THE COSMIC SMÖRGÅSBORD:

CMB

GALAXY SURVEYS

GRAVITATIONAL LENSING

DISTANT SUPERNOVAE

X-RAY CLUSTERS

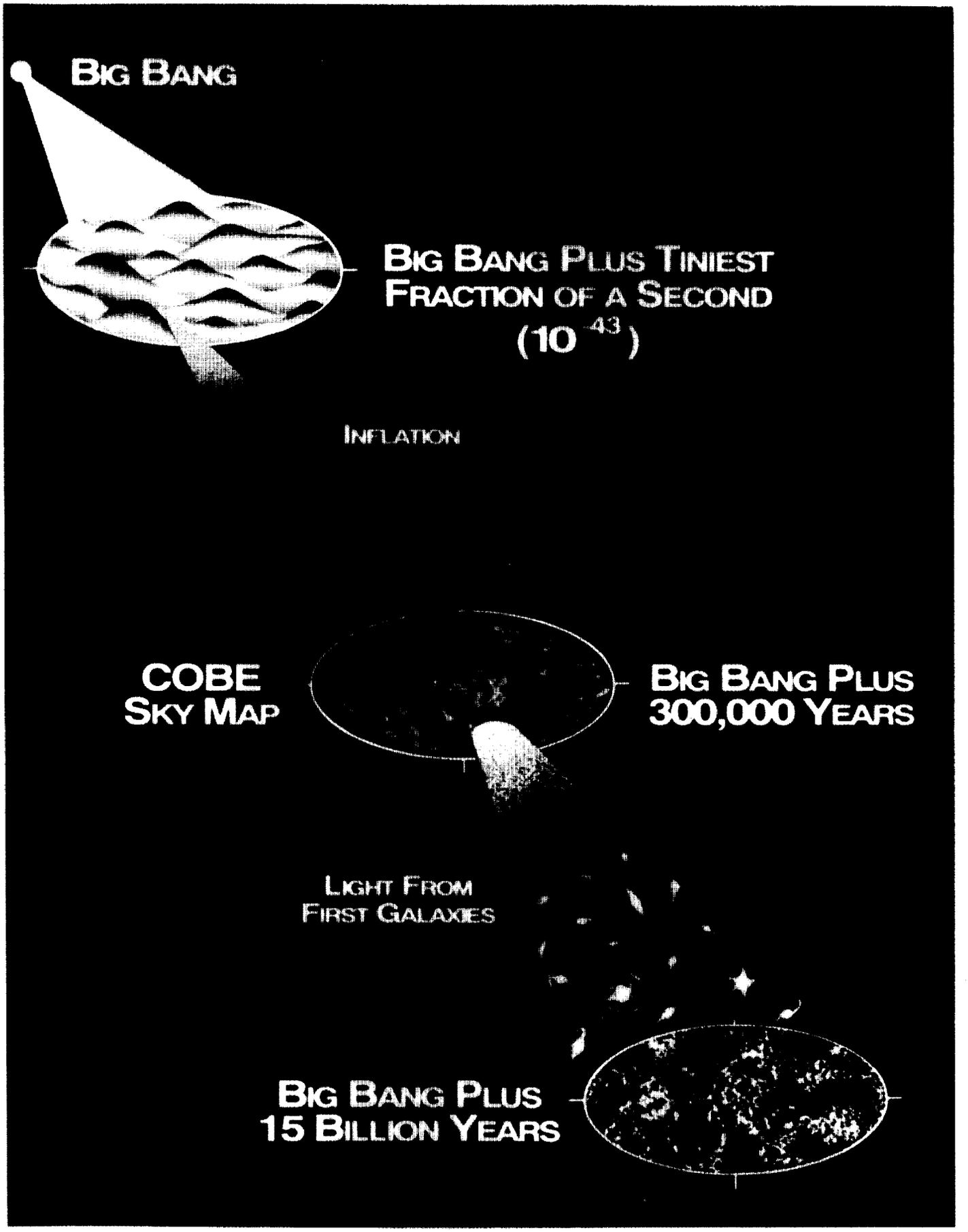
QUASARS, AGN

COMPLEMENTARITY

MAX TEGMARK (IAS, PRINCETON)

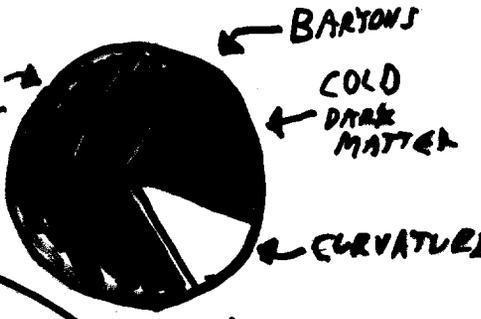
WITH

DANIEL EISENSTEIN & WAYNE HU


BIG BANG
BIG BANG PLUS TINIEST FRACTION OF A SECOND (10^{-43})
INFLATION
COBE SKY MAP
BIG BANG PLUS 300,000 YEARS
LIGHT FROM FIRST GALAXIES
BIG BANG PLUS 15 BILLION YEARS

PARAMETERS OF THE "MINIMAL COSMOLOGICAL STANDARD MODEL"

MATTER BUDGET

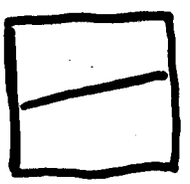


- T_0 Photons — $\varrho_\gamma \propto T_0^4$
- Y Helium — $\omega_{He} = Y \omega_b$
- ω_b Hydrogen — $\omega_H = (1-Y)\omega_b$
- ω_c CDM
- ω_ν Massive neutrinos — $\omega_i \equiv h^2 \Omega_i = \text{const} \cdot \varrho_i$
- ω_Λ Vacuum energy, Λ
- ω_Ω Curvature

EXTENSIONS:

Generalized dark matter, e.g. quintessence

INPUT FLUCTUATIONS



- Q, n, α } Adiabatic scalar
- T/S, n_T } Tensor

EXTENSIONS:

- Isocurvature
- Topological defects
- Other non-Gaussian

GASTROPHYSICS

- τ Reionization optical depth
- b Bias of galaxies

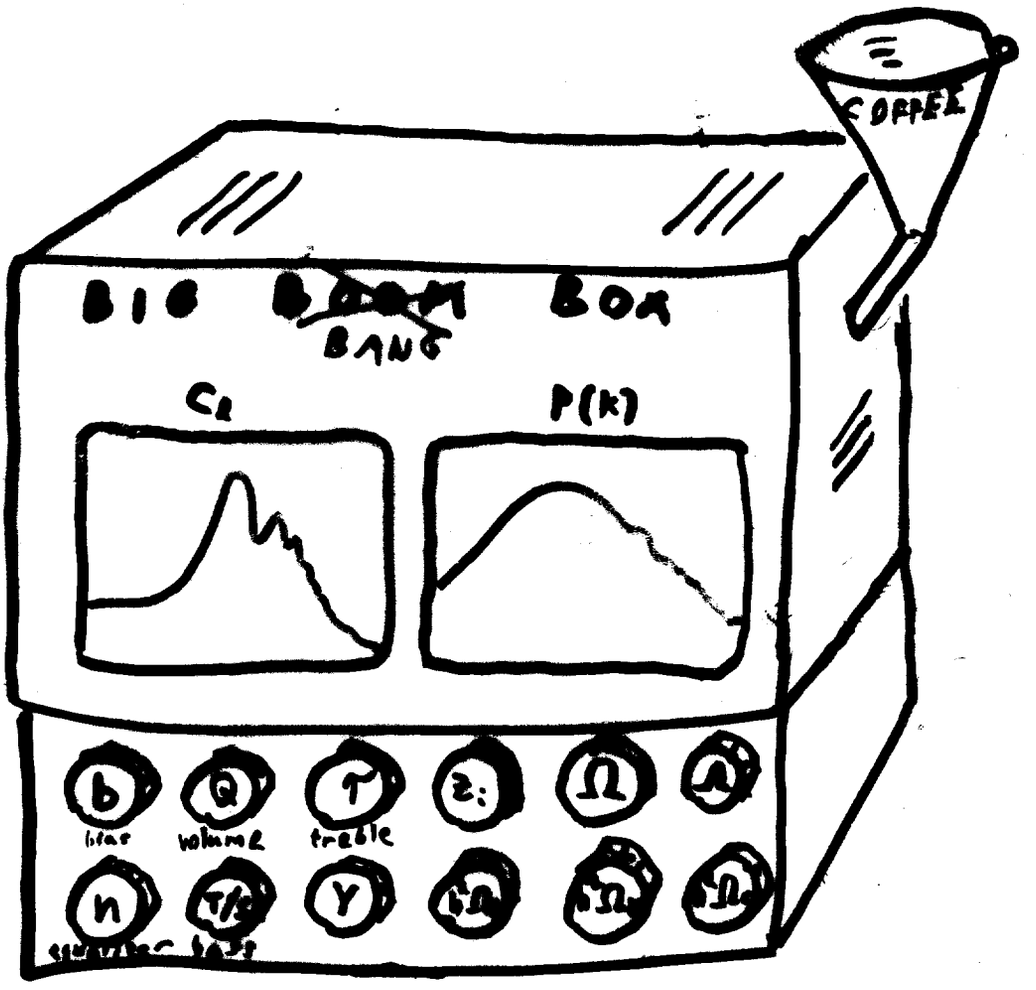
EXTENSIONS:

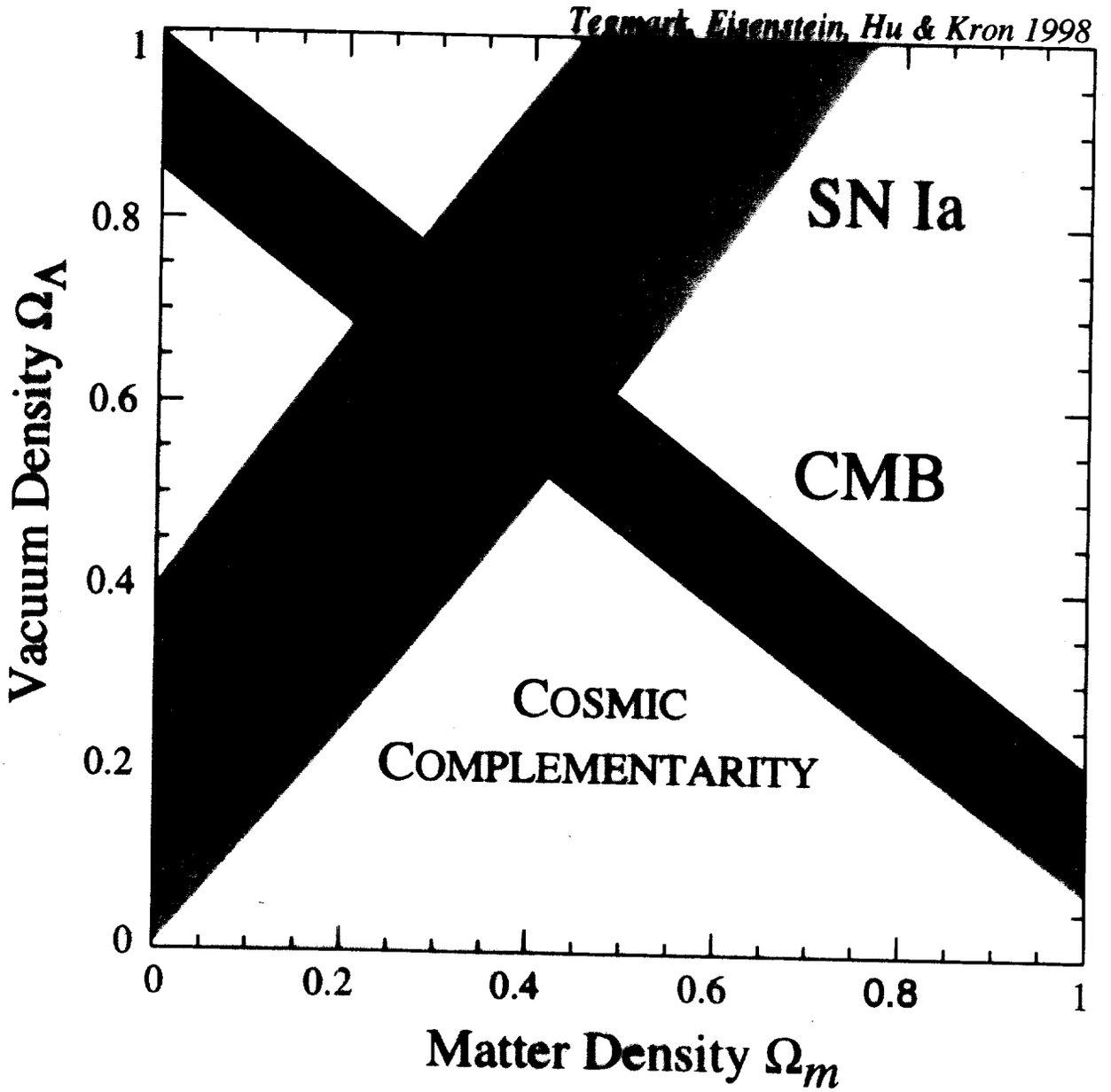
- Stochastic bias
- Nonlinear bias
- Scale-dependent bias
- Two CMB foreground parameters (Q_{PS} & Q_{Galaxy})
- Bias depending on galaxy type

SUM: 14 PARAMETERS

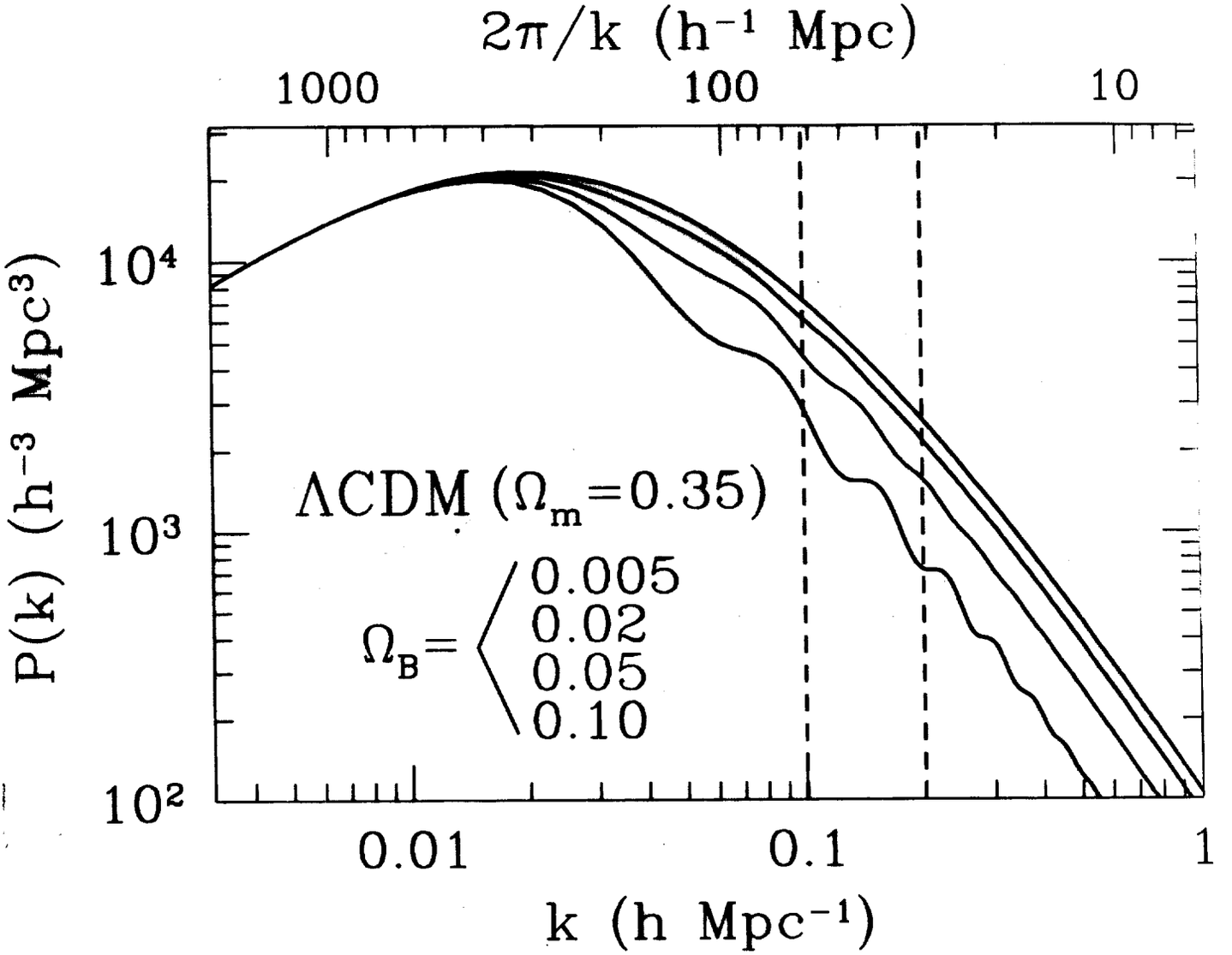
REDUNDANT PARAMETERS (DETERMINED BY THOSE ABOVE)

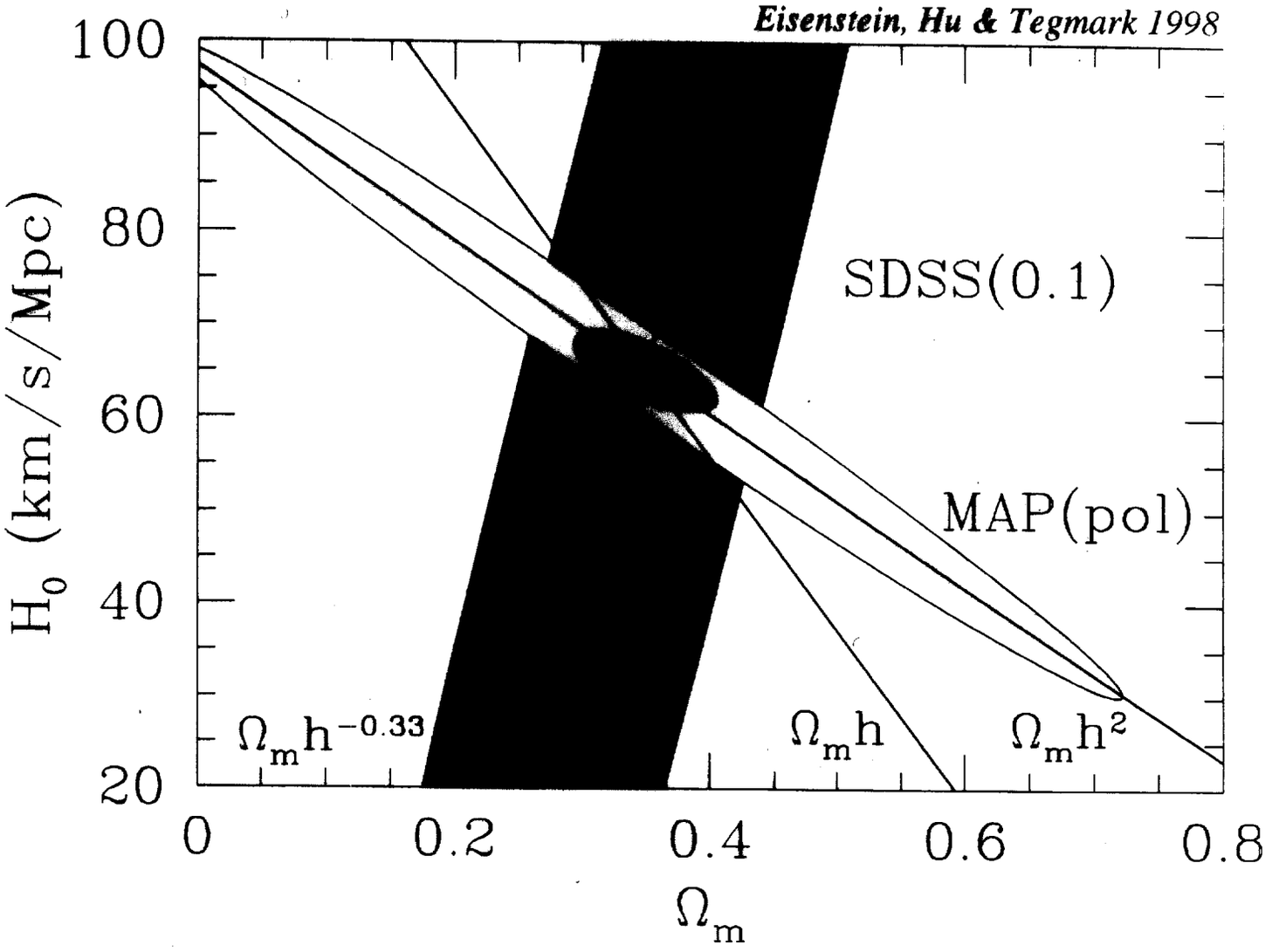
- h Hubble constant ← $h^2 = \sum \omega_i$
- t Age of Universe
- σ_8 Galaxy fluctuation normalization


COPPER
BIG BANG BOX
C_ℓ
P(k)
bias
volume
treble

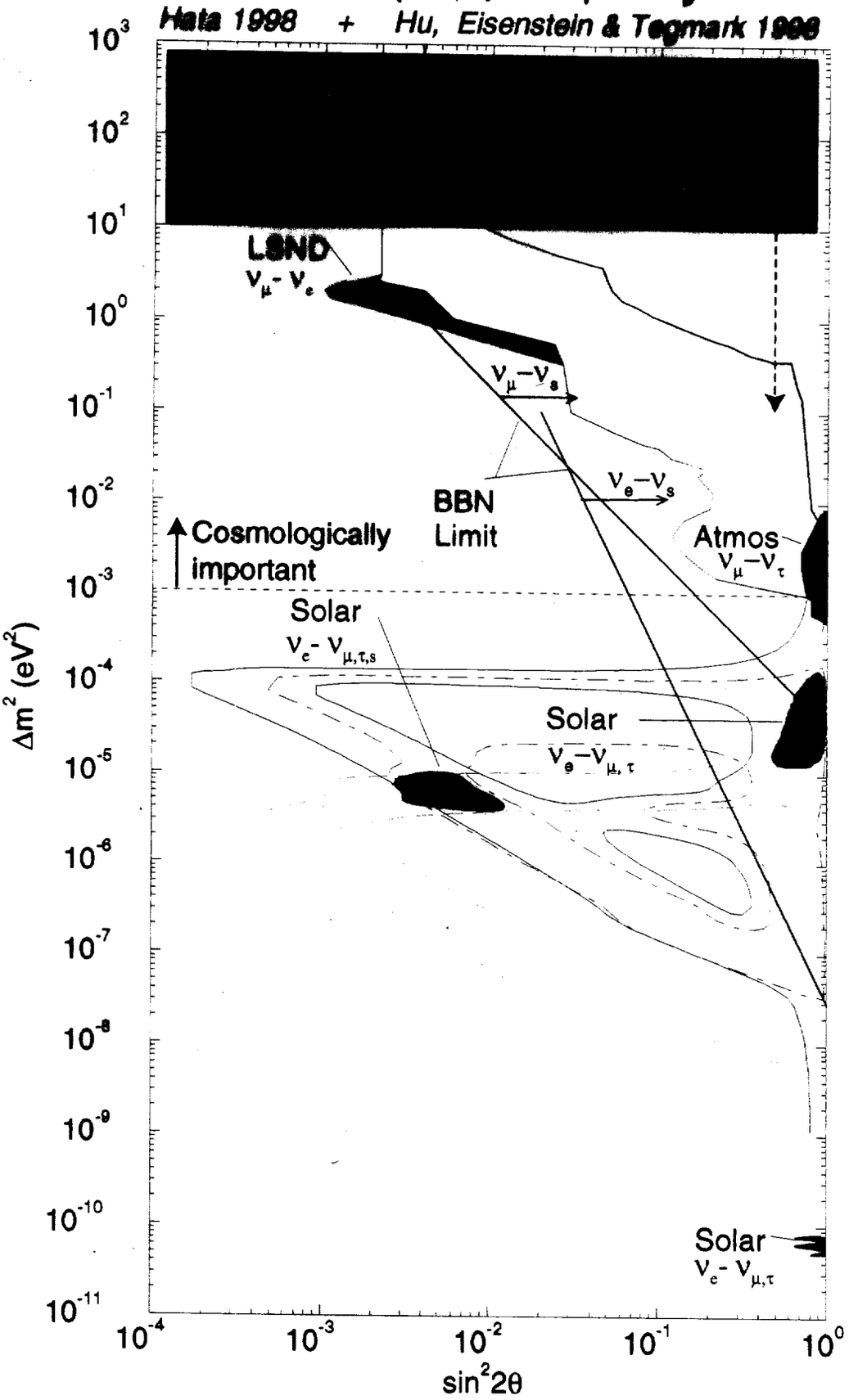

Tegmark, Eisenstein, Hu & Kron 1998
SN Ia
CMB
COSMIC
COMPLEMENTARITY
Vacuum Density Ω_Λ
Matter Density Ω_m
0
0.2
0.4
0.6
0.8
1

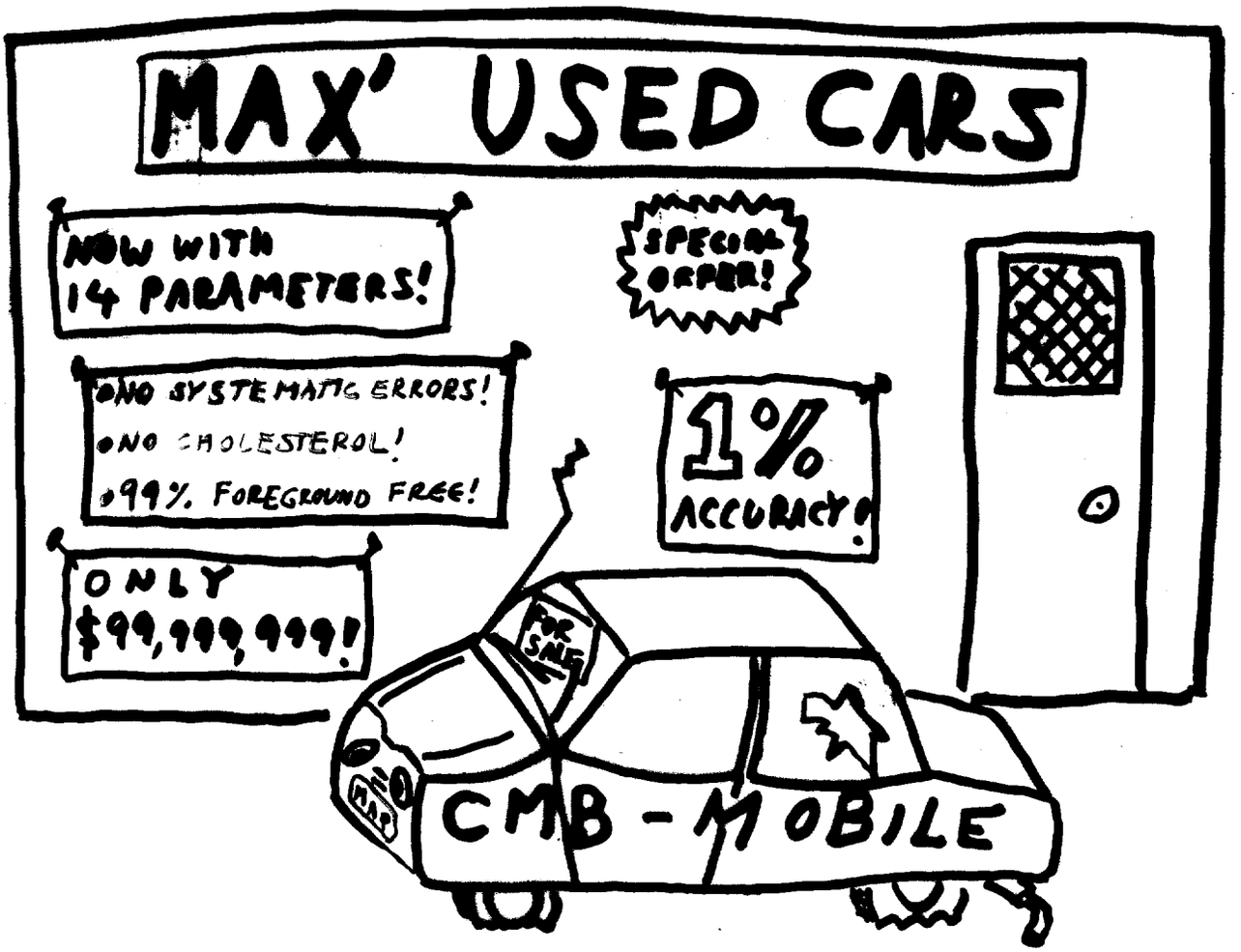
EISENSTEIN, HU & TEGMARK '98



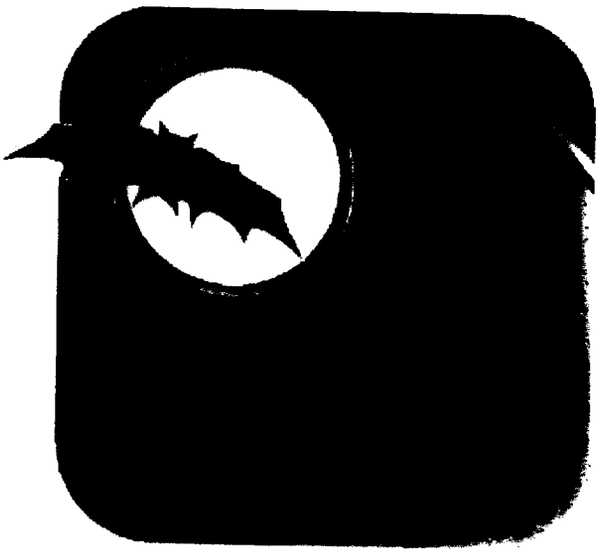

Eisenstein, Hu & Tegmark 1998
100
80
60
40
20
H_0 (km/s/Mpc)
SDSS(0.1)
MAP(pol)
$\Omega_m h^{-0.33}$
$\Omega_m h$
$\Omega_m h^2$
0
0.2
0.4
0.6
0.8
Ω_m

(PRL, in press)


Hata 1998 + Hu, Eisenstein & Tegmark 1998
LSND
$\nu_\mu - \nu_e$
$\nu_\mu - \nu_s$
$\nu_e - \nu_s$
BBN
Limit
Cosmologically
important
Atmos
$\nu_\mu - \nu_\tau$
Solar
$\nu_e - \nu_{\mu,\tau,s}$
Solar
$\nu_e - \nu_{\mu,\tau}$
Solar
$\nu_e - \nu_{\mu,\tau}$
Δm^2 (eV^2)
$\sin^2 2\theta$
10^3
10^2
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^0


MAX' USED CARS
NOW WITH 14 PARAMETERS!
SPECIAL OFFER!
•NO SYSTEMATIC ERRORS!
•NO CHOLESTEROL!
•99% FOREGROUND FREE!
1% ACCURACY!
ONLY $99,999,999!
FOR SALE
CMB-MOBILE

MAX' LITTLE SHOP OF HORRORS:



CMB:
* Instrumental noise
* Incomplete sky coverage
* Foreground contamination
* Errors in theoretical predictions

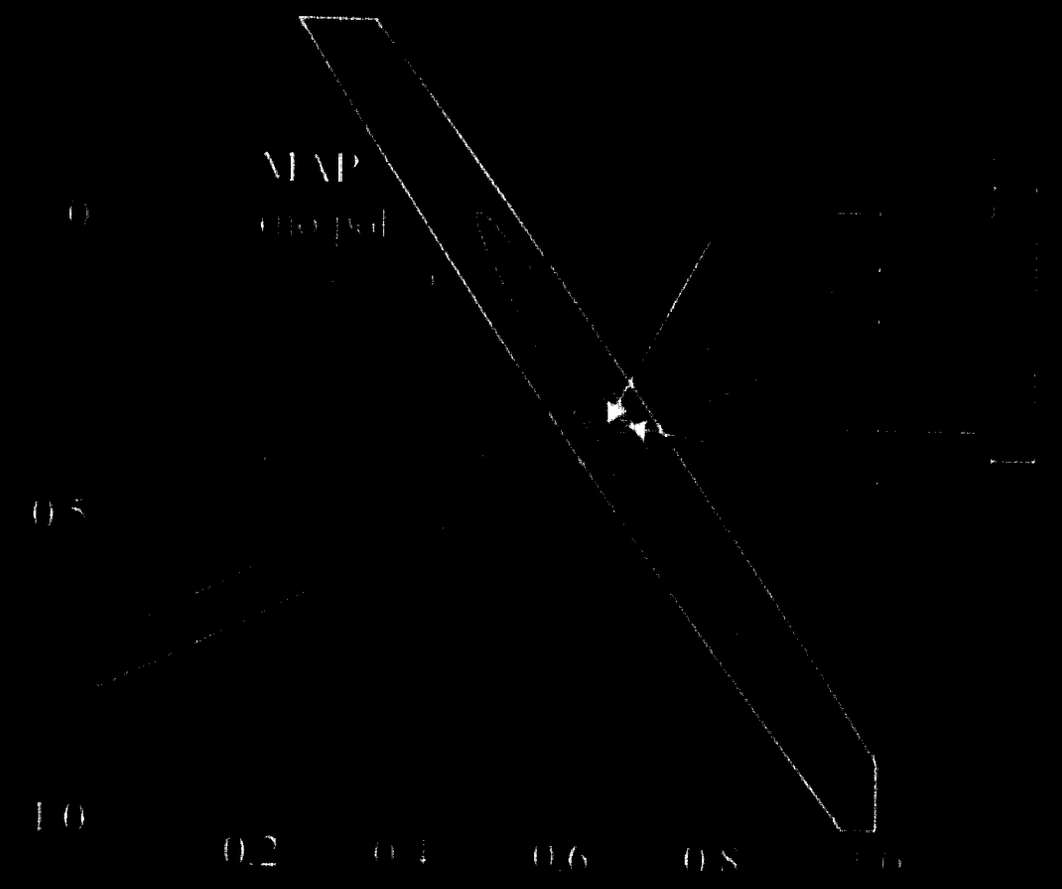
GALAXY SURVEYS:
* Scale-dependent biasing
* Luminosity-dependent biasing
* Morphology-dependent biasing
* Non-linear biasing
* Non-linear evolution
* Edge effects
* Redshift-space distortions
* Extinction

BOTH:
* Too much data to handle properly
* Systematic errors
* Degeneracies

Approaching A

Hu, Eisenstein, Teemark, White (1995)

- and distinction disappears
  [uncertainty on increases]
- and disappear
  [degeneracy must be broken by shape, etc]
- and more important



Tegmark, Eisenstein, Hu & Kron 1998