teachers guide

Cosmology 1

History of the Universe

Components

	NAME	DESCRIPTION	AUDIENCE
	History of the Universe teachers guide	This guide contains presentation notes and questions to promote discussion about the history of the Universe.	teachers
	History of the Universe presentation	This presentation is designed to engage students in a conversation about the history of the Universe, including the evolution of fundamental interactions and matter, and formation of stars and galaxies.	students
	Timeline of the Universe fact sheet	This timeline summarises the events cosmologists believe have occurred since the Big Bang.	students

Purpose

To **Engage** students' interest and provide information on the history of the Universe.

Outcomes

Students:

- describe and explain Big Bang theory and the history of the Universe, and
- describe and explain the expansion of the Universe.

Activity summary

ACTIVITY	POSSIBLE STRATEGY
Teacher introduces the notion of how the Universe began by asking questions, such as: • How did the Universe begin? Likely answers include 'Big Bang' or 'an act of creation'. • What happened after the Big Bang? • Is there any evidence today that the Big Bang occurred? Teacher explains that information in this presentation is the best explanation we have of the history of the Universe, that is supported by scientific evidence.	whole class, teacher-directed questioning
Teacher shows slides 1–7, then pauses for students to discuss any questions about what the Big Bang was, and what it wasn't. Teacher shows slides 8–11 on the evolution of fundamental interactions. The presentation could be stopped at this point to allow a discussion of interactions and forces, such as how these fundamental interactions explain pushes and pulls, magnetic attraction and electrostatic forces in everyday life. Teacher shows slides 12–17 on the evolution of matter, including quarks, leptons, hadrons, matter and anti-matter, through to the formation of deuterium and helium nuclei, and eventually stable atoms of hydrogen and helium.	small group discussion or whole class sharing of ideas
The presentation could be stopped at this point to allow a discussion of the evolution of matter, or to consolidate students' understanding of the Standard Model of particle physics. Slides 18–22 describe the formation of stars, galaxies and Solar System, and briefly touches on the synthesis of elements, from carbon to iron, by fusion of lighter elements.	group activity
Teacher distributes the fact sheet, *Timeline of the Universe*.	

Information for teachers

The history of the Universe is the first of three presentations that enable students to explore and explain cosmological concepts, discoveries and theories.

The presentation is designed to engage students in a conversation about aspects of the history of the Universe and a discussion of the scientific evidence and theories that underpin modern cosmology. Presenters' notes are included to provide background information on likely discussion points or concepts where students may require more information.

The presentation contains four main sections.

SECTION	CONTENTS
What the Big Bang was, and what it wasn't	This section deals with some possible alternative conceptions of Big Bang theory.
Fundamental interactions	The fundamental interactions are gravity, the strong interaction, electromagnetism and the weak interaction. See notes to slide 8 below for some important distinctions between forces and interactions.
The evolution of matter	Matter includes hadrons and leptons; matter and anti-matter; and the formation of nuclei and stable atoms.
The formation of structures within the Universe	Structures include stars, galaxies and the Solar System.

The fact sheet, *Timeline of the Universe*, summarises this presentation.

Note: Research into the timeline of events that followed the Big Bang reveals a range of responses that, while generally supporting a consistent sequence of events, frequently differ in their timing — especially during the first 10 seconds or so. This presentation draws together information from a number of sources into a similar sequence to that presented in en.wikipedia.org/wiki/Timeline_of_the_Big_Bang.

The following notes accompany the presentation, *History of the Universe* (notes are only provided for slides that require additional information).

SLIDE	NOTES
1	This presentation has been constructed using information drawn from a number of sources, the major source being Universe 101 Big Bang Theory http://map.gsfc.nasa.gov/universe/. It is highly recommended reading for physics teachers.
2	Cosmology is the scientific study of large-scale properties of the Universe as a whole. It endeavors to use the scientific method to understand the origin, evolution and ultimate fate of the Universe. Like any field of science, cosmology involves the formation of theories or hypotheses that make specific predictions for phenomena that can be tested by observations. Depending on the outcome of such observations, theories may be abandoned, revised or extended to accommodate data. Image: The Milky Way arches across this 360-degree panorama of the night sky above the European Southern Observatory's Very Large Telescope in Chile. To the right in the image, below the arc of the Milky Way, two of our galactic neighbours can be seen: the Small and Large Magellanic Clouds. Source: http:// commons.wikimedia.org/wiki/File:360-degree_Panorama_of_the_Southern_Sky_edit.jpg
3	Big Bang theory is a broadly accepted model for the origin and evolution of the Universe. It postulates around 12 to 14 billion years ago the portion of the Universe we can see today was compressed into a singularity only a few millimetres across. The Universe has since expanded from this hot dense state into the vast and much cooler cosmos we currently inhabit. The best available measurements, as of 2011, suggest that the Big Bang occurred between 13.3 and 13.9 billion years ago. Big Bang theory doesn't attempt to explain how the singularity came into existence, or what gave rise to the Big Bang. If students ask what happened before the Big Bang, the conventional answer is that there is no such thing as 'before the Big Bang'. The Big Bang is the event that started everything, including time. But the right answer, says physicist Sean Carroll, is "We just don't know." Source: http://www.universetoday.com/15051/thinking-about-time-before-the-big-bang/
4	The Big Bang was the beginning of the Universe as we know it.
5	The Universe didn't expand into anything, because there wasn't anything for it to expand into. Everything, including space itself, was created in the Big Bang. The Universe expanded because the space between the galaxies expanded. • To the galaxies, there is no centre from which expansion occurred. Expansion from a central point could only be evident to an observer 'outside the Universe' (but we don't know that there is such a place). • Cosmologists believe that Dark Energy is causing the Universe to expand. This is discussed further in the SPICE resource, *Cosmology 3: The future of the Universe*.

SLIDE	NOTES
7	The Planck era (the first 10^{-43} seconds after the Big Bang) is the earliest period in the history of the Universe during which quantum effects of gravity were significant. Planck time (approximately 10^{-43} s) is thought to be the shortest interval of time that could be measured. As of 2010, the shortest time interval measured directly was about 10^{-17} s (about 10^{26} Planck times). Research into the timeline of events that followed the Big Bang provides a range of responses, which while generally supporting a consistent sequence of events, frequently differ in their timing — especially during the first 10 seconds or so. This presentation has drawn together information from a number of sources into the sequence presented in http://en.wikipedia.org/wiki/Timeline_of_the_Big_Bang.
8	Any force you can think of, whether it's friction, magnetism, gravity, or nuclear decay, is caused by one of the four fundamental interactions: gravity, electromagnetism, the strong and the weak interactions. • Gravity is an interaction that exists between all matter in the Universe. • Electromagnetism determines how electrically charged particles interact with each other and with magnetic fields. • The strong interaction holds quarks together in protons and neutrons. Residual strong interactions hold the nuclei of atoms together by overcoming electrostatic repulsion between protons. • The weak interaction is responsible for radioactive decay of some nuclei by controlling the beta decay process in which neutrons split into protons, electrons, and antineutrinos. What is the difference between a force and an interaction? • A force is the effect on a particle (attraction, repulsion) due to the presence of other particles. • An interaction includes all forces that affect a particle, and any decays and annihilations that it may experience. While some interactions give rise to conventional forces they don't always do so. For example, the weak interaction never gives rise to forces – it simply mediates nuclear decay. Similarly, the electromagnetic interaction sometimes is responsible for phenomena that aren't forces, such as when an electron and a positron annihilate to produce two photons.
9	10^{-43} seconds after the Big Bang, gravity separated from the unified interactions. Grand Unified Theory (GUT) describes interactions between electromagnetism, the strong and the weak interactions.
10	The GUT era ended when the strong interaction separated from the electromagnetic and weak interactions, 10^{-35} seconds after the Big Bang. Separation of the strong interaction set off a rapid expansion (inflation) of the Universe. Inflation theory was developed in the 1980s to explain how very distant parts of the Universe could once have been in close contact. It proposes that the linear size of the Universe expanded by a factor of 10^{25} in a fraction of a second. Inflation theory is considered to be an extension of Big Bang Theory.
11	10^{-12} seconds after the Big Bang, the final separation occurred. The four fundamental interactions were now distinct, as they remain to this day.
12	For further information on the Standard Model and sub-atomic particles, including hadrons, quarks, leptons, neutrinos and a range of anti-particles, see the SPICE resource, *Matter and relativity 1: Quarks*.
15	The annihilation of an electron and a positron creates two gamma ray photons.
17	Some photons from this era are still evident in the Universe today in the form of cosmic microwave background radiation (CMBR). For more information on CMBR, see the presentation in the SPICE resource, *Cosmology 2: Evidence for the Big Bang*.

Technical requirements

The guide and fact sheet require Adobe Reader (version 5 or later), which is a free download from www.adobe.com. The presentation is provided in two formats: Microsoft PowerPoint and Adobe PDF.

Image credits

Presentation, *History of the Universe*

- '360-degree Panorama of the Southern Sky' by European Southern Observatory. CC-BY-3.0, commons.wikimedia.org/wiki/File:360-degree_Panorama_of_the_Southern_Sky_edit.jpg
- 'The spiral galaxy NGC 4414, imaged by the Hubble Space Telescope', NASA/ESA, en.wikipedia.org/wiki/File:NGC_4414_%28NASA-med%29.jpg
- 'The Solar System' by NASA/JPL, solarsystem.nasa.gov/multimedia/display.cfm?IM_ID=10164
- Albert Einstein, photo by Ferdinand Schmutzer, commons.wikimedia.org/wiki/File:Einstein1921_by_F_Schmutzer_2.jpg

Associated SPICE resources

Cosmology 1: History of the Universe may be used in conjunction with related SPICE resources to address cosmological concepts within the broader topic of Unit 3BPHY: Particles, waves and quanta.

DESCRIPTION	LEARNING PURPOSE
Cosmology (sequence overview) This learning pathway shows how a number of SPICE resources can be combined to teach the topic of cosmology.	
Cosmology 1: History of the Universe This resource introduces students to Big Bang theory and events that have occurred since that time to create the Universe we see today.	**Engage/Explain**
Cosmology 2: Evidence for the Big Bang This resource introduces major pieces of evidence that led to the development of Big Bang theory, and discoveries that have since added further support to it.	**Explore/Explain**
Cosmology 3: Future of the Universe This resource introduces students to the principles by which scientists predict possible scenarios for the future of the Universe.	**Explore/Explain**
Cosmology 4: Shifted light A video explains red and blue-shift of light, and how it is used in astronomy to measure velocity and distance.	**Explain**

Acknowledgements

Thanks to Winthop Professor Ian McArthur and staff of the School of Physics at The University of Western Australia.

Designed and developed by the Centre for Learning Technology, The University of Western Australia. Production team: Graham Baker, Alwyn Evans, Dan Hutton, Jenny Gull and Michael Wheatley, with thanks to Bob Fitzpatrick, Pauline Charman and Wendy Sanderson.

In preparing these SPICE resources, the resource Cosmology: The Study of the Universe from the Wilkinson Microwave Anisotropy Probe has been used as a significant source. These materials can be found at http://map.gsfc.nasa.gov/universe/.

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