

Dr. Perry Phillips, Herman Lecture Series: 2022

Big Bang: The Beginning of the Universe (Part 1): The Expanding Universe/Red Shift

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Abstract

This lecture, delivered by Dr. Perry Phillips as part of the Hermann Lecture Series, explores the scientific evidence supporting the hot Big Bang theory, focusing on the first of its three pillars: the expanding universe and the redshift. Phillips explains how the historical discoveries of Vesto Slipher and Edwin Hubble showed that galaxies are moving away from us, proving that the universe is not static. He describes the Doppler effect as the physical mechanism of the redshift and explains that space itself is expanding rather than galaxies moving through it. Finally, the lecture discusses Albert Einstein's general theory of relativity, the cosmological constant, and the biblical and theological implications of an expanding universe that had a beginning roughly 14 billion years ago.

Outline

- **I. Introduction to the Lecture Series**
 - **A. Opening greetings and acknowledgments** (Dr. Brink, Gordon College, Hermann Family, Templeton Foundation)
 - **B. Dr. Phillips' background in quality assurance engineering** and system testing (Verizon voicemail/SMS)
 - **C. Framework of the three-part lecture series** on the origin, history, and future of the universe
 - **D. Introduction of the Big Bang** as the premier scientific model for the creation of the universe

1. Note on Fred Hoyle's origin of the term "Big Bang" as a pejorative
 2. Use of a woodcut analogy representing science peeking behind the scenes of nature
- **II. The Three Pillars of the Hot Big Bang Theory**
 - **A. Pillar 1: The expanding universe and redshift** (focus of this session)
 - **B. Pillar 2: Cosmic elemental abundance**
 1. Big Bang predictions of elemental ratios in the universe
 2. Ratios of helium-4, hydrogen, deuterium, and other light elements
 - **C. Pillar 3: Cosmic background radiation**
 1. Remnants of the hot fireball of creation bathing the universe in radio waves
 2. Detection across the sky using specialized antennas
 - **III. Cosmology Science Investigation (CSI) Framework**
 - **A. Aligning cosmology with a crime scene investigation** (Who, Why, When, Where, How)
 - **B. Biblical and theological points of agreement:**
 1. Who: God of the Bible as Creator (Genesis 1:1)
 2. Why: For God's glory (Psalm 19:1)
 3. When: Scientifically dated to approximately 14 billion years ago (specifically 13.78 billion years)
 4. Where: Occurred everywhere, encompassing the entire creation
 - **C. Scientific point of concentration:** How the universe developed through physical processes
 1. The concept of a "hot" Big Bang where the universe was once much hotter and denser
 - **IV. Pillar One: The Expanding Universe and the History of Redshift**
 - **A. Historical observations of Vesto Slipher (1912)**
 1. Attempted to measure galaxy rotation using Doppler shift

- 2. Observed that all measured galaxies were unexpectedly moving away from us
 - 3. Challenged the scientific consensus of an infinite, static universe where random, non-directional motion was expected
- **B. Edwin Hubble's advancements** (late 1920s to 1930s)
 - 1. Utilized the Mount Wilson 100-inch telescope and later Mount Palomar 200-inch telescope
 - 2. Collaboration with Milton Humason to photograph and analyze galaxy spectra
- **V. The Physics of Redshift and Spacetime Expansion**
 - **A. The Doppler Effect**
 - 1. Sound wave analogy (pitch drop of an approaching and receding car horn)
 - 2. Light wave application: approaching sources shift to blue (compressed waves), receding sources shift to red (stretched waves)
 - **B. Exceptions to cosmic redshift:** gravitationally bound local systems
 - 1. Gravity overrides expansion on smaller scales (within ~250 million light-years)
 - 2. Example of the Andromeda galaxy showing a blue shift as it moves toward the Milky Way
 - **C. Definitions of distance and time**
 - 1. Light-year: A unit of distance representing how far light travels in one year (~6 trillion miles)
 - 2. Lookback time: Looking farther out in distance means observing objects as they existed earlier in cosmic history
- **VI. Theoretical Underpinnings: Einstein and General Relativity**
 - **A. Albert Einstein's General Theory of Relativity (1915)**
 - 1. Incorporation of gravity into the geometry of the universe

2. Equations correlating spacetime geometry with matter and energy density
- **B. The Cosmological Constant (Lambda)**
 1. Artificial "fudge factor" introduced to maintain a static, stable universe
 2. Mathematical proofs by Lemaitre, de Sitter, and Friedman showing that general relativity mandates an expanding or contracting universe
 - **C. Einstein's retraction**
 1. Personal visit with Hubble to view observational data
 2. Discussion with George Gamow where Einstein called Lambda his "biggest blunder"
 3. The irony that Lambda remains essential to modern accelerating universe models
- **VII. Hubble's Law and the Mechanics of Space Expansion**
 - **A. Hubble's Law formulation**
 1. Linear relationship: The farther away a galaxy is, the faster it recedes from us
 2. Deviances/bending of the linear graph at extreme cosmic distances
 - **B. Modern confirmations and data richness**
 1. Sloan Digital Sky Survey taking millions of spectra compared to historical days-long single exposures
 2. Deep field images from the Hubble Space Telescope verifying universal expansion
 - **C. The Raisin Cake Model of spacetime**
 1. Separation is driven by the expansion of space (the dough) rather than galaxies moving through space
 2. Spacetime can expand faster than the speed of light at extreme distances (the cosmic horizon)
 - **D. Running expansion backward: The single point origin**

1. All matter, space, and energy compressed into a state smaller than a single proton
2. Infinite density, heat, and energy at the beginning of cosmic expansion

- **VIII. Biblical and Theological Reflections**

- **A. Scriptural depictions of a dynamic, expanding cosmos**

1. "Stretching out the heavens" as a recurring biblical phrase
2. Examples: Job 9:8, Isaiah 40:22, Isaiah 51:13

- **B. Linguistic and conceptual observations**

1. Use of present continuous tense indicating an active, ongoing expansion
2. Comparison to pitching and spreading a tent (Isaiah 40:22)

- **C. Apologetic significance:** Scriptural text containing a scientific nugget that aligns with modern discoveries and testifies to divine communication

- **IX. Future Cosmic Outlook and Acceleration**

- **A. Models of cosmic fate determined by gravity**

1. Closed universe: Gravity stops expansion, leading to a "Big Crunch"
2. Open universe: Gravity is insufficient, leading to infinite, rapid expansion
3. Critical universe: Expansion at exactly escape velocity, slowly decelerating forever

- **B. The 1990s discovery of accelerating expansion**

1. Reversal of the expectation that gravity slows expansion over time
2. The role of dark energy and dark matter in driving cosmic acceleration

- **X. Question and Answer Session Analysis**

- **A. The Singularity and the limits of physics**

1. Physics cannot reach absolute $t=0$ (the singularity) due to a lack of unified theory

2. Scientific analysis begins at the Planck Time (10^{-43} seconds) and Planck Distance (10^{-33} cm)

- **B. Experimental particle physics and early cosmology**

1. Smashed beams of protons in the Large Hadron Collider recreate early universe plasma conditions (10^{-13} seconds after the Big Bang)

- **C. Dynamics of the Andromeda galaxy's blue shift** (local gravitational binding overcoming general expansion)

- **D. The cosmic horizon and spacetime expanding faster than the speed of light**