Module 5: Cosmology (The Big Bang)

This section (*along with Stars*) provides knowledge and understanding of stars, Wien’s displacement law, Stefan’s law, Hubble’s law and the Big Bang. Learners have the opportunity to appreciate how scientific ideas of the Big Bang developed over time and how its validity is supported by research and experimental work carried out by the scientific community. *It has a lot of required technical words (see Key Terms)!*

| Specification reference | Checklist questions |
| --- | --- |
| 5.5.3 a | Can you calculate distances measured in astronomical units, light-years, and parsecs? |  |
| 5.5.3 b | Can you define stellar parallax? |  |
| 5.5.3 c | Can you understand the equation relating the parallax *p* in seconds of arc and the distance *d* in parsec? |  |
| 5.5.3 e | Can you explain the Doppler effect? |  |
| 5.5.3 e | Can you describe the Doppler shift of electromagnetic radiation? |  |
| 5.5.3 f | Can you demonstrate the Doppler equation for a source of electromagnetic radiation moving relative to an observer, ? |  |
| 5.5.3 g | Can you demonstrate Hubble’s law, *v* ≈ *H0d*, for receding galaxies? |  |
| 5.5.3 h | Can you explain galactic red shift and the model of an expanding Universe? |  |
| 5.5.3 i | Can you explain Hubble constant *H*0 in km s−1 Mpc−1 and s−1? |  |
| 5.5.3 j | Can you explain the Big Bang theory? |  |
| 5.5.3 k | Can you describe the experimental evidence for the Big Bang theory from microwave background radiation? |  |
| 5.5.3 l | Can you explain the idea that the Big Bang gave rise to the expansion of space-time? |  |
| 5.5.3 m | Can you explain the estimation of the age of the Universe? |  |
| 5.5.3 m | Can you demonstrate that *t* ≈ *H0−*1? |  |
| 5.5.3 n | Can you describe the evolution of the Universe after the Big Bang to the present? |  |
| 5.5.3 o | Can you explain current ideas about the composition of the Universe in terms of dark energy, dark matter, and a small percentage of ordinary matter? |  |

**Homework and Independent Study**

HW: Assessed past-paper questions. Kerboodle online task(s)

Revision: As part of ‘Space’ half-term test (Gravity, Stars and Cosmology)

IS: Textbook summary questions on each sub-topic, to self-assess.

Zig-zag booklets for revision and IS. *Answers distributed at end of topic.*

Use of online resources including physicandmathstutor.com, Seneca Learning and Kerboodle textbook, Chapter 20. Practise past-paper questions at the end of topic (textbook pages 395-97).

**Key Terms**

**Absorption Line Spectrum:** A spectrum consisting of dark lines at specific frequencies that have been absorbed by the gases present. Elements can only absorb certain energies (frequencies) of photons.

**Astronomical Unit:** The mean distance of the earth to the sun.

**Big Bang Theory:** The theory that the universe originated as a small, dense and hot region that expanded and cooled forming the structures in the universe we see today.

**Black Hole:** A law stating that the power output (luminosity) of a star is directly proportional to its surface area and its absolute temperature to the 4th power.

**Chandrasekhar Limit:** The maximum mass that a white dwarf star can have whilst remaining stable.

**Key Terms (continued)**

**Comets:** Concentrated clusters of ice and dust that travel through space. When near the sun, they begin to melt and so leave a trail as they move.

**Continuous Spectrum:** A spectrum that covers a full range of frequencies without any gaps. The electromagnetic spectrum is an example of a continuous spectrum.

**Cosmological Principle:** A principle stating that the universe is isotropic (same in all directions to all observers) and homogenous (matter is distributed evenly).

**Dark Energy:** An energy that is responsible for the acceleration in the expansion of the universe which cannot be explained by any observable energy.

**Doppler Effect:** The apparent change in the wavelength of a wave as the source moves relative to an observer. For a source moving away the wavelength increases, for a source moving towards the observer the wavelength decreases.

**Electron Degeneracy Pressure:** The outwards force, resisting the inwards force of gravity, produced as a result of multiple electrons not being able to exist in identical states in an energy level.

**Emission Line Spectrum:** A series of bright lines at specific frequencies that have been emitted by the gases present. Elements can only release photons of certain energies, and therefore frequencies.

**Galaxies:** Collections of billions of stars, planets, gases and dust, held together by gravity.

**Hertzsprung-Russell Diagram:** A visual representation of the lifecycle of a star. Plots luminosity against temperature.

**Hubble’s Law:** The speed of a galaxy moving away from ours is proportional to its distance away from us. The constant of proportionality is Hubble’s constant.

**Light-Year:** The distance travelled through space by a photon in a year.

**Nebula:** A cloud of dust and gas in space.

**Neutron Star:** An incredibly dense star that is formed when the core of a large star collapses. Protons and electrons are forced together under gravity to form neutrons.

**Parsec:** The distance at which the angle of parallax is 1 arcsecond.

**Planet:** A body that orbits around a star, in our case, the Sun.

**Planetary Satellites:** Bodies that orbit a planet. The gravitational force of the planet’s mass provides the centripetal force of rotation.

**Red-Giant:** A stage in the life cycle of a star less than 3 solar masses, in which the hydrogen has run out and the temperature of the star increases. Helium nuclei fuse to form heavier elements.

**Solar Systems:** A collection of planets that orbit a common star.

**Stefan’s Law:** A law stating that the power output (luminosity) of a star is directly proportional to its surface area and its absolute temperature to the 4th power.

**Stellar Parallax:** The change in position of an object depending on the viewing angle. It can be used to estimate the distance of a star, based on how much it moves relative to the background of stars in the time it takes for the earth to move half an orbit.

**Supernova:** When a star greater than 1.4 solar masses dies, the core collapses rapidly inward and becomes rigid. The outer layers then fall inward and rebound off of the core in a shockwave, causing heavy elements to be fused and distributed into space in an explosion.

**Universe:** The name given to all space and matter.

**White Dwarf:** A dense star, similar mass to the sun, similar size to the earth. A final stage of a low mass star’s life with low luminosity.

**Wien’s Displacement Law:** A law stating that the peak wavelength of emitted radiation is inversely proportional to its absolute temperature.