THEORETICAL ASTROPARTICLE PHYSICS
PRIN 2012 Project

Report on WP3 - Cosmological Aspects

Convenors: A. Mechiorri, M. Pietroni

- > 40 papers on cosmological aspects
- all RU’s involved
- topics covered: CMB, LSS, BBN, Inflation, Leptogenesis, Modified GR, …

Selected topics

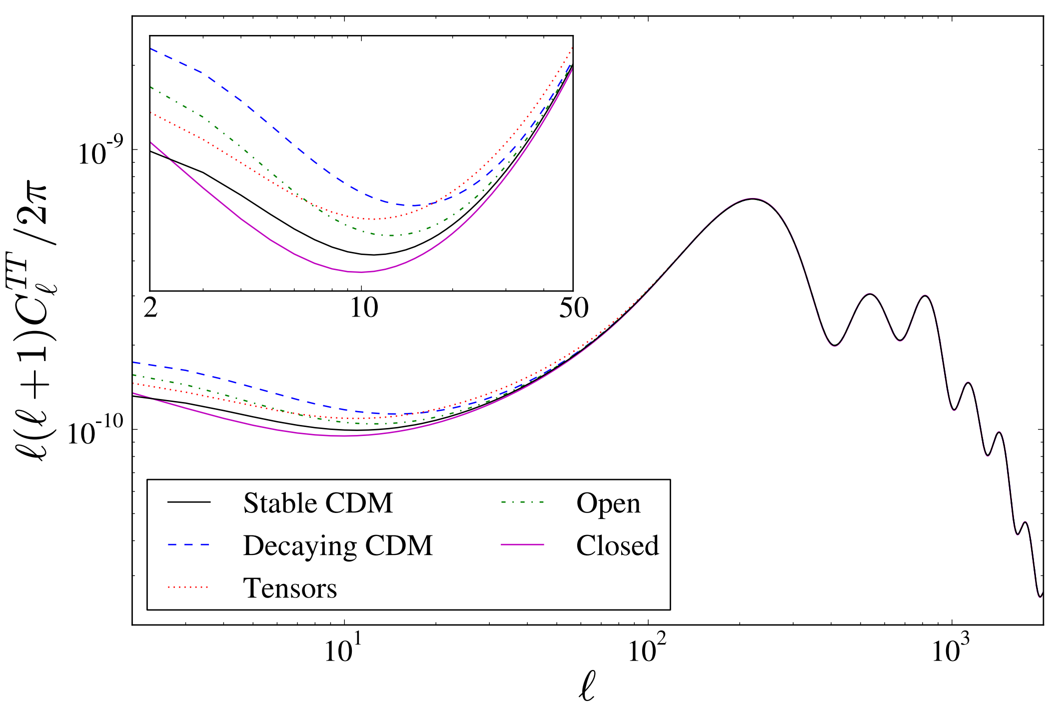
- Constraints on New Physics from Cosmological Observables (decaying DM, axions)
- Primordial Universe (Inflation, Leptogenesis)
- Large Scale Structure of the Universe (BAO’s and neutrino masses, galaxy clusters)
- Gravity and New Gravity

Decaying Dark Matter (I)

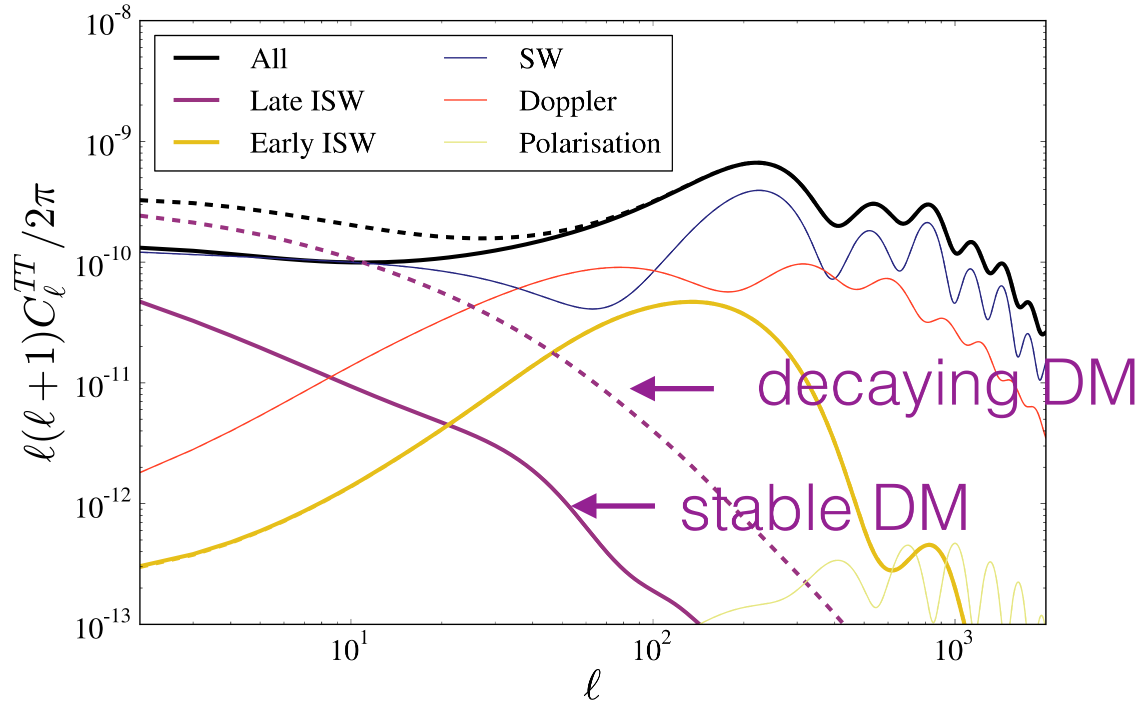
JCAP 1412 (2014) 12, 028

Strongest model-independent bound on the lifetime of Dark Matter

Benjamin Audren,[a] Julien Lesgourgues,[a,b,c] Gianpiero Mangano,[d] Pasquale Dario Serpico,[c] and Thomas Tram[a]



main effect at low l
possibly degenerate with open universe, tensor modes



decaying DM = decaying grav. pot
= Late ISW effect

including data on from Planck, WMAP on lensing, polarisation + BAO's data (Wigglez, BOSS):

$$\tau_{DM} > 160 \text{ Gyr} \quad (95\,\% \;\; c.l.)$$

(100% of DM decays, relativistic products)

Decaying Dark Matter (II)

PRL, to appear

Reconciling Planck results with low redshift astronomical measurements

Zurab Berezhiani,[1,2] A.D. Dolgov,[3,4] and I.I. Tkachev[5,3]

Planck 2015

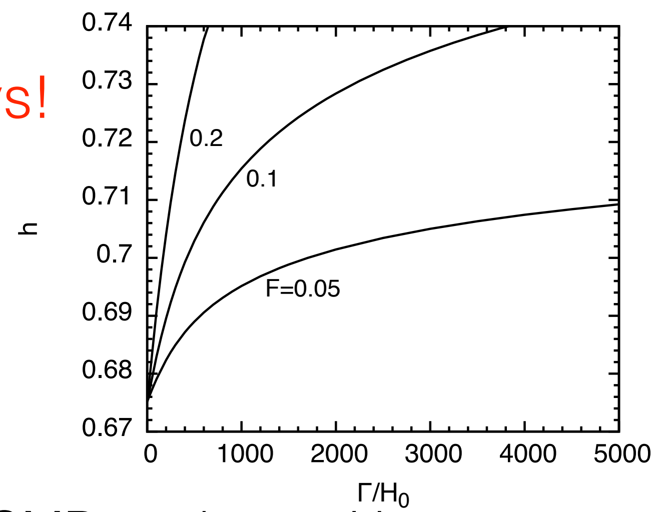
h = 0.6727 ± 0.0066

low redshift data

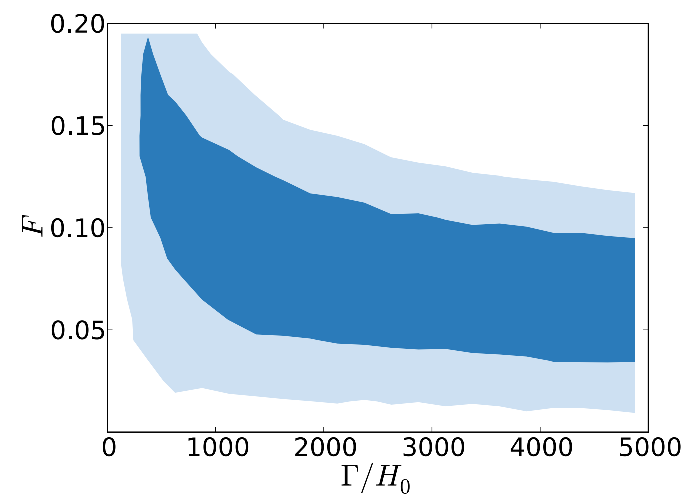
h = 0.738 ± 0.024 HST

only a fraction of DM decays!

$$F \equiv \frac{\omega_{ddm}}{\omega_{sdm} + \omega_{ddm}}.$$

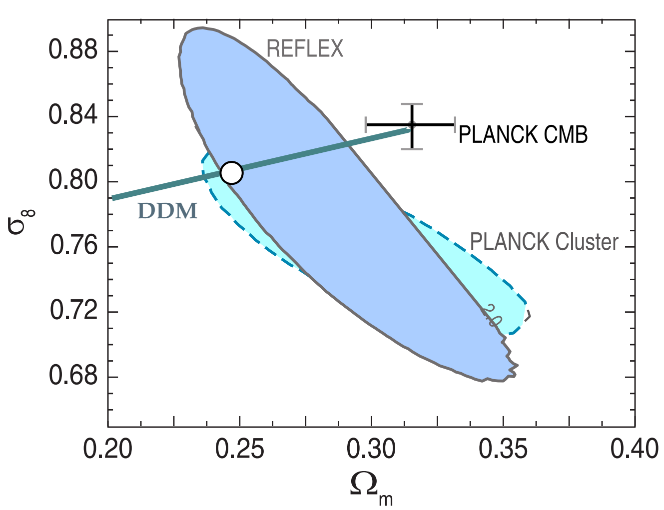


keeping CMB peaks position constant



combining Planck+HST +SnIa

Adjusts also tensions between CMB and Clusters

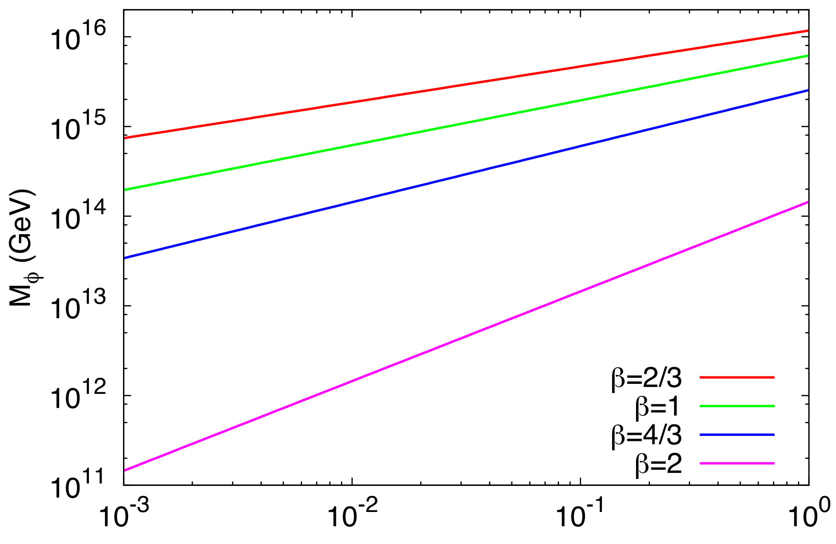


Decaying Dark Matter (III)

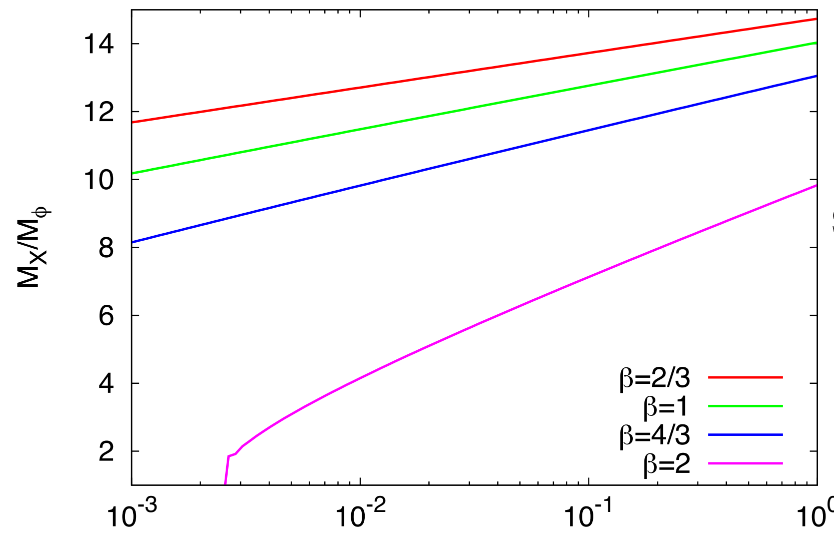
JCAP (submitted) arXiv:1504.01319

Super Heavy Dark Matter in light of BICEP2, Planck and Ultra High Energy Cosmic Rays Observations

R. Aloisio[1,2], S. Matarrese[3,1] and A.V. Olinto[4]

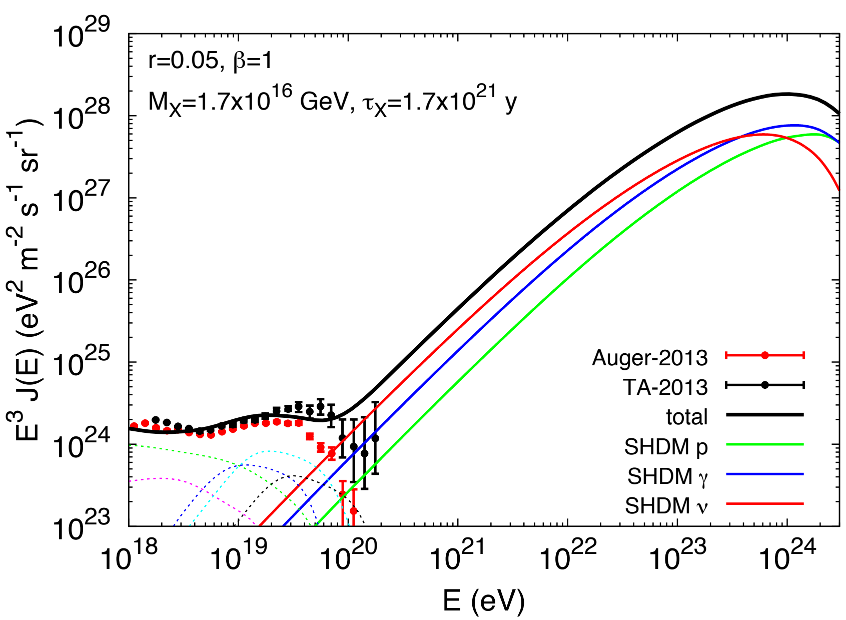


inflaton mass vs r=tensor/scalar

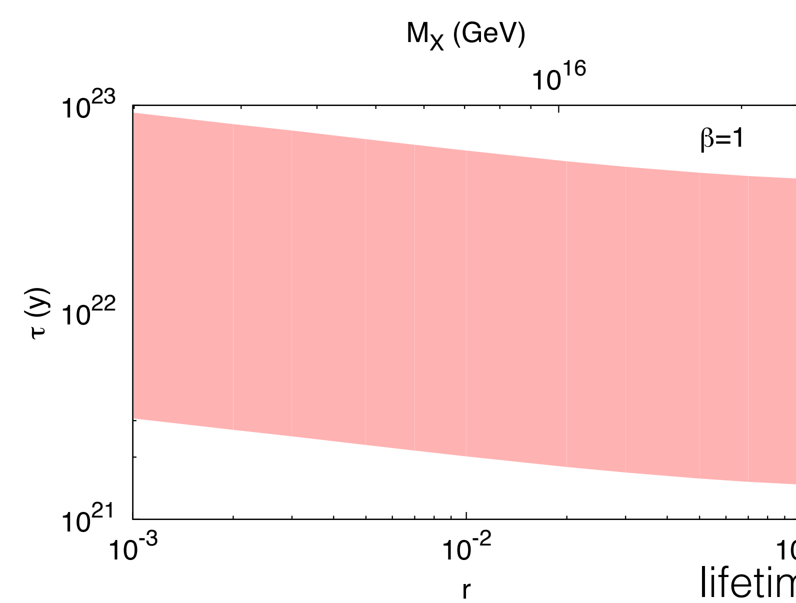


$$\Omega_X(t_0) \simeq 10^{-3}\Omega_R \frac{8\pi}{3}\left(\frac{T_{RH}}{T_0}\right)\left(\frac{M_\phi}{M_{Pl}}\right)^2\left(\frac{M_X}{M_\phi}\right)^{5/2} e^{-2M_X/M_\phi}$$

Super Heavy DM mass (assuming grav. production during inflation)



Flux in UHECR



lifetime/Mx tested in JEM-EUSO

Axions

Phys.Rev. D90 (2014) 4, 043534

Axion cold dark matter: status after Planck and BICEP2

Eleonora Di Valentino,[1] Elena Giusarma,[1] Massimiliano Lattanzi,[2] Alessandro Melchiorri,[1] and Olga Mena[3]

Axion DM for $f_a < \left(\frac{H_I}{2\pi}\right)$

$$\Omega_a h^2 = 2.07\,(1 + \alpha_{dec})\left(\frac{f_a}{10^{12}\ \text{GeV}}\right)^{7/6}$$

Parameter	ADM+r
$\Omega_b h^2$	0.02204 ± 0.00028
$\Omega_a h^2$	0.1194 ± 0.0027
θ	1.04127 ± 0.00064
τ	0.089 ± 0.013
n_s	0.9614 ± 0.0075
$log[10^{10} A_s]$	3.086 ± 0.025
H_0[km/s/Mpc]	67.4 ± 1.2
r	< 0.12
$m_a(\mu eV)$	81.5 ± 1.6
$N_{\rm eff}$	(3.046)
$\sum m_\nu(eV)$	(0.06)
w	(-1)
$m_s^{\rm eff}(eV)$	(0)
n_t	(0)
$dn_s/d\ln k$	(0)

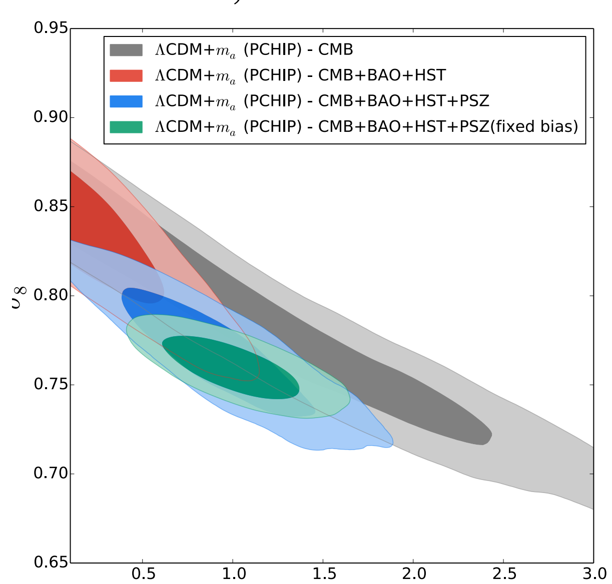
From Planck + WMAP pol.

Phys.Rev. D91 (2015) 12, 123505

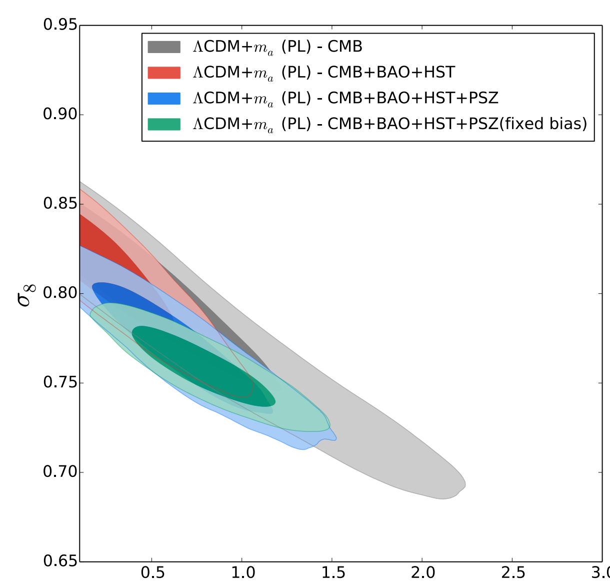
Robustness of cosmological axion mass limits

Eleonora Di Valentino,[1, 2] Stefano Gariazzo,[3, 4] Elena Giusarma,[5] and Olga Mena[6]

For thermal axions (similar to neutrinos)



non-power law PS



power law PS

Mass constraints are quite insensitive to the shape of the primordial PS

Primordial Universe (I)

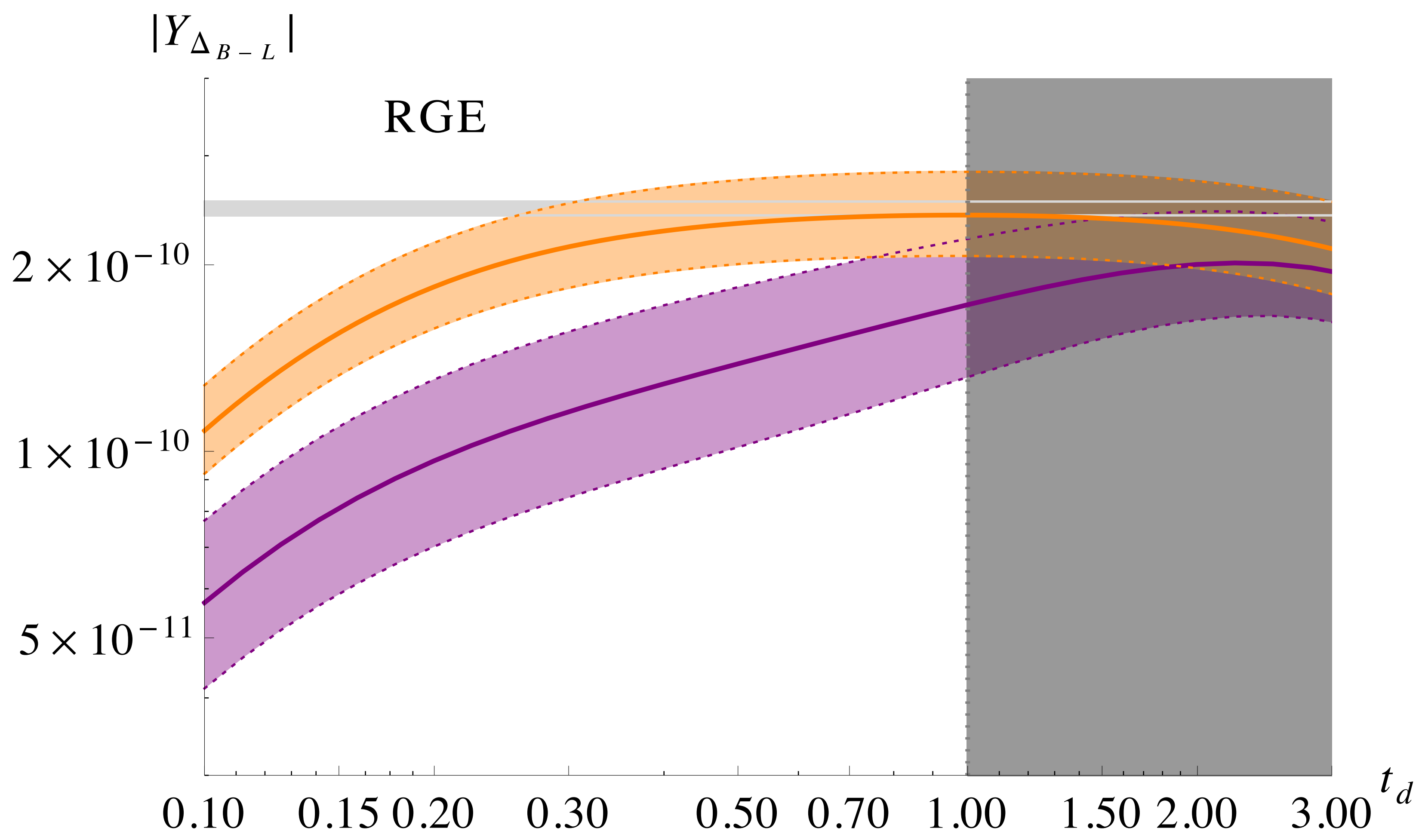
JHEP 1501 (2015) 111

Leptogenesis in SO(10)

Chee Sheng Fong , Davide Meloni , Aurora Meroni, Enrico Nardi

non-supersymmetric SO(10) GUT

once the model parameters are fixed in terms of measured low energy observables, the requirement of successful leptogenesis can fix the only one remaining high energy parameter.



$$t_d = \left[\frac{\langle \Sigma_d^\dagger \Sigma_d \rangle}{\langle H_d^\dagger H_d \rangle}\right]^{1/2}$$

ratio of high energy vevs

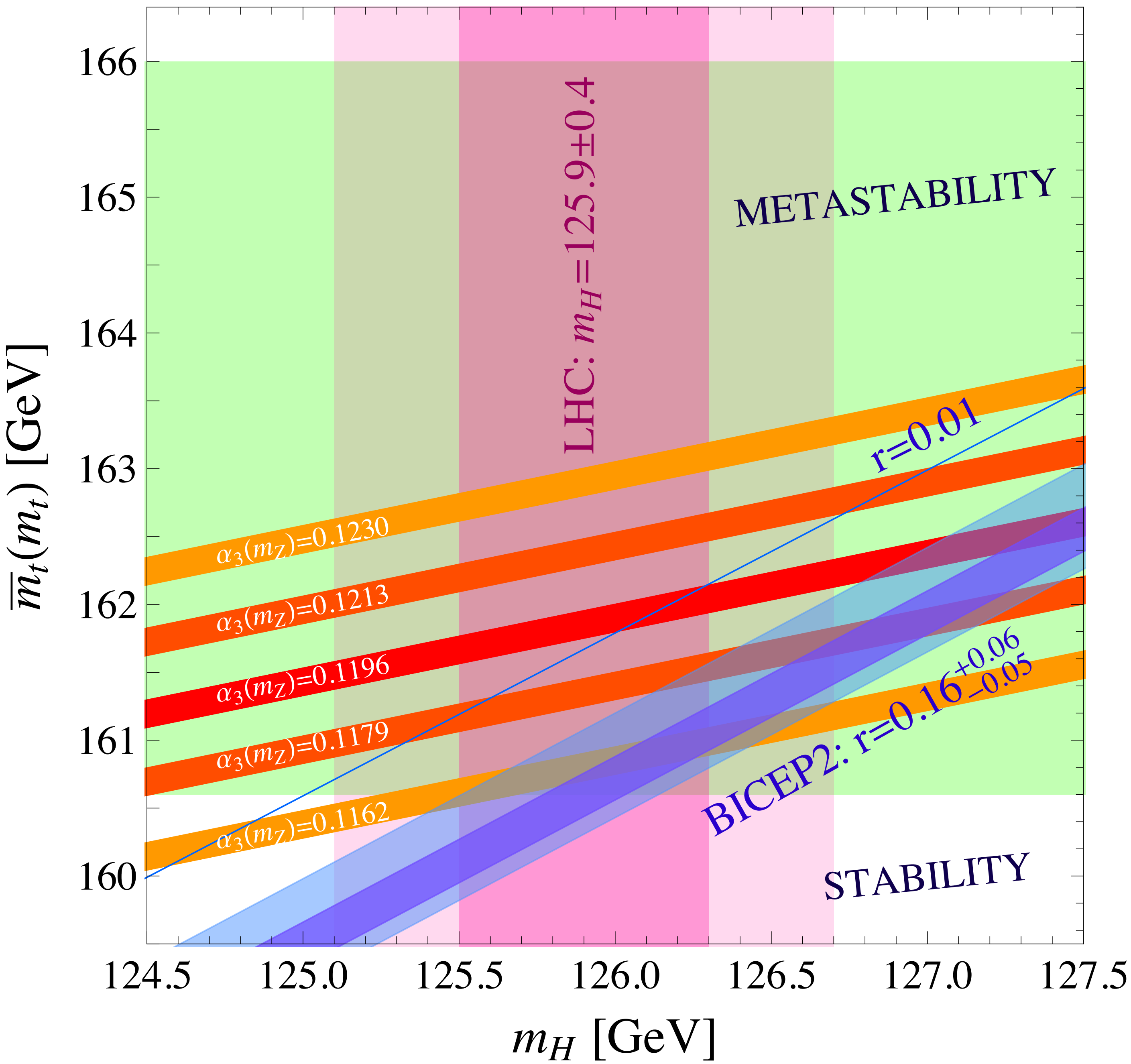
Primordial Universe (II)

Phys. Rev. D 89 (2014) 12, 123505

The Gravitational Wave Background and Higgs False Vacuum Inflation

Isabella Masina

regions consistent with of the hypothesis that inflation occurred in a SM shallow false vacuum at about 2×10^{16} GeV



Large Scale Structure (I)

JCAP 07(2015)001

The effect of massive neutrinos on the BAO peak

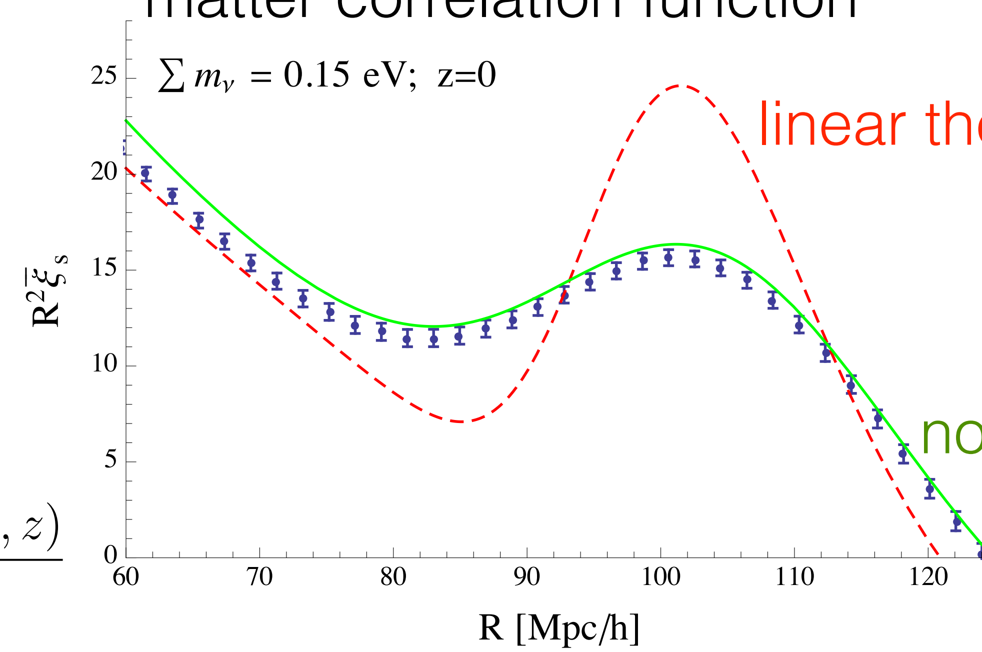
Marco Peloso, Massimo Pietroni, Matteo Viel, e and Francisco Villaescusa-Navarro

nonlinear effects degrade the BAO peak
usually seen as a “noise” to remove

main nonlinear effect: large scale flows
simple analytic description!

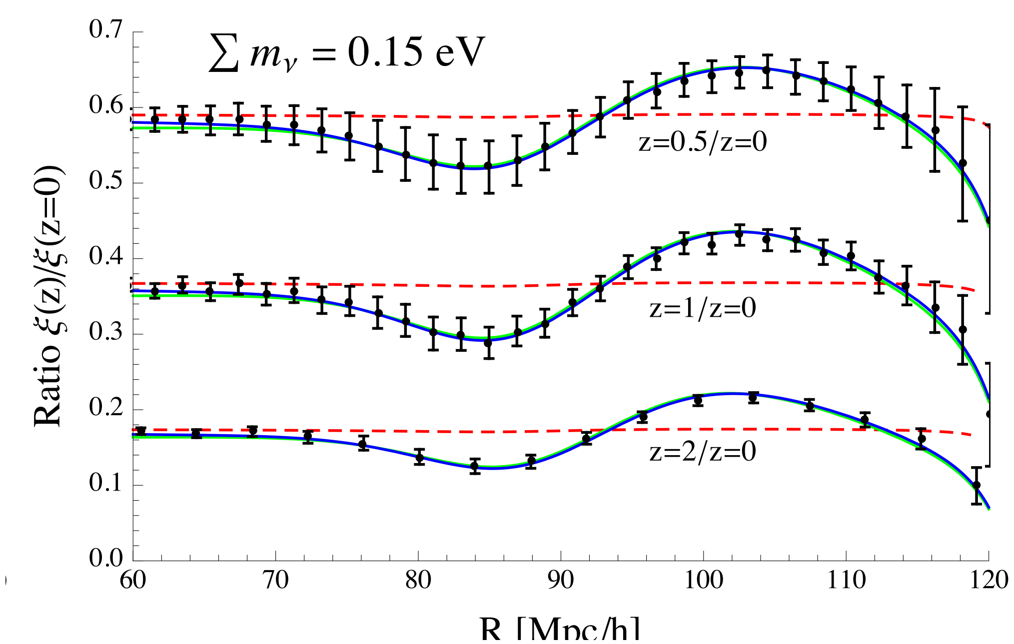
$$P^{(1)}(k,z) = e^{-k^2\sigma_v^2(z)} P^{lin}(k,z) \qquad \sigma_v^2(z) = \frac{1}{3}\int \frac{d^3q}{(2\pi)^3}\,\frac{P^{lin}(q,z)}{q^2}$$

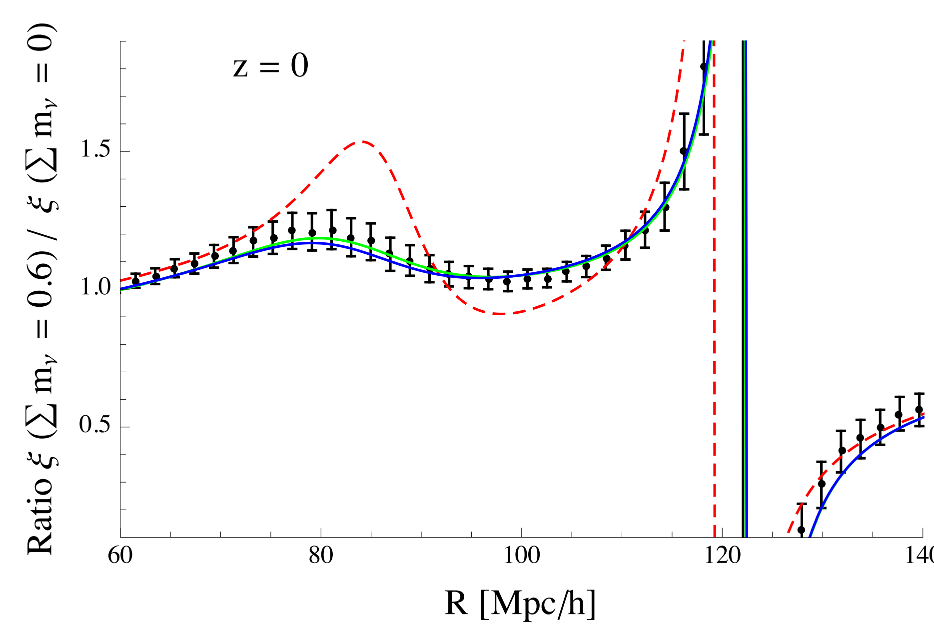
matter correlation function



linear theory

nonlinear





redshift dependence

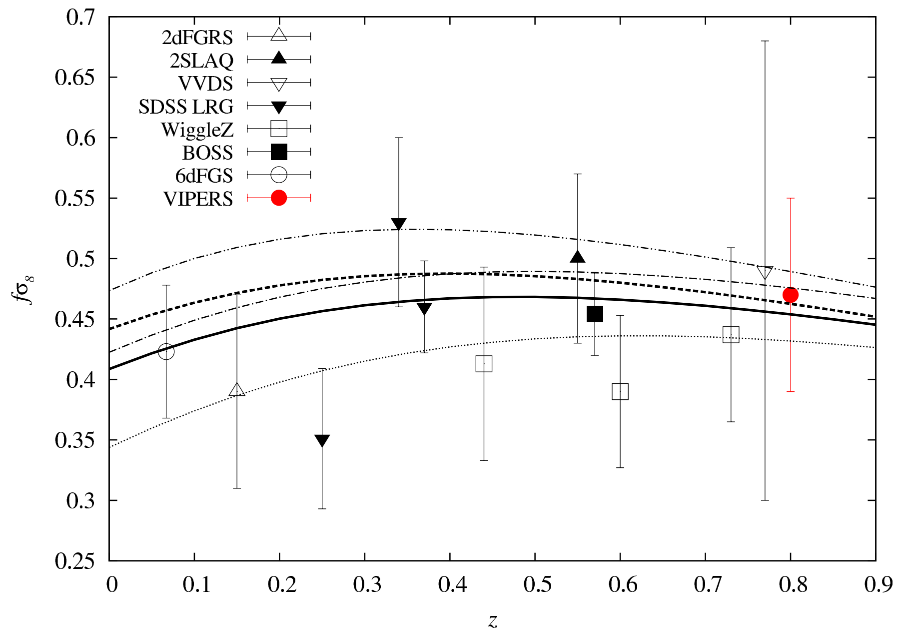
neutrino mass dependence

Large Scale Structure (II)

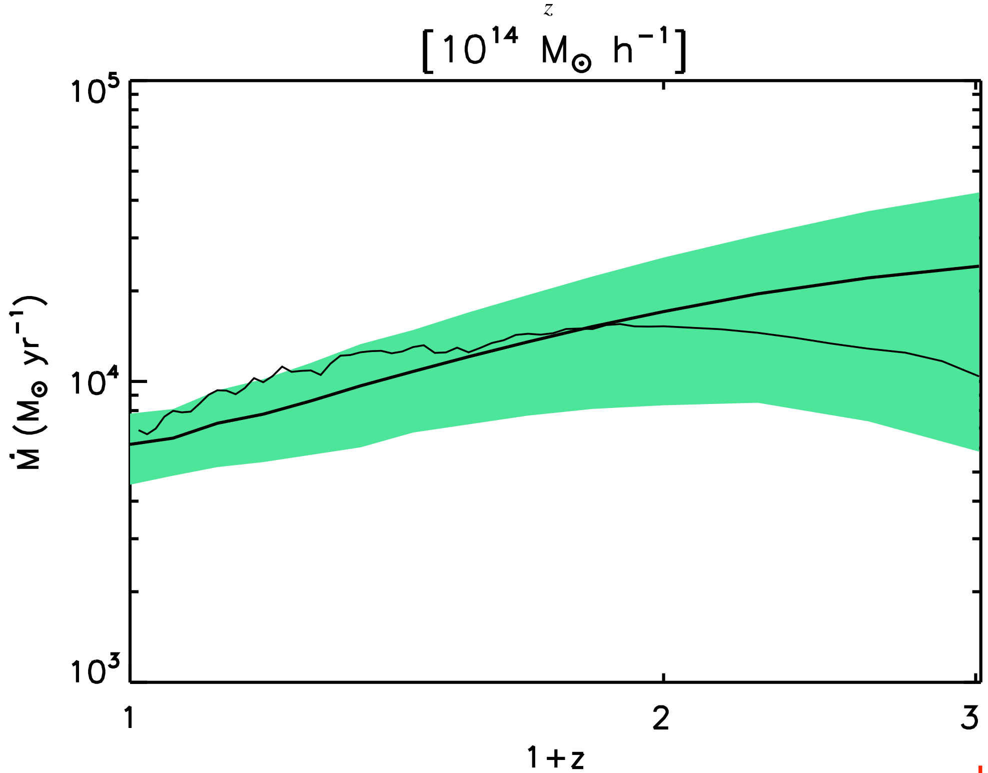
arXiv:1501.01977

THE MASS ACCRETION RATE OF GALAXY CLUSTERS: A MEASURABLE QUANTITY

C. DE BONI[1,2], A.L. SERRA[3], A. DIAFERIO[1,2], C. GIOCOLI[4,5,6], AND M. BALDI[4,5,6]



growth function (large scales)



MAR of clusters (smaller scales)

$$\dot{M} = \frac{M[<r_{200}(1+\delta_s)] - M_{200}}{\Delta t}(1+z)^{3/2}$$

$\Delta t = 0.1$ Gyr $\quad \delta_s = 100H^2(z)\Delta t^2$

estimated by the amount of matter in the cluster outskirt

arXiv:1506.02003 [astro-ph.CO]

A new approach to the propagation of light-like signals in perturbed cosmological backgrounds

G. Fanizza[a,b] , M. Gasperini[a] , G. Marozzi[b] , G. Veneziano[c]

new method to compute the deflection of light rays in a perturbed FLRW geometry.

Phys.Rev. D90 (2014) 084003

FRW Cosmological Perturbations in Massive Bigravity

D. Comelli [a,b] M. Crisostomi [c,d,e] and L. Pilo [d,f]

Cosmological perturbations of FRW solutions in ghost free massive bigravity