Problem I CCD image (35 points)

Information:

Picture 1 presents a negative image of sky taken by a CCD camera attached to a telescope whose parameters are presented in the accompanying table (which is part of the FITS datafile header).
Picture 2 consists of two images: one is an enlarged view of part of Picture 1 and the second is an enlarged image of the same part of the sky taken some time earlier.
Picture 3 presents a sky map which includes the region shown in the CCD images.

The stars in the images are far away and should ideally be seen as point sources. However, diffraction on the telescope aperture and the effects of atmospheric turbulence (known as 'seeing') blur the light from the stars. The brighter the star, the more of the spread-out light is visible above the level of the background sky.

Questions:

1. Identify any 5 bright stars (mark them by Roman numerals) from the image and mark them on both the image and map.
2. Mark the field of view of the camera on the map.
3. Use this information to obtain the physical dimensions of the CCD chip in mm.
4. Estimate the size of the blurring effect in arcseconds by examining the image of the star in Picture 2. (Note that due to changes in contrast necessary for printing, the diameter of the image appears to be about 3.5 times the full width at half maximum (FWHM) of the profile of the star.)
5. Compare the result with theoretical size of the diffraction disc of the telescope.

6. Seeing of 1 arcsecond is often considered to indicate good conditions. Calculate the size of the star image in pixels if the atmospheric seeing was 1 arcsecond and compare it with the result from question 4.
7. Two objects observed moving relative to the background stars have been marked on Picture 1. The motion of one ("Object 1") was fast enough that it left a clear trail on the image. The motion of the other ("Object 2") is more easily seen on the enlarged image (Picture 2A) and another image taken some time later (Picture 2B).

Using the results of the first section, determine the angular velocity on the sky of both objects. Choose which of the statements in the list below are correct, assuming that the objects are moving on circular orbits. (Points will be given for each correct answer marked and deducted for each incorrect answer marked.)The probable causes of the different angular velocities are:

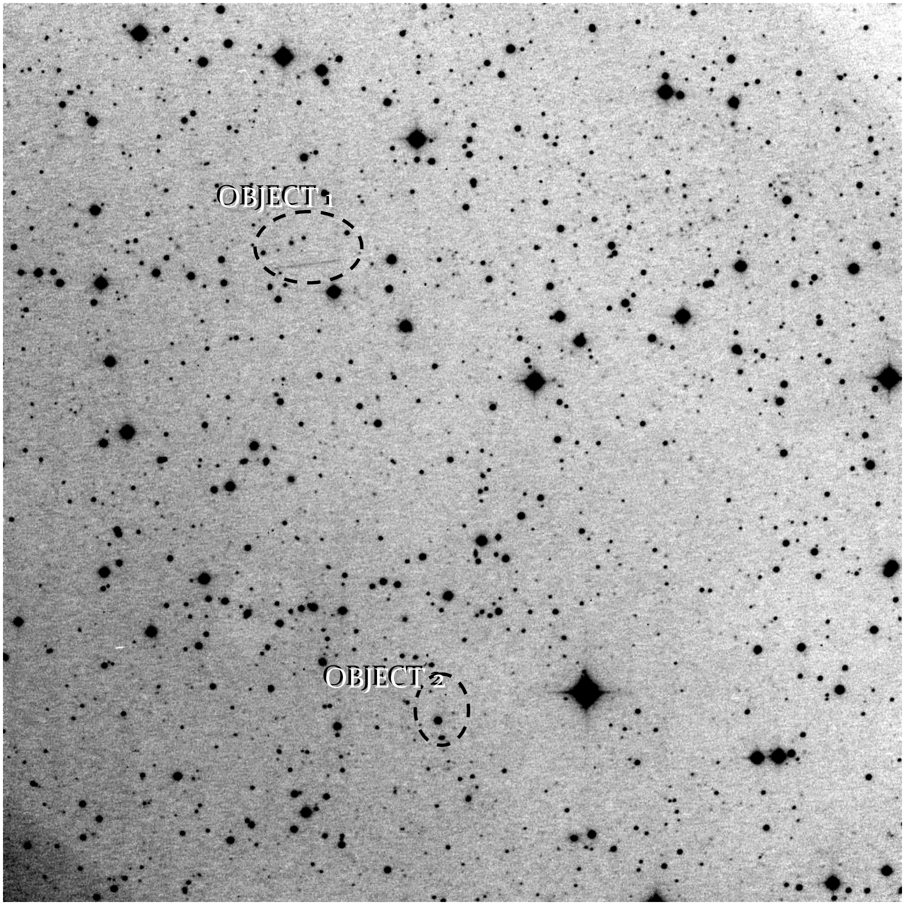
a) different masses of the objects,
b) different distances of the objects from Earth,
c) different orbital velocities of the objects,
d) different projections of the objects' velocities,
e) Object 1 orbits the Earth while Object 2 orbits the Sun.

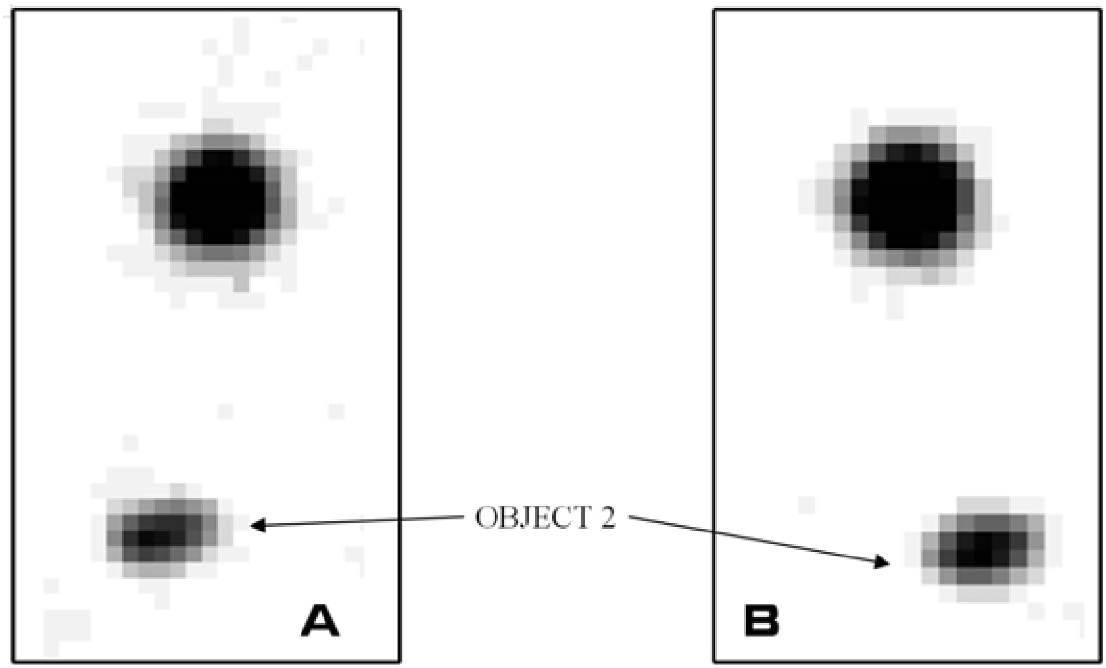
Data:

For Picture 1, the data are,

BITPIX =	16	/ Number of bits per pixel
NAXIS =	2	/ Number of axes
NAXIS1 =	1024	/ Width of image (in pixels)
NAXIS2 =	1024	/ Height of image (in pixels)
DATE-OBS= '2010-09-07	05:00:40.4'	/ Middle of exposure
TIMESYS = 'UT'		/ Time Scale
EXPTIME =	300.00	/ Exposure time (seconds)
OBJCTRA = '22 29 20.031'		/ RA of center of the image
OBJCTDEC= '+07 20 00.793'		/ DEC of center of the image
FOCALLEN= '3.180m'		/ Focal length of the telescope
TELESCOP= '0.61m '		/ Telescope aperture

Picture 1 for Problem I





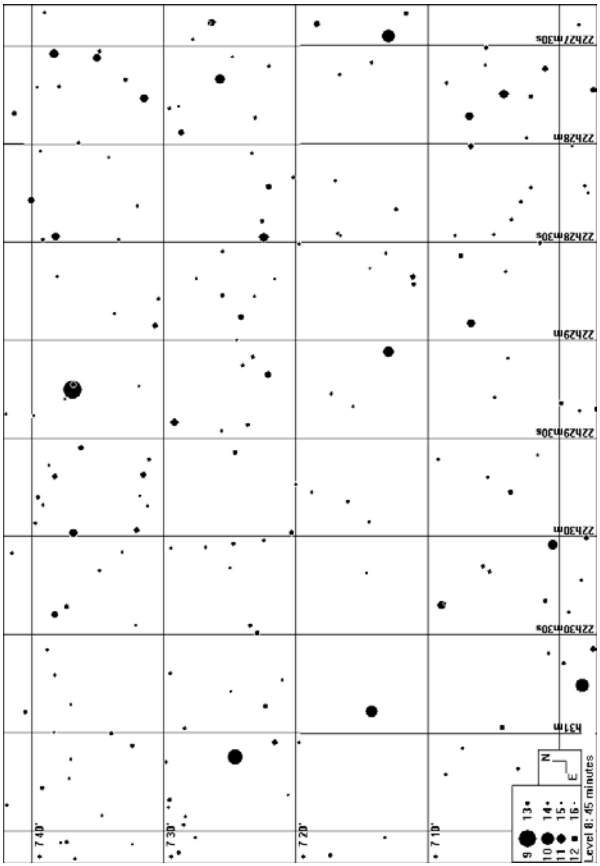
Picture 2 for Problem I:

A: The same area observed some time earlier. For this image the data are :

DATE-OBS= '2010-09-07 04:42:33.3' / Middle of exposure

B: Enlargement of Picture 1 around Object 2,

Picture 3 for Problem I:



Solution:

Problem II: Light curves of stars (35 points)

A pulsating variable star KZ Hydrae was observed with a telescope equipped with a CCD camera. Figure 1 shows a CCD image of KZ Hya marked together with the comparison star and the check star. Table 1 lists the observation time in Heliocentric Julian dates, the magnitude differences of KZ Hya and the check star relative to the comparison star in V and R band.

The questions are:

1) Draw the light curves of KZ Hya relative to the comparison star in V and R band, respectively.
2) What are the average magnitude differences of KZ Hya relative to the comparison star in V and R, respectively?
3) What are the photometry precisions in V and R, respectively?
4) Estimate the pulsation periods of KZ Hya in V and R.
5) Give the estimation of the pulsation amplitudes of KZ Hya in V and R
6) What is the phase delay between the V and R bands, in term of the pulsation period?

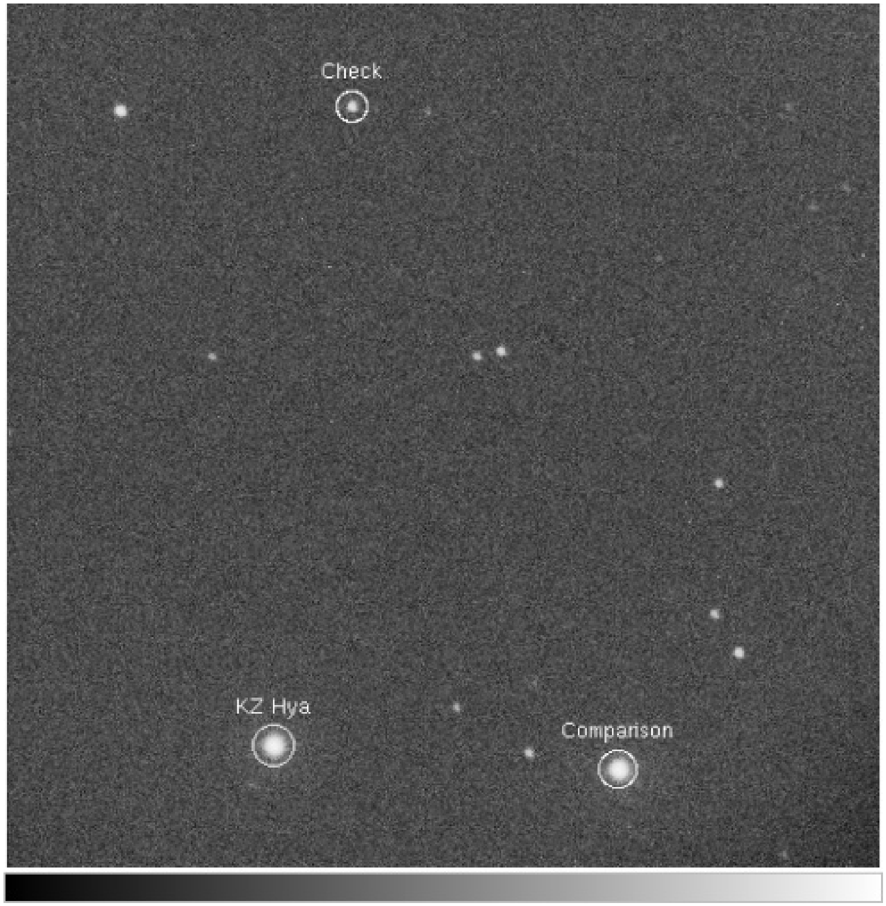


Fig. 1 for Problem II: A CCD image of KZ Hya.

Table 1 for Problem II: Data for the light curves of KZ Hya in V and R. ΔV and ΔR are KZ Hya relative to the comparison in V and R. ΔV_{chk} and ΔR_{chk} are the check star relative to the comparison in V and R.

HJD-2453800(t)	ΔV(mag)	ΔV_{chk}	HJD-2453800(t)	ΔR(mag)	ΔR_{chk}
3.162	0.068	4.434	3.1679	0.260	2.789
3.1643	0.029	4.445	3.1702	0.185	2.802
3.1667	-0.011	4.287	3.1725	-0.010	2.789
3.1691	-0.100	4.437	3.1749	-0.147	2.809
3.1714	-0.310	4.468	3.1772	-0.152	2.809
3.1737	-0.641	4.501	3.1796	-0.110	2.789
3.1761	-0.736	4.457	3.1820	-0.044	2.803
3.1784	-0.698	4.378	3.1866	0.075	2.805
3.1808	-0.588	4.462	3.1890	0.122	2.793
3.1831	-0.499	4.326	3.1914	0.151	2.793
3.1855	-0.390	4.431	3.1938	0.177	2.782
3.1878	-0.297	4.522	3.1962	0.211	2.795
3.1902	-0.230	4.258	3.1986	0.235	2.796
3.1926	-0.177	4.389	3.2011	0.253	2.788
3.195	-0.129	4.449	3.2035	0.277	2.796
3.1974	-0.072	4.394	3.2059	0.288	2.783
3.1998	-0.036	4.362	3.2083	0.296	2.796
3.2023	-0.001	4.394	3.2108	0.302	2.791

3.2047	0.016	4.363	3.2132	0.292	2.806
3.2071	0.024	4.439	3.2157	0.285	2.779
3.2096	0.036	4.078	3.2181	0.298	2.779
3.2120	0.020	4.377	3.2206	0.312	2.787
3.2145	0.001	4.360	3.2231	0.313	2.804
3.2169	0.001	4.325	3.2255	0.281	2.796
3.2194	0.005	4.355	3.2280	0.239	2.795
3.2219	0.041	4.474	3.2306	0.115	2.792
3.2243	0.009	4.369	3.2330	-0.111	2.788
3.2267	-0.043	4.330	3.2354	-0.165	2.793
3.2293	-0.183	4.321	3.2378	-0.152	2.781
3.2318	-0.508	4.370	3.2403	-0.088	2.787
3.2342	-0.757	4.423	3.2428	-0.014	2.780
3.2366	-0.762	4.373	3.2452	0.044	2.766
3.2390	-0.691	4.427	3.2476	0.100	2.806
3.2415	-0.591	4.483	3.2500	0.119	2.791
3.2440	-0.445	4.452	3.2524	0.140	2.797
3.2463	-0.295	4.262	3.2548	0.190	2.825