The Cosmic Microwave Background

Michael Mistretta, QuarkNet, July 2014, Johns Hopkins University

Abstract

My goal is to analyze the Cosmic Microwave Background, critically examine anisotropies in the images released by Cobe, WMAP, and Planck determine what these anisotropies signify about the early stages of the universe. By looking at essentially the afterglow of the big bang, we can learn more about the birth of the universe and potentially improve upon thesis such as the theory of inflation. Recent releases by the BICEP-2 Collaboration contain potential evidence of gravitational waves which could lead to a refined model of the Inflation theory

ISSUES

Temperature Fluctuations

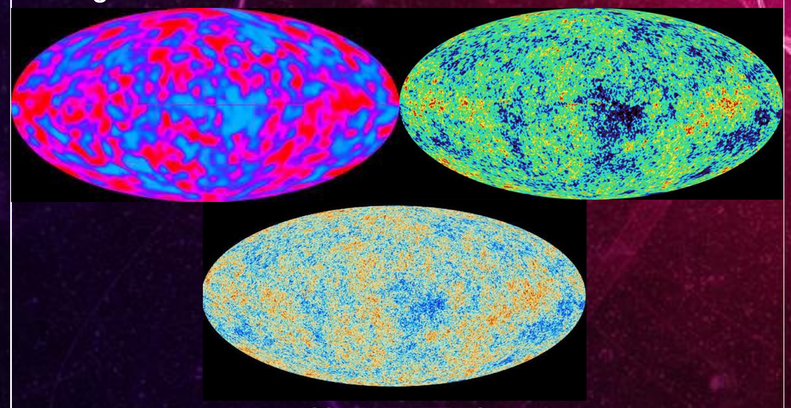
•Ideally the radiance of the CMD would be uniform, but recent advancements have shown that this is not the case.

Lensing

•The photons emitted by the CMD have to travel billions of light-years before reaching our telescopes and satellites and can be led off track as they pass through strong gravitational forces from different galaxies. This lensing must be corrected before analysis can be completed

Foreground Pollution

•Being billions of light-years away, the CMB has various astronomical bodies in front of it. In order to observe the CMB and receive useful data, the foreground must be removed.

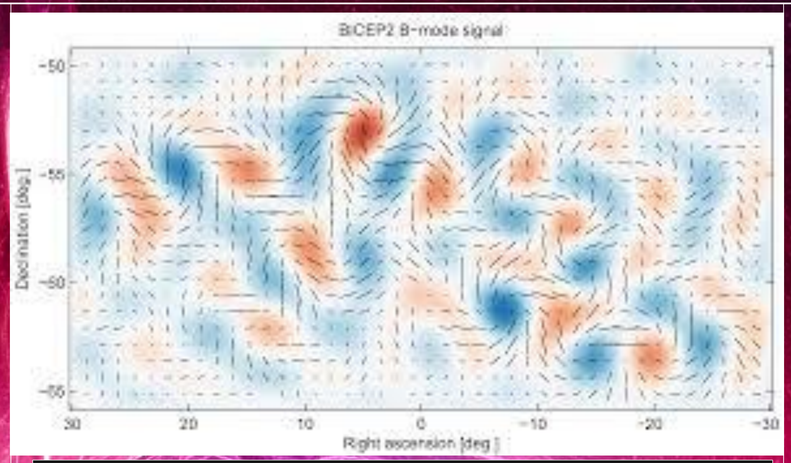


SOME KEY TERMS

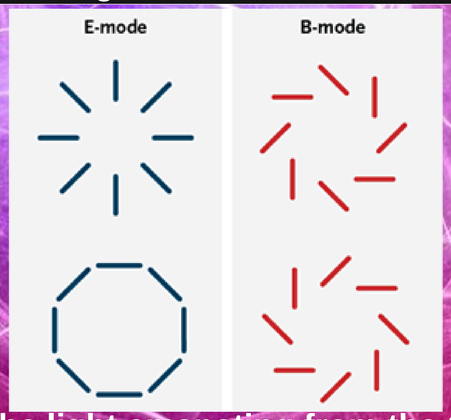
Blackbody- an idealized body which absorbs all incident radiation no matter what wavelength. It emits as much or more than a body of the same temperature isotropically.

Cosmic inflation- The rapid expansion of space at a rate much faster than the speed of light. The inflationary epoch lasted from lasted from 10^{-36} seconds after the Big Bang to about 10^{-33} or 10^{-32} seconds.

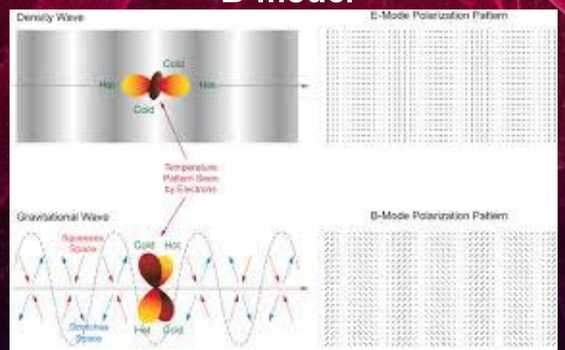
Gravitational Waves- expansion and contractions in space itself



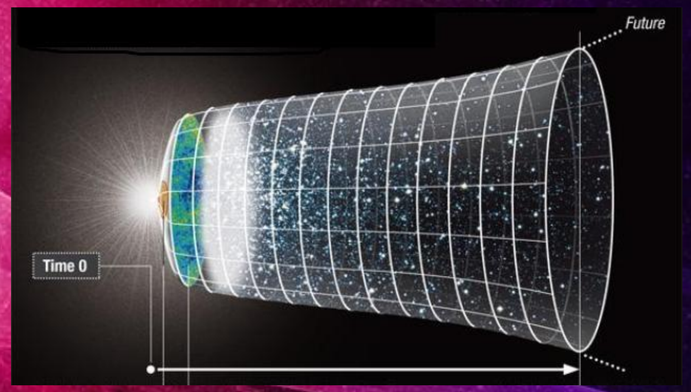
In May of 2014 BICEP-2 released the above, claiming to have found evidence of gravitational waves in the CMB, which would show direct evidence of inflation in the early stages of the universe.



All of the light emanating from the CMB is polarized, but how its polarized is important. Density, scalar, perturbations produce only E-mode polarization. Gravitational waves, or tensor perturbations produce both E and B-mode.



BICEP-2 reported a surprisingly larger value for the ratio of gravitational wave fluctuations to fluctuations caused by perturbations in the density of matter at about .20 ,which is significantly different from the previously estimated value from WMAP and Planck which was >.11. This shows that inflation may have occurred earlier than models had previously predicted. The timing of Inflation can also inform researchers of the energy scale of the universe during inflation. The new ratio provided by BICEP-2 supports the unification theory, as the energy level appears to be on the same scale as all of the natural forces excluding gravity, suggesting that they all must have been unified at some point. These finding are narrowing the list of plausible inflationary models.



My Plans For Advancement

I plan to continue to research the CMB in order to further understand how the physicists and researchers are reaching the conclusions that they have been able to reach using information from the CMB. I am going to continue to read through the papers being published by those who are scrutinizing these discoveries and how the researchers are responding to scrutiny. I would like to gain better understanding on how these researchers have been able to obtain such immense certainty in their findings. I also will be researching how the CMB is being used to obtain information on other aspects of the universe such as the existence and properties of dark matter.

SOURCES

Kovac, John et. al, BICEP2 II: Experiment and Three-Year Data Set, 17 Mar 2014 (v1), last revised 3 Apr 2014(v2), accessed July 25, 2014

Matson, John, *Primordial Gravitational Waves Provide a Test of Cosmological Theories , May 21, 2010, Accessed July 25, 2014*

Bleem et al, **A Measurement of the Correlation of Galaxy Surveys with CMB Lensing Convergence Maps from the South Pole Telescope**. arXiv:1203.4808

BICEP-2 COLLABORATION

***Cowen, Ron,* Gravitational wave discovery faces scrutiny, May 16, 2014**

Planck 2013 results. I. Overview of products and scientific results
Planck Collaboration, et.al

Plait, Phil, Cosmic News: Astronomers Find the Twisted Fingerprints of Inflation in the Background Glow of the Universe

Smoot et al, The Cosmic Microwave Background Radiation, accessed July 25,2014

Hu Wayne, White Martin, Cosmic Symphony, accessed July 25, 2014