Astrophysics (Things to remember)

Astronomical unit (AU)	Average distance between the earth and sun
Light year (ly)	Distance light travels in one year
Parsec (pc)	Distance of a star from the Earth that subtends a parallax angle of 1 arcsecond
Parallax angle	Half the angle between star and earth measured six months apart (draw diagram) The angle at which a star subtends 1 AU
Main-sequence stars	Star that fuses hydrogen into helium in its core
Binary star systems	A star system in which two stars that are gravitationally bound together orbit a common centre
Nebula	An interstellar cloud of gas and dust that acts as a stellar nursery
Constellations	A group of stars that are not gravitationally bound which form a recognisable pattern
Standard candles	Stellar structures of known luminosity
Cepheid variables	Stars that have periodic and recognisable changes in its luminosity
Dark matter	Matter that is too cold to radiate
Dark energy	Energy which causes a repulsive force that dominates gravity which is responsible for the expansion of the universe
Big bang model	Universe started off at an infinitely dense point at enormous temperatures which has

	resulted in the expansion of the universe
Homogeneity of universe	Universe is uniform in all directions
Isotropy of the universe	Universe looks the same in all directions
Cosmological scale factor	Parameter that describes the expansion of the universe and which is used to measure the size of the universe; expressed as a ratio of the present radius of the universe to the radius at some point in the past -> used to compare physical distancez
Critical density	Density of a flat, euclidean universe/ Critical density is the density for which the universe stops expanding after an infinite amount of time

- Difference between open and globular clusters:
    1. Open clusters contain younger stars
    2. Open clusters contain active stars
    3. Open clusters contain denser stars
    4. Open clusters are irregular in shape while globular clusters are spherical

- Difference between constellations and stellar clusters
    1. Stellar clusters contain stars that are gravitationally bound
    2. Constellations contain stars that come from the same gas cloud
    3. Stars in a stellar cluster are the same age

- Difference between planets and comets:
    - Comets have ice tails
    - Comets are ice-bodies while planets are mainly ice or gas
    - Planets must clear objects out of its way in its near vicinity comets don’t

- **Process of cepheid variables**
    1. Radiation ionises helium in atmosphere
    2. Freed electrons collide in atmosphere and heat up
    3. Pressure increases which causes star’s outer layer to expand and radius to increase

4. Surface temperature decreases
5. Star cools and contracts, surface temperature increases

- How are main sequences stable:
  - Force of gravity acts inwards working to collapse the star
  - Radiation pressure created by fusion in the core acts outwards
  - Star is in hydrostatic equilibrium

- Stellar evolution for low mass stars (< 1.4 $M_{\odot}$):
  - Main sequence -> Red Giant -> Planetary Nebula -> White Dwarf

- Steps for main sequence star evolving into a red giant:
  1. Fusion of hydrogen stops in the core
  2. Core contracts and hydrogen in the outer layer starts fusing
  3. Star expands and surface cools
  4. Helium starts fusing in the core
  5. Star becomes more luminous

- Steps for red giant to white dwarf:
  1. Helium flash (helium fuses into carbon)
  2. Outer shell expands and surface temperature increases
  3. Undergoes a planetary nebula phase

- White dwarfs are stable due to electron degeneracy pressure that develops in the core which acts against the force of gravity working to collapse the star

- Stellar evolution for large mass stars:
  - Main sequence -> Red supergiant -> Type II supernova -> Neutron star
  - Main sequence -> Red supergiant -> Type II supernova -> Black hole (> $3M_{\odot}$)

- Characteristics of CMB:
  1. Isotropic
  2. Homogenous
  3. Black-body radiation corresponding to temperature of 2.7 K

- How does CMB provide support for Big-Bang:
    1. As the universe expands, so wavelength in the past was smaller indicating a greater temperature
    2. the isotropic black-body radiation has since cooled to its present value of 2.7 K

- Difference between supernovae:

Type Ia	Type II
Formed from white dwarf in a binary system accreting mass from its companion star beyond Chandrasekhar limit, initiating nuclear fusion and releasing energy	Explosion of a red supergiant due to its core collapsing (core contracts due to gravity as elements beyond iron cannot be fused)
Can be used as standard candles	Cannot
Has a strong ionised silicon in its spectral line	Has hydrogen in spectral lines

- How are Type Ia supernova used as standard candles:
    - Standard candles are stellar objects of known luminosity
    - All Type Ia supernova occur at the same mass and so have same luminosity
    - Apparent brightness can be measured on Earth
    - $d = \sqrt{\frac{L}{4\pi b}}$ can be used to extrapolate distance

- How do Type Ia supernova give evidence for dark energy:
    - Type Ia supernova were dimmer than expected
    - Thus, universe's expansion must be accelerating
    - Dark energy used to posit this

- **Jeans Criterion for star formation:** Gravitational potential energy of the particles in a gas cloud exceeds the kinetic energy of the particles, causing the cloud to collapse and form a protostar

- Evidence for dark matter:

    1. Velocity of stars expected to decrease as distance from centre of galaxy increases
    2. Rotation curve of galaxies show that rotation speeds at the edge of galaxy is greater than expected
    3. Density at the edges must be greater than what can be provided by luminous matter alone
    4. Flat curve suggests existence of matter that cannot be seen

- CMB anisotropies: Fluctuations in temperature (not constant in different directions) and density which are the cause for the formation of stellar structures
    - This is linked to colliding galaxies as gravitational attraction between these stellar structures leads to collision

- Cosmological redshift
    1. Caused by expansion of universe
    2. Space between stellar structures is stretched (stretching of spacetime)
    3. Wavelength is stretched, leading to observed redshift

- Why must have stars have high mass for fusion:
    - High mass stars have greater pressure at their cores so higher temperatures, nuclei will have enough KE to overcome electrostatic forces of repulsion

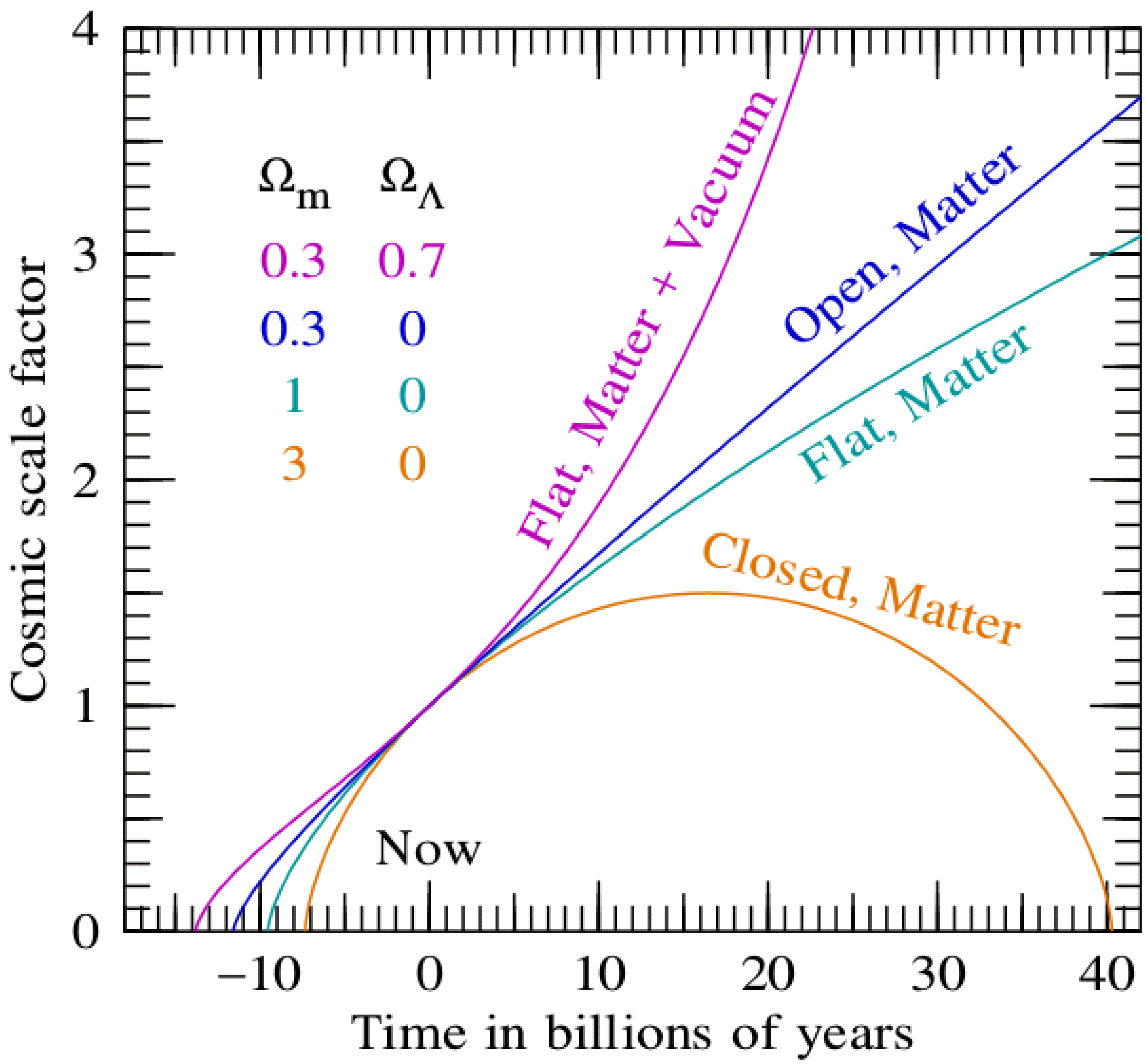
- Why is iron the heaviest element that can be produced
    - Iron has highest average binding energy per nucleon
    - Nuclear fusion no longer energetically favourable

- S (slow)-process neutron capture:
    - Occurs in giant stars
    - Atom of element absorbs a neutron and forms an unstable isotope
    - Unstable isotope undergoes beta-minus decay causing atomic number to increase by 1 and forming a heavier element
    - Isotope has enough time to decay before absorbing another neutron
    - Produces till bismuth

- R (rapid)-process neutron capture:
    - Occurs in type II supernova
    - Atom of element absorbs a neutron and forms an unstable isotope

- Unstable isotope does not have enough time to decay before another neutron is absorbed
- Neutron rich isotopes are formed
- Elements heavier than bismuth formed

- Dark matter graphs:



- Closed universe: $\rho > \rho_c$

- Flat universe: $\rho = \rho_c$
- Open universe (saddle universe): $\rho < \rho_c$
- Purple line: Dark energy