

STATUS REPORT OF THE CMB TASK FORCE

Rainer Weiss, MIT
on behalf of the Task Force

HEPAP meeting February 15, 2005

Washington DC

AAAC meeting February 16, 2005

Arlington, Virginia

MEMBERS OF THE CMB TASK FORCE

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AGENCY OBSERVERS

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Charter of CMB Task Force

- OSTP response to Turner Panel “From Quarks to Cosmos” sponsored by DOE, NASA and NSF.
- Recommend a program of research of CMB observations to understand the properties of the inflationary epoch of cosmology
- Primary objective to present plan to measure CMB polarization
- HEPAP and AAAC Committees to receive report
- Full report available mid March 2005

THE BASIC QUESTIONS

- How did the universe begin

Is inflation correct and how can it be tested

- What is the fundamental physics

What is the energy scale and the interaction

What are the constituents of the primeval universe

- How did the universe evolve

What is the nature of the dark energy

What is the geometry of the universe

INFLATION

fraction
of a second

**CMB
last scattering**

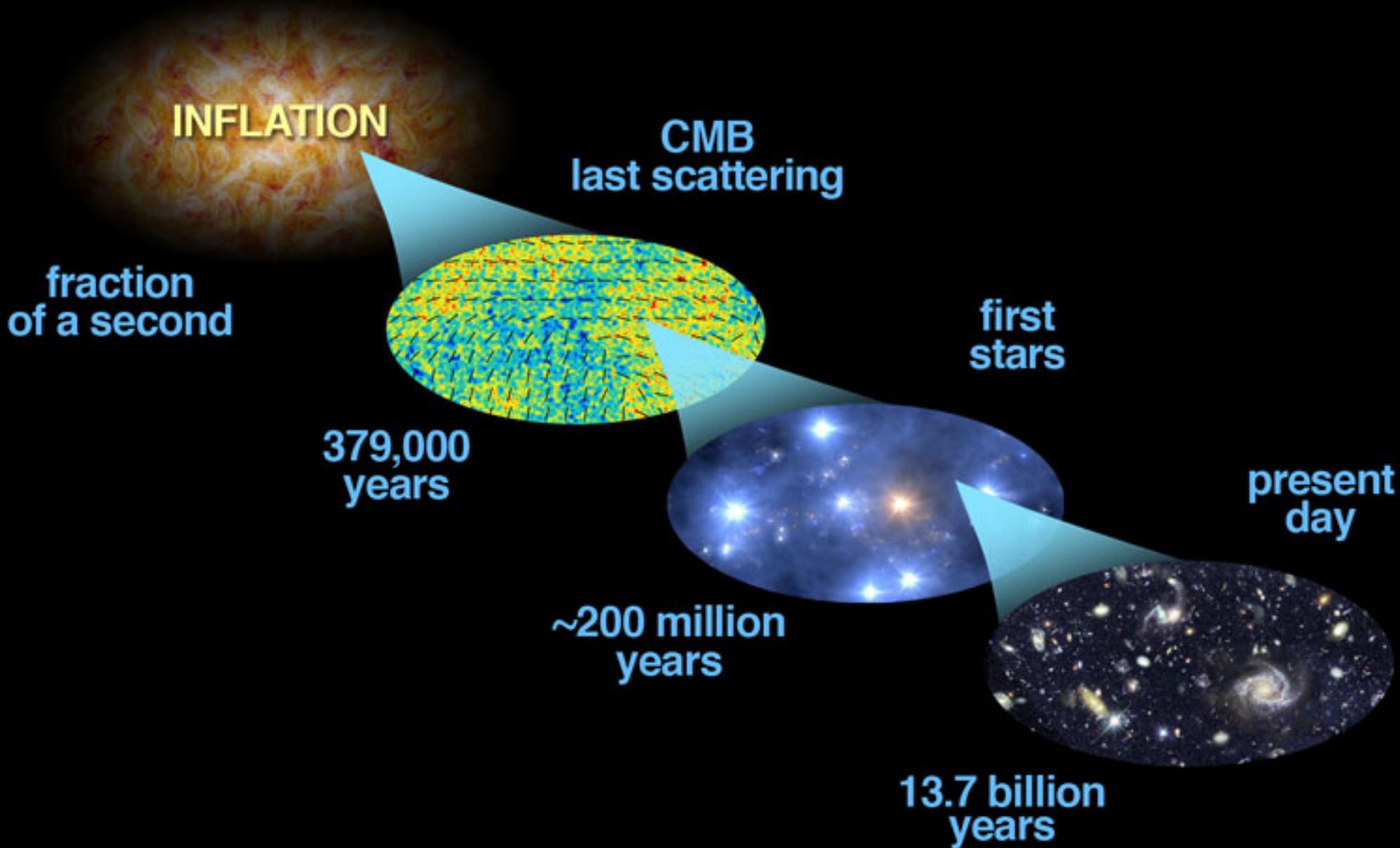
**379,000
years**

**first
stars**

**~200 million
years**

**present
day**

**13.7 billion
years**



Properties of "standard " inflation measurable with the CMB

- Spectrum of spatial temperature fluctuations
 - Intrinsic quantum fluctuations both scalar and tensor
 - Scale invariant spectrum k^n , $n \sim 1$
- Gaussian probability distribution of fluctuations
- Tensor gravitational waves generated due to acceleration during inflation, related to energy scale of inflation

$$r = \frac{\Delta T_{\text{tensor}}}{\Delta T_{\text{scalar}}} \leq 0.3$$

- cause quadrupolar density and temperature fluctuations in the primeval plasmas
- uniquely measurable in the patterns of the CMB polarization due to Thomson scattering of the CMB by electrons (B modes)

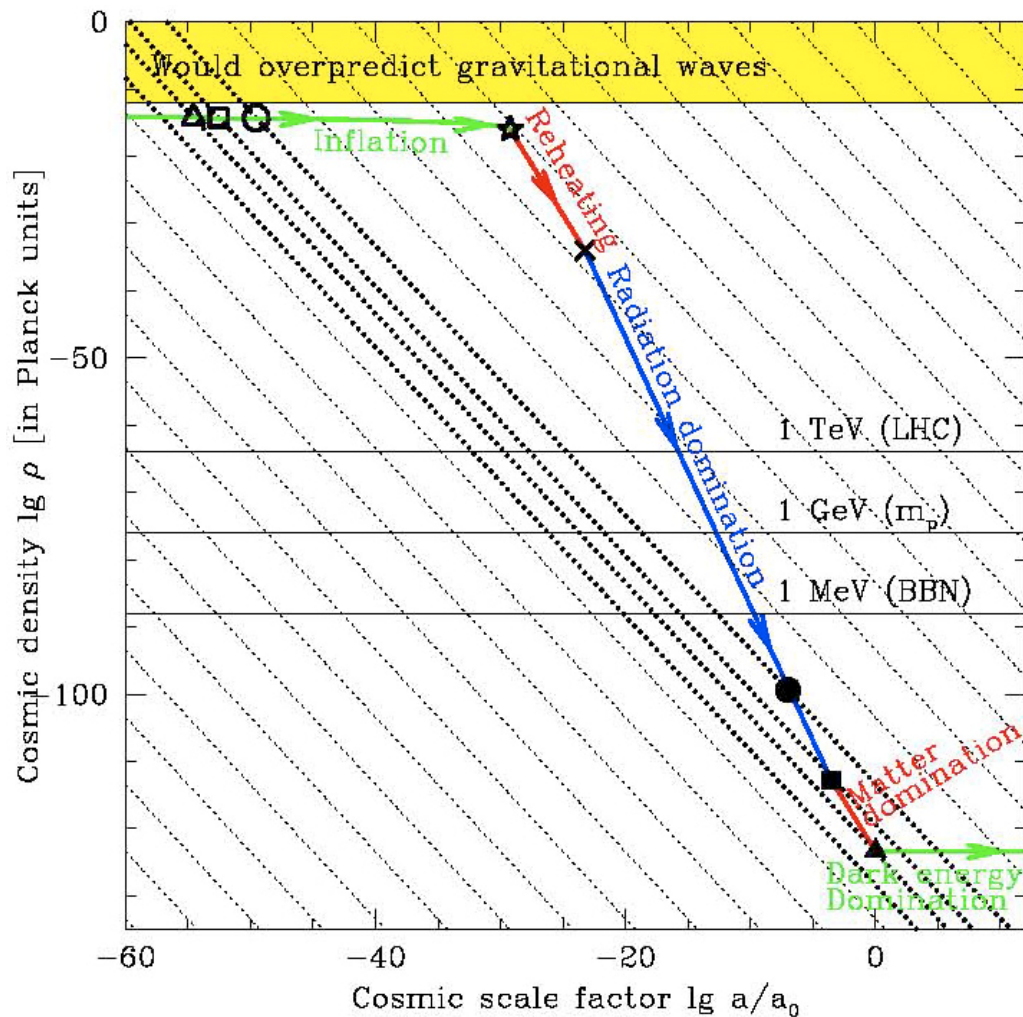
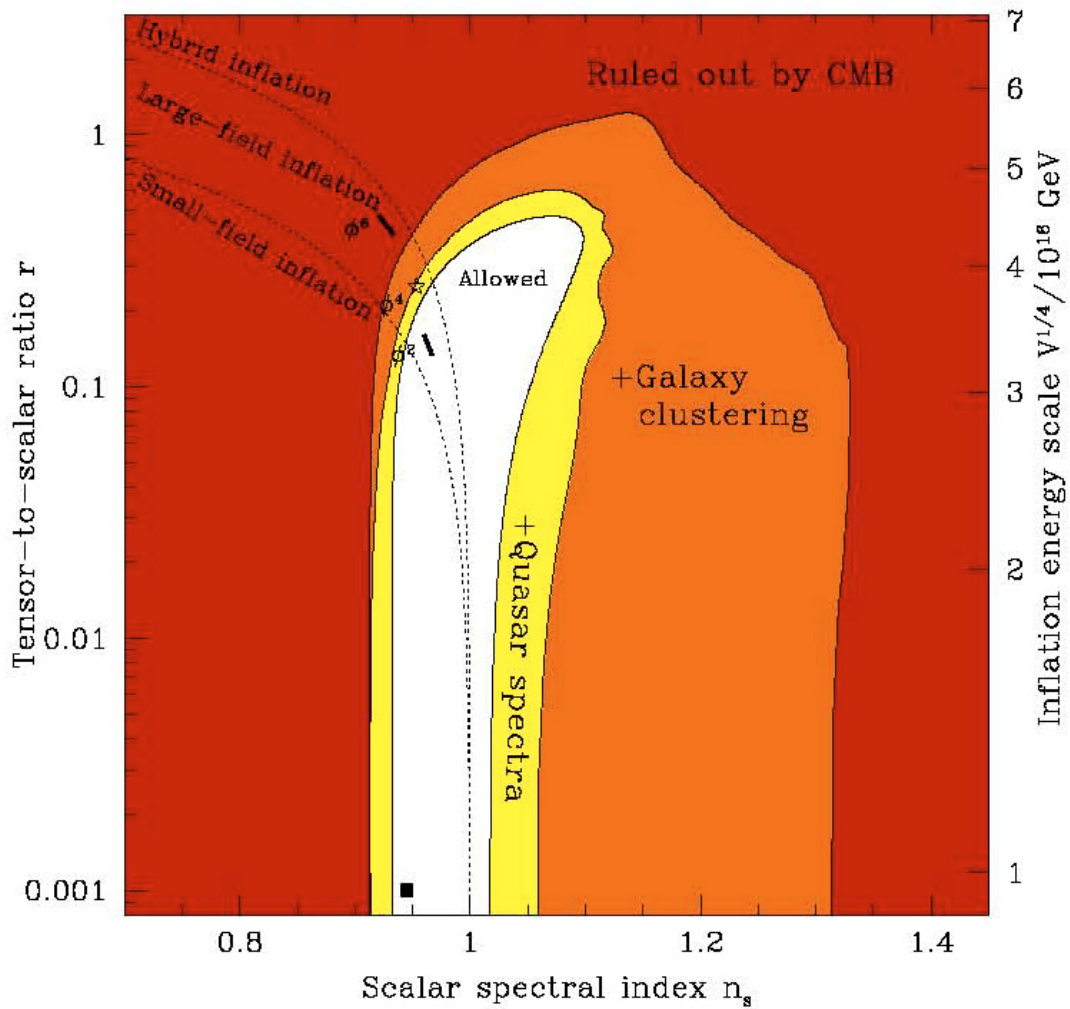
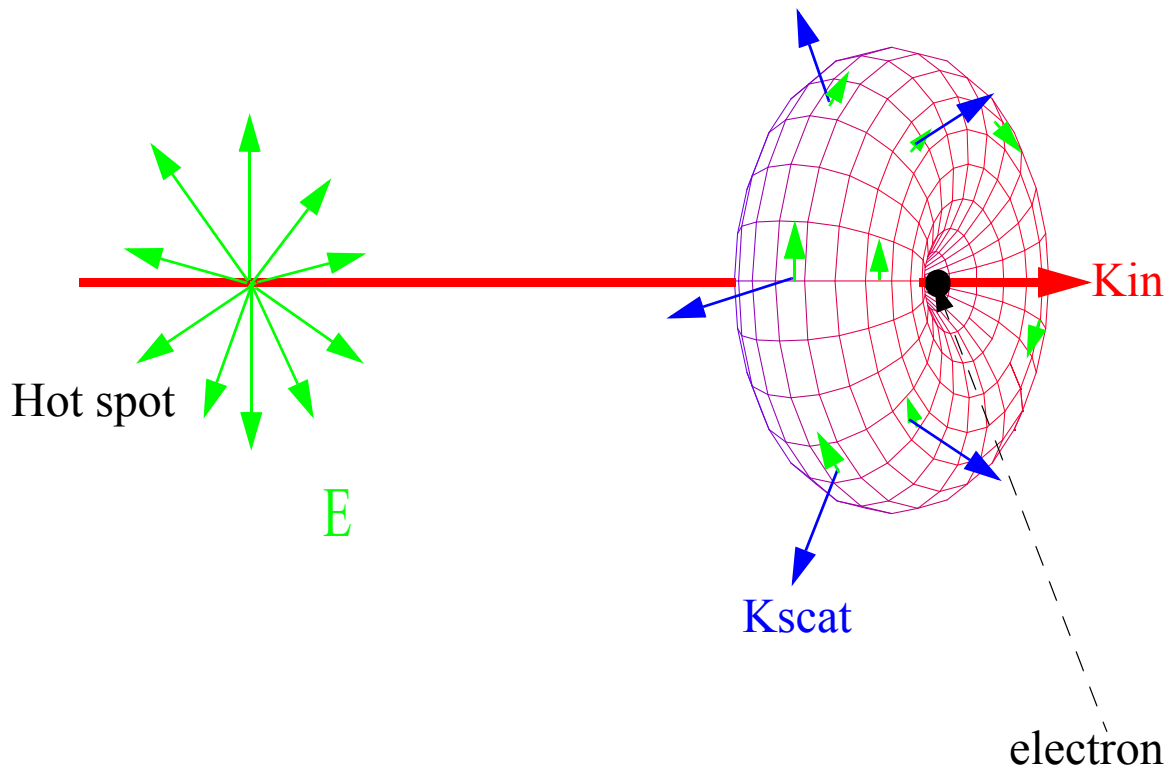
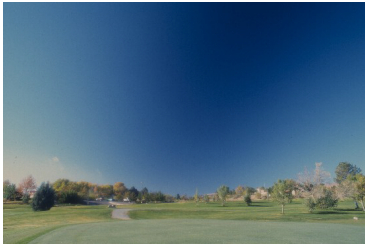


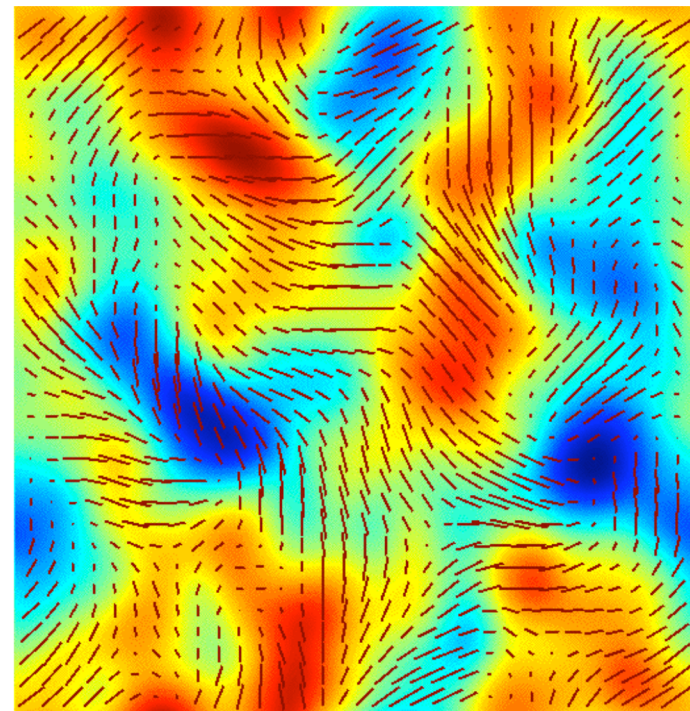
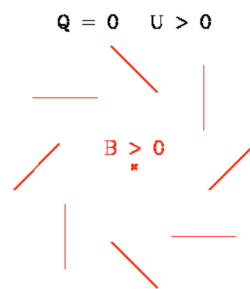
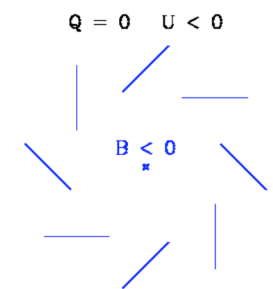
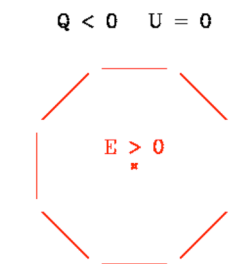
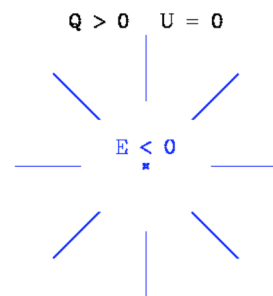
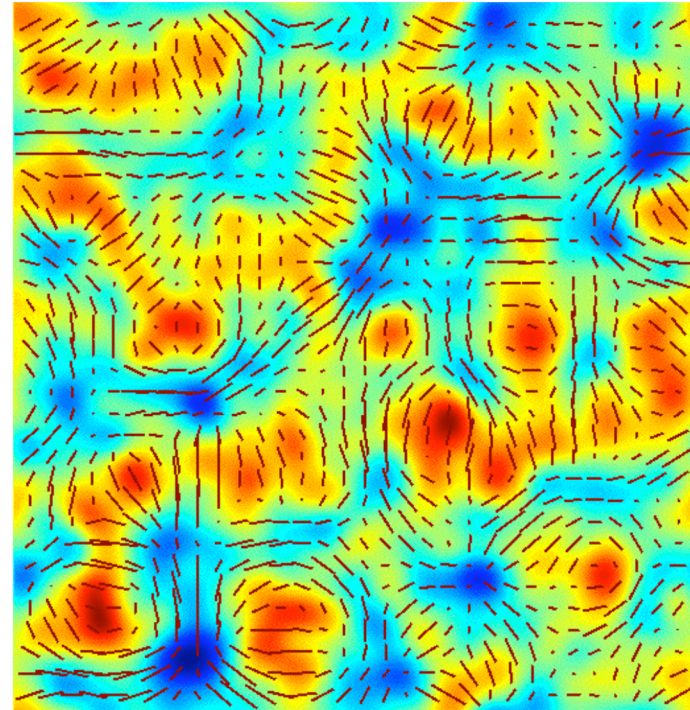
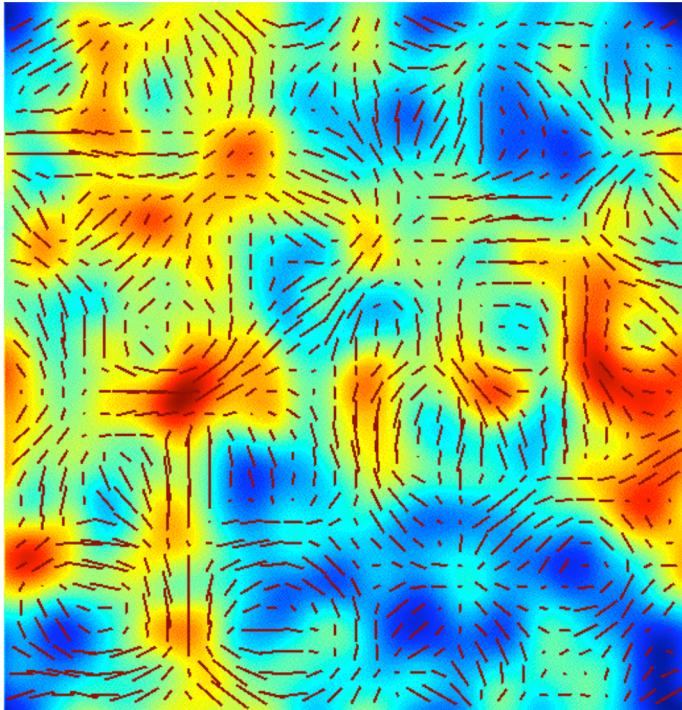
Figure 1: The cosmic mean density (solid curve) is diluted as the Universe expands. Inflation is a period when there is almost no dilution, causing the expansion to accelerate. The result is that the curve decreases slower than the dotted diagonal lines of slope -2 . The two triangles lie on the same diagonal, which means that quantum fluctuations generated during inflation at the open triangle have been stretched into the horizon-scale fluctuations that we observe today at the filled triangle in the CMB. Detecting inflationary gravitational waves with CMB polarization would directly measure the shape of this cosmic density curve in the upper left corner of the plot, just as the proposed Joint Dark Energy mission would directly measure the same curve in the lower right corner.



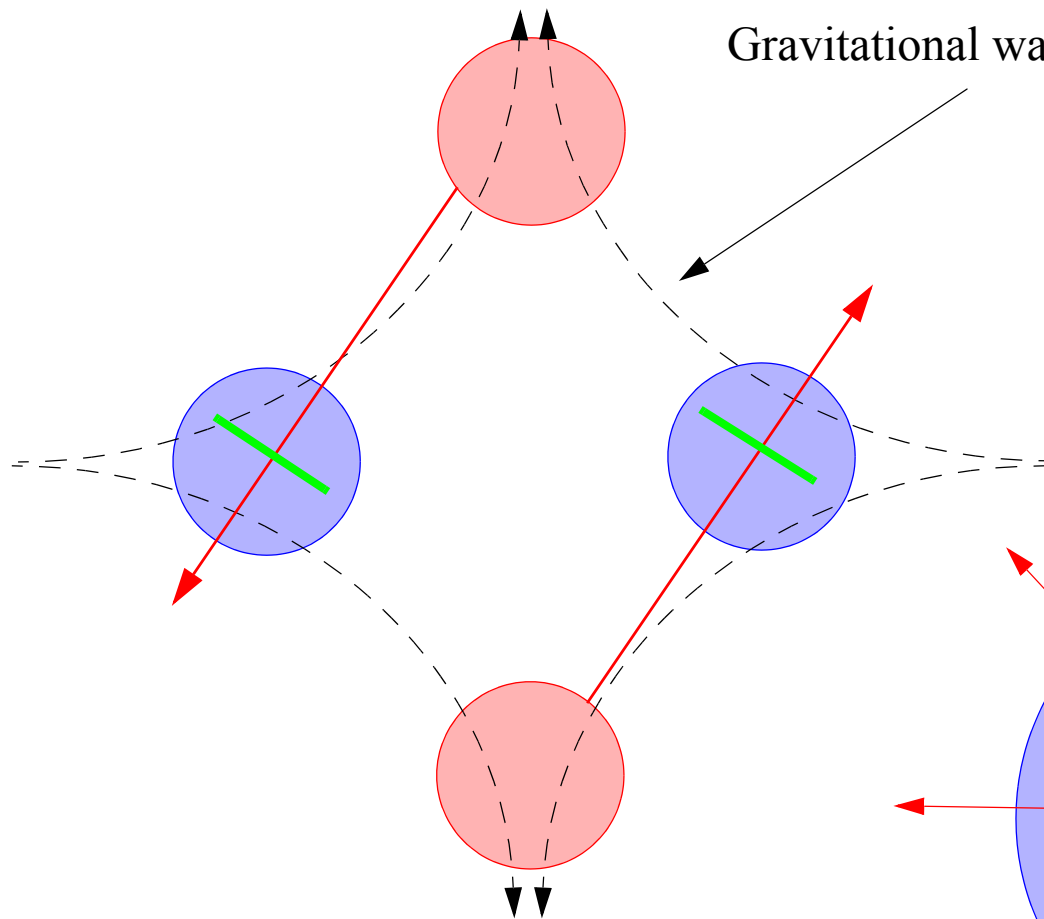




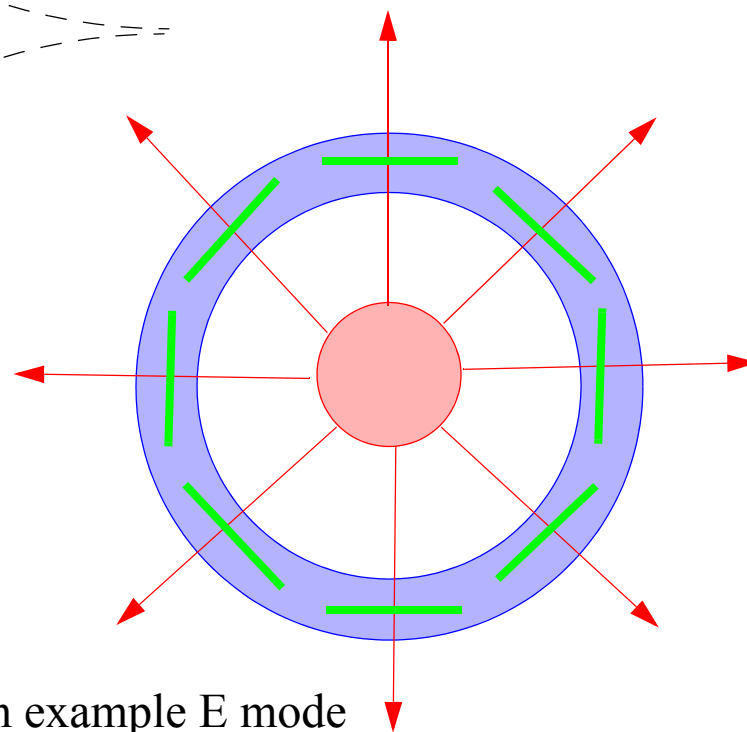
H. Edens



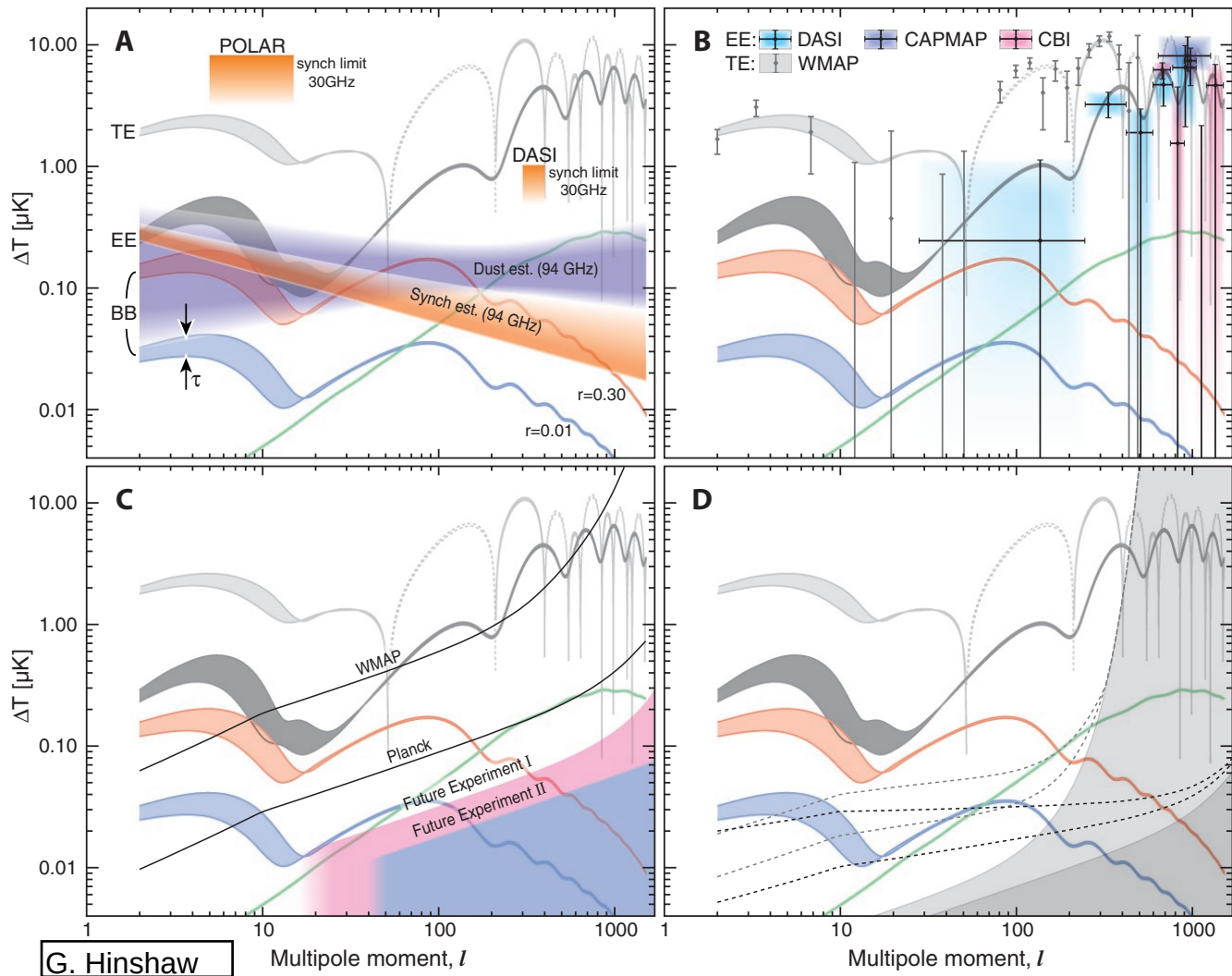
Gravitational wave strain pattern



components of a B mode



an example E mode



Major components of the program

- Completion of WMAP and successful launch and operation of PLANCK (TE, EE and foregrounds)
- Ground based observations of small angular scale temperature variations (n and SZ effect)
- Ground based and balloon borne program to measure polarization of the CMB and develop techniques and technology for a space mission (CMBPOL) in the next decade designed to measure the B modes to a level limited by the ability to model foregrounds.
 - Program to measure polarized foregrounds
 - Program to develop polarization sensitive receivers incorporating arrays of 1000s of detectors operating at the background limit of the CMB
- Cooperative interagency program of research supported by DOE, NASA, NSF, NIST makes good sense.

