Stars and Galaxies

Observational Techniques Homework Set 4 – Solutions

1) X-ray telescopes have long focal length because they use grazing incidence (since the energy of the photons is so high that it does not reflect well and is instead absorbed).

(from lecture 2) The plate scale ($\mathrm{d}\theta\,/\,\mathrm{d}s$) and focal length ($f$) are related by $\mathrm{d}\theta\,/\,\mathrm{ds} = 1\,/\,f$ (where θ is the angular size and s is the distance along the detector).

The physical size of detector is $32 \times 625\,\mu\mathrm{m} = 20\,\mathrm{mm}$.

Hence $\mathrm{d}\theta\,/\,\mathrm{ds} = 400''\,/\,20\,\mathrm{mm} = 20''\,/\,\mathrm{mm}$

The focal length is given by $\mathrm{d}\theta\,/\,\mathrm{ds} = 1\,/\,f$

Hence $f = 1\,/\,20'' \times 206265\,/\,1000 \underline{= 10.3\,\mathrm{m}}$. [3 marks]

2a) The angular resolution of an interferometer is given by $\theta = \lambda\,/\,D$. With $D = 55$ and $\lambda = 700\,\mathrm{nm}$, $\theta = 2.6\,\mathrm{mas}$. [1 mark]

b) $\mathrm{d[pc]} = 1\,/\,\phi('')$ so $d = 1\,/\,0.130$ or $d = 7.7\,\mathrm{pc}$. [1 mark]

c) Diameter, $D = d\theta$. With $d = 7.7\,\mathrm{pc}$ and $\theta = 2.6\,\mathrm{mas}$ gives $D = 3.0 \times 10^6\,\mathrm{km}$ (which is $\sim 2.6\,\mathrm{D}_\odot$).

To find the luminosity, use Luminosity = $4\,\pi\,d^2 \times 3.92 \times 10^{-8} = 2.8 \times 10^{28}\,\mathrm{W}$ (which is $\sim 70\,L_\odot$).

Luminosity = $4\,\pi R^2 \sigma T^4$. With $R = 1.5 \times 10^6\,\mathrm{km}$ and $\mathrm{L} = 2.8 \times 10^{28}\,\mathrm{W}$, $T = 11{,}500\,\mathrm{K}$.

On a HR-diagram, Vega is a Main-Sequence, late B or early A-type star (with a mass of $\sim 2\,\mathrm{M}_\odot$). [2 marks]

3) a) The scientific ranking that you give these proposals is entirely your judgement. There is no "correct" answer, so long as you can justify your choice. I would probably rank these are: (1) Proposal #1; (2) Proposal #2; (3) Proposal #3. Reasons: Proposal #1 is addressing the most "fundamental" problem of how stars form; Proposal #2 is addressing fundamental questions regarding the formation of the Hubble sequence; Proposal #3 is more "niche" and aimed at understanding this one object, although the science case is still compelling.

b) Again, there is no "correct" answer, so long as you justify your answer. However, I would order these as: (1) proposal #1 requires the best conditions since they require adaptive optics (which can only be performed if there is no cloud and the atmospheric conditions are stable). Proposal #3 requires good (but not excellent) conditions since they are trying to measure the position of a magnetar in a ground based image. Proposal #2 can probably cope with the worst conditions since they are measuring galaxy integrated spectra, so do not require good seeing. Their targets are also nearby and bright, so some cloud is less likely to jepordise the results.