

EINSTEIN'S UNIVERSE – HIGH-ENERGY ASTRONOMY.

- A. *Introduction to Science and the Cosmos*
- The nature of science and the scientific method
 - A Grand Tour of the Physical Universe
- B. *Classical Physics*
- The beginnings of physics—Galileo and the experimental method
 - Newton's Laws: The Constitution of the Universe
 - i. Work, Energy, Power
 - ii. Classical Gravitation
- C. *The Life and Time of Albert Einstein*
- Brief biographical overview
 - Einstein's views of science and the world
 - Einstein, Relativity and the Rest of Human Culture
 - Images of Einstein in popular culture & the public view of scientists
- D. *The Special Theory of Relativity*
- Time Dilation, Lorentz-Fitzgerald Contraction, the Twins Paradox
 - The role of mass and energy
 - The meaning of $E = mc^2$
 - Realistic Space Travel as an Illustration of Special Relativity Theory
- E. *The General Theory of Relativity*
- Spacetime
 - i. Curved Spacetime
 - ii. Evidence of Warped Spacetime
 - iii. Bending of Light
 - iv. Slowing Down of Time (Time Dilation)
 - Gravitational Redshift
 - Gravitational Waves
 - Time Machines in Science: Using General Relativity
- F. *Stellar Remnants*
- Degenerate matter
 - i. White Dwarfs
 - ii. Novae and Supernovae Type I
 - iii. Neutron Stars
 - Pulsars

- i. Lighthouse Model
 - ii. Energy from Spin
 - iii. Spin Glitch
- Black Holes
 - i. Ultra-strong Gravity
 - ii. General Relativity
 - iii. Detecting Black Holes
 - iv. Mass of Companion in Binary
 - v. X-rays from Accretion Disk

G Active Galaxies

- The Active Galaxy “Zoo”
 - i. Quasars
 - ii. QSO’s
 - iii. Seyferts
 - iv. Blazars
 - v. Liners
 - vi. OOV’s
- Active Galaxies
 - i. Power Source for Active Galaxies and Quasars
 - ii. The Short Life of an Active Galaxy

H The Hubble Constant

- Steps to the Hubble Constant Distance scale ladder
 - i. Step 1 The Astronomical Unit
 - ii. Step 2 Geometric Methods
 - iii. Step 3 Main Sequence Fitting and Spectroscopic Parallax
 - iv. Step 4 Period-Luminosity Relation for Variable Stars
 - v. Step 5a Galaxy Luminosity vs. Another Bright Feature
 - vi. Step 5b Luminosity or Size of Bright Feature
 - vii. Step 6 Galaxy Luminosity and Inverse Square Law
 - viii. Step 7 Hubble Law

I Observations and Implications

- Universe Contains Mass---Why has the Universe Not Collapsed?
- Olbers’ Paradox and the Dark Night Sky
 - i. Universe is Expanding
 - ii. Universe is Uniform on Large Scales
 - iii. Cosmological Principle
 - iv. Perfect Cosmological Principle

- No Center to the Expansion in 3-D Space
- Cosmic Microwave Background Radiation
 - i. Observation
 - ii. Interpretation
- Matter to Energy to Matter Conversion
 - i. Cosmic Abundance of Helium and Hydrogen
 - ii. Elements heavier than Helium
 - iii. Deuterium as a probe of the early universe
- Evidence Supporting the General Big Bang Scheme

J Fate of the Universe

- Depends on Mass (Curvature of Space)
- Critical density
- Is The Universe Open or Closed?
- Dark Matter Observations:
 - i. Orbital speeds of stars in galaxies
 - ii. Faint gas shells around ellipticals
 - iii. Motion of galaxies in a cluster
 - iv. Hot gas in clusters
 - v. Quasar spectra
 - vi. Gravitational Lensing
- Embellishments on the Big Bang
- Flatness and Horizon problems
- Inflation
- The Cosmological Constant
- Deriving the Geometry of the Universe from the Background Radiation
 - i. The Size of the Universe
 - ii. The Observational horizon

K Recent Developments

- Stephen Hawking's work combining relativity & quantum mechanics
- Quantum black holes
- Accelerating Universe Model – The “Big Rip”!
- Branes
- The Multiverse