Solutions

Solution 1: CCD Image Processing

a) To measure instrumental magnitude we should choose an aperture. Careful investigation of the image, shows that a 5×5 pixel aperture is enough to measure m_I for all stars. m_I can be calculated using:

$$m_I = -2.5 \log\left(\frac{\sum_{i=1}^{N} I_{i(star)} - N\bar{I}_{Sky}}{Exp}\right)$$

where $I_{i(star)}$ is the pixel value for each pixel inside the aperture, N is number of pixels inside the aperture, $\bar{I}_{Sky}$ is the average of sky value per pixel taken from dark part of image and Exp is the exposure time. Table (1.4) lists values for m_I and $Zmag$ calculated for all three identified stars.

$$\bar{I}_{Sky} = 4.42$$

$$N = 25$$

$$Exp = 450$$

Table (1.4)

Star	m_I	m_t	$Zmag$
1	-3.02	9.03	12.38
3	-5.85	6.22	12.40
4	-4.04	8.02	12.39

b) Average $Zmag$ = 12.4

c) Following part (a) for stars 2 and 5, we can calculate true magnitudes (m_t) for these stars

Table (1.5)

Star	m_I	m_t
2	-2.13	9.93
5	-0.66	11.4

d) Pixel scale for this CCD is calculated as

$$p = \frac{pixel\ size}{focal\ length} \times \frac{180 \times 3600}{\pi}$$

$$= 4.30''$$

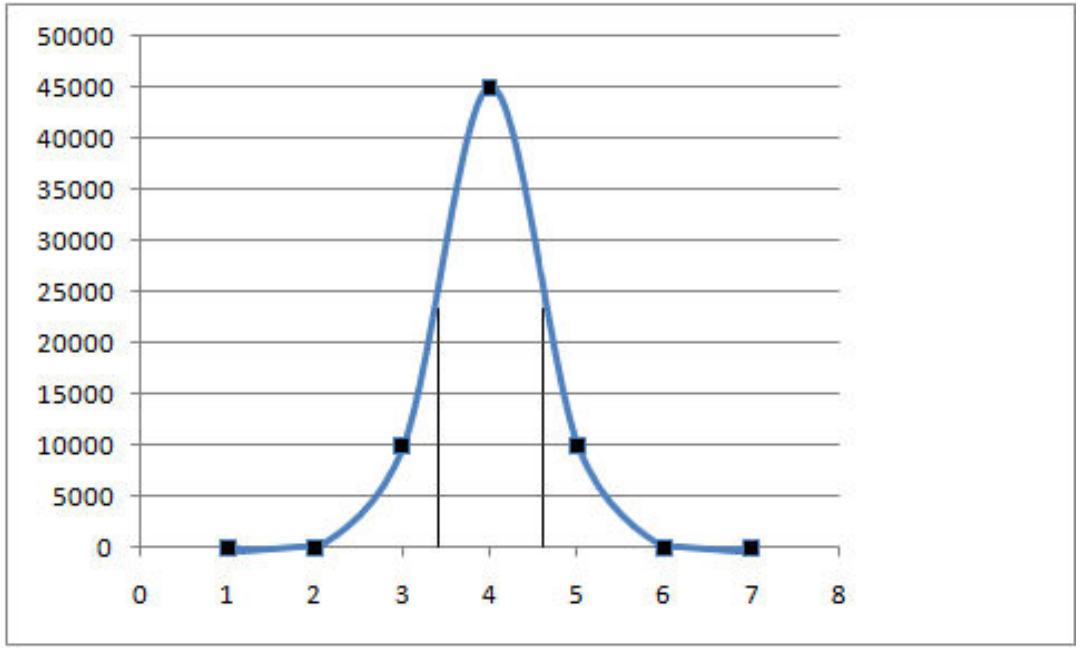
e) Average sky brightness:

$$m_{sky} = -2.5 \log \frac{\bar{I}_{\mathrm{Sky}}}{(Exp)(p)^2} + Zmag$$

$$= 20.6$$

f) To estimate astronomical seeing, first we plot pixel values in x or y direction for one of the bright stars in the image. As plot (1) shows, the FWHM of pixel values which is plotted for star 3, is 1 pixel , hence astronomical seeing is equal to

$$seeing \cong 4''$$



Plot (1)

CCD Image Problem Marking Scheme

Part	Tot. Pts.	Details	Max.	Explanation
a	10	Relation	2	Each value :+2 $\overline{I}_{sky}$ (within calculation) : +2 m_I relation (in calculation) +2
		m_I	6	
		$\overline{I}_{sky}$	2	
b	10	Z_{mag}	10	$3Z_{mag}$ and average , for each less: - 2
c	10	m_t	10	For each one:+ 5, for each numerical mistake: -2
d	10	P (pixel Scale)	10	
e	10	Relation of m_{sky}	5	
		Value of m_{sky}	5	
f	10	Seeing	10	Seeing: +4, Gaussian profile: +3, FWHM: +3