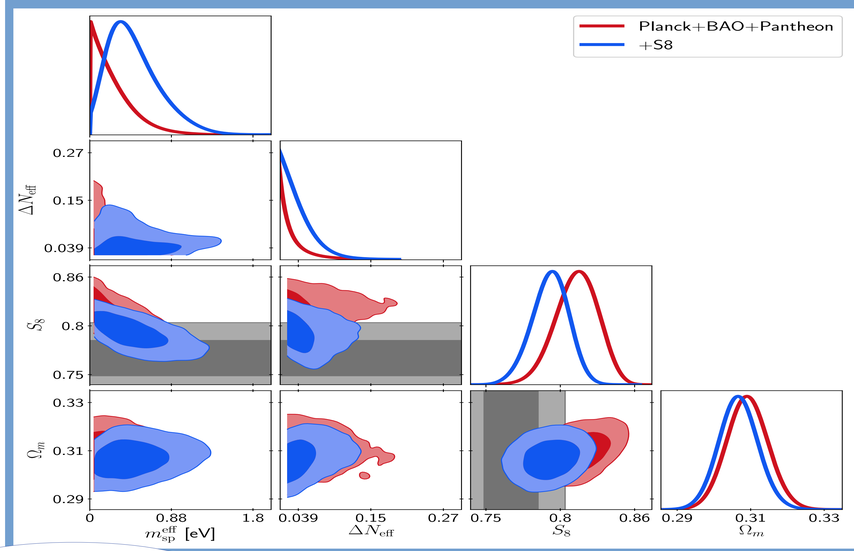
- Nonthermal sterile particle produced from moduli decay
- Sterile particle obeying Nonthermal Dodelson widrow distribution
- Thermal sterile particle with a different temperature in the hidden section

All three Non-thermal models have same cosmological implications

Model	Non-thermal		Thermal		Dodelson Widrow	
Data set	$m_{\rm sp}$ [eV]	$B_{\rm sp}$	$m_{\rm sp}$ [eV]	$\frac{T_s}{T_\nu}$	$m_{\rm sp}$ [eV]	χ
Planck	0.05	0.01	0	0.40	0	0.03
Planck+S_8	38.62	0.012	11.36	0.43	26.43	0.03
Planck+Ext	18.98	0.01	04.59	0.36	12.85	0.02
Planck+Ext+S_8	39.81	0.01	11.75	0.43	27.49	0.03

MCMC Analysis Results



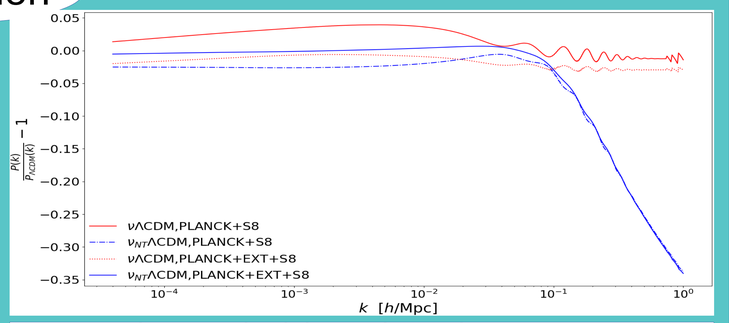


Conclusion

Planck data+S8 Prior we get $S_8(\nu_{NT}\Lambda CDM) = 0.816^{+0.022}_{-0.016}$ i.e. value get 1 sigma downward shift compared to LCDM. The chi2 is also improved by -4.8.

Inclusion of BOSS+Pantheon with Planck and S8 prior we get. $S_8(\nu_{NT}\Lambda CDM) = 0.795^{+0.015}_{-0.013}$. The tension get allevieted . How ever the inlcusion of S8 prior in with these additional data sets are not favoured by chi2 numbers

We have got contraints on other nonthermal models mainly Dodelsonwidrow model and thermal hidden sector with a different temperature. Contraint shown in table



Compared to standard thermal neutrinos, $\nu_{NT}\Lambda CDM$ leads to a much stronger suppression in the matter power spectrum at late-times thus significant decrease in S8.

Future Goals

In future ,improving BAO data sets may show better consistency with our model

Analysis including results of short base line neutrino oscillation

In future N-body simulations may help to distinguish among all three Nonthermal models

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