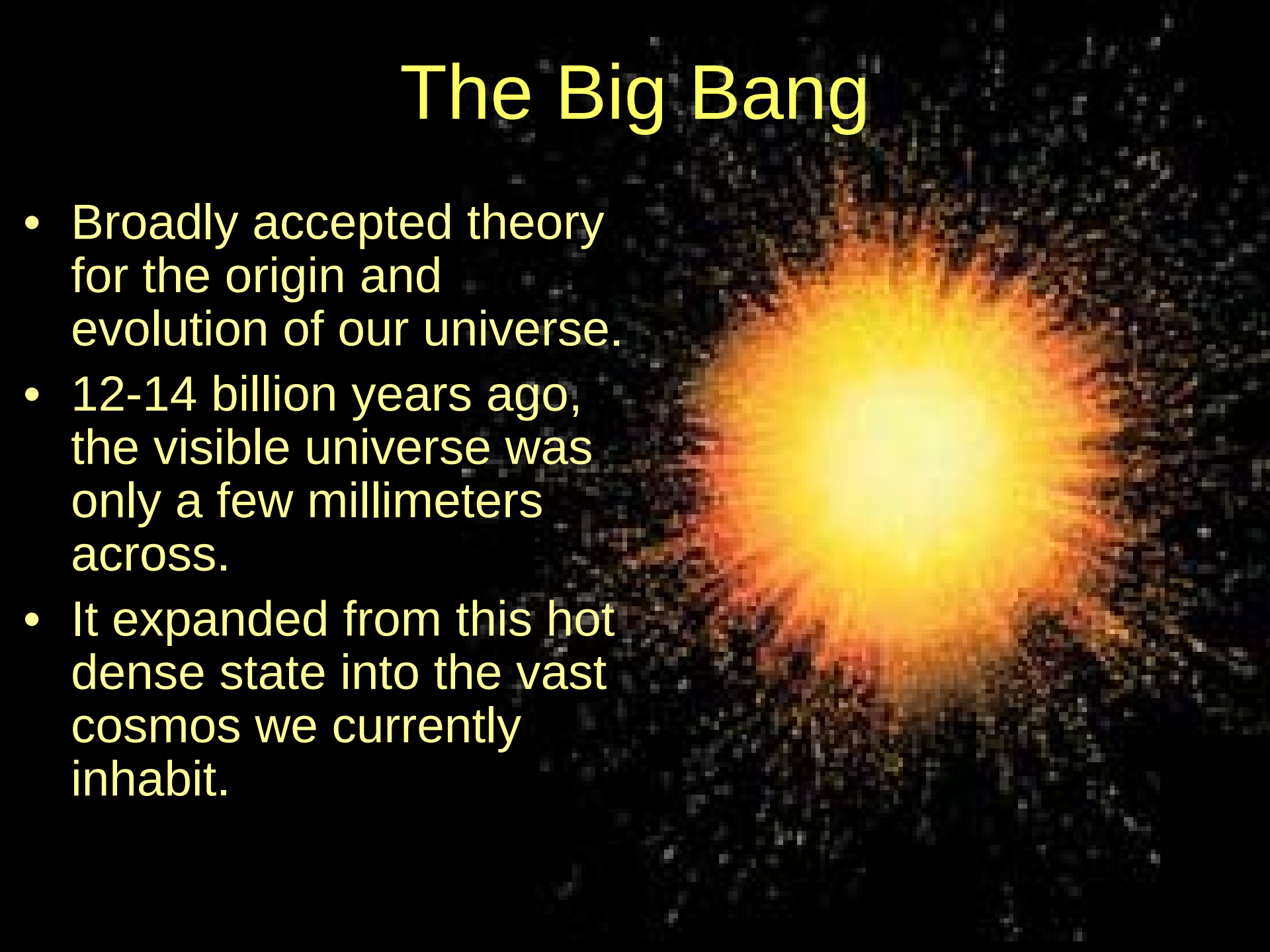
The Big Bang

- Broadly accepted theory for the origin and evolution of our universe.
- 12-14 billion years ago, the visible universe was only a few millimeters across.
- It expanded from this hot dense state into the vast cosmos we currently inhabit.



Tests of Big Bang Cosmology

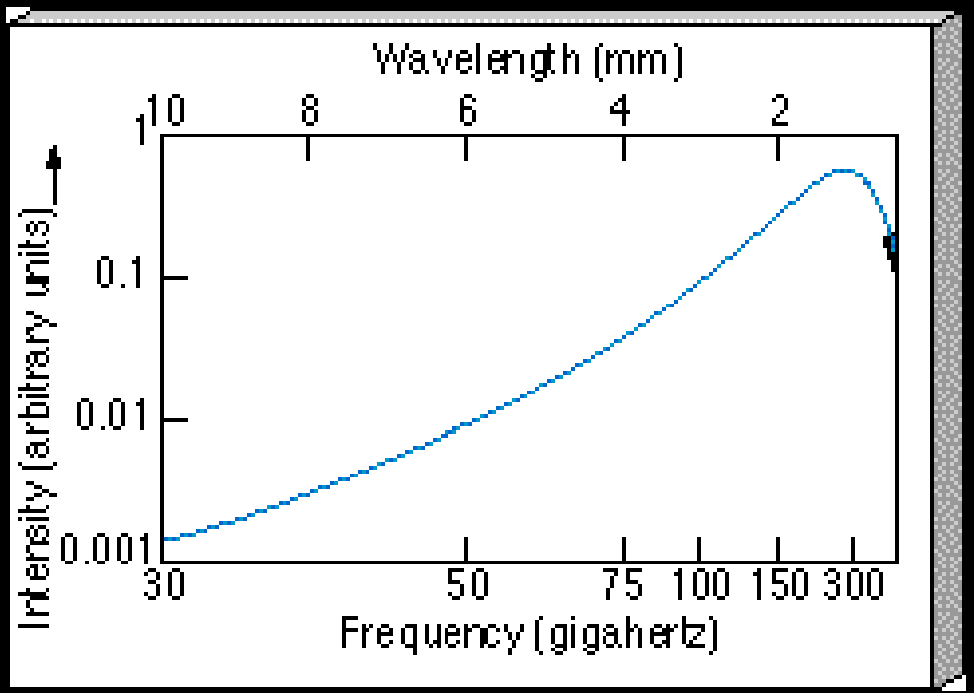
- The Big Bang Model is supported by a number of important observations
- The expansion of the universe
  - The observation that galaxies are receding from us
- The abundance of the light elements H, He, Li
  - these elements were fused from protons and neutrons in the first few minutes after the Big Bang.
- The cosmic microwave background (CMB) radiation
  - The early universe was very hot. The CMB radiation is the remnant heat leftover from the Big Bang.

COBE

- **CO**smic microwave **B**ackground **E**xplorer (COBE) satellite
- Observed microwave emissions from the edge of the Universe for two years

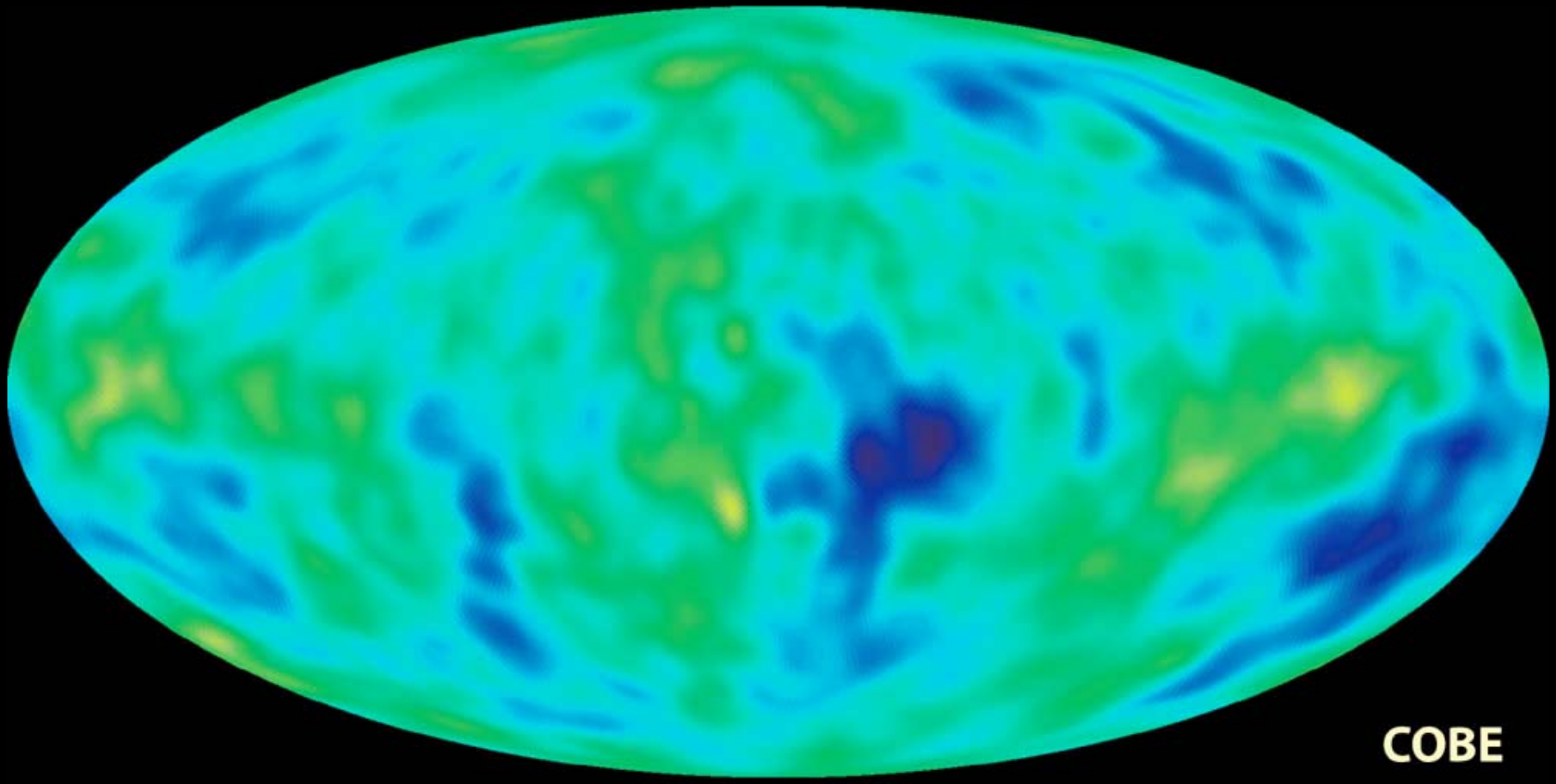
Results from COBE

- Distribution of intensities consistent with a black body at 2.736 K



Results from COBE

- Immense clouds that are 2.7 x 10^{-5} K warmer than background

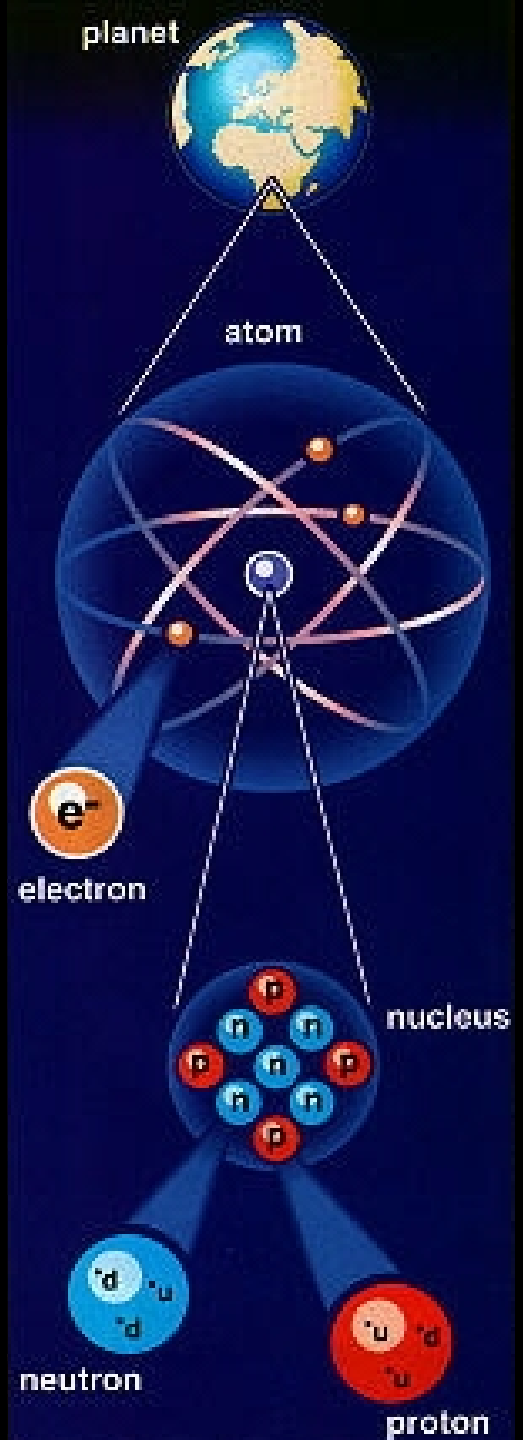


Probing the Early Universe

- The COBE satellite observed the edge of the visible Universe
- Prior to this time, photons were not free to travel through space
- It is impossible to see beyond this
- The conditions that existed in the Universe at this time can be recreated in the laboratory

The Ultimate Structure of Matter

- Experiments at Fermilab and other particle accelerators show that protons and neutrons can be further broken down into “quarks”
- A neutron contains:
  - 2 down, 1 up quark
- A proton contains:
  - 2 up, 1 down quark



COBE Case Study

Academy of Program/Project & Engineering Leadership

APPEL

Case Studies

Text Size

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Redesigning the Cosmic Background Explorer (COBE)

How did the universe begin? Humans have asked the question for millennia. In the modern age, scientists have focused on determining the physical origins of the universe. The designers of the Cosmic Background Explorer (COBE) satellite proposed to provide hard evidence to support some longstanding hypotheses about the nature of the early universe. COBE's instruments were built to measure two types of radiation — diffuse infrared and microwave radiation — that many physicists, including the COBE Project Scientist believed to be artifacts of the Big Bang, the moment when the universe burst into existence.

The proposal that NASA approved called for COBE to carry three instruments: a Diffuse Infrared Background Experiment (DIRBE) to search for cosmic infrared background radiation, a Differential Microwave Radiometer (DMR) to search for fluctuations in the brightness of the cosmic microwave background (CMB) radiation, and a Far Infrared Absolute Spectrophotometer (FIRAS) to compare the spectrum of the cosmic microwave background radiation with a precise blackbody. (A blackbody is an object that absorbs all electromagnetic radiation that reaches it; none passes through it and none is reflected.) Designing these instruments and a spacecraft that could provide the proper operating conditions to gather reliable measurements would prove extremely complex.

COBE was slated to launch on the Shuttle in 1989 from Vandenberg Air Force Base. The Shuttle would place the satellite at an altitude of 300 kilometers, and an on-board propulsion system would then raise it to a circular 900 kilometer sun-synchronous orbit.

The loss of the Space Shuttle Challenger 73 seconds after liftoff on January 28, 1986, changed everything. The Shuttle program's future was now uncertain and

The COBE dewar, a 650 liter liquid