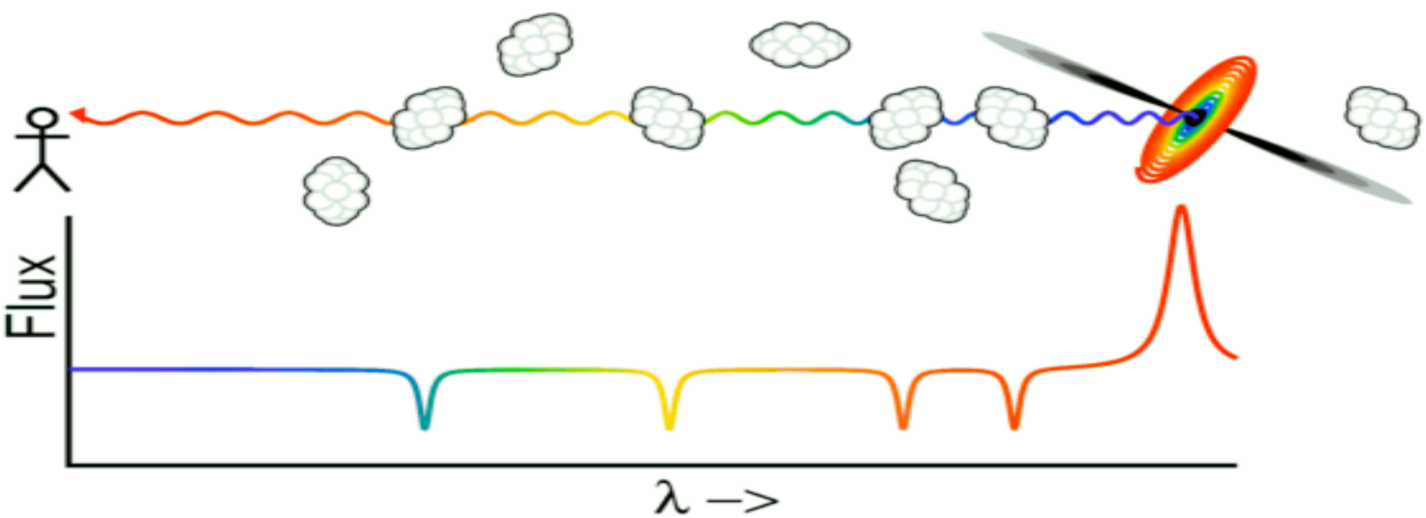
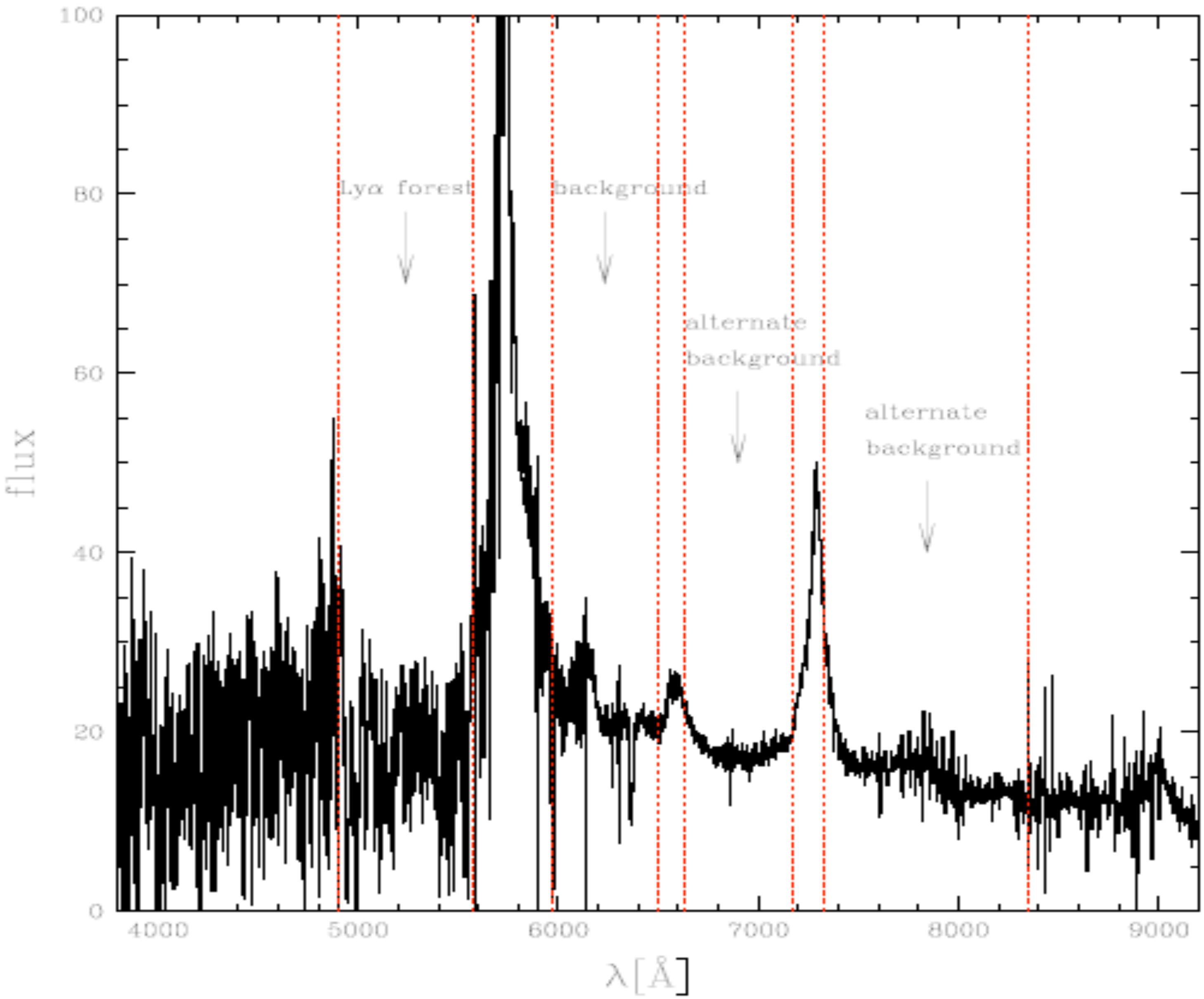
Cosmological parameter analysis including SDSS Lyα forest and galaxy bias: Constraints on the primordial spectrum of fluctuations, neutrino mass, and dark energy.

Seljak et. al.

Lyman α Forest

- The "Lyα forest" is a series of spectral lines caused by the absorption of light from distant quasars by neutral hydrogen gas in the intergalactic medium.
- Wavelength of absorption lines depends on expansion of universe via red shift, providing a method of observing the effect of dark energy.
- Neutral Hydrogen gas acts as a tracer of dark matter.

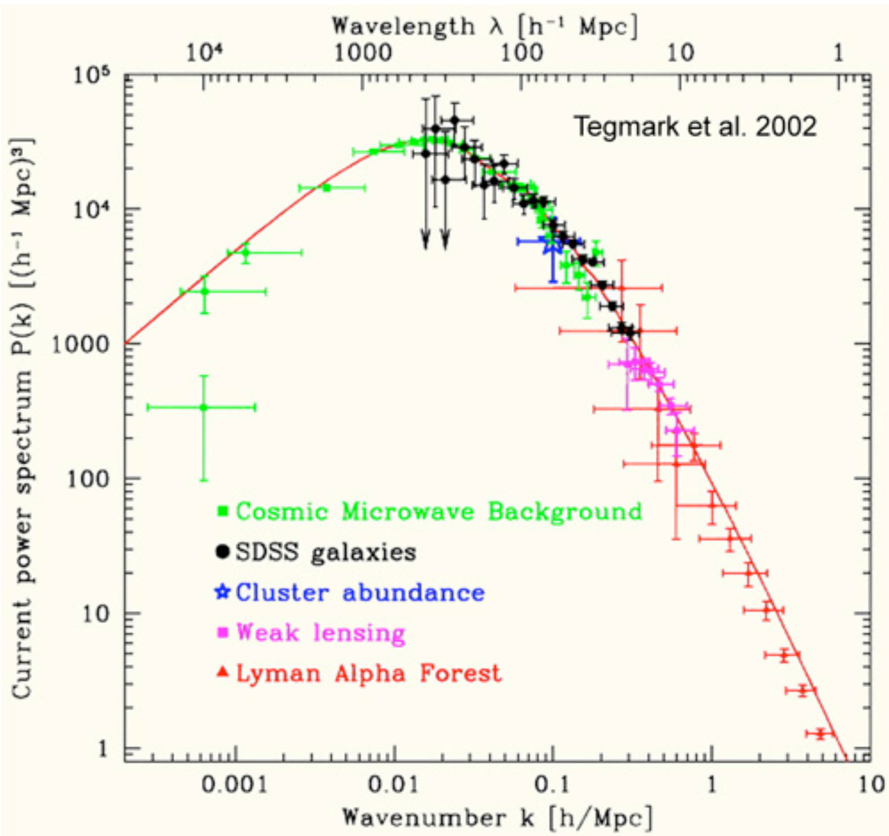




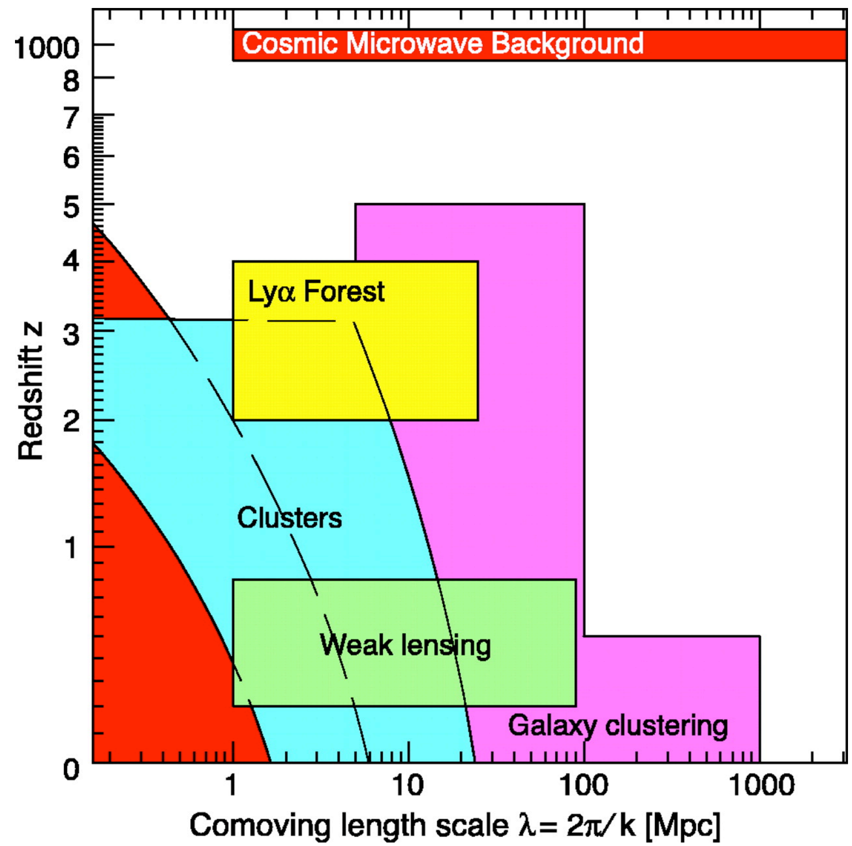
Lyα forest
background
alternate
background
alternate
background
flux
λ[Å]
0
20
40
60
80
100
4000
5000
6000
7000
8000
9000

Small scale fluctuations

- Previous constraints on CMB power spectrum based on large scale observations
- Initial fluctuations in power spectrum are damped on small scales due to non-linear evolution of matter on these scales.
- Observations of Lyα absorbtion lines at high red shift ($2 < z < 4$) can give precise information on fluctuations at the Mpc scale.



Wavelength λ [h⁻¹ Mpc]
Tegmark et al. 2002
Current power spectrum P(k) [(h⁻¹ Mpc)³]
Cosmic Microwave Background
SDSS galaxies
Cluster abundance
Weak lensing
Lyman Alpha Forest
Wavenumber k [h/Mpc]



Cosmic Microwave Background
Lyα Forest
Clusters
Weak lensing
Galaxy clustering
Redshift z
Comoving length scale λ= 2π/ k [Mpc]

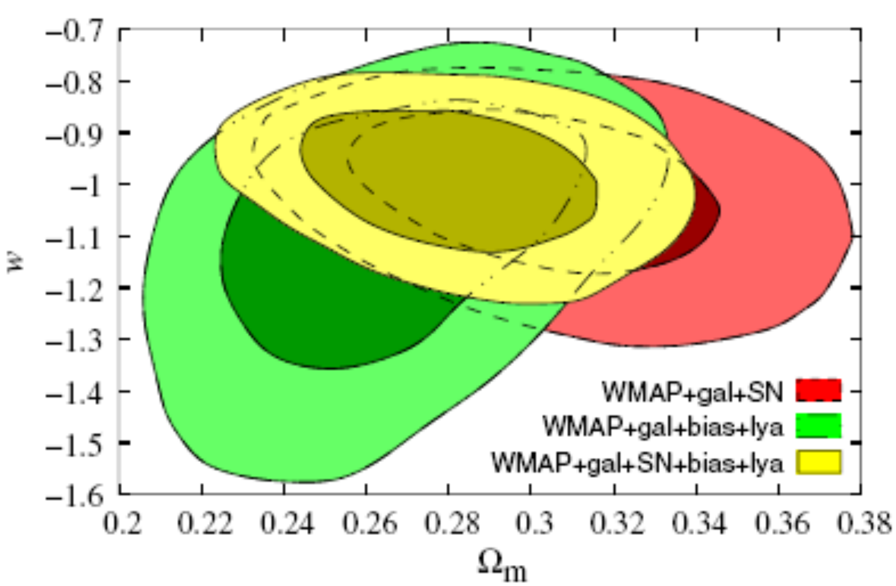
Method

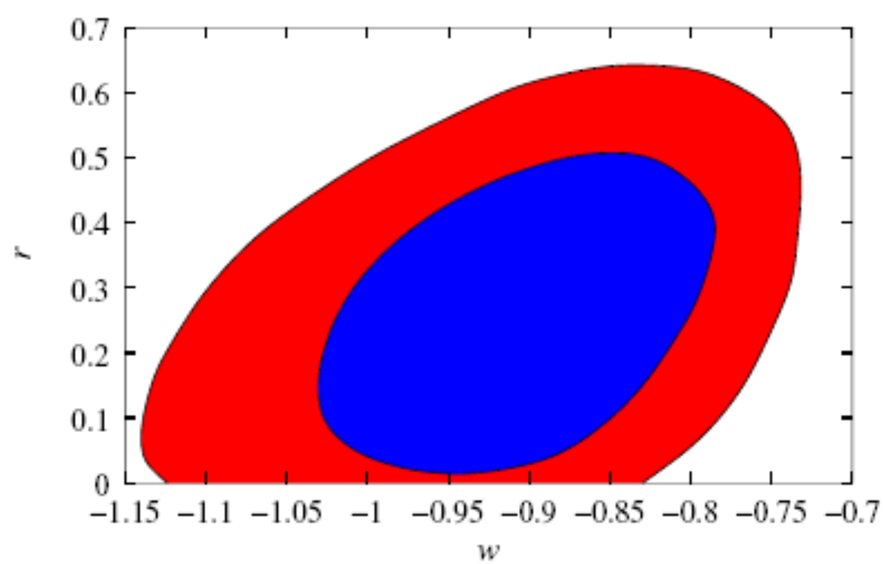
- A combination of data from SDSS (Lyα emissions and galaxy clustering) and WMAP(CMB power spectrum) used to constrain cosmological parameters.

	6-p WMAP + gal	6-p WMAP + gal+lyα	6-p all	6-p+r WMAP + gal+lyα	6-p+r all
$10^2\omega_b$	$2.38^{+0.14+0.27+0.39}_{-0.12-0.23-0.33}$	$2.31^{+0.09+0.17+0.26}_{-0.08-0.17-0.24}$	$2.33^{+0.09+0.17+0.26}_{-0.08-0.17-0.25}$	$2.40^{+0.12+0.26+0.47}_{-0.105-0.19-0.30}$	$2.40^{+0.11+0.23+0.33}_{-0.10-0.19-0.27}$
Ω_m	$0.294^{+0.041+0.089+0.143}_{-0.034-0.061-0.082}$	$0.299^{+0.037+0.082+0.133}_{-0.032-0.061-0.084}$	$0.281^{+0.023+0.046+0.070}_{-0.021-0.040-0.061}$	$0.278^{+0.036+0.076+0.118}_{-0.033-0.062-0.094}$	$0.270^{+0.022+0.045+0.072}_{-0.021-0.041-0.060}$
n_s	$0.994^{+0.044+0.077+0.101}_{-0.035-0.060-0.080}$	$0.971^{+0.023+0.048+0.070}_{-0.019-0.038-0.055}$	$0.980^{+0.020+0.041+0.065}_{-0.019-0.037-0.051}$	$1.00^{+0.034+0.070+0.124}_{-0.028-0.050-0.076}$	$1.00^{+0.027+0.056+0.085}_{-0.024-0.045-0.063}$
τ	$0.176^{+0.078+0.117+0.124}_{-0.071-0.124-0.161}$	$0.133^{+0.052+0.104+0.148}_{-0.045-0.087-0.126}$	$0.160^{+0.040+0.079+0.117}_{-0.041-0.080-0.120}$	$0.138^{+0.050+0.096+0.151}_{-0.045-0.085-0.118}$	$0.155^{+0.040+0.078+0.112}_{-0.040-0.077-0.114}$
σ_8	$0.951^{+0.090+0.173+0.224}_{-0.079-0.142-0.261}$	$0.890^{+0.034+0.065+0.096}_{-0.032-0.060-0.089}$	$0.897^{+0.033+0.065+0.097}_{-0.031-0.058-0.086}$	$0.901^{+0.035+0.069+0.107}_{-0.033-0.062-0.096}$	$0.904^{+0.035+0.069+0.106}_{-0.031-0.059-0.094}$
h	$0.706^{+0.037+0.068+0.097}_{-0.034-0.065-0.091}$	$0.694^{+0.030+0.059+0.092}_{-0.028-0.057-0.086}$	$0.710^{+0.021+0.044+0.066}_{-0.021-0.040-0.061}$	$0.719^{+0.036+0.076+0.133}_{-0.032-0.061-0.091}$	$0.726^{+0.025+0.052+0.081}_{-0.023-0.045-0.068}$
r	0	0	0	$<0.38(0.55)$	$<0.36(0.51)$

Dark Energy

- The equation of state of dark energy (w) can be constrained by comparing fluctuation amplitude of CMB at high red shift, using Lyα data, to observations of galaxy clustering at low red shift.





Conclusions

- Combined data supports scale invariant model for CMB fluctuations.
- No evidence for tensor contributions to the primordial power spectrum.
- No (cosmological) evidence for non-zero neutrino mass.
- Dark energy best characterized by $w=-1$.