Cosmology with the Lyman-α Forest as Probed by the Sloan Digital Sky Survey

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Lam Hui (Fermilab); Adam Lidz (Columbia); and the SDSS collaboration

Cosmology Day at Los Alamos, 15th of April 2004

Picture of M78 Nebula Taken by the Sloan Digital Sky Survey

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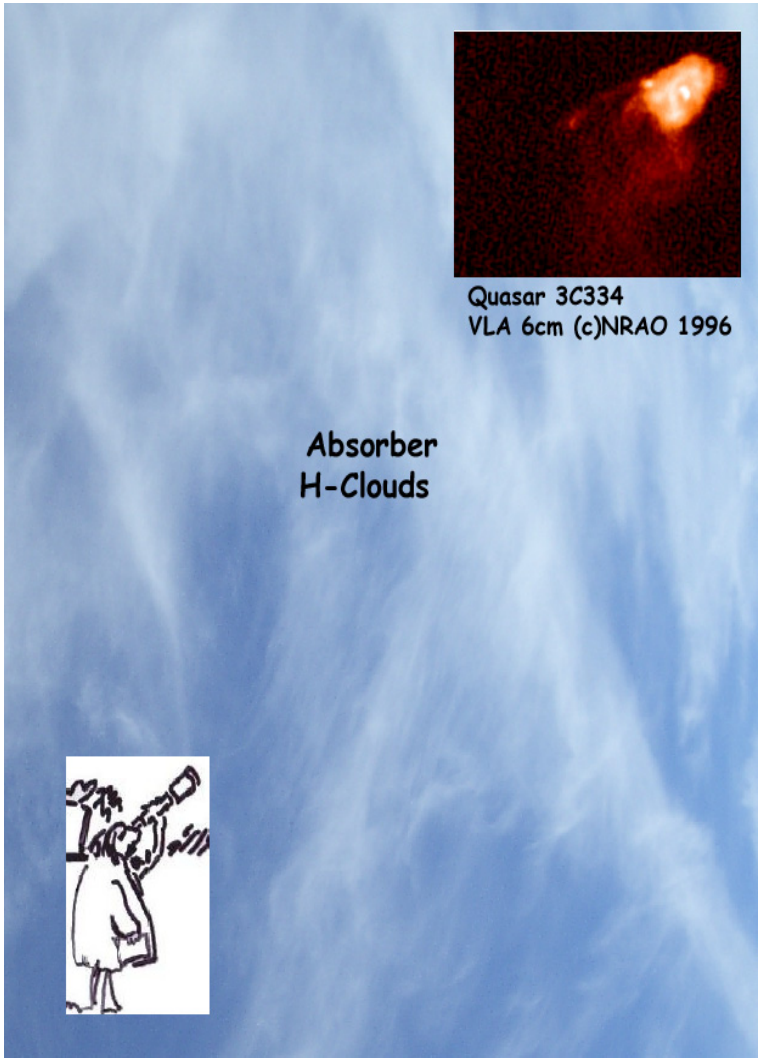
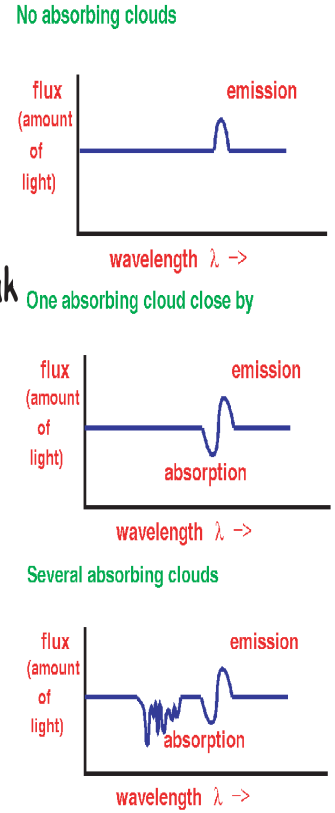


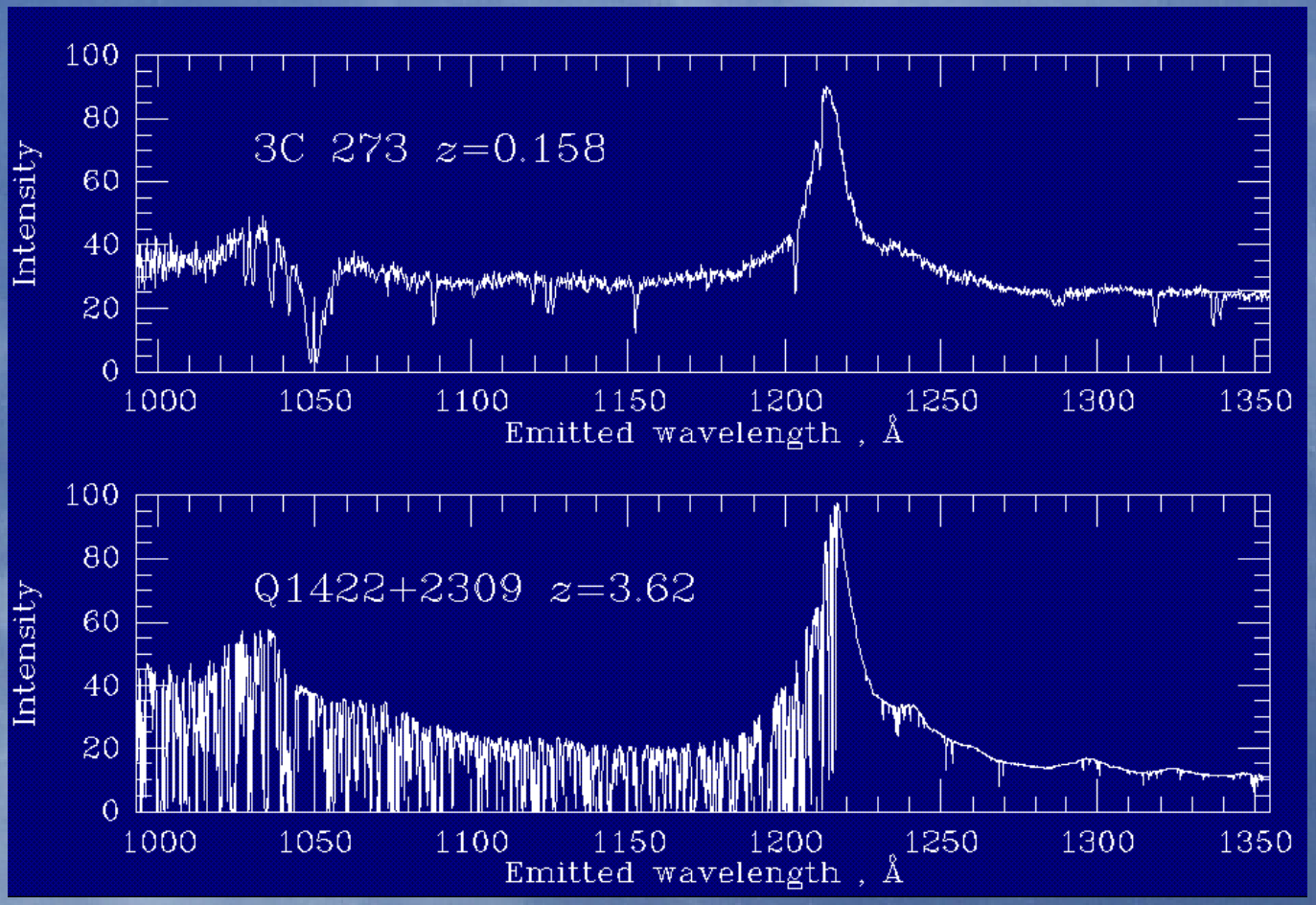
Concept:

- quasar emitts continuum spectrum
- around quasar: ionized hydrogen cloud
  - -> exicited electrons fall back into ground state
  - -> emission of 1216 Å photons -> Lyman alpha peak
- close by neutral hydrogen absorbs photon -> dip
- Universe expands: photons redshifted
- every time redshifted photon at 1216 Å hits neutral hydrogen -> absorption -> dip
- in restframe of quasar: bluewards -> FOREST



Thanks to J.Cohn

Lyα Forest at Low and High Redshift



What Can We Learn about Cosmology From the Lyα Forest?

- Distribution of neutral hydrogen

- Observation: lumpy regions of neutral hydrogen

$\Rightarrow$ what is ionizing the rest of the hydrogen?

- Structure formation

- Tracers of dark matter:

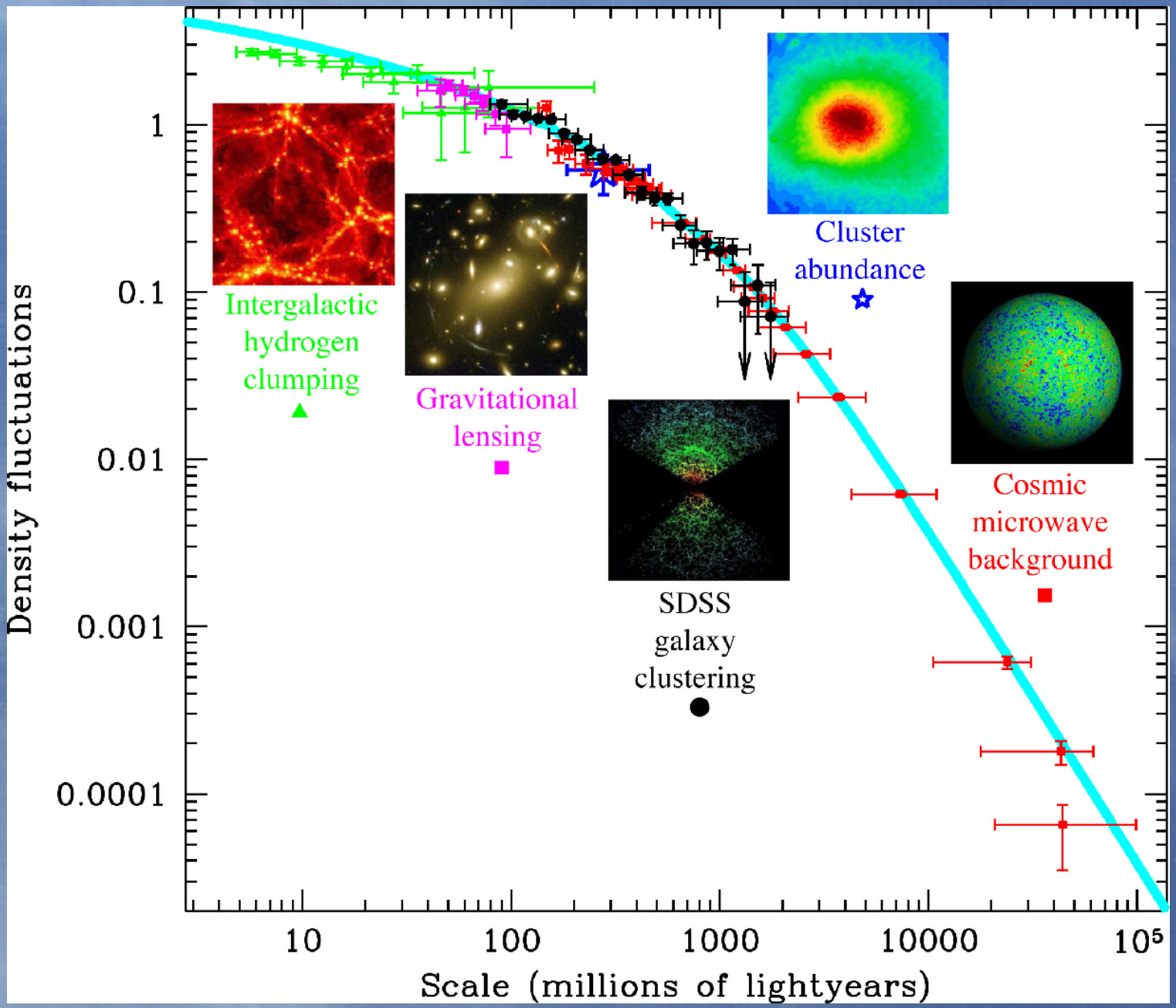
Lyα regions are formed by

gas falling into gravitational potential wells

- Mass power spectrum at high k

$\Rightarrow$ Neutrino mass constraints

$\Rightarrow$ Running of the spectral index



Thanks to Max Tegmark...

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Sloan Digitial Sky Survey

- 2.5m telescope at Apache Point
- Map 1/4 of entire sky in detail
- determine abs. brightness and position of > 100 Mill. objects
- distance to > 1 Mill. galaxies, quasars
- 100.000 quasars
- up to now 3000 quasars for Lyα (Keck: 67)

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Apache Point Observatory

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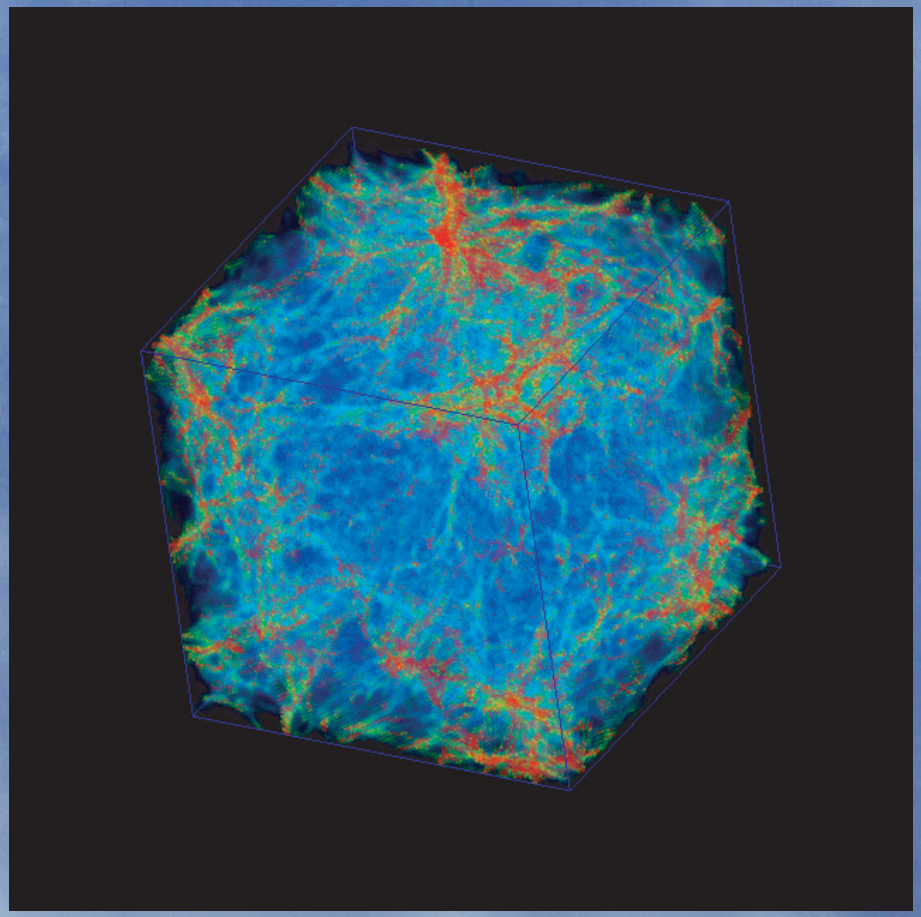
Cosmological Parameter Estimation



- Measure flux power spectrum from quasars between $z = 2 - 4$
- Run suite of simulations
- Compare!

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Simulation Strategy

- Full hydro-simulations

  + Most accurate

  - Too many ingredients

  - slow

- Pure dark matter simulations + gaussian smoothing

  + Simple, no specification of reionization history etc.

  + Very fast

  - Not very accurate

  - How to fix smoothing scale?

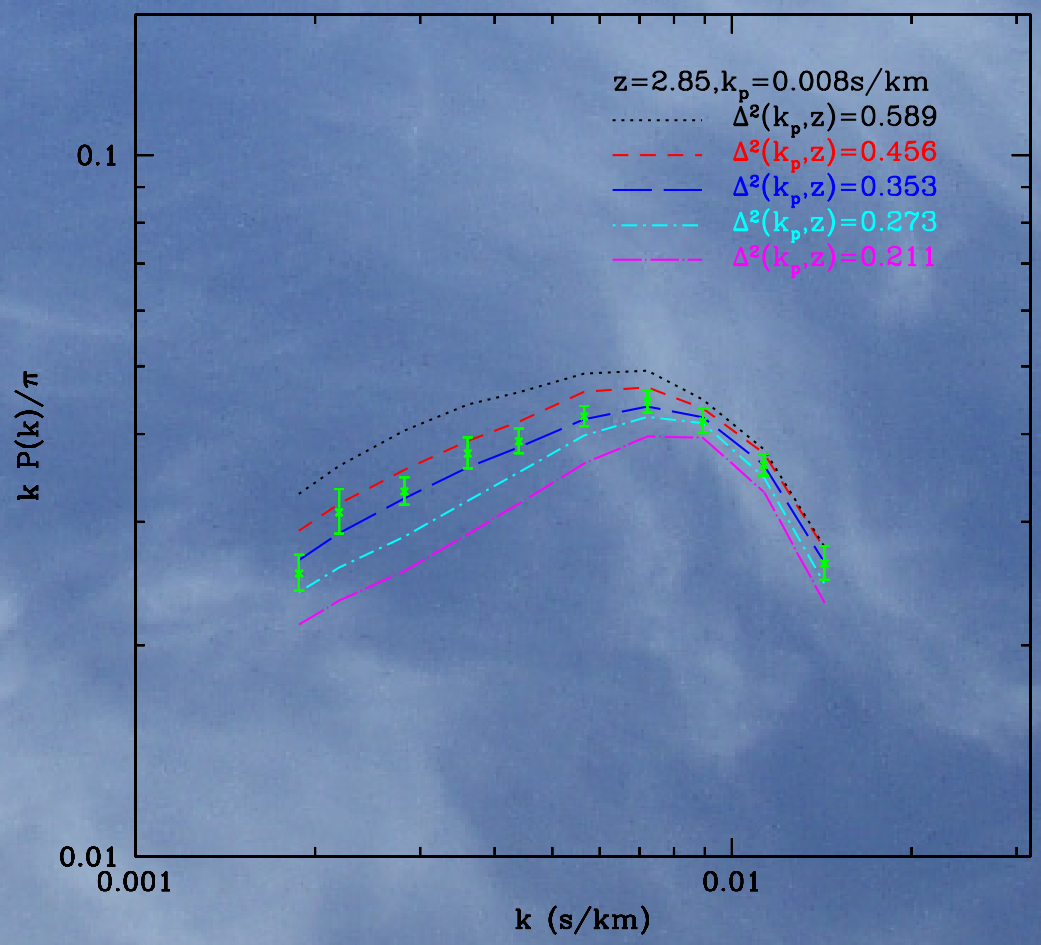
- Hydro-Particle Mesh: DM + baryons, additional pressure smoothing

  + still fast

  + more realistic than pure DM, still not too many parameters

  - missing physics

Preliminary Result for the Flux Power Spectrum



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Preliminary Results

Princeton

- Agressive error estimates in analysis of spectra
- Evidence for running of spectral index!!

Fermilab

- Conservative error estimations
- NO evidence for running of spectral index

Outlook

- Detailed comparison of Hydro/DM/HPM
- Analysis of Keck data
- Investigation of the IGM at high redshift
- Lyα Forest and gamma ray bursts?

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