Lab 4: Cluster Photometry

Overview

Using your abilities at the telescope and some knowledge of astrophysics and CCD instrumentation, you will make multiple, independent measurements of the distance to the open cluster, M44 (Praesepe). By comparing your results with the known distance, you will confirm how B-V color changes with spectral type.

Theoretical

1.1 Geometric Dilution of light energy through Space

As light propogates outward from a star, flux (f) decreases as the inverse square of the distance (d) due to the spreading of the spherical wavefront in space. $f=L4pd^2$

1.2 Magnitudes and Parallax

For historical reasons, the magnitude scale is logarithmic. The following equations relate apparent magnitude (m) and absolute magnitude (M) to flux (f) luminosity (L). K_1 and K_2 are constants established by convention. $m=-2.5\log_{10}f + K_1$ $M=-2.5\log_{10}L + K_2$ Parallax relates linear distance to angular shift in the following simple way, where distance (d) is defined as 1 parsec when the parallactic angle (p) is 1 arcsecond. d=1p

1.3 Magnitudes and Distance

Combining equations 1, 2 and 3 gives the following expression that relates magnitudes to distance. The constant was chosen so that the absolute magnitude (M) is to be the apparent magnitude (m) if the star were placed 10 parsecs from the earth. $m_V-M_V = 5\log_{10}d-5$

Procedure

1.4 Preparing for the Run

Choose any 6 stars from the table below, and make finder charts for each of them. It is often handy to make 2 maps for each target star, one at 1-3 times the array field of view (FOV) and another that is about half of the finder scope FOV. (into which the moon can fit).
See the following webs site for making star charts:

http://skyview.gsfc.nasa.gov/cgi-bin/skvadvanced.pl
http://simbad.u-strasbg.fr/sim-fid.pl

Sample of M44 Cluster Members

Object Name	Coordinates (1950) hr min sec deg amin asec	m_V	Spectral Type
HD 74780	8 43 42.5 +18 56 40	9.25	A5
HD 74718	8 43 23.8 +19 53 33.8	8.39	A5
BD+20 2180	8 38 35.1 +19 43 17	9.59	F4
HD 73397	8 35 54.9 +19 40 38	9.01	F4
BD+20 2143B	8 36 17.9 +19 51 18	9.41	F6
HD 73597	8 37 1.32 +20 44 16.4	9.34	F6
Cl*NGC2632 ART 835	8 36 53.9 +19 32 40	10.66	G0
BD+20 2195	8 40 19.9 +20 3 33	9.93	G5
HD 72115	8 28 49.3 +19 09 27.9	6.49	K0
Cl*NGC2632 RUS88	8 35 42.0 +20 02 17	9.18	K4
Cl*NGC2632 ART 2637	8 38 57.8 +19 22 32	14.31	K8
Cl*NGC2632 HSHJ281	8 36 49.2 +20 12 19	15.41	M1

1.5 Data at the Telescope

Take multiple images (5-10 each) of each target cluster star at 2 different exposure times through the B and V Johnson filter. Choose your exposure times to insure your stellar images have ample signal without saturating the CCD. Recall the range in ADU of a raw image from zero point to saturation (33,200 – 48,000).

Take groups of darks at identical exposure times as for all your target images. You need flats, as well. You may choose either dome flats or sky flats, and get 5-10 frames at two different exposure times that give good signal, but are not saturating (this is usually a good data taking policy - assuming you aren't trying to expose rapidly for other reasons like to do speckle imaging). Don't forget to take darks that go with your flats.

1.6 Data Reduction a la IRAF

For every stellar image and flat field, subtract the corresponding dark from it. (imarith).

Next, average together each group of images (now dark subtracted) of the same type, exposure time, and filter setting. To correct for pixel values that may have received a spurious signal (i.e. a cosmic ray hit), though are good pixels normally, set the following parameters in imcombine as shown:

reject = "sigclip"
lsigma = "3"
hsigma= "3"

This will protect the average value in 9 frames from being heavily weighted by a cosmic ray event in only one frame.

Create a normalized flat field from each of the two different exposure times. As before, examine a histogram (imhist) of your dark subtracted, averaged flat frame to determine the appropriate range to calculate the mean from. Dividing by this mean (imarith) then gives you a flat field normalized to 1.

After you divide your cluster star frames by one of your normalized flats, proceed to count ADUs on the chip of your target star. Use phot and follow the same procedure as with lab 3.

1.7 Computing Magnitudes and Colors

Using your throughput measurements from Lab 3, convert the summed ADUs to electrons and then to photons. For your V band measurements, compare your derived magnitudes with the ones given in the table above to check the accuracy of your magnitude conversions. (namely, your throughput value) Derive magnitudes for your B band measurements in the same way. Now you can determine the B-V color ($m_B - m_V$) for each of your targets.

For each star at the two exposure times, obtain from your data the apparent magnitude in the V band (m_V) and the B-V color. Using the handout included with this lab, convert the B-V color of each star to an absolute V magnitude (M_V). Use equation 5 to derive the distance to the each of your stars.

Make a plot of spectral type vs. derived distance to the cluster. Note on the plot where the true distance to M44 is.

Conclusion

Since each star in the table belongs to the Beehive Cluster (Praesepe, M44), your distance measurements should be in some agreement. What is the standard deviation (s) in your distance results. Does the average of your distance determinations agree to within $\pm$ s with the accepted distance to the cluster? Are the results from the different exposure times for each star consistant with one another? If not, could the beginning of saturation account for what you observe? By not accounting for reddening due to the cluster itself, does this cause you to derive a distance that's too large or small? Are there any observable trends in your plot of distance vs. spectral type? Did your brighter targets give you better results?