Neutrino and dark matter

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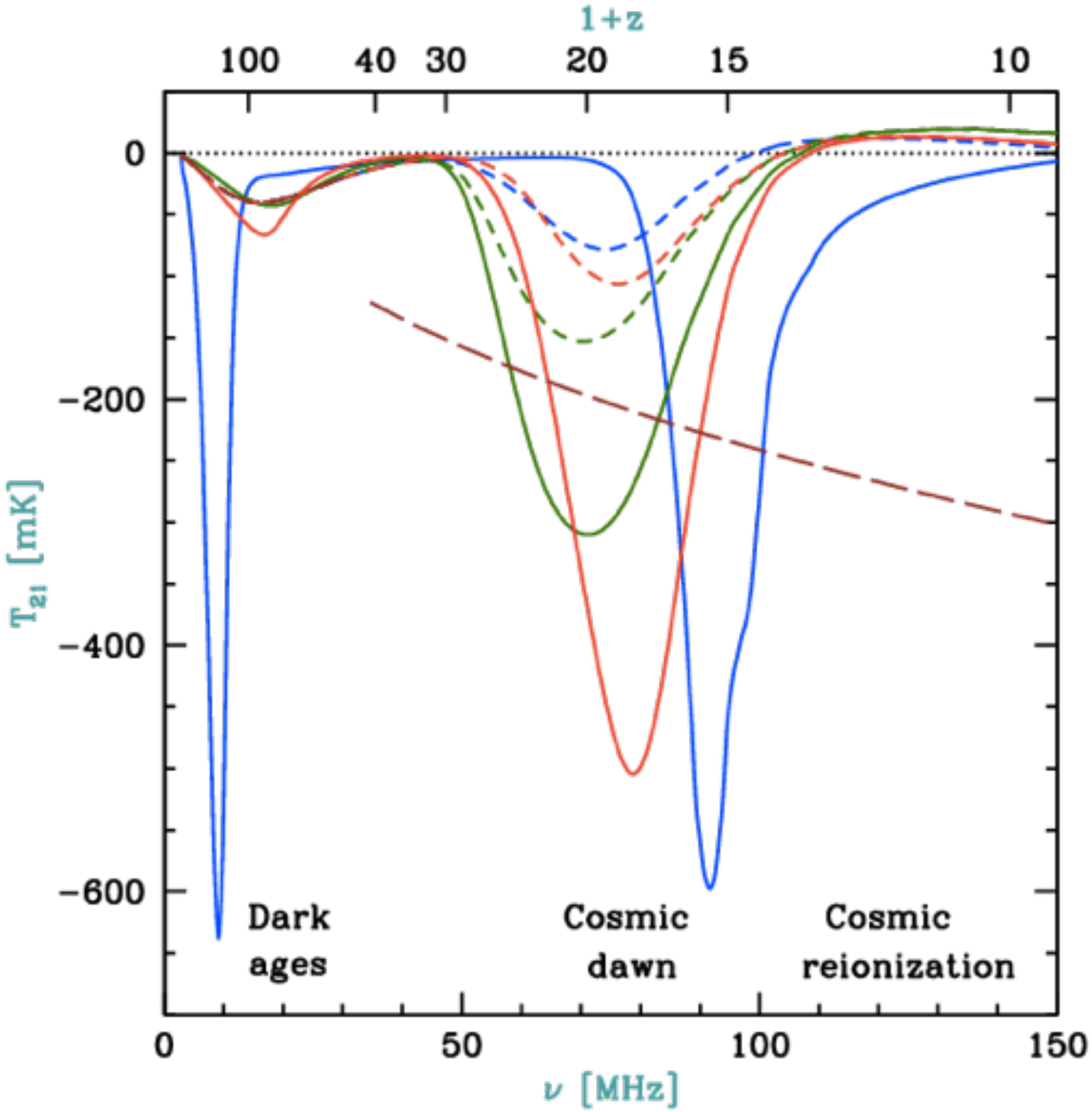
21-cm EDGES experiment Bowman et al Nature 2018



DM-baryon Cross-section σ=8×10−20~cm2 and DM particle mass $m\chi$=0.3~GeV (red); σ=3×10−19~cm2 and $m\chi$=2~GeV (green), and σ=1×10−18~cm2 and $m\chi$=0.01~GeV (blue). The corresponding 21-cm signals in the absence of b-DM scattering are shown as short-dashed curves.

Barkana, Nature, 2018, Possible signature of Dark Matter

Stacy McGaugh Phys Rev Lett. 2018

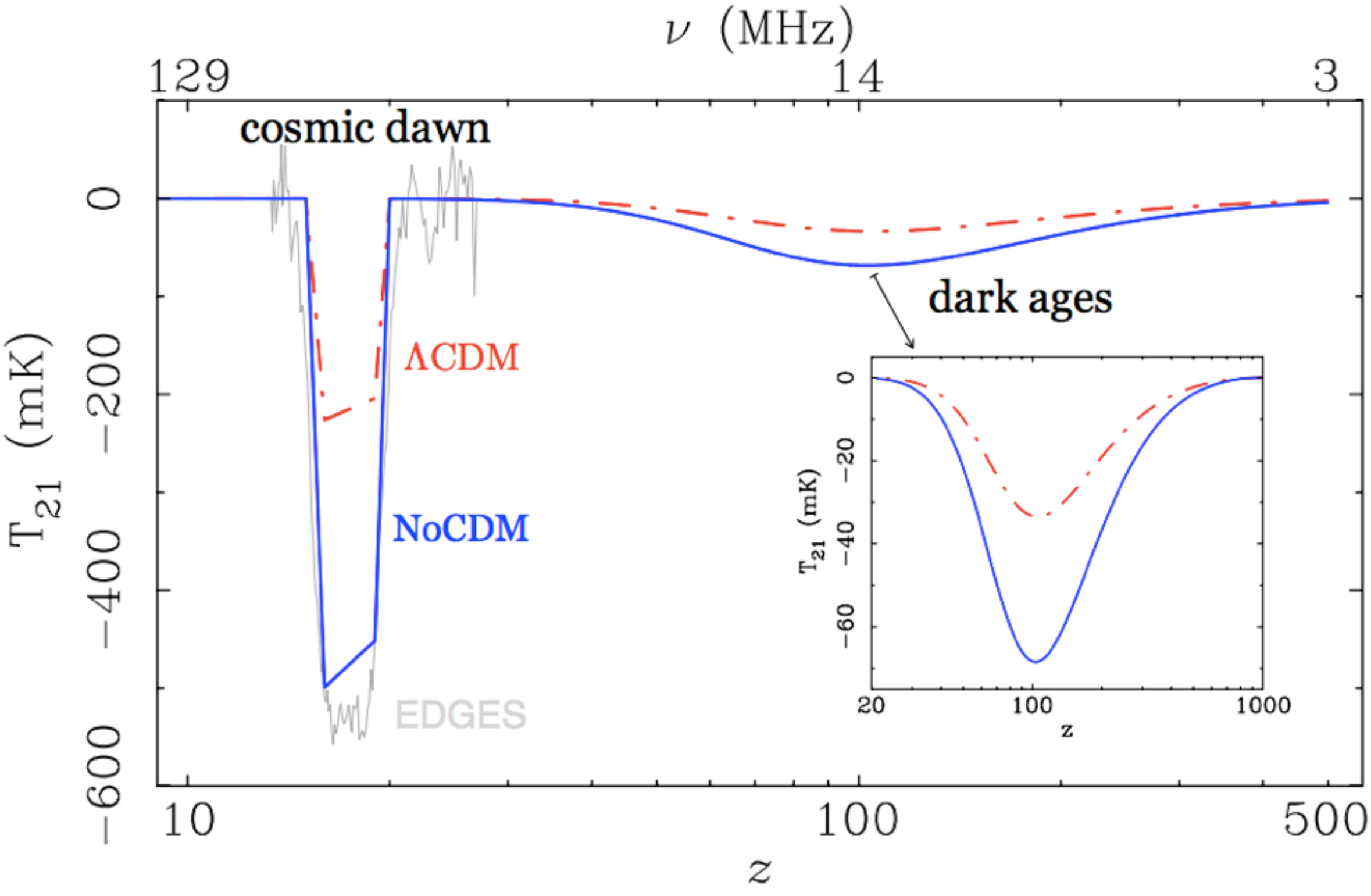


TABLE I. Predicted Spin Temperatures and 21cm Absorption

			ΛCDM[a]	NoCDM[b]	ΛCDM	NoCDM
z	ν (MHz)	T_γ (K)	T_S (K)		T_{21} (mK)	
Cosmic Dawn						
16	83	46.3	6.16	6.56	−226	−499
17	79	49.1	6.90	7.34	−218	−482
18	75	51.8	7.67	8.15	−211	−467
19	71	54.5	8.48	9.02	−204	−452
Dark Ages						
50	28	139	119	119	−10	−22
100	14	275	197	203	−33	−68
200	7	548	471	478	−19	−37

[a] ΛCDM: $\Omega_b = 0.0488$, $\Omega_{\rm CDM} = 0.2633$, $\Omega_\Lambda = 0.6879$, $h = 0.675$.
[b] NoCDM: $\Omega_b = 0.039$, $\Omega_{\rm CDM} = 0$, $\Omega_\Lambda = 0.91$, $h = 0.75$ (RECFAST inputs).

Does neutrino self-interaction have an effect on 21-cm absorption ?

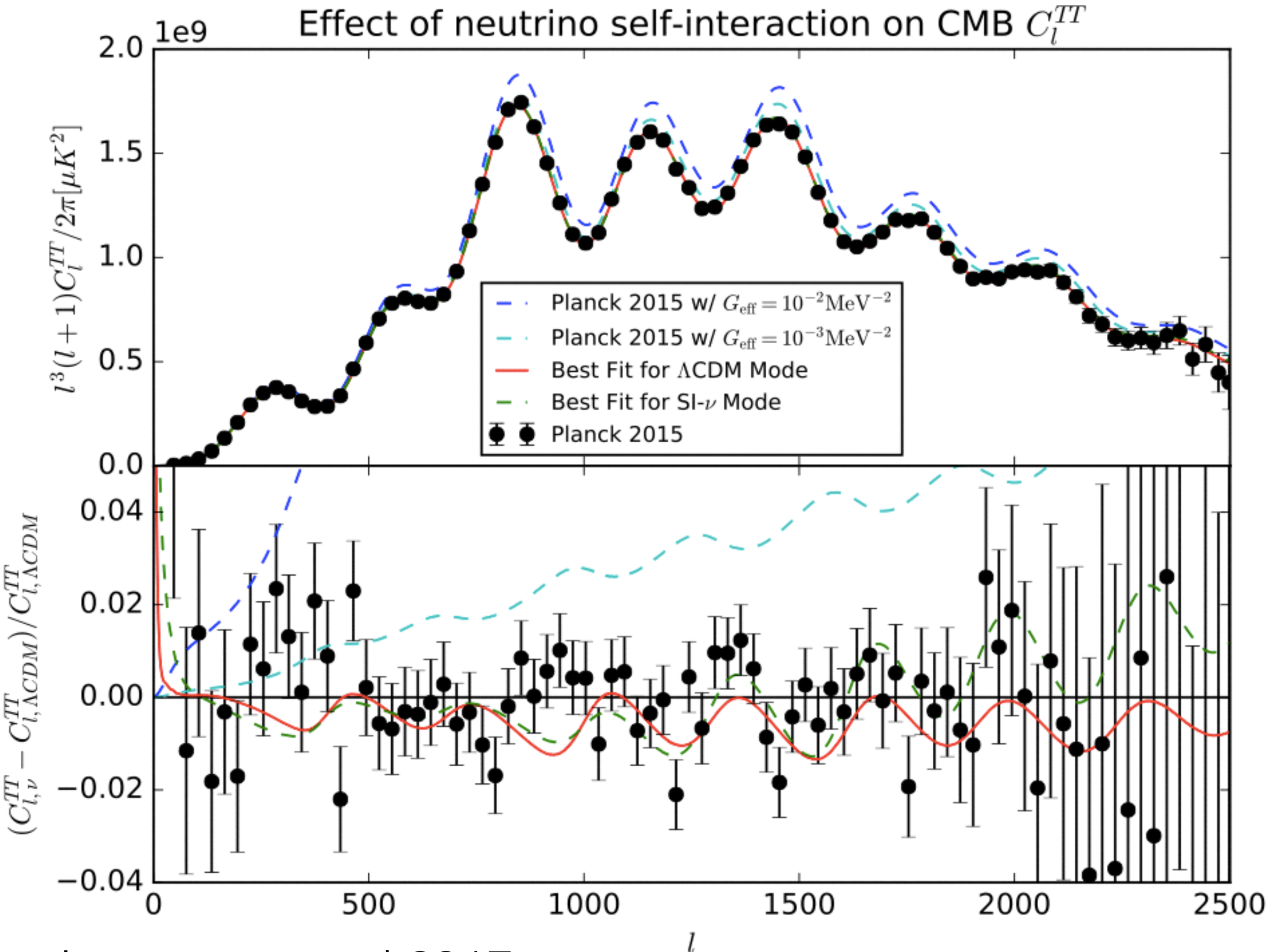
Interactions between active neutrinos

Lancaster et al-1704.06657

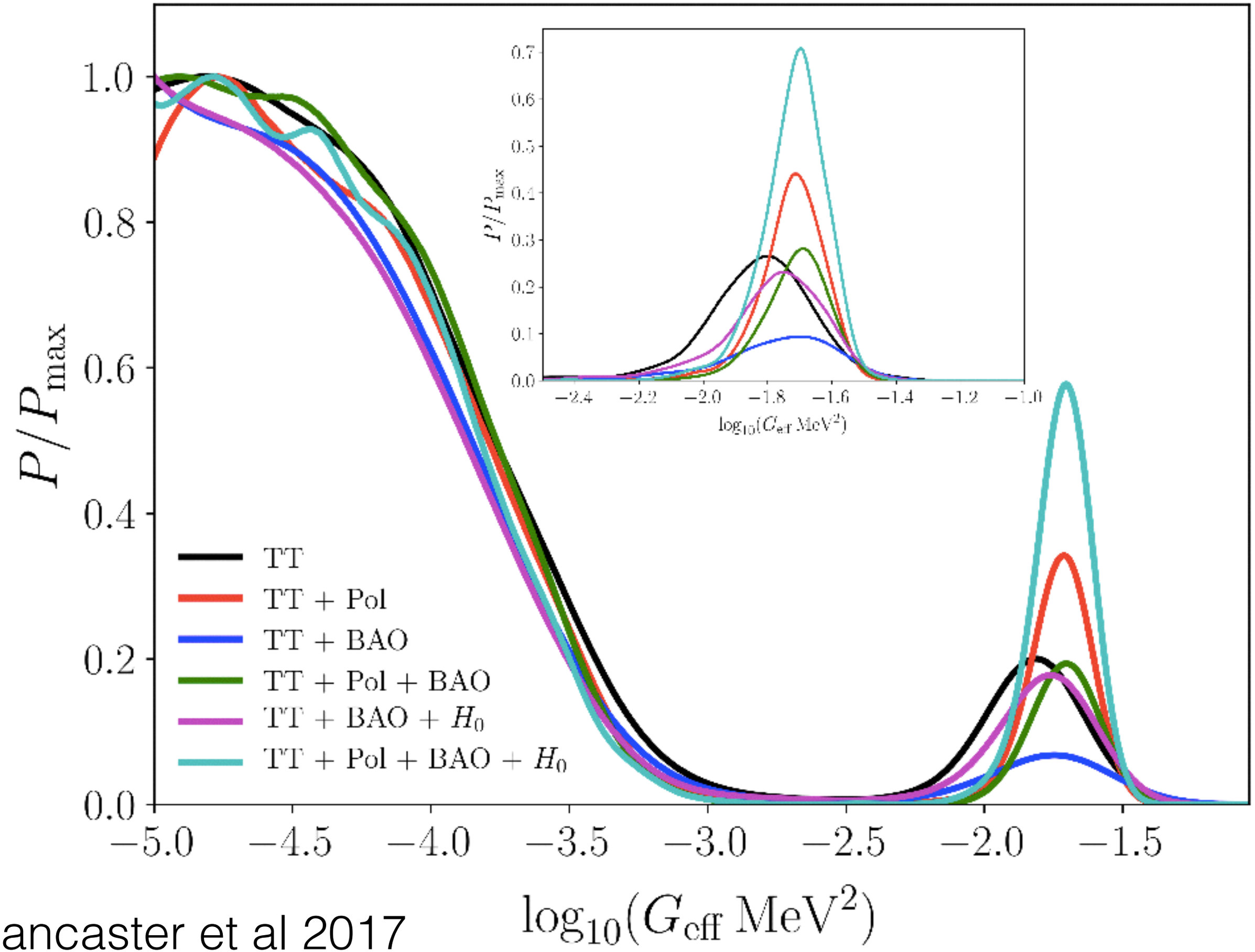
$$\mathcal{L} = y\,\phi\,\nu^c\,\nu$$

$$G = \frac{y^2}{M_\phi^2}$$

Constraints on from CMB, LSS ..



Lancaster et al 2017



Lancaster et al 2017

Table 1. Parameter constraints in the ΛCDM mode for 4 different data combinations. Unless otherwise noted, we display the 68% confidence limits.

Parameter	TT	TT + Pol	TT + Pol + BAO	TT + Pol + BAO + H_0
$\Omega_b h^2$	0.02222 ± 0.00027	0.02223 ± 0.00017	0.02226 ± 0.00014	0.02231 ± 0.00014
$\Omega_c h^2$	0.1190 ± 0.0026	0.1193 ± 0.0016	0.1189 ± 0.0011	0.1183 ± 0.0011
H_0 [km/s/Mpc]	68.1 ± 1.2	67.90 ± 0.72	68.11 ± 0.50	68.36 ± 0.50
τ_{reio}	0.098 ± 0.033	0.095 ± 0.024	0.099 ± 0.022	0.104 ± 0.022
n_s	0.9634 ± 0.0082	0.9620 ± 0.0057	0.9634 ± 0.0047	0.9650 ± 0.0047
$10^9 A_s$	2.28 ± 0.14	2.27 ± 0.10	2.284 ± 0.096	2.304 ± 0.098
$\log_{10}(G_{eff}\mathrm{MeV}^2)$	< -3.48 (95%)	< -3.55 (95%)	< -3.57 (95%)	< -3.60 (95%)

Table 2. Parameter 68% confidence limits within the interacting neutrino mode.

Parameter	TT	TT + Pol	TT + Pol + BAO	TT + Pol + BAO + H_0
$\Omega_b h^2$	0.02256 ± 0.00033	0.02248 ± 0.00017	0.02240 ± 0.00016	0.02244 ± 0.00016
$\Omega_c h^2$	0.1177 ± 0.0028	0.1200 ± 0.0017	0.1210 ± 0.0013	0.1206 ± 0.0012
H_0 [km/s/Mpc]	70.4 ± 1.3	$69.59^{+0.74}_{-0.71}$	69.13 ± 0.51	69.33 ± 0.52
τ_{reio}	0.113 ± 0.036	$0.103^{+0.022}_{-0.024}$	$0.094^{+0.021}_{-0.023}$	0.098 ± 0.021
n_s	$0.9431^{+0.0091}_{-0.0084}$	0.9376 ± 0.0054	$0.9344^{+0.0045}_{-0.0047}$	0.9359 ± 0.0047
$10^9 A_s$	$2.21^{+0.15}_{-0.16}$	$2.164^{+0.093}_{-0.10}$	$2.131^{+0.087}_{-0.095}$	2.145 ± 0.091
$\log_{10}(G_{eff}\mathrm{MeV}^2)$	-1.83 ± 0.16	$-1.727^{+0.10}_{-0.092}$	$-1.711^{+0.099}_{-0.11}$	$-1.720^{+0.10}_{-0.094}$

Lancaster et al 2017

Consequences of neutrino self-interactions in ‘observed’ cutoff at IceCube

* Cutoff of IceCube Neutrino Spectrum due to t-channel Resonant Absorption by CνB - Sadhukhan, Ashish Narang, SM,

arXiv:1808.01272

* Are We Looking at Neutrino Absorption Spectra at IceCube? - Sidhartha Karmakar, Sujata Pandey, Subhendu Rakhshit

arXiv:1810.04192

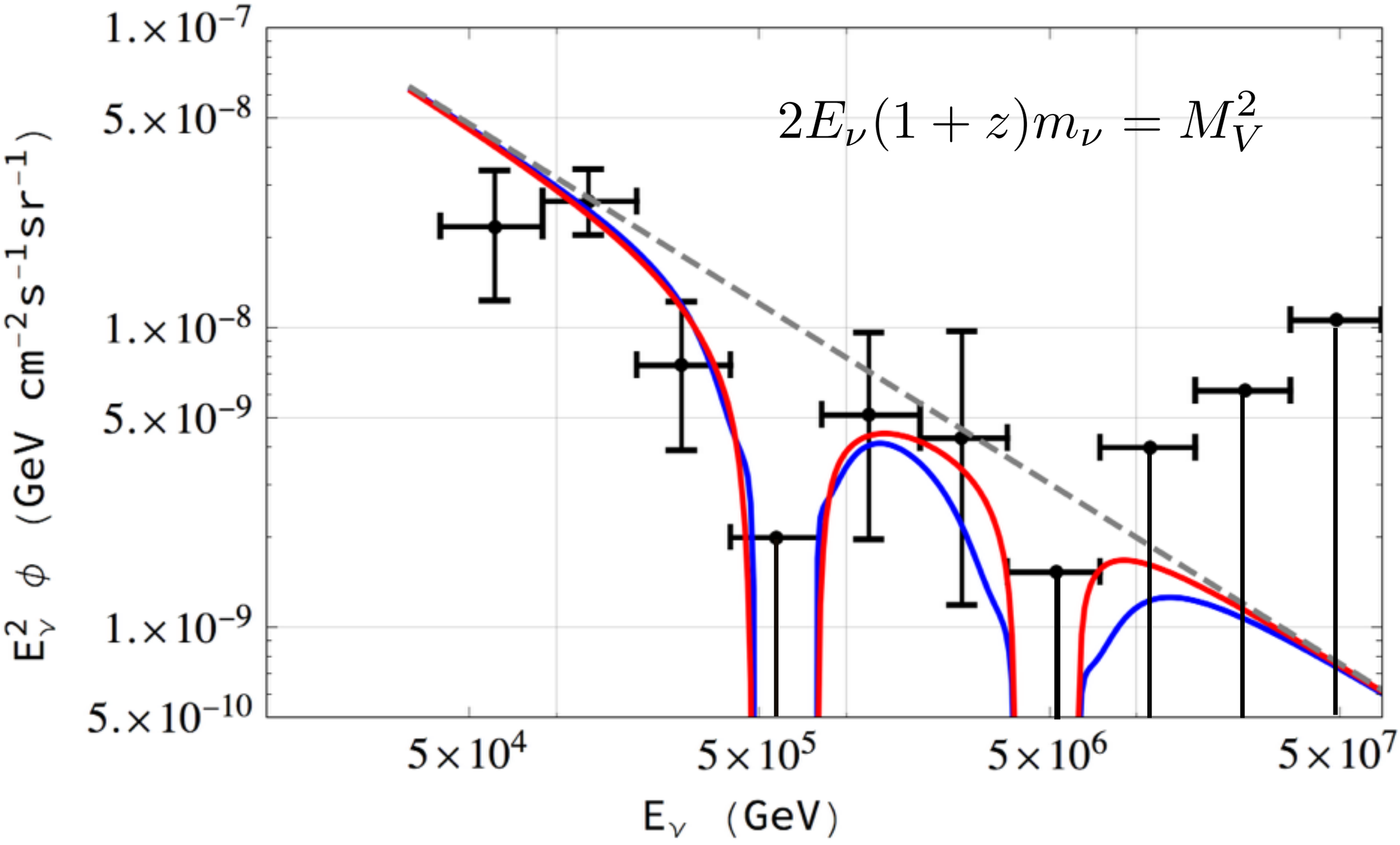
eV sterile neutrino

- LSND, MiniBoone, Reactor oscillation experiments
- Too comply with BBN and large mixing with active neutrinos- require self interactions via MeV scale vector or scalar particles - Basudeb Dasgupta...

$$L = \bar{\nu}_s \gamma^\mu P_L \nu_s V^\mu, \qquad \mathrm{M}_V \sim 10 MeV$$

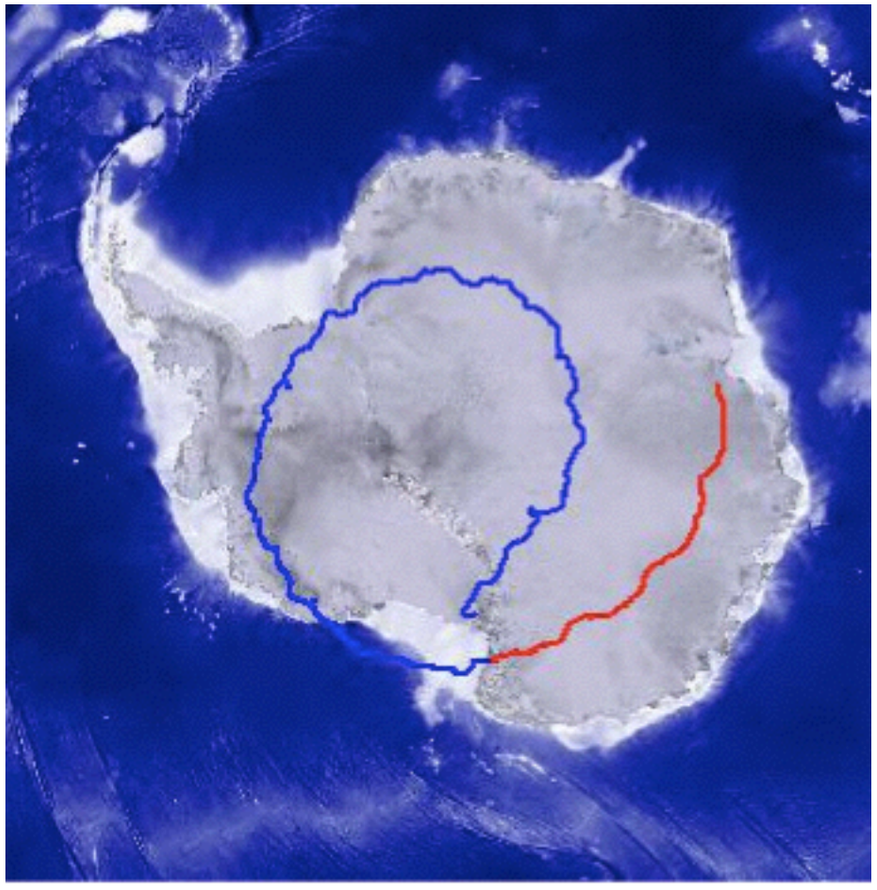
IceCube Signal

Bhavesh Chauhan and SM - 1808.04774



ANITA

ANtarctic Impulsive Transient Antenna



Measures cosmic ray induced showers by their radio emission

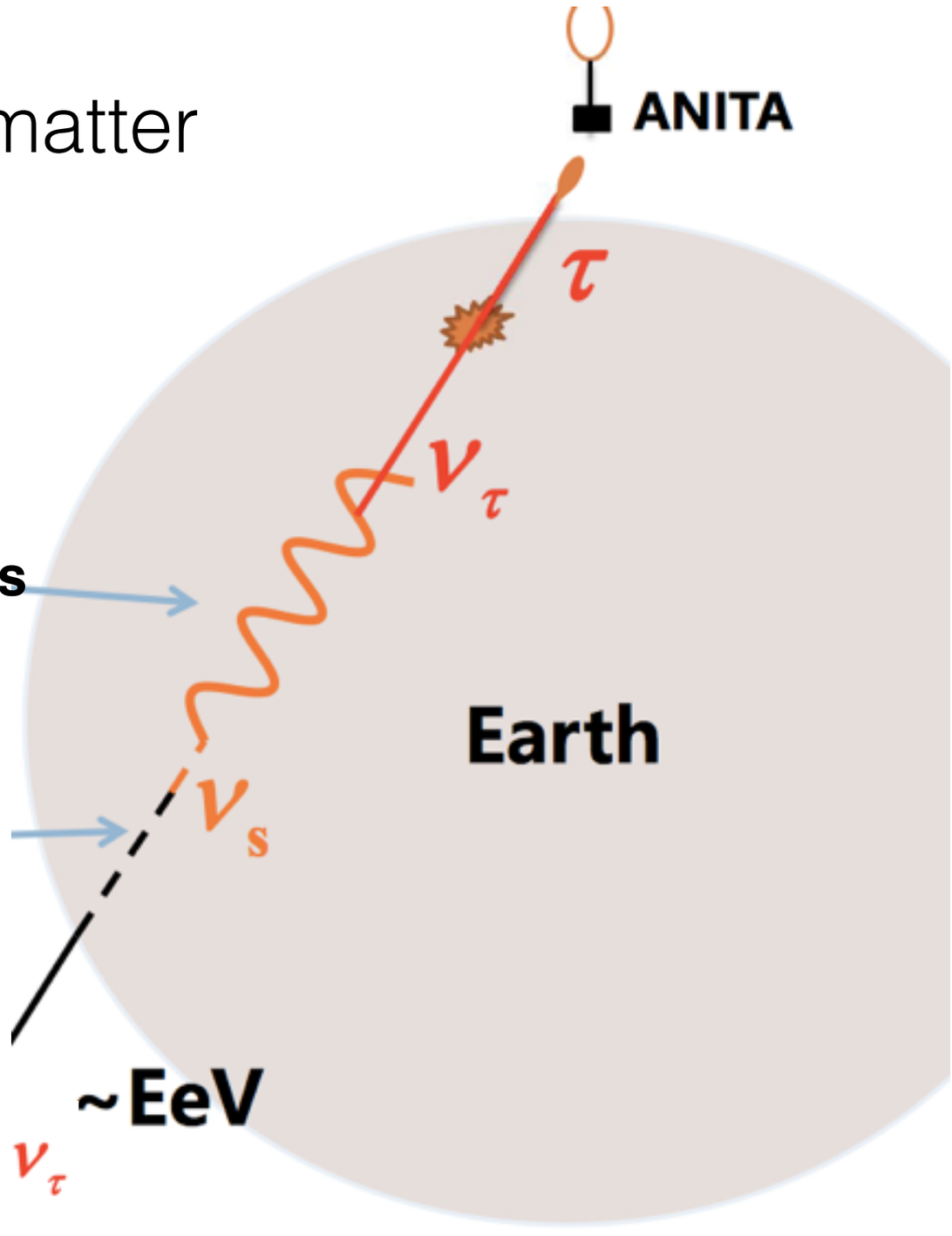
ANITA anomalous events

event,flight	3985267,ANITA-I	15717147,ANITA-III
date	2006-12-28	2014-12-20
altitude	2.56 km	2.75 km
angle θ_h	-27.4±0.3°	-35.0±0.3°
shower energy	0.6±0.4 EeV	$0.56^{+0.3}_{-0.2}$ EeV
chord length	5800 km	7300 km

- **2 keV sterile neutrino G Huang 1804.0536**

$\theta = 0.1$

Cannot be dark matter



Sterile to active oscillations

$$\nu_4 = \cos\theta\,\nu_s + \sin\theta\,\nu_\tau$$

Relating flavour and neutrino anomalies

- Lepton flavour unitarity violation in

$b \to s \mu^+ \mu^-$ $\qquad$ $b \to c \tau \nu$

- Magic bullet is the vector Leptoquark : U1=(3,1,2/3)

U1 Leptoquark couplings

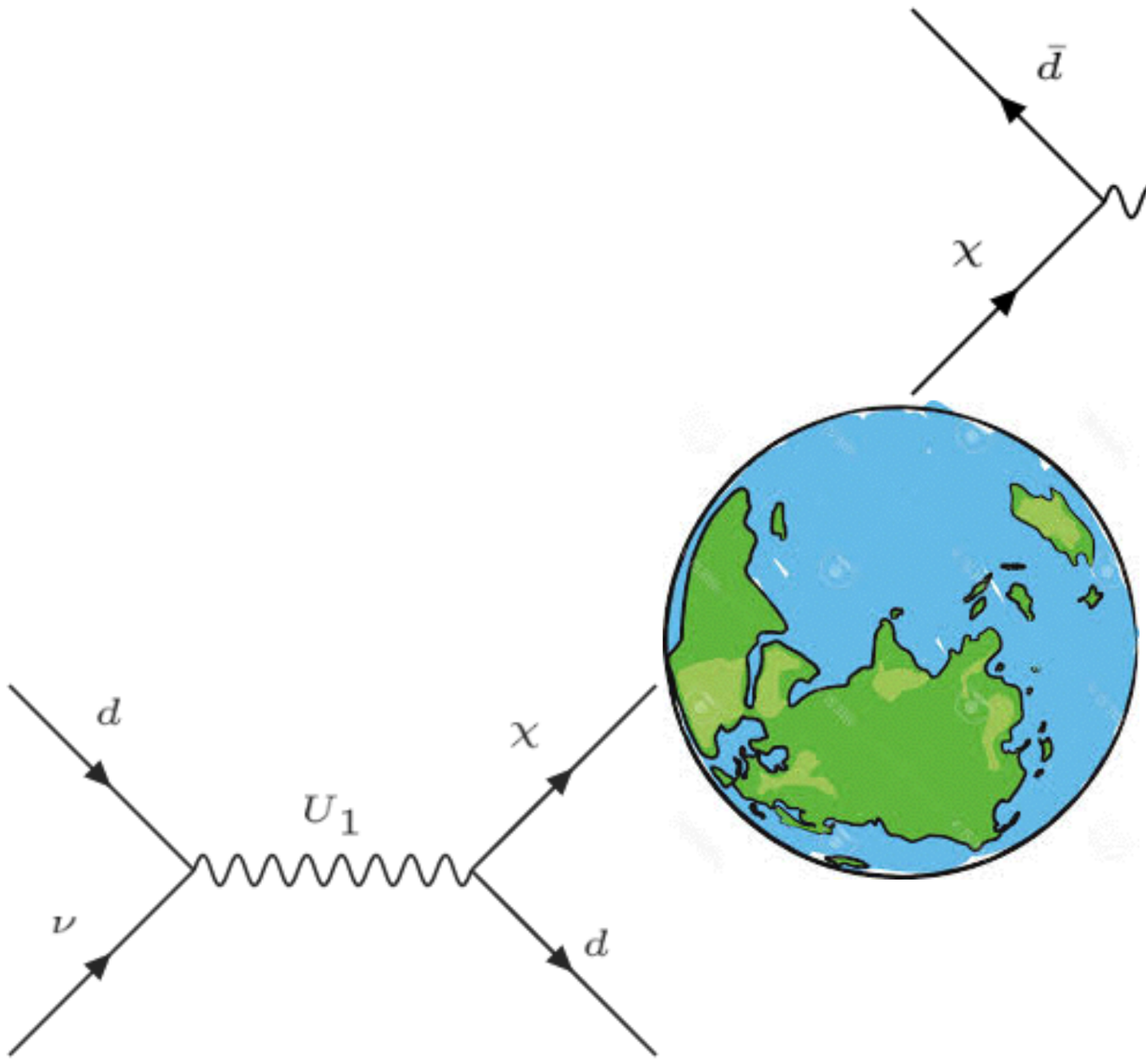
$$-\mathcal{L} \supset (V \cdot g_L)_{ij}\ \bar{u}^i_L \gamma^\mu U_{1,\mu} \nu^j_L$$

$$+ (g_L)_{ij}\ \bar{d}^i_L \gamma^\mu U_{1,\mu} e^j_L$$

$$+ (g_R)_{ij}\ \bar{d}^i_R \gamma^\mu U_{1,\mu} e^j_R$$

$$+ (g_\chi)_i\ \bar{u}^i_R \gamma^\mu U_{1,\mu} \chi_R$$

Explaining ANITA events by Leptoquarks
- Bhavesh Chauhan, SM 1812.00919



- Survey of DM-neutrino interaction operators and experimental signatures - Interactions of Ultrahigh Energy Neutrinos with Dark Matter: A model building perspective - Pandey, Karmakar, Rakshit - arXiv:1810.04203

- Supersymmetric gauged U(1) Lμ–Lτ model for neutrinos and the muon (g-2) anomaly
  Heerak Banerjee, Pritibhajan Byaktiand Sourov Roy
  1805.04415 - AMS-02 positron excess.
  Leptophilic DM.

Thank You