ASTROPHYSICS

1-5 Telescopes and technology

1. Complete table:

Type	Location	Wavelength range	Resolution/degrees	Major advantages	Major disadvantages
Optical	Ground or satellite	350-850 nm	10^{-5} for HST (500 nm)	- gives very detailed images; - can detect distant galaxies	- ground telescopes suffer from atmospheric refraction
Radio	Ground	1 mm to 10 m	0.2 for Lovell (21 cm waves)	- radio waves pass through dust in space and through the atmosphere	- large supporting structure needed for a steerable dish
Infrared	Ground or satellite	700 nm (or 0.0007 mm) to 1 mm	0.05 for IRAS (0.5 mm) 2.4×10^{-5} for HST (0.001 m or 1000 nm)	- can detect warm objects that do not emit light - can detect dust clouds in space	- mirror needs to be cooled - ground based telescopes need to be situated where atmosphere is dry and as high as possible
Ultraviolet	Satellite	115 -400 nm	3.2×10^{-5} for XMM-Newton (170 nm)	- maps hot gas clouds near starts - allows study of hot objects like comets, supernovae and quasars	- must be above the Earth's atmosphere e.g. on a satellite
x-ray and gamma ray	Satellite		0.2 for INTEGRAL	- used to discover X-ray pulsars and - x-ray and gamma ray bursters	- must be above the Earth's atmosphere e.g. on a satellite

2. (a) (i) HST at λ = 0.001 mm = 1×10^{-6} m; Objective diameter = 2.4 m

$$\theta = \frac{\lambda}{D} = \frac{1 \times 10^{-6}}{2.4} = 4.2 \times 10^{-7} \text{ rad}$$

$$= \frac{4.2 \times 10^{-7} \times 180}{\pi}$$

$$= 2.4 \times 10^{-5} \text{ degrees}$$

(ii) XMM- Newton at λ = 170 nm = 170 x 10^{-9} m; Objective diameter = 30 cm = 0.30 m

$$\theta = \frac{\lambda}{D} = \frac{170 \times 10^{-9}}{0.30} = 5.67 \times 10^{-7} \text{ rad}$$

$$= \frac{5.67 \times 10^{-7} \times 180}{\pi}$$

$$= 3.2 \times 10^{-5} \text{ degrees}$$

3. See table, column 5

4.

Telescope	diameter
HST	2.4 m
INTEGRAL	0.60 m
IRAS	0.60 m
Lovell	76 m
XXM-Newton	0.30 m

Collecting power is proportional to the diameter^2

(a)

Lovell	most
HST	↓
INTEGRAL + IRAS	
XXM-Newton	least

(b) As the linked system has a much larger effective width it has a much greater collecting power than the single Lovell telescope does as collecting power is proportional to the diameter^2.
As resolving power is inversely proportional to the diameter, the large the array the smaller the angular separation of the objects that can be separated. The linked system can therefore resolve objects that the Lovell telescope on its own could not as its minimum angular resolution is smaller.