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QUESTION WORKBOOK

Telescopes across the spectrum

Astrophysics · Year 13

AQA 3.9.1.3, 3.9.1.4

20 questions · 57 marks

PRINT EDITION

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SECTION A · Warm-up

A1 Explain why ultraviolet and X-ray telescopes must be placed in orbit, while radio telescopes work at ground level. [2]

A2 State the Rayleigh criterion for two point sources to be just resolved by a telescope of aperture D observing at wavelength λ. [2]

A3 Define the quantum efficiency of a detector, and give typical values for a CCD and for the human eye. [2]

A4 The reflecting surface of a large radio dish can be open wire mesh, yet an optical telescope's mirror must be polished smooth. Explain the difference. [2]

A5 State the two regions of the electromagnetic spectrum for which the atmosphere is transparent down to sea level. [2]

A6 Give two reasons a radio telescope can observe for more hours in a year than an optical telescope at the same site. [2]

SECTION B · Standard

B1 Calculate the smallest angle a telescope with a 5.0 m mirror can resolve when observing at 550 nm. [2]

B2 A dark-adapted pupil is 5.0 mm across and works at about 500 nm. A radio dish 64 m across observes at 0.21 m. Calculate the resolving power of each and state which can resolve the finer detail. [4]

B3 Calculate the ratio of the collecting powers of a 10 m telescope and a 2.0 m telescope. [2]

B4 A space telescope has a 2.4 m mirror and observes at 550 nm. The Moon is 3.8×10^8 m away. Estimate the smallest feature it can resolve on the lunar surface. [4]

B5 An amateur telescope has an objective 130 mm in diameter and observes at 550 nm. The two stars of a binary are separated by an angle of 2.2×10^{-6} rad. Determine whether the telescope can resolve the pair. [3]

B6 A telescope of aperture 0.50 m collects enough light from a faint galaxy in a 1.0 hour exposure. Calculate the exposure a 0.25 m telescope of the same design would need to collect the same amount of light. [3]

B7 A telescope of aperture 0.30 m can observe through a blue filter at 400 nm or a red filter at 700 nm. Calculate the smallest resolvable angle with each filter, and state which filter shows the finer detail. [3]

B8 During one exposure, 6.0×10^4 photons from a faint galaxy arrive at a detector. Calculate the number registered by a CCD of quantum efficiency 80%, and by an eye of quantum efficiency 1%. [2]

SECTION C · Stretch

C1 Calculate the dish diameter a radio telescope observing at 0.21 m would need to match the resolving power of a 15 cm optical telescope working at 500 nm. Comment on your answer. [4]

C2 An astronomy society is debating whether to image a faint galaxy by eye or with a CCD camera. Give four distinct reasons the CCD will out-perform the eye. [4]

C3 Describe one way the structure or siting of an infrared telescope and of an X-ray telescope must each differ from an ordinary optical telescope, giving the reason in each case. [3]

C4 An astronomy society may borrow one instrument to try to split a double star of angular separation 3.0×10^{-6} rad: an optical telescope of aperture 0.20 m used at 550 nm, or a radio dish of diameter 25 m used at 0.21 m. Deduce which instrument, if either, can resolve the pair, and determine the dish diameter a radio observatory would need to match it. [4]

C5 Two radio dishes 320 km apart are linked so that they act as a single aperture equal to their separation, observing at 0.060 m. Calculate the resolving power of the linked pair and of a single 64 m dish at the same wavelength, and state the improvement factor. [4]

C6 Estimate the greatest distance at which a dark-adapted eye, pupil diameter 4.0 mm working at 500 nm, could resolve a car's two headlamps, which are 1.5 m apart. [3]