Edexcel IAL Physics A-Level

Topic 5.6 - Astrophysics and Cosmology

Flashcards

What is a gravitational field?

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A region where an object with mass experiences a non-contact force.

What type of matter is affected by a gravitational field?

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What is the magnitude of the gravitational force dependent on?

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$$F = GMm / r^2$$

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The potential energy per kilogram, at any point in the field. 0 potential is defined at infinity, hence at a point close to a mass the potential of an object would be negative.

$$V = -GM / r$$

What are some similarities between electric and gravitational fields?

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Similarities	
Gravitational fields	**Electric fields**
Gravitational field strength (g) is force per unit mass	Electric field strength (E) is force per unit +ve charge
Newton's Law of gravitation for force between 2 masses is an inverse square law	Coulomb's Law for electric force between 2 +ve point charges is an inverse square law
The field lines around a point mass show the force acting on a point mass	The field lines around a point charge show the force acting on a positive point charge
Gravitational potential (V_{grav}) is the potential energy per unit mass, and is 0 at infinity	Electric potential (V) is the potential energy per unit positive charge, and is 0 at infinity

What are some differences between electric and gravitational fields?

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Differences	
Gravitational fields	**Electric fields**
Forces are always attractive	Forces can be attractive or repulsive
Objects cannot be shielded from the field	Objects *can* be shielded from the field
The size of the force *doesn't* depend on the medium between masses	The size of the force *does* depend on the medium between charges

What is a black body radiator?

What is a black body radiator?

It is a body that absorbs all wavelengths of magnetic radiation and can emit all wavelengths of electromagnetic radiation.

What is Wien's Law and what is the peak wavelength?

What's Wien's Law?

Peak wavelength x Temperature = 2.898×10^{3}

$$\lambda_{max}T = 2.898 \times 10^{3}$$

Peak wavelength is the wavelength at which the emitted radiation is most intense ie. there is a peak on the black body radiation curve.

What is the stefan-boltzmann law equation?

What is the stefan-boltzmann law equation?

$$L=\sigma AT^4$$

L is power output (W), σ is the stefan-boltzmann constant, A is the surface area of the black body (m^2) and T is the temperature (K).

Define 1 Astronomical Unit.

Define 1 Astronomical Unit.

1 Au is the mean distance between the Earth and the Sun. It is estimated at 1.496×10^{11}m.

Define the light year.

Define the light year.

One light year is the distance that electromagnetic waves travel in one year. For example, if we see a star from 5 light years away, we are seeing it as it was 5 years ago.

1ly = 63000 Au

How can the distance to nearby stars be measured?

How can the distance to nearby stars be measured?

Trigonometric Parallax - as we rotate around the sun, we will be at two opposite points around it at two different points in the year. Because of this, stars may appear in different positions in the sky due to the fact our position has shifted. Using trigonometry and working out the angle of parallax (the angle between the two positions), we can work out a rough distance of the star. This only works up to a certain length however, as if the parallax angle is too small, it becomes insignificant and other methods must be used.

How can we work out the surface temperature of a star?

How can we work out the surface temperature of a star?

By using the equation for luminosity:

$$L = 4\pi r^2 \sigma T^4$$

R = radius of the star, σ = stefan-boltzmann constant, T = surface temp (K)

Draw the Hertzsprung-Russell diagram

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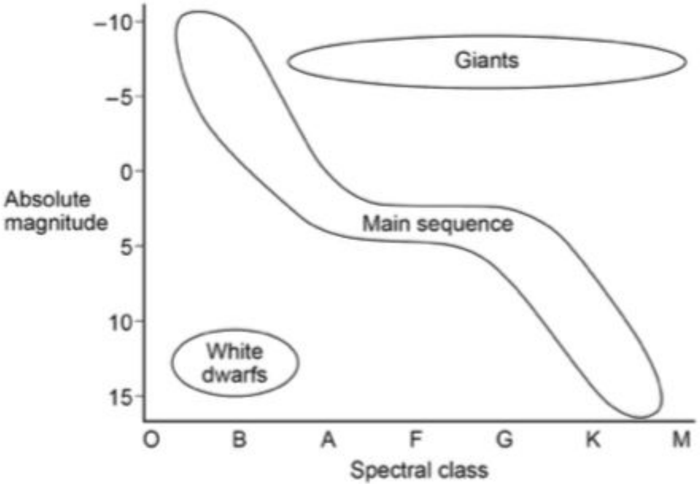

https://filestore.aqa.org.uk/resources/physics/AQA-7407-7408-TG-A.PDF

Annotate the Hertzsprung-Russell diagram to show the sun’s evolution.

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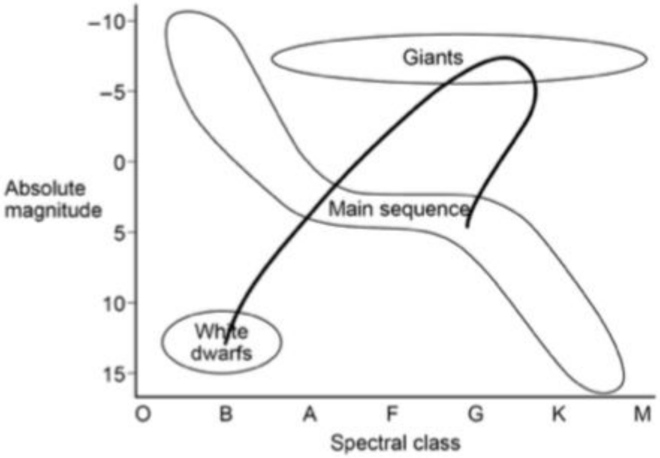

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How can standard candles be used to find distances to galaxies?

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Standard candles, which are normally cepheid variable stars, have a known luminosity. Because of this known luminosity, the inverse square law can be used to find its distance. Due to this, the distance to the galaxy containing the star can be found, as stars in the same galaxy are relatively close to each other.

What does a Hertzsprung-Russell diagram show?

What does a Hertzsprung-Russell diagram show?

The diagram compares luminosity against surface temperature. There is not a random collection, but distinct areas on the plot. The distinct areas are main sequence, red giants and white dwarfs. These show up on the diagram as they are in stable stages, whereas stars in transitional periods don't show up as they are unstable and happen too quickly.

What are the first two stages of a star?

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Stars start as a cloud of dust and gas, which slowly clump together due to the gravitational force between them all. When its dense enough, the dust and gas becomes a protostar, meaning it begins to become more dense and heats up. As it heats up, nuclear fusion occurs, causing hydrogen nuclei to turn into helium. This process causes thermal expansion, which means the star continues to grow.

What are the following two stages of a star?

What are the following two stages of a star?

Once the star reaches equilibrium, it becomes a main sequence star. Once the star runs out of hydrogen, it becomes a Red Giant. Depending on the mass of the star, the brighter and hotter it is, the bigger the size. Stars that are less massive are dimmer and cooler. If the star has a large enough mass, it will become a red supergiant.

What happens to low mass red giants?

What happens to low mass red giants?

Once all the reactions have occurred, the star will begin to collapse under its own weight. The core temperature will not be high enough to cause any more fusion so it will continue to contract until it becomes a White Dwarf, which is a star with a low luminosity and high temperature.

What happens to high mass red giants?

What happens to high mass red giants?

High mass stars (red supergiants) use up their energy more quickly and fuse heavier elements all the way up to iron. Once all the fusion has occurred, the star explodes into a supernova, which then transforms into either a neutron star or (if heavy enough) a black hole.

What is the difference between a neutron star and a black hole?

What is the difference between a neutron star and a black hole?

A neutron star is incredibly small and dense, with approximately a 10km radius. They also rotate extremely fast and emit radio waves from their poles.

A black hole is a point in space that is infinitely dense. The gravitational pull from this point is so strong that the escape velocity is greater than the speed of light.

What can H-R diagrams be used to show?

What can H-R diagrams be used to show?

They can be used to work out the age of star clusters. As the stars get older, lower mass stars become red giants and supergiants will dwindle to become white dwarfs.

What is the doppler effect?

What is the doppler effect?

It is an observed change in the frequency of any wave when the source of the wave is moving. When the source of a wave moves toward the observer, each disturbance reaches the observer in a time less than the previous disturbance.

What is the frequency change in the doppler effect dependent on?

What is the frequency change in the doppler effect dependent on?

The frequency (and wavelength) change in dependent on the velocity of the source relative to the observer.

What is the equation for redshift / blueshift?

What is the equation for redshift/blueshift?

$$Z = \Delta\lambda/\lambda = \Delta f/f = v/c$$

λ= emitted wavelength   f= emitted frequency

v = velocity of the source relative to the observer

c = speed of light

State Hubble’s law.

State Hubble's law.

The velocity of receding galaxies is proportional to the distance they are from Earth.

$$V = H_0 d$$

v = velocity of a galaxy, in km/s. d = Distance. H_0 = Hubble Constant, measured in km/s/Mpc.

What does redshift show?

What does redshift show?

Redshift shows the universe is expanding, as it shows the recessional velocity increases as the distance between the galaxies increases.

$$\textit{Recessional velocity} = H_o \times \textit{distance in Mpc}$$

How can one use Hubble’s law to determine the age of the universe?

How can one use Hubble's law to determine the age of the universe?

time = distance / velocity = 1 / H_o

The units of Hubble's constant must be converted to SI units

H_o=65 $kms^{-1}Mpc^{-1}$

Age = = 1.5 $x10^{10}$ years

What is the Hot Big Bang theory?

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The theory is that the universe started off very hot and very dense and has been expanding ever since.

What is the critical density?

What is the critical density?

The critical density is the density of the universe required for the process of expansion to halt and stay at a constant size.

What happens if the actual density of the universe is more than / equal to / less than the critical density?

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MORE = the big crunch: The gravitational pull of the universe would be enough to stop the expansion and cause the universe to contract.

EQUAL = stationary: The gravitational pull will be equal to the expansion, meaning the size of the universe stays stationary.

LESS = expansion: The gravitational pull will be less than the expansion so won't be able to stop it, meaning the universe will continue expanding forever.

Why is it difficult to find out the density of the universe?

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Due to dark matter which we can’t see, however is affected by gravity, we can’t accurately predict the mass, and therefore the actual density of the universe.

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The work done by moving a mass in a field is?

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Mass x change in potential

What is the gravitational potential difference?

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Gravitational potential difference is the difference in the gravitational potentials of two points in a gravitational field.