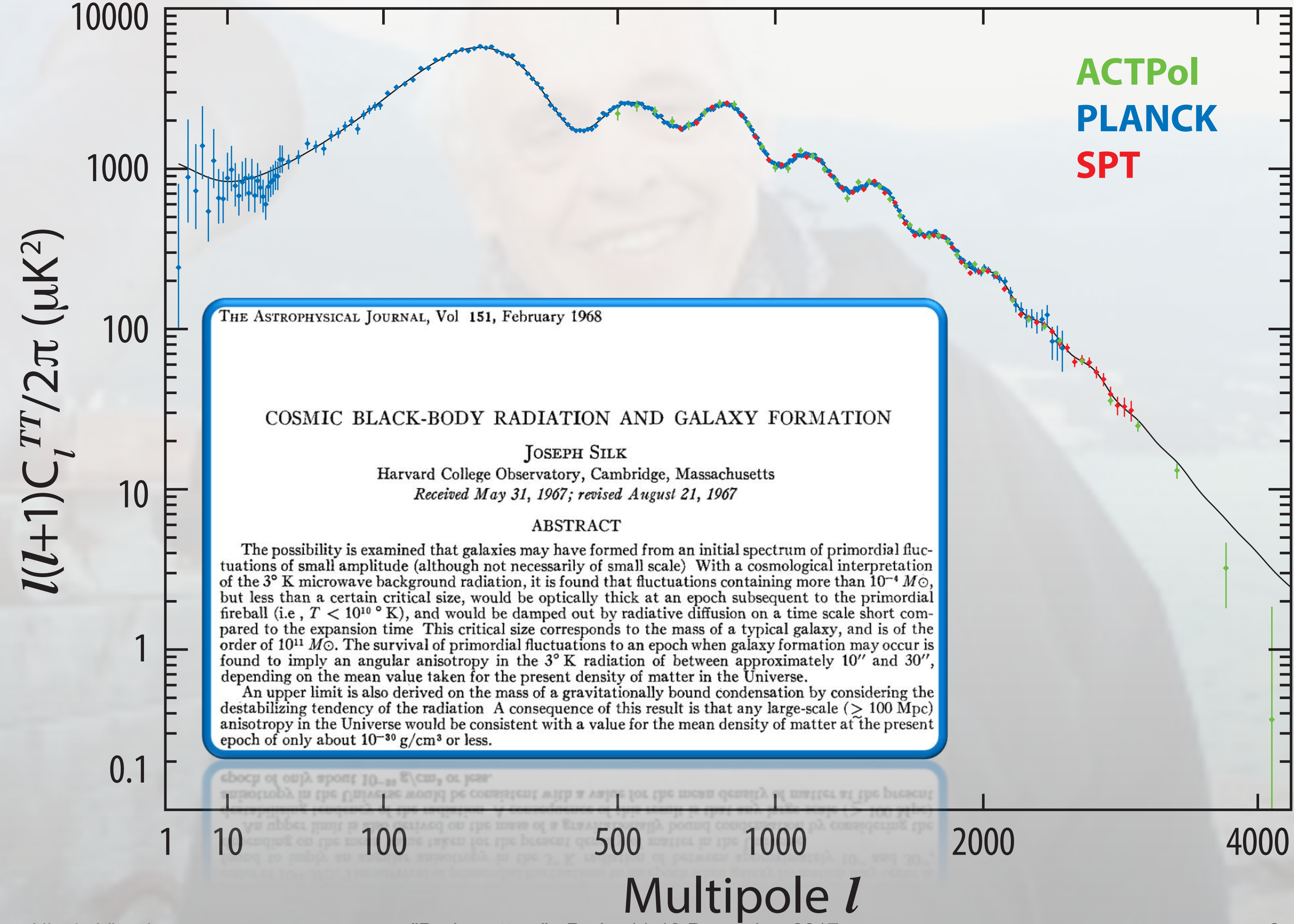
JOE SILK'S 75TH BIRTHDAY

What Joe has taught us?

JOE AND CMB



THE ASTROPHYSICAL JOURNAL, Vol 151, February 1968

COSMIC BLACK-BODY RADIATION AND GALAXY FORMATION

JOSEPH SILK
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Received May 31, 1967; revised August 21, 1967

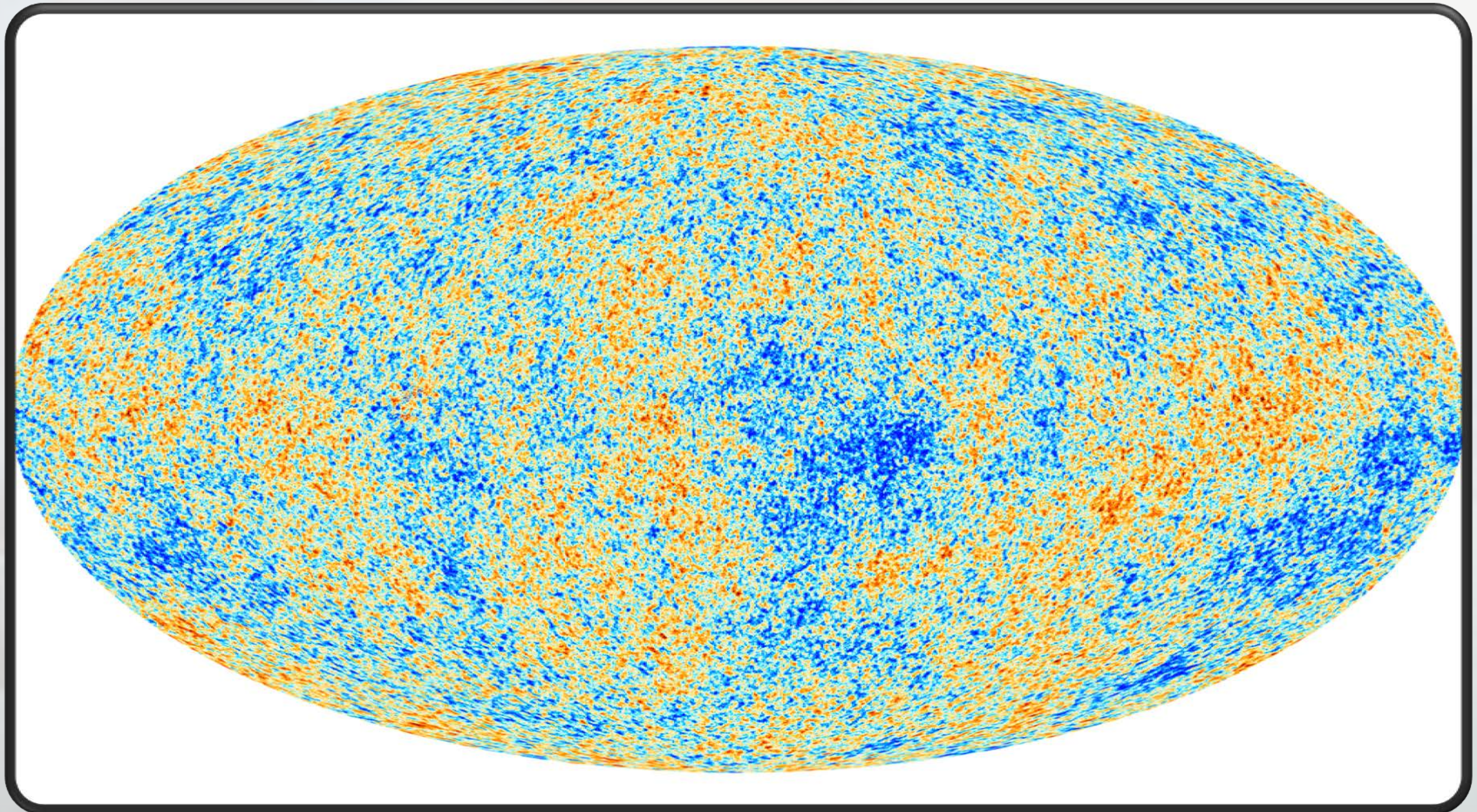
ABSTRACT

The possibility is examined that galaxies may have formed from an initial spectrum of primordial fluctuations of small amplitude (although not necessarily of small scale) With a cosmological interpretation of the 3° K microwave background radiation, it is found that fluctuations containing more than 10^{-4} $M_\odot$, but less than a certain critical size, would be optically thick at an epoch subsequent to the primordial fireball (i.e , $T < 10^{10}$ ° K), and would be damped out by radiative diffusion on a time scale short compared to the expansion time This critical size corresponds to the mass of a typical galaxy, and is of the order of 10^{11} $M_\odot$. The survival of primordial fluctuations to an epoch when galaxy formation may occur is found to imply an angular anisotropy in the 3° K radiation of between approximately 10″ and 30″, depending on the mean value taken for the present density of matter in the Universe.

An upper limit is also derived on the mass of a gravitationally bound condensation by considering the destabilizing tendency of the radiation A consequence of this result is that any large-scale ($\gtrsim$ 100 Mpc) anisotropy in the Universe would be consistent with a value for the mean density of matter at the present epoch of only about 10^{-30} g/cm³ or less.

LAMBDA - February 2017

PLANCK CMB SKY



JOE AND CMB

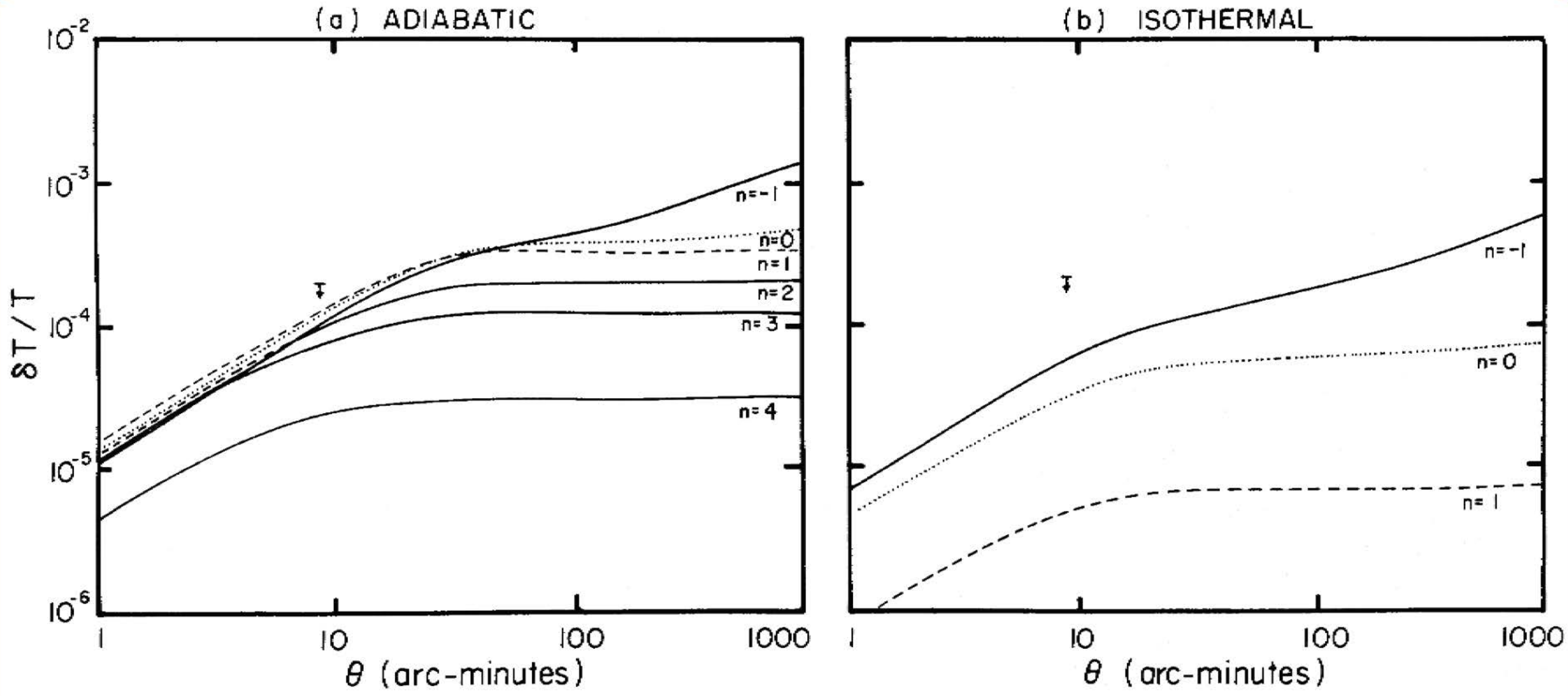


FIG. 5.—Temperature fluctuations for $\sigma = 1'.5$. The observational upper limit shown is from Partridge (1980).

ON THE ANISOTROPY OF THE COSMOLOGICAL BACKGROUND MATTER AND RADIATION DISTRIBUTION. I. THE RADIATION ANISOTROPY IN A SPATIALLY FLAT UNIVERSE

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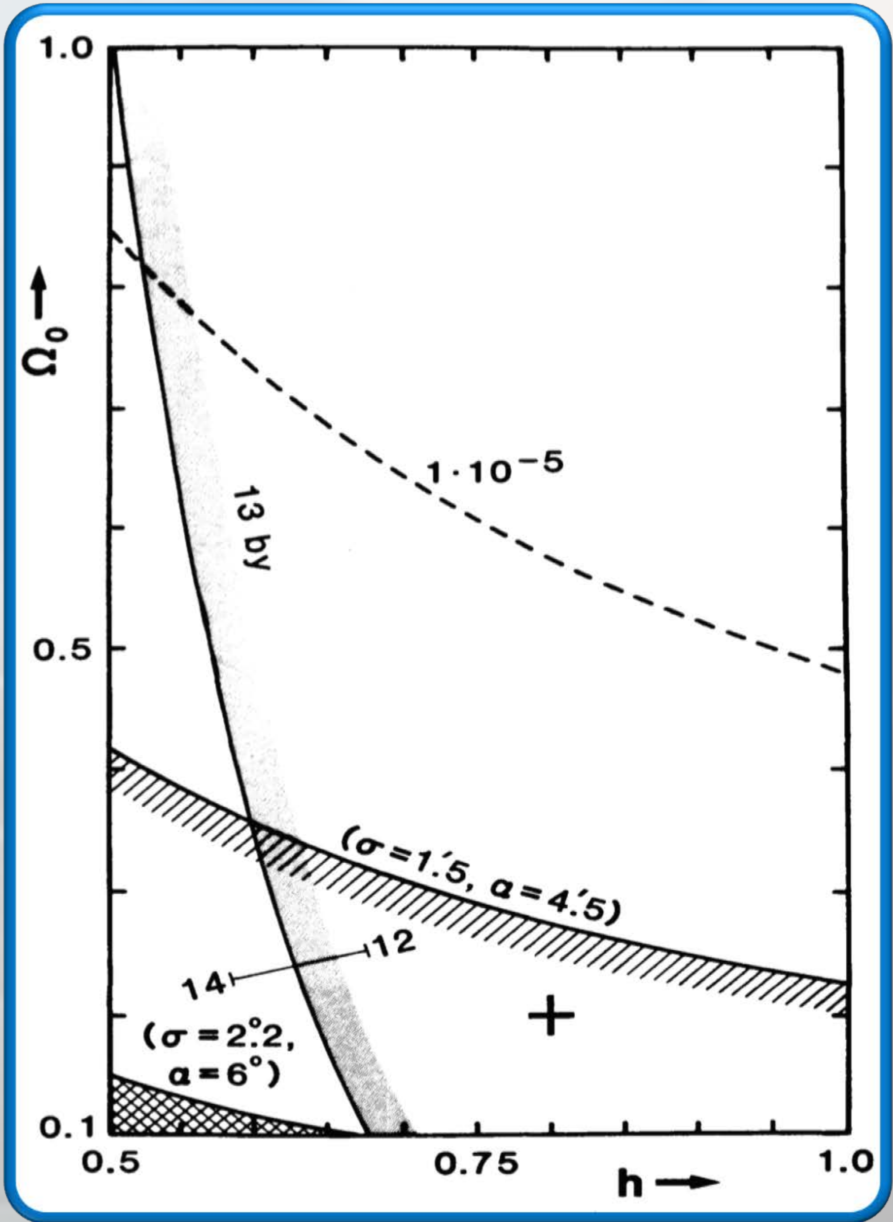
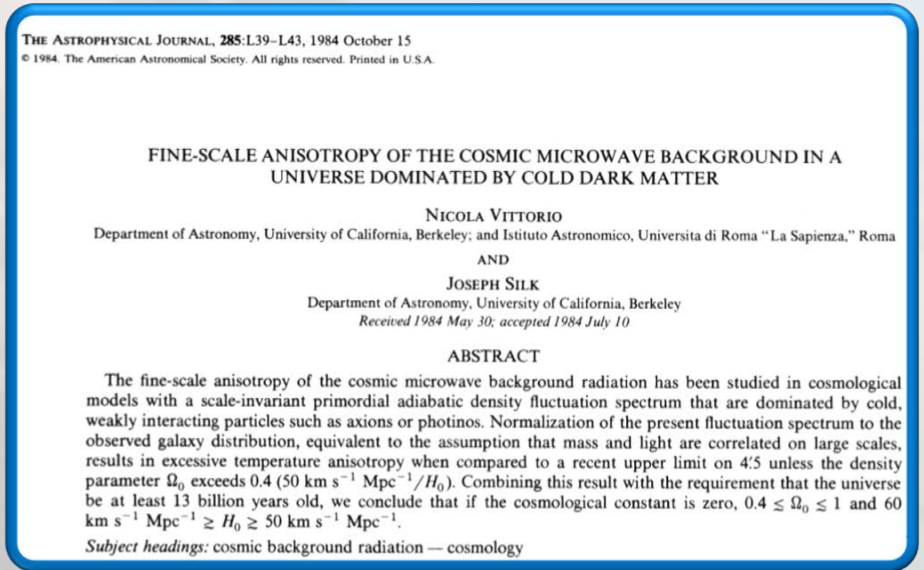
Received 1980 April 18; accepted 1980 July 25

JOE AND THE CMB




THE ASTROPHYSICAL JOURNAL, 285:L39–L43, 1984 October 15

FINE-SCALE ANISOTROPY OF THE COSMIC MICROWAVE BACKGROUND IN A UNIVERSE DOMINATED BY COLD DARK MATTER

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Department of Astronomy, University of California, Berkeley; and Istituto Astronomico, Universita di Roma "La Sapienza," Roma
AND
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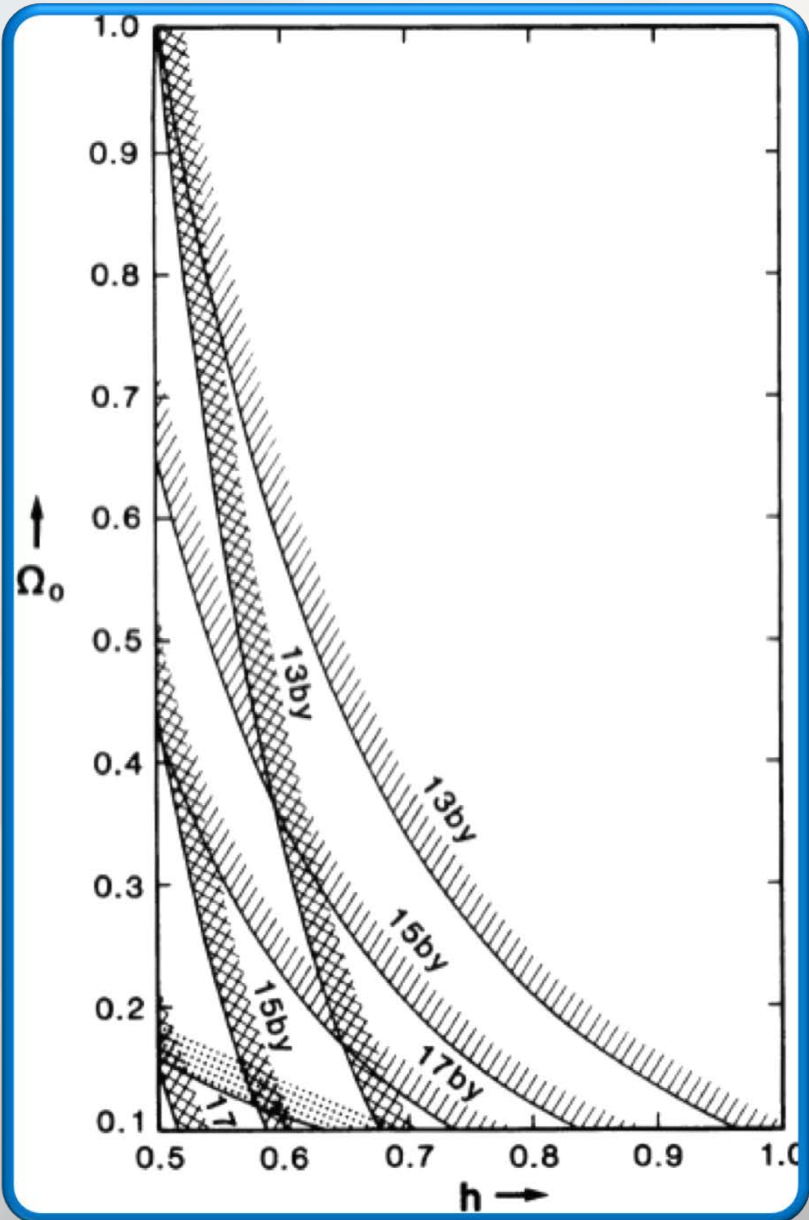
Received 1984 May 30; accepted 1984 July 10

ABSTRACT

The fine-scale anisotropy of the cosmic microwave background radiation has been studied in cosmological models with a scale-invariant primordial adiabatic density fluctuation spectrum that are dominated by cold, weakly interacting particles such as axions or photinos. Normalization of the present fluctuation spectrum to the observed galaxy distribution, equivalent to the assumption that mass and light are correlated on large scales, results in excessive temperature anisotropy when compared to a recent upper limit on 4.'5 unless the density parameter Ω_0 exceeds 0.4 (50 km s^{-1} Mpc$^{-1}/H_0$). Combining this result with the requirement that the universe be at least 13 billion years old, we conclude that if the cosmological constant is zero, $0.4 \leq \Omega_0 \leq 1$ and 60 km s^{-1} Mpc$^{-1} \geq H_0 \geq 50$ km s^{-1} Mpc^{-1}.

Subject headings: cosmic background radiation — cosmology

JOE AND THE CMB



THE ASTROPHYSICAL JOURNAL, **297**:L1–L4, 1985 October 1

CAN A RELIC COSMOLOGICAL CONSTANT RECONCILE INFLATIONARY PREDICTIONS WITH THE OBSERVATIONS?

NICOLA VITTORIO[1,2,3]

AND

JOSEPH SILK[1,2]

Received 1985 April 11; accepted 1985 July 9

ABSTRACT

We calculate the small-scale anisotropy in pure baryonic universes, with and without a cosmological constant. If we restrict ourselves to the inflationary requirement of a flat universe, pure baryonic models are not consistent with the present upper limits on the fine-scale anisotropy even if recourse is made to a cosmological constant $\Lambda = 1 - \Omega_0$. However, a cold dark matter–dominated model may be consistent with the observations if $\Omega_0 h \geq 0.05$ and $\Lambda = 1 - \Omega_0$. Such a scheme might reconcile the astronomical determinations of Ω_0 with the inflationary prediction of a flat universe.

JOE AND CMB

Annu. Rev. Astron. Astrophys. 1994. 32: 319–70

ANISOTROPIES IN THE COSMIC MICROWAVE BACKGROUND

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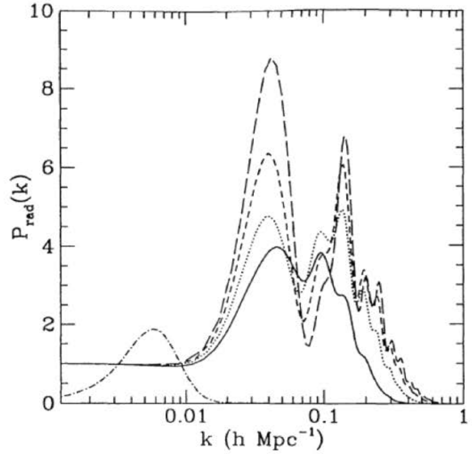


Figure 2 Power spectrum for "standard" CDM models ($h = 1/2$, $\Omega_0 = 1$ and $\Omega_\nu = \Omega_\Lambda = 0$) with $\Omega_B = 0.01$ (*solid*), 0.03 (*dotted*), 0.06 (*short-dashed*), and 0.10 (*long-dashed*) consistent with the range from BBN, from Sugiyama & Gouda (1992). The curves have been normalized to unity at small k. For comparison we also show a fully-ionized BDM model (*dot-dashed line*) with $\Omega_0 = 0.1$, $n = 0$, and $h = 0.5$, chosen (arbitrarily) to match at $k = 0.002\,h$ Mpc^{-1}.

The physics of microwave background anisotropies

Wayne Hu, Naoshi Sugiyama & Joseph Silk

Nature **386**, 37–43 (06 March 1997) Published online: 06 March 1997

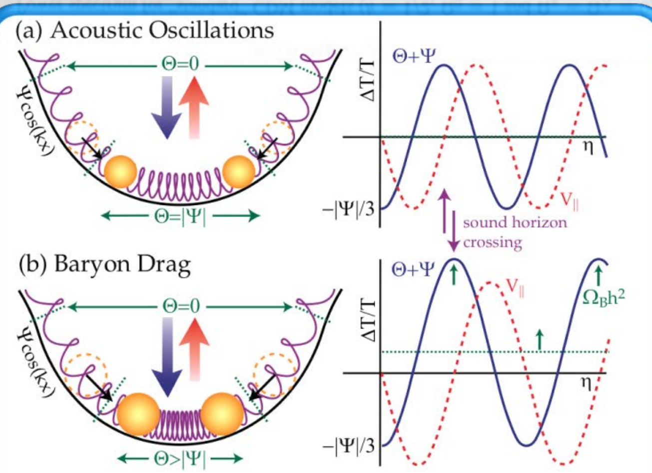
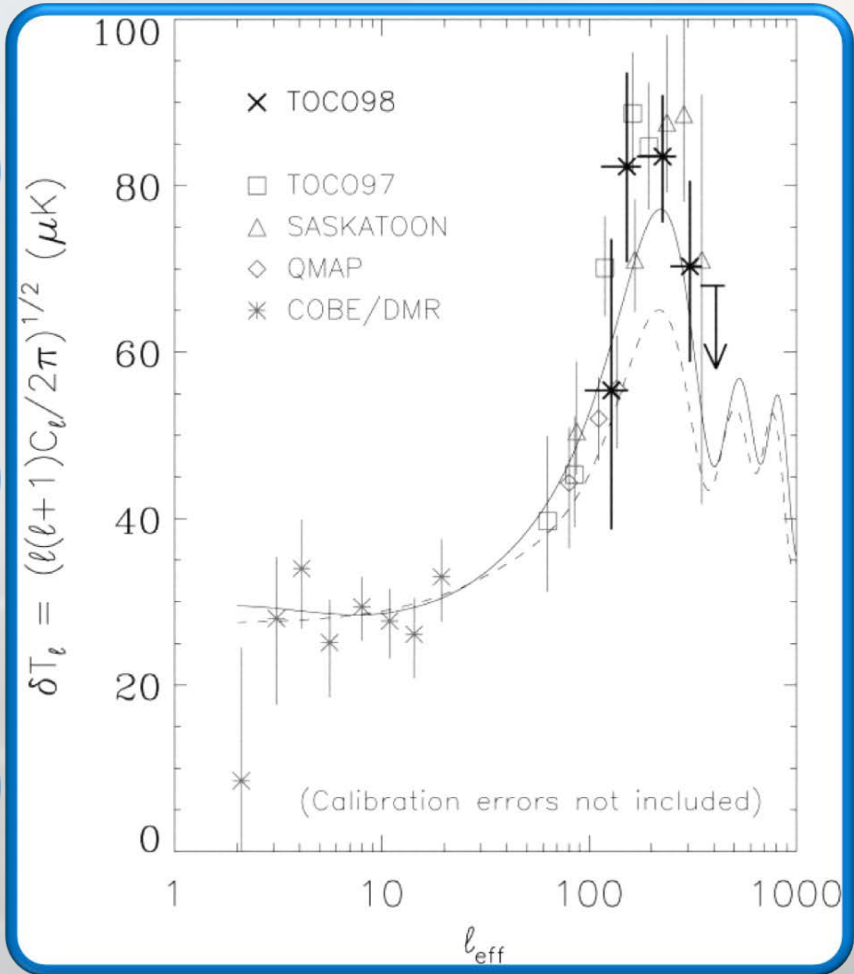
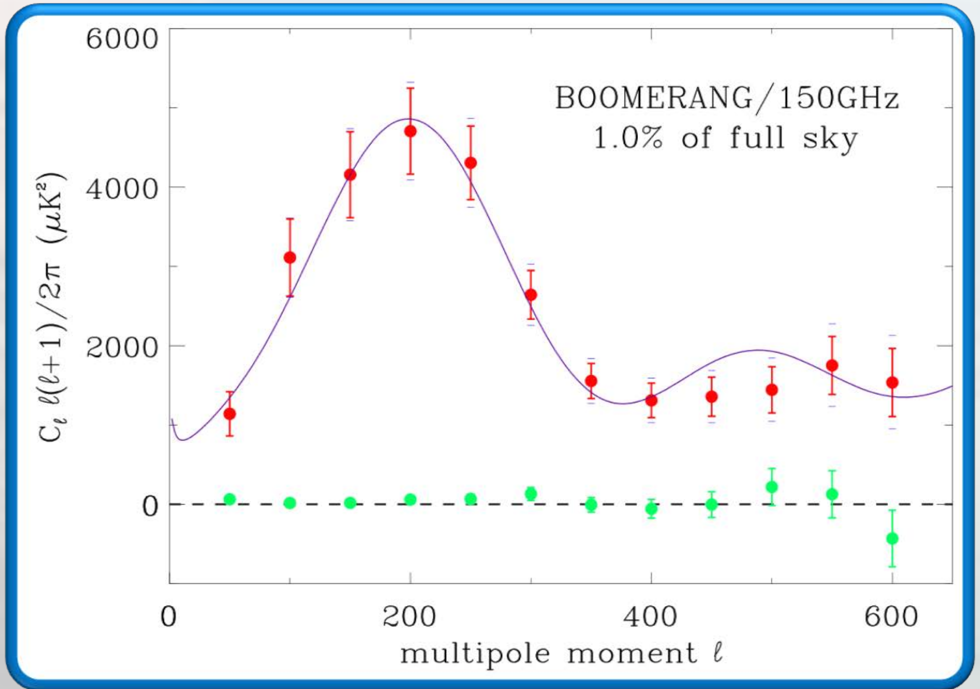


Figure 1. (a) Acoustic oscillations. Photon pressure resists gravitational compression of the fluid setting up acoustic oscillations (left panel, real space $-\pi/2 \lesssim kx \lesssim \pi/2$). Springs and balls schematically represent fluid pressure and effective mass respectively. Gravity displaces the zero point such that $\Theta\cos(kx) = -\Psi\cos(kx)$ at equilibrium with oscillations in time of amplitude $\Psi/3$ (right panel). The displacement is cancelled by the redshift $\Psi\cos(kx)$ a photon experiences climbing out of the well. Velocity oscillations lead to a Doppler effect $V_\parallel$ shifted by $\pi/2$ in phase from the temperature perturbation. (b) Baryon drag increases the gravitating mass, causing more infall and a net zero point displacement, even after redshift. Temperature crests (compression) are enhanced over troughs (rarefaction) and Doppler contributions.

A FLAT UNIVERSE



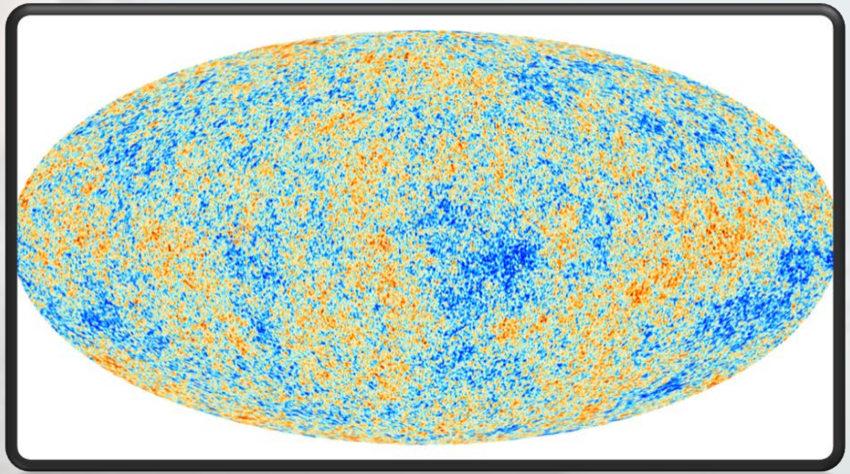
Miller AD, et al. 1999. Ap. J. 524:L1



P. de Bernardis et al, 2000
Nature, 404, 955,

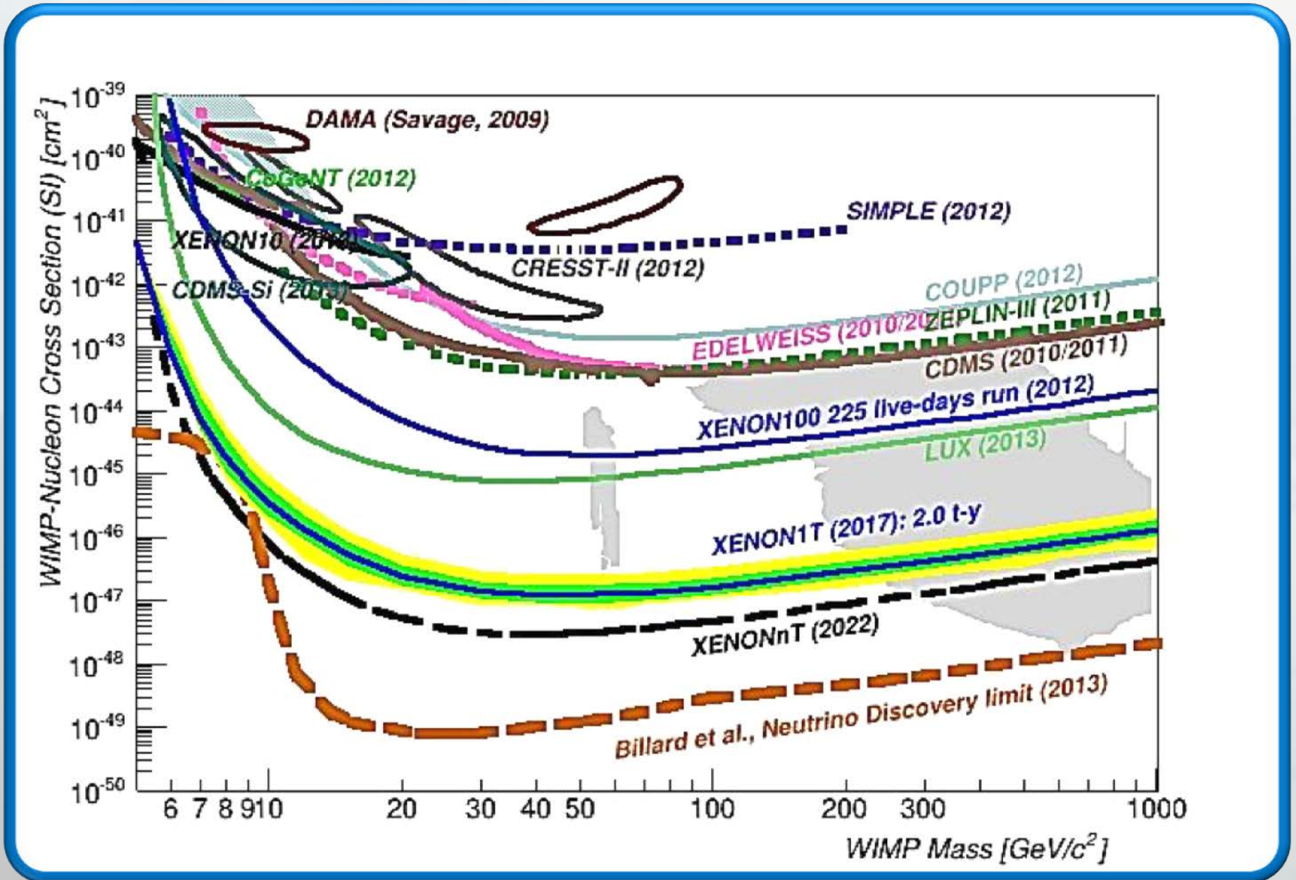
PLANCK CMB SKY

ΛCDM parameters
$\Omega_b = 0.0486 \pm 0.0005$
$\Omega_m = 0.3089 \pm 0.0062$
$\Omega_\Lambda = 0.6911 \pm 0.0062$
$\sigma_8 = 0.8159 \pm 0.0086$
$n_s = 0.9667 \pm 0.004$
$H_0 = 67.74 \pm 0.46$
$\tau = 0.056 \pm 0.009$



DARK MATTER

- ❑WIMP's?
- ❑Axions?
- ❑Dark Stars?
- ❑PBHs
- ❑…modified gravity
- ❑More exotic candidates?



JOE AND DARK MATTER

Fermi National Accelerator Laboratory

FERMILAB-Pub-85/62-A
April 1985

THE PHOTINO, THE SUN AND HIGH ENERGY NEUTRINOS

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Dark matter annihilation at the galactic center

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If cold dark matter is present at the galactic center, as in current models of the dark halo, it is accreted by the central black hole into a dense spike. Particle dark matter then annihilates strongly inside the spike, making it a compact source of photons, electrons, positrons, protons, antiprotons, and neutrinos. The spike luminosity depends on the density profile of the inner halo: halos with finite cores have unnoticeable spikes, while halos with inner cusps may have spikes so bright that the absence of a detected neutrino signal from the galactic center already places interesting upper limits on the density slope of the inner halo. Future neutrino telescopes observing the galactic center could probe the inner structure of the dark halo, or indirectly find the nature of dark matter.

ELSEVIER

Physics Reports

Volume 405, Issues 5–6, January 2005, Pages 279-390

Particle dark matter: evidence, candidates and constraints

Gianfranco Bertone [a], Dan Hooper [b], Joseph Silk [b]

GALAXY FORMATION

THE ASTROPHYSICAL JOURNAL, **303**:39–55, 1986 April 1

THE ORIGIN OF DWARF GALAXIES, COLD DARK MATTER, AND BIASED GALAXY FORMATION

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Received 1985 April 25; accepted 1985 August 14

A&A manuscript no.
(will be inserted by hand later)

Your thesaurus codes are:
02(02.13.5; 09.13.2; 12.03.4)

ASTRONOMY AND ASTROPHYSICS

Quasars and Galaxy Formation

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Received October 9, 1997 / Accepted

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CMBNET

2nd general meeting
CMBNet
Cosmic Microwave Background Network in Europe for Theory and Data Analysis
a European Research Training Network

- A European Research Training Network
  - *5th EU Framework Program*
- Network for Theory and Data Analysis
  - *2000 2004*
  - *Network 8 nodes with 8 researchers*
  - *Roma Tor Vergata, IAP, Santander, MPI, Oxford, Geneve, Warsaw, Cambridge*

LHC IN SCIENCE OF THE UNIVERSE

TOR VERGATA, 2005

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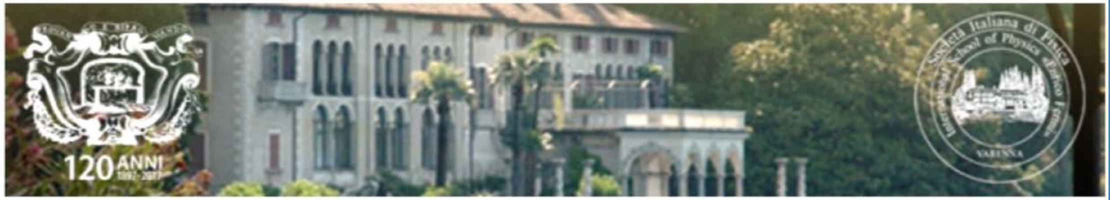
International School of Physics "Enrico Fermi"



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JOE AND THE CMB

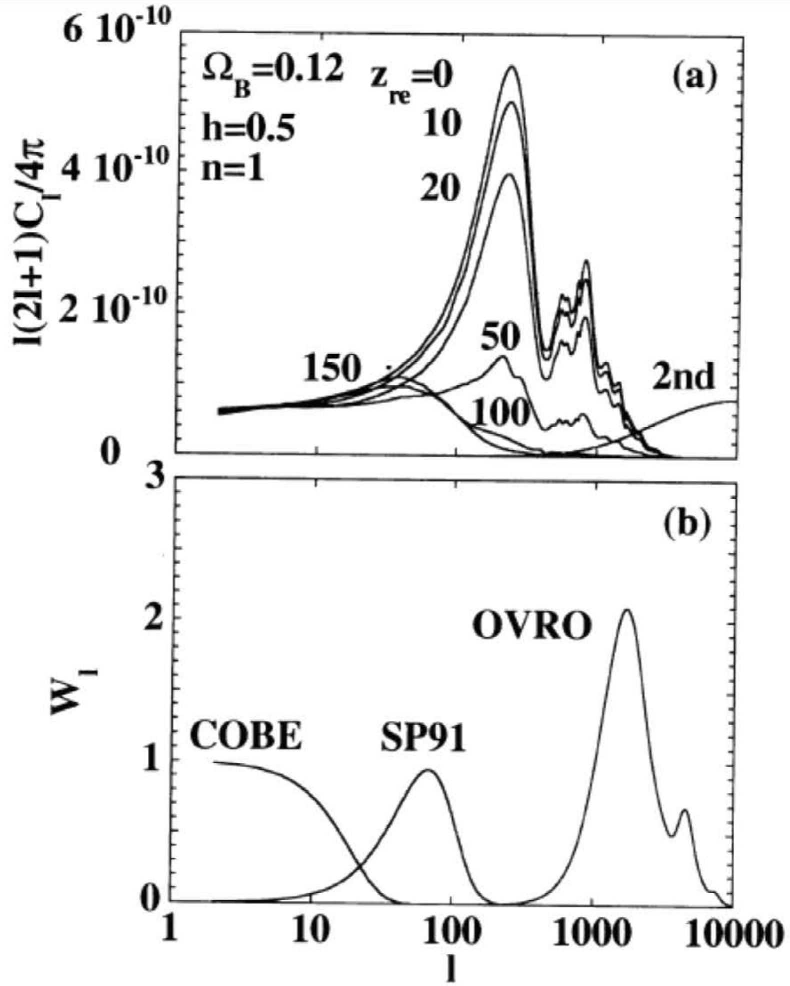

FIG. 3.—(*a*) Power spectrum of temperature anisotropies $\ell(2\ell + 1)C_\ell/4\pi$ as a function of ℓ for various reionization epochs. The contribution of the Vishniac effect in the optically thick universe is shown for large ℓ (labeled "2nd"). We multiply this effect by the factor 10, since it is so small. (*b*) Window functions W_ℓ are shown for *COBE*, SP91, and OVRO.

THE ASTROPHYSICAL JOURNAL, 419:L1–L4, 1993 December 10

REIONIZATION AND COSMIC MICROWAVE ANISOTROPIES

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Received 1993 August 30; accepted 1993 September 21

ABSTRACT

The effects of reionization, occurring after standard recombination in cold dark matter–dominated models, on cosmic microwave background (CMB) anisotropies are investigated. Late-time reionization reduces the CMB anisotropies, in particular, on degree scales. It is found that constraints on cold dark matter–dominated models from the highest frequency channel of the 9-point South Pole data are significantly relaxed for models which are consistent with big bang nucleosynthesis if reionization is assumed to have occurred by redshift ~20.


HAPPY
BIRTHDAY