

## Weekly Topics

### Week 1 : Introduction

Preview the territory of the class; course logistics and expectations. Set the stage by providing a global overview of the Universe

### Week 2 : Evidence for the Big Bang

Why are astronomers so sure there was a creation event – a “Big Bang”? Consider: cosmic expansion; the age limit for stars; the change of galaxies with lookback time; the helium and deuterium abundance; the microwave background.

### Week 3 : The First Million Years: Light & Heat

General description of the early expansion — the thinning, cooling, “atmosphere”; light’s brilliance; the color/temperature changes; the lack of transparency.

### Week 4 : The Cosmic Microwave Background (CMB)

Our remarkable ability to see the early fireball — the young Universe. The phenomenon of recombination; the reason we can see so deep into cosmic history; the human history of discovering and trying to measure the CMB. Thermal radiation and the redshift from light to microwaves. The detection of patchiness.

### Week 5 : Seeing Sound Waves

The properties of sound : volume, pitch, quality. How to measure quality in terrestrial sound and in cosmic sound. Use of the Spectrogram program to measure sound spectra. Sound spectra of pure tones; musical instruments; the human voice. The projected sound spectrum,  $C(l)$ , seen on the CMB.

### Week 6 : Distortions in the Cosmic Concert Hall

Understanding in more detail the form of the projected sound spectrum,  $C(l)$ . The presence of distorting effects, such as Doppler motion; gravitational red/blue-shifts; smearing of high pitches; foreground contamination. Removing the distortion — working with the true sound,  $P(k)$ .

### Week 7 : Removing Distortions: CMBFAST Recreates the Big Bang

Solving the physics of the early Universe on a computer. Discovering the pure sound  $P(k)$ . Adding back the distortions to simulate the CMB. Generating the sound’s full development. The descending pitch and expanding horizons.

## **Week 8 : Sound as Diagnostic Tool — the Concordance Model**

Why different objects “sound” different when they vibrate. The application of this to cosmology to measure fundamental cosmic parameters. The emergence of the so-called concordance cosmology — the astronomers best evaluation of the cosmic parameters. What these parameters mean: dark matter; dark energy; critical density; age; expansion rate.

## **Week 9 : Harmonic Analysis – the Music of Creation**

The origin of harmonics, in musical instruments and the early Universe. The physics of musical instruments. Harmonic and anharmonic instruments. Anharmonicity and the strike tone in bells. Similarities to the cosmic harmonic development.

## **Week 10 : Post Recombination — From Sound into Stars**

What happens after the fog clears. The crucial role of dark matter. The growth of structure for dark matter and baryons. Expansion turns around. Collapse to form the first generation of stars at roughly 100 Million years. The acoustic signature of this process — the “hiss” of the small scale structure.

## **Week 11 : The Next 14 Billion Years**

How structure then develops in a hierarchical manner — first stars, then galaxies, then groups, then clusters, now the tapestry. The present day distribution of galaxies. How this is measured. The sloan digital sky survey. The creation of heavy elements paving the way for planets and people.

## **Week 12 : Cosmological Problems and their Solution: Inflation**

A return to the question of horizons. Why is the CMB so uniform ? The horizon “problem”. Other problems in cosmology : the flatness problem; the isotropy problem. The suggestion of inflation. Why inflation is so helpful.

## **Week 13 : The Initial Sound Spectrum — Quantum Hiss**

The origin of cosmic fluctuations from quantum fluctuations, amplified by inflation. Witnessing these on the CMB. The CMB as the ultimate microscope, as well as the ultimate telescope. The form of the Initial Sound Spectrum. The Universe as a resonant system, responding to this initial driving source.

## **Week 14 : Can Modern Cosmology Provide a Rich Mythology?**

Creation stories have played an important role in the spiritual life of many cultures. Is the current story different or similar? Can it have the same emotional resonance that traditional cosmologies often have? Why is the Big Bang so understandable — sound and light, they are so “human” — why do we have relatively easy mental access to these outrageously remote times? What, if any, deep mysteries remain?