Title: CMB Cosmic String B-Modes

Date: Jun 05, 2008 03:00 PM

URL: http://pirsa.org/08060158

Abstract:

N-Body Degravitation: (the talk you came for)

- **question:** how does a massive self-interacting graviton (which *may* solve the cosmological constant problem) affect structure formation?
- **approach:** N-body code for modified gravity
- **results:** *coming soon!*

with Justin Khoury and Nathan Chow (PI)

CMB experiments: the next round

- **B-modes:**
  - search is on (many experiments!) for **tensor modes**, which *may* be present from inflation
- **High-ℓ:**
  - PLANCK, Atacama Cosmology Telescope, South Pole Telescope will measure the TT power to ever higher ℓ

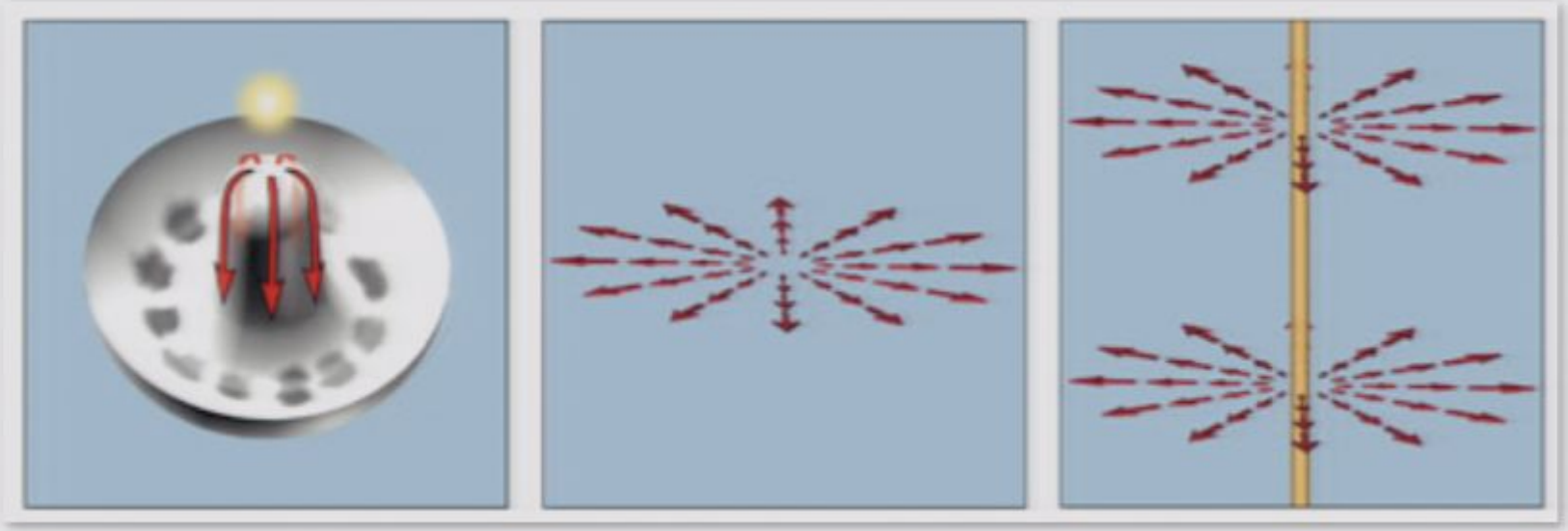
CMB experiments: where strings come in

- **B-modes:**
  - Cosmic strings, if present, ***copiously produce*** B-mode polarization because they source vector mode perturbations
- **High-ℓ:**
  - Strings also produce ***more power*** at high-ell than the primordial inflationary spectrum

Cosmic strings: what are they?

Kibble mechanism for defect formation:

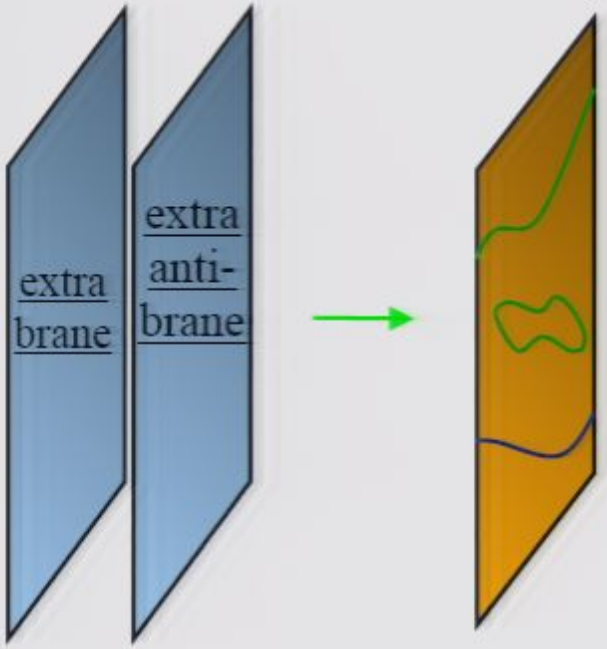
Regions larger than H^{-1} are out of causal contact!



Cosmic string defect for U(1) symmetry

Brane inflation: New source for cosmic strings

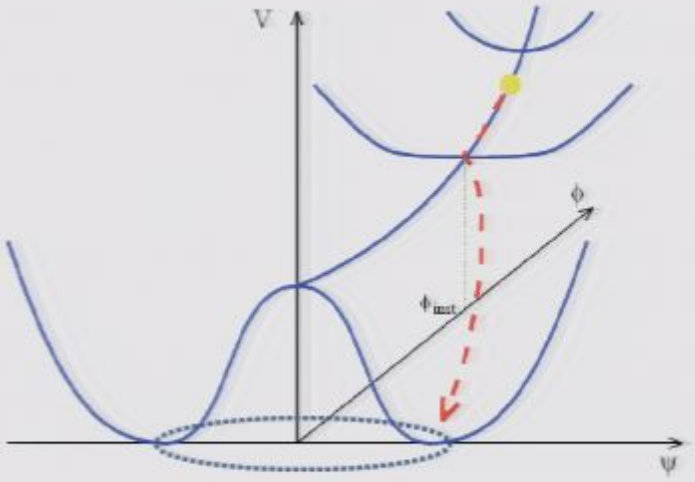
(Tye and Sarangi 2002, Jones, Stoica, and Tye 2002, Copeland, Myers, and Polchinski 2004)



- Annihilation of inflating branes can produce strings (actual 1-D objects *or* "wrapped" higher-D objects)
- Predicts: few x $10^{-7} > G\mu > 10^{-11}$
- caveat: possible stability problems
- Not ruled out; potentially detectable

Not just brane inflation...

- Strings are produced in many hybrid inflationary models (e.g., from SUSY)



Cosmic strings

$G\mu$: key dimensionless parameter

G = Newton's constant $\quad (\hbar = c = 1)$

μ = string tension

$G\mu \sim$ string tension in Planck units

$\sim$ gravitational coupling of string = size of metric perturbation.

$\sim 10^{-6}$ for μ at GUT scale ($\sim 10^{21}\ {}^{g}/_{cm}$)

String network evolution: scaling

Network energy lost in loops (Kibble)

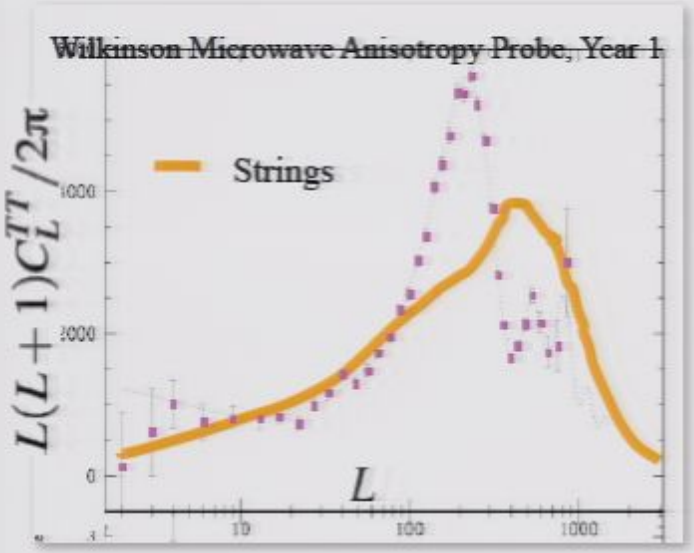
Naively, $\Omega_{strings} \sim \frac{G\mu}{a^2}$

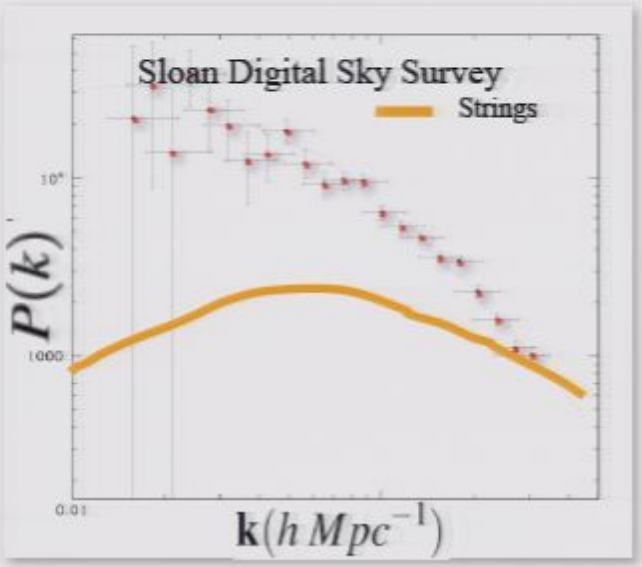
Simulations find $\Omega_{strings} \sim G\mu$

in Matter ***and*** Radiation Eras

Confronting data

$$\frac{C^{TT}_{strings}}{C^{TT}_{tot}} \lesssim 0.1$$





CMB + LSS:
Wyman et al '05

Recent finding

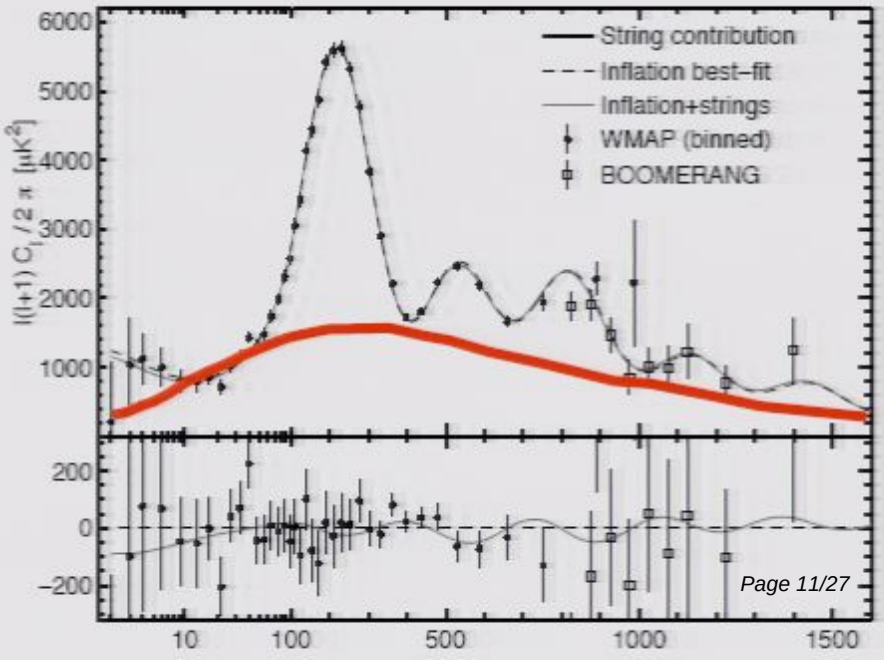
$$G\mu = 0.7 \times 10^{-6}$$

Strings + HZ ($n_s \equiv 1$) **better fit** to CMB data than $n_s \neq 1$

Bevis et al, 2008

$$\Delta\chi^2 = -3.9$$

versus usual fit



Key Difference:

Low-ell peak =
replaces red tilt!

Bevis et al, 2008

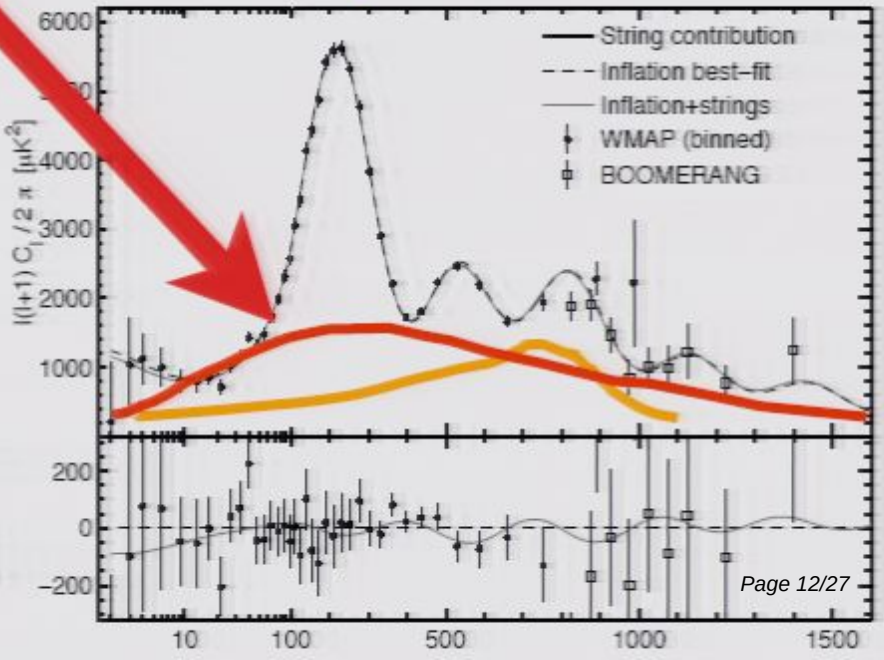
Wyman et al '05

may PERMIT

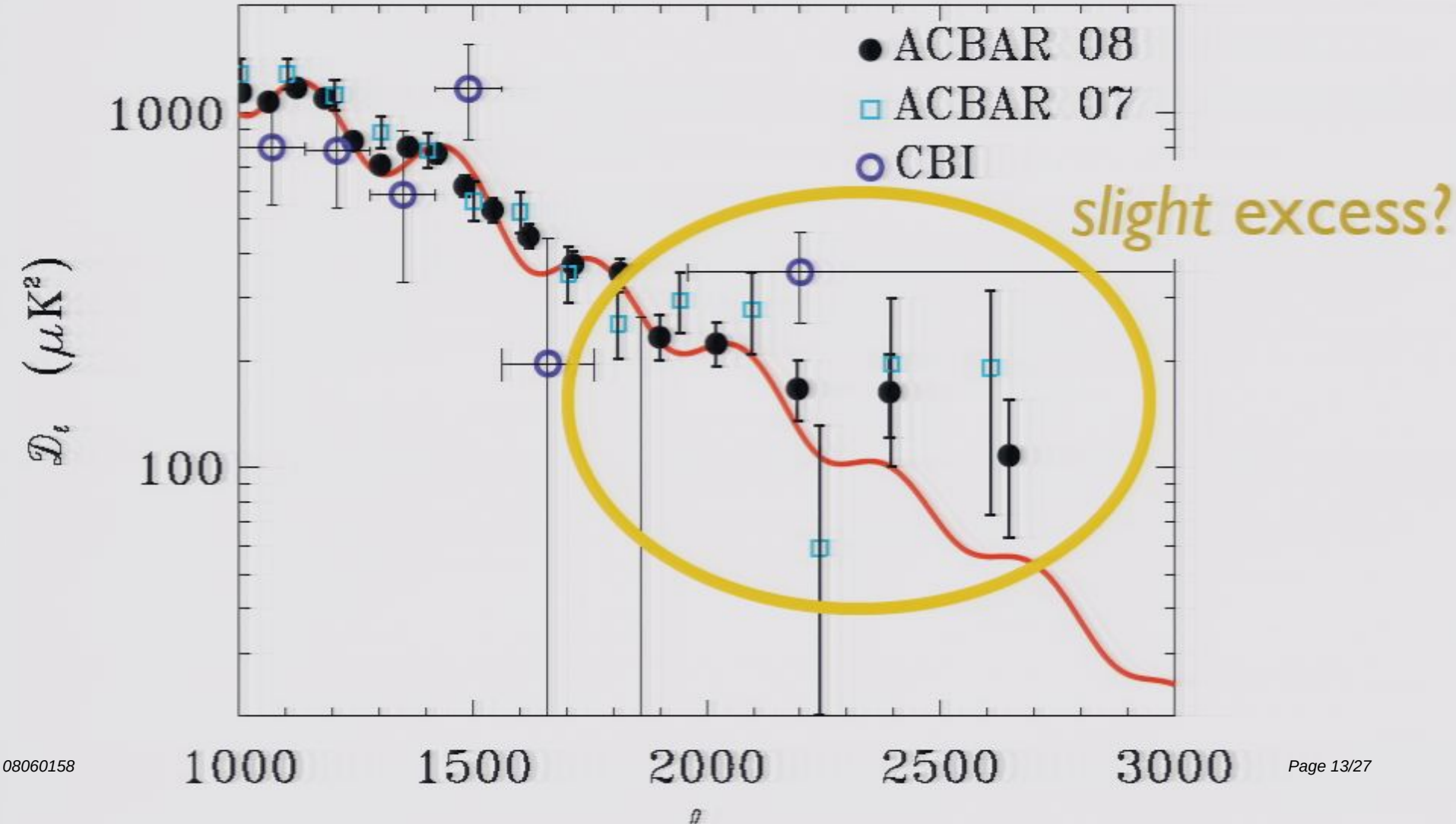
$$n_s = 1$$

inflationary models ...

(e.g., D3/D7 inflation -- see Haack et al, Becker, Leblond, Shandera



High-ℓ: ACBAR+ CBI



Key Difference:

Low-ell peak =
replaces red tilt!

Bevis et al, 2008

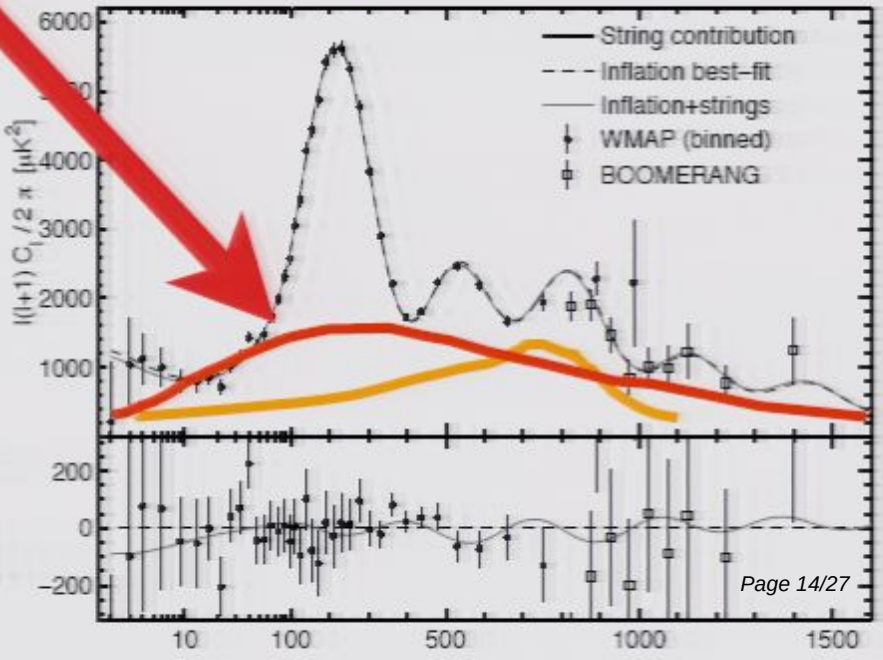
Wyman et al '05

may PERMIT

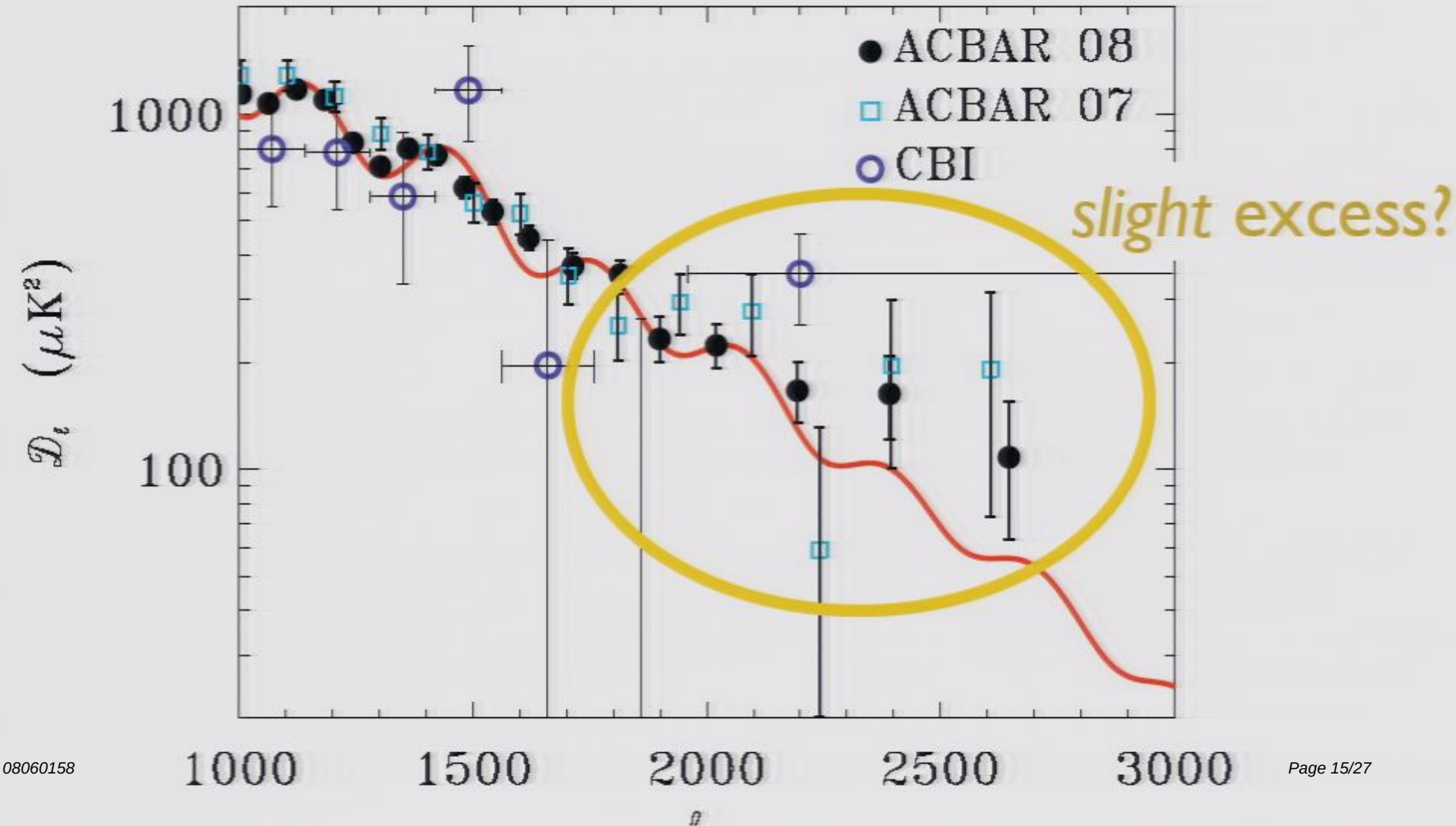
$$n_s = 1$$

inflationary models ...

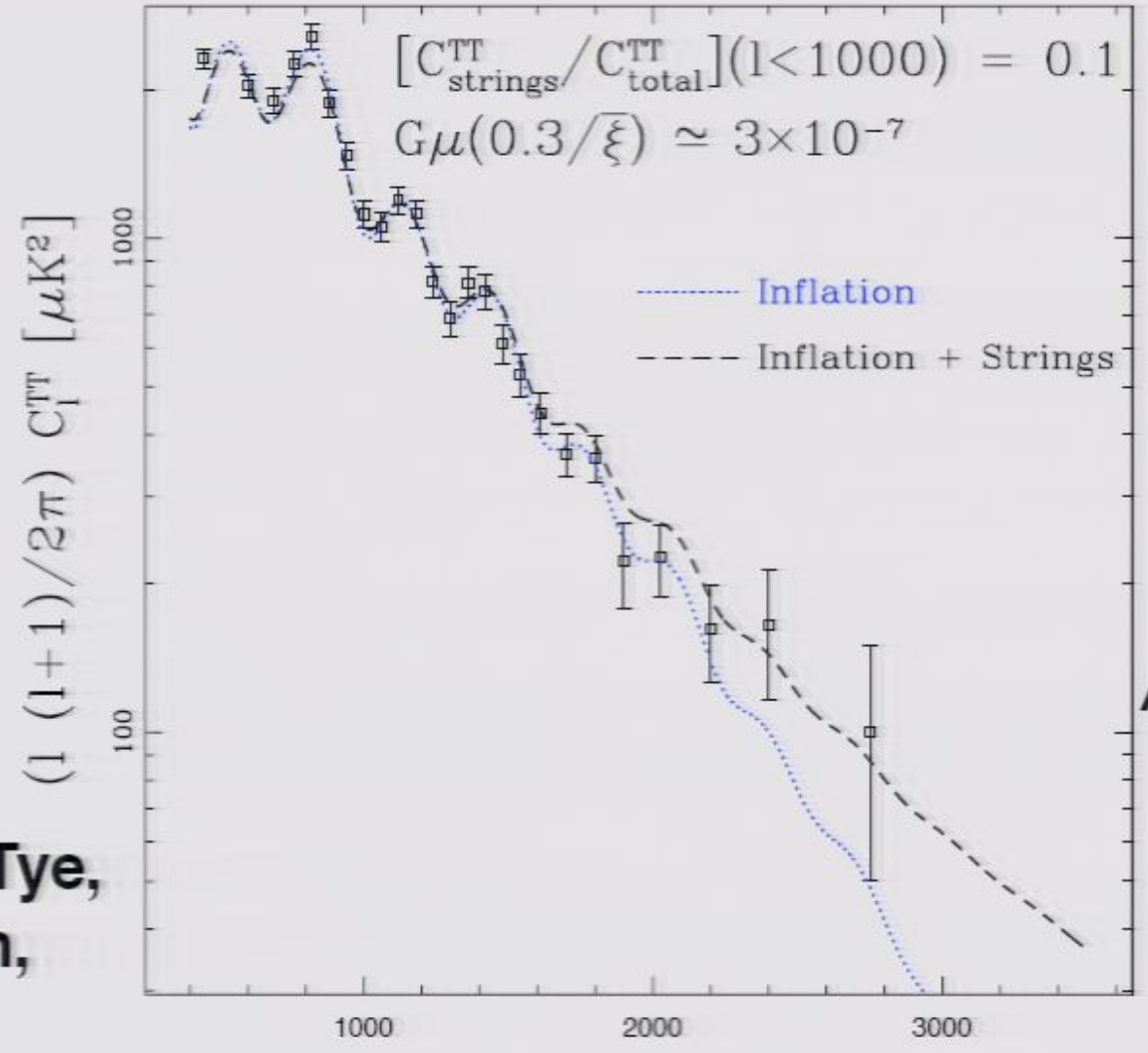
(e.g., D3/D7 inflation -- see Haack et al, Becker, Leblond, Shandera



High-ℓ: ACBAR+ CBI



High-ℓ: 10% strings

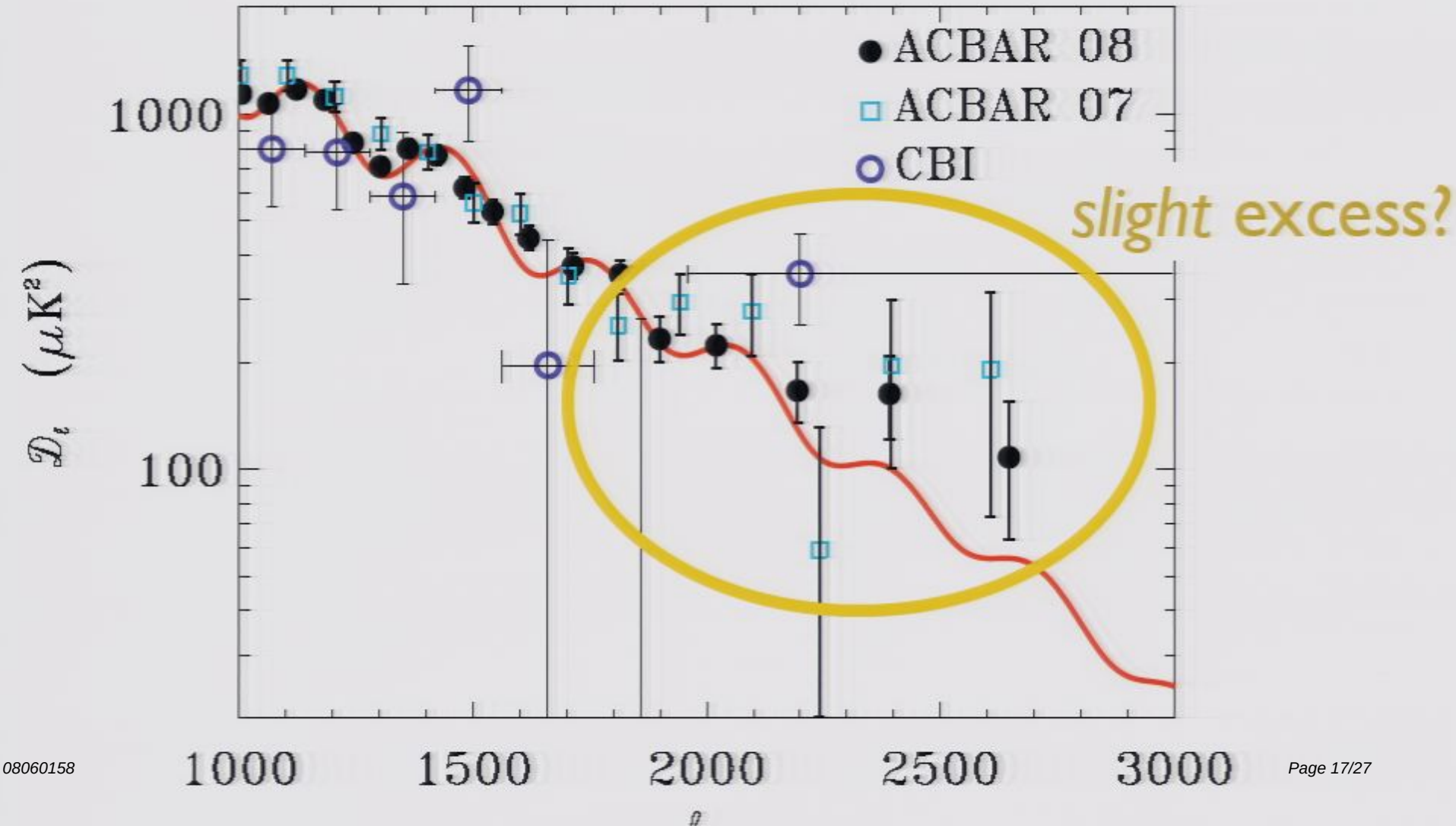


Data from ACBAR 2008

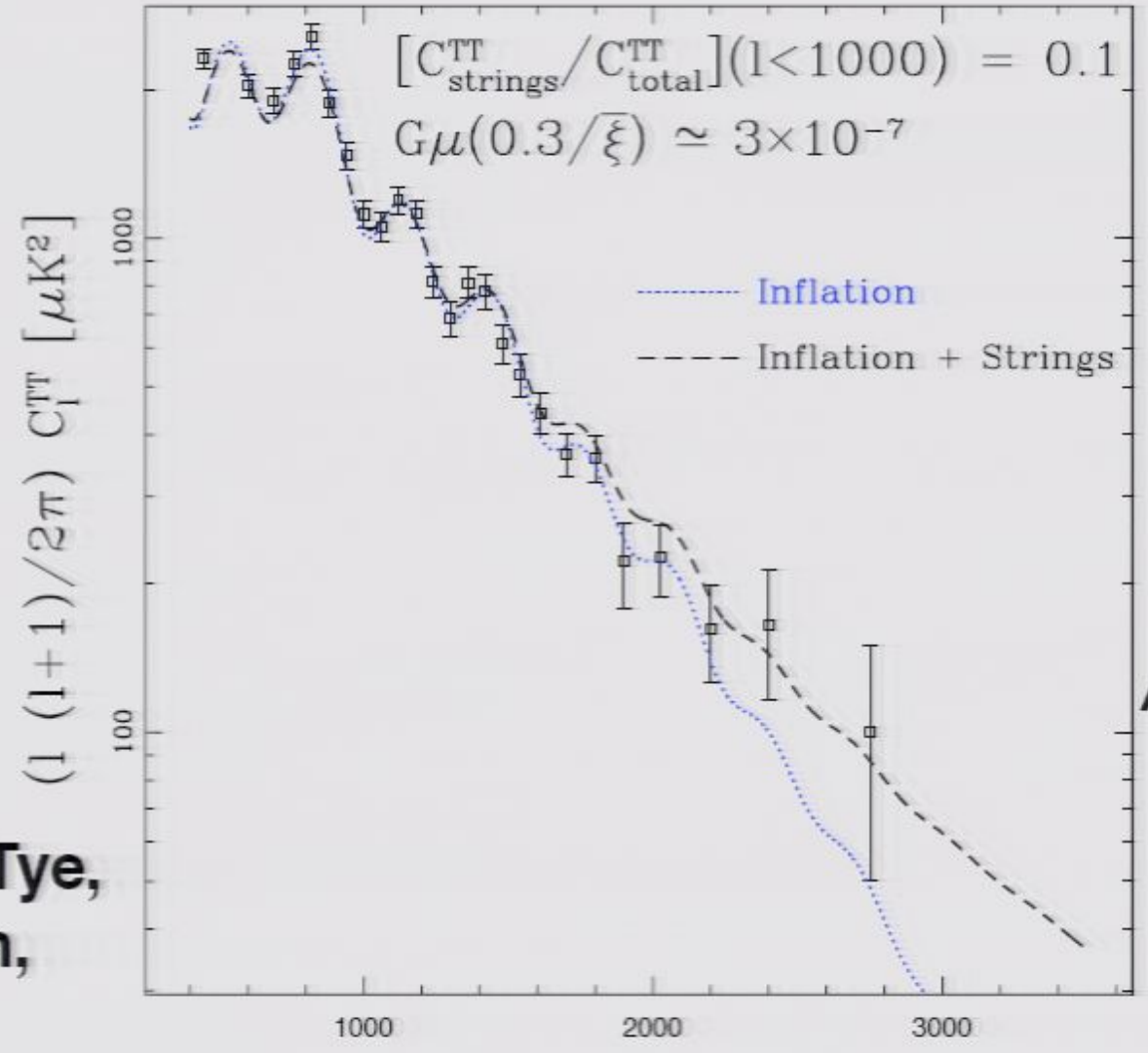
Pogosian, Tye, Wasserman, MW

0804.0810

High-ℓ: ACBAR+ CBI



High-ℓ: 10% strings

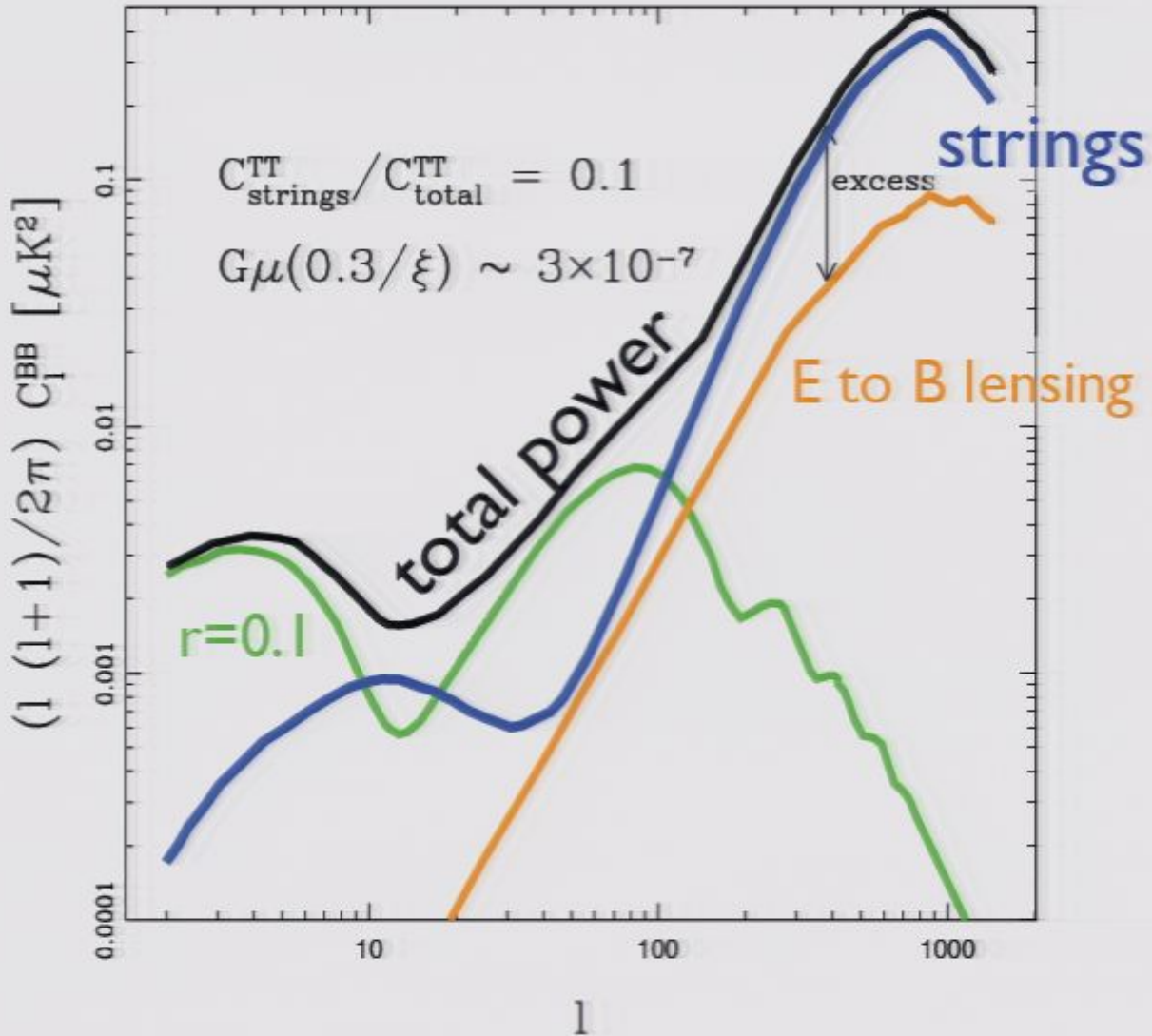


Data from ACBAR 2008

Pogosian, Tye, Wasserman, MW

0804.0810

B-modes: spectra



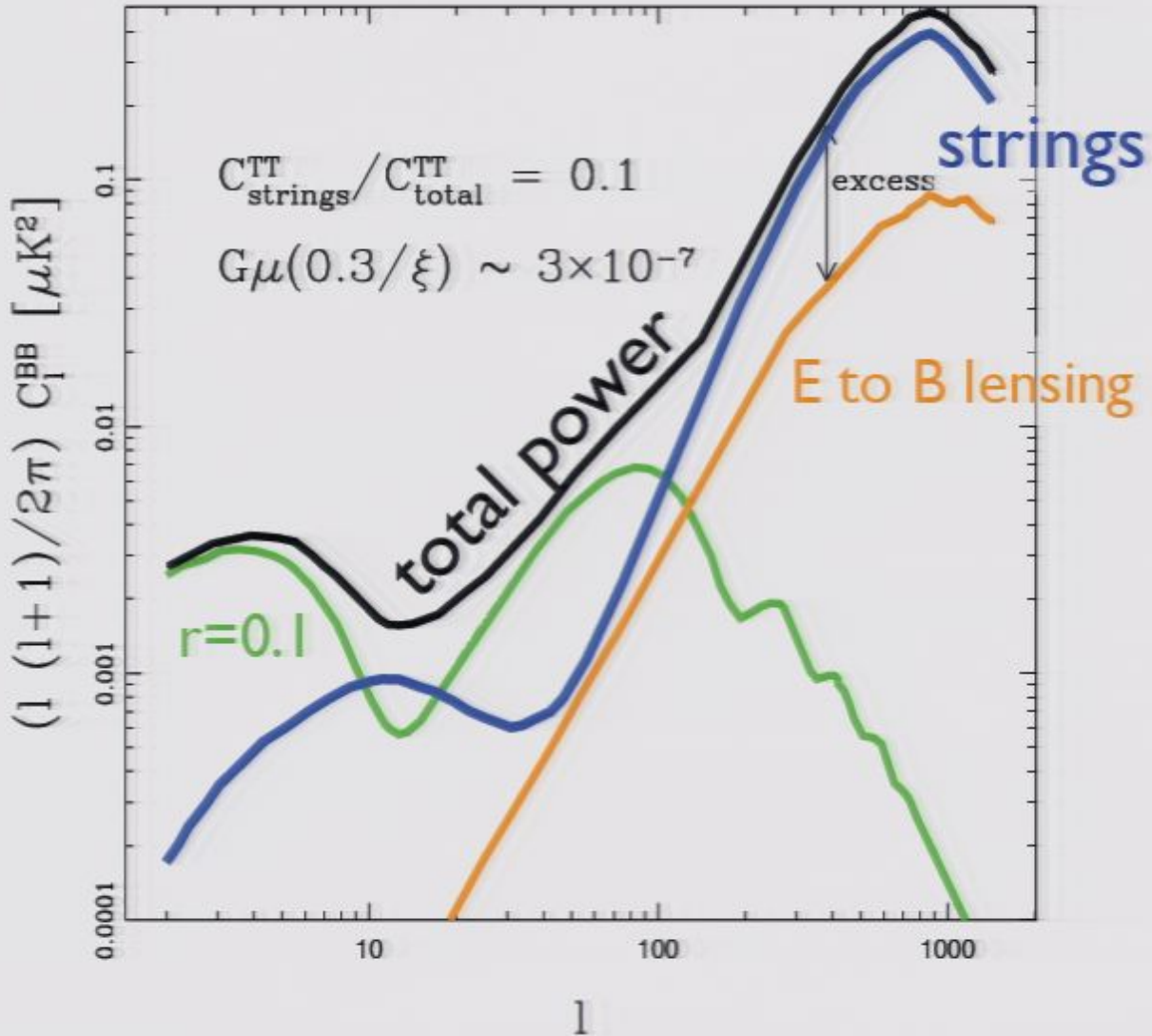
Two important regions of ℓ

- low-ℓ: up to ~100, "gravity wave region"
  - strings and gravity waves could be confused
  - translation formula:

$$G\mu \leftrightarrow 1.4 \times 10^{-6} \sqrt{r} \left(\frac{0.65}{v_{rms}} \right) \sqrt{\frac{\xi}{0.3}} \alpha \qquad 2 < \ell < 100$$

- high-ℓ: "E to B lensing region"
  - strings as **excess** over expected B-mode power

B-modes: spectra



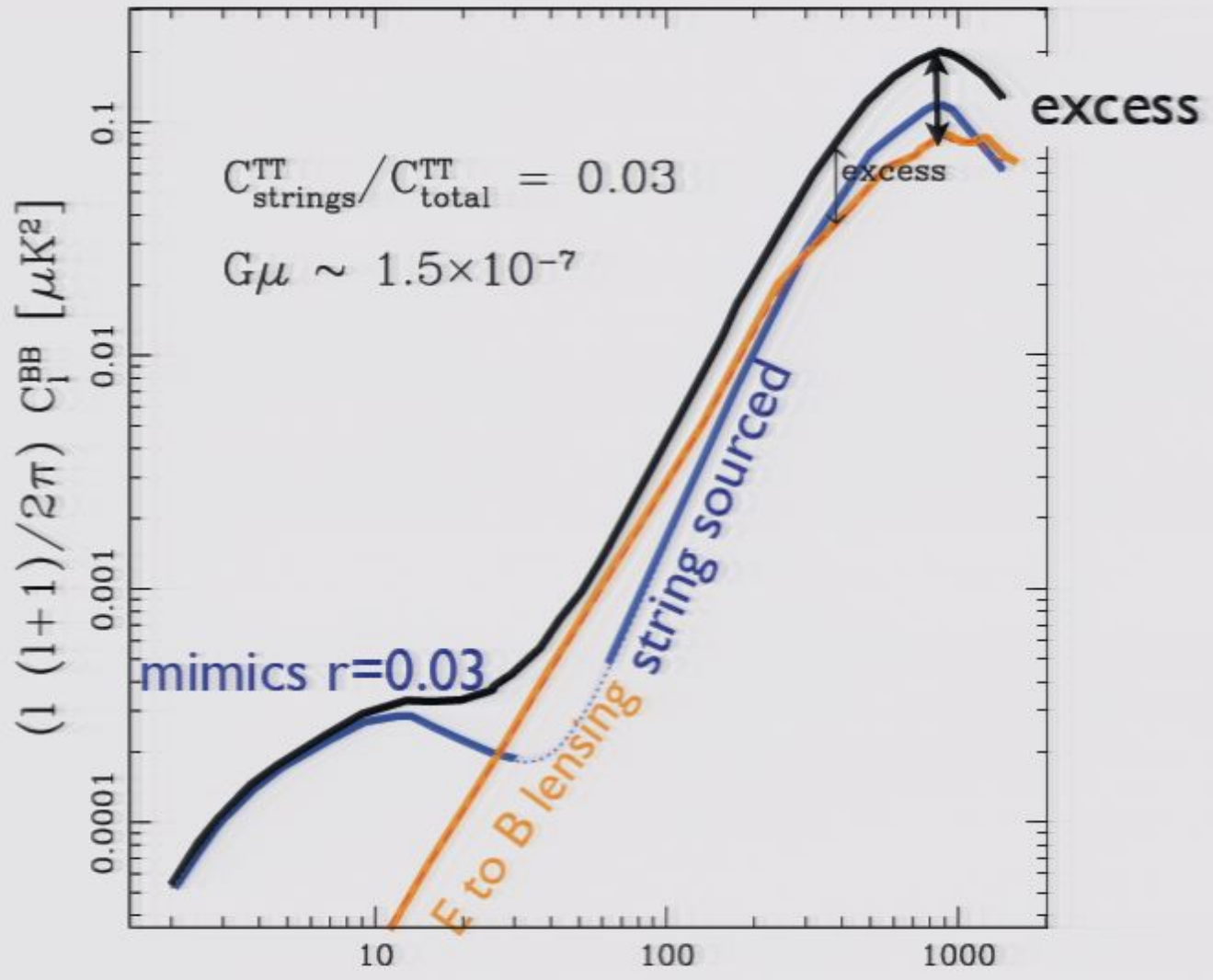
Two important regions of ℓ

- low-ℓ: up to ~100, "gravity wave region"
  - strings and gravity waves could be confused
  - translation formula:

$$G\mu \leftrightarrow 1.4 \times 10^{-6} \sqrt{r} \left(\frac{0.65}{v_{rms}} \right) \sqrt{\frac{\xi}{0.3}} \alpha \qquad 2 < \ell < 100$$

- high-ℓ: "E to B lensing region"
  - strings as **excess** over expected B-mode power

Minimal *clear detection* scenario



Some prospects, low-ℓ:

$$G\mu \leftrightarrow 1.4 \times 10^{-6} \sqrt{r} \left(\frac{0.65}{v_{rms}} \right) \sqrt{\frac{\xi}{0.3}} \alpha \qquad 2 < \ell < 100$$

QUaD: 25<l<100, r>0.14

BICEP: 20<l<120, r>0.1

EBEX: 20<l<1000, r>0.06

CLOVER: 20<l<1000, r>0.01

QUIET: 50<l<250, r=?

Some prospects, high-ℓ:

EBEX: 20<l<1000, lensing

CLOVER: 20<l<1000, lensing

QUIET: 450<l<1700

PolarBeaR: 100<l<2000,
phase 1(2) : 9(20) bins in l

Some prospects, low-ℓ:

$$G\mu \leftrightarrow 1.4 \times 10^{-6} \sqrt{r} \left(\frac{0.65}{v_{rms}} \right) \sqrt{\frac{\xi}{0.3}} \alpha \qquad 2 < \ell < 100$$

QUaD: 25<l<100, r>0.14

BICEP: 20<l<120, r>0.1

EBEX: 20<l<1000, r>0.06

CLOVER: 20<l<1000, r>0.01

QUIET: 50<l<250, r=?

Summary: don't forget strings!

- hybrid inflation "predicts" $r \lesssim 10^{-4}$
- brane inflation (sometimes) $r \sim 10^{-10}$
- String B-modes observationally distinctive
- Broaden class of testable inflationary models
- Hints in TT data already? high-L experiments will **test** *soon*
- If observed: could be a first observational hint of string theory