Chapter 5

ERROR ANALYSIS

The fifth chapter deals with a brief discussion on errors and sources of errors, different sources of errors in the present study and how these errors propagated via calculations to the final result.

Errors and its types

No measurement is perfectly accurate or exact. Many instrumental, physical and human limitations cause measurements to deviate from the actual values of the quantities being measured. These deviations are called "experimental uncertainties," but more commonly the shorter word "error" is used.

The error arising out in an experiment is of two types, (1) Systematic error and (2) Random error or noise.

A common cause of systematic error is a miscalibrated scale or eqipment or bias on the part of the observer. Systematic errors are not easy to detect and not easily studied by statistical analysis. They can only be estimated from an analysis of the experimental conditions and techniques. Every effort should be made to minimize the possibility of these errors, by careful calibration of the apparatus and by use of the best possible measurement techniques.

Random errors are the fluctuations in observations. They may result from instrumental uncertainties (instrumental errors) or statistical fluctuations (statistical errors).

Instrumental errors:

These types of errors generally come from fluctuations in readings of the instruments, either because of imprecision in the measuring instruments or because of human imprecision or a combination of both. Such errors are called instrumental because they arise from a lack of perfect precision in the measuring instruments including the observer.

Statistical errors:

These types of errors are also called photon noise error in photometry. They arise, not from a lack of precision in the instruments but from overall statistical fluctuations in the collections of finite number of counts over finite intervals of time which can be calculated using statistics.

Propagation of errors

A measurement or experimental result is of little use if nothing is known about the probable size of its error. Reporting photometric error/uncertainty is a very important part of the observing process. That is why it is important to combine errors in separate measurements to find the error in a result calculated from those measurements.

The errors in individual measurements are combined to estimate the errors in the final result or, data errors propagate through the calculations to produce errors in results. Here are some cases related to the present study, showing how errors propagate:

(i) $Z = aA \pm bB$ (weighted sum and difference), then error in Z is

$\Delta Z = \sqrt{(a^2 (\Delta A)^2 + b^2 (\Delta B)^2}$

(ii) $Z = AB$,

$\Delta Z = \sqrt{(B^2 (\Delta A)^2 + A^2 (\Delta B)^2)}$

the result is the same for division as it is for multiplication.

(iii) $Z = A^2$ then the error in Z due to an error in A is,

$\Delta Z = 2A\ \Delta A$

Different sources of errors and their propagation in the present case

The sources of "noise" in the present analysis are in the readout and photon noise in the signal from the object. The signal to noise ratio of the object is estimated from the data values in the following way using the standard relation

$S/N = N_* / \sqrt{(N^* + n_{pix}(N_s + N_r^2)}$ ..... (15)

Where, N_* is the total(sky subtracted) source count, n_{pix} is the number of pixels contained within the software aperture, N_s is the background sky count per pixel and N_r is the read noise in electrons per pixel(Howell 1989). The N_* N_s are derived in net number of electrons (counts multiplied by gain). In the present case, Gain =1.22 e^-/ ADU, Read noise = 4.8 e^- and the calculated S/N is 501.5. The estimated error of the instrumental magnitude in the aperture is approximately given by, merr=1.0857× (ΔN_*/ N_*) where

ΔN_* is the measurement error (in electrons) of the estimated number of electrons from the star within the aperture (Davis 1987, Mighell 1999). The parameters that must be set correctly to estimate the uncertainties in the computed Apphot magnitude are:

(1) Noise model

There are two noise models → (i) poisson and (ii) constant. In poisson model the poisson statistics in the object and the sky background are used to estimate the error in the object measurement. The total noise includes poisson noise from the object and the sky noise.

In constant model the standard deviation of the sky background is used to estimate error in the object measurement. The total noise is assumed to be due to noise in the sky background alone.

In the present case, poisson model has been used to compute the magnitude errors.

(2) Gain and read noise

The parameter gain define image gain in electrons per adu and read noise define readout noise of the image in electrons. The values of gain and read noise, in the present analysis, are Gain =1.22 e^-/ ADU, Read noise = 4.8 e^-.

Thus all B, V, R magnitudes have been found to have observational errors in the range 0.001-0.05, with 0.05 as a safe upper limit.

The errors in extinction coefficients (**k**) in BVR bands are $\Delta k(B)=0.029$, $\Delta k(V)=0.032$, $\Delta k(R)=0.037$. These errors have been combined with observational errors to produce errors in instrumental magnitudes of the field stars for the three clouds in the following way:

$$m_i = m_0 - kX$$

The errors in air mass values are $\Delta(kX)$ and Δm_0 are the observational errors, thus errors in instrumental magnitude are

$\Delta m_i = \sqrt{((\Delta m_0)^2 + (\Delta kX)^2)}$ where

$\Delta kX = \sqrt{(X^2 (\Delta k)^2 + k^2 (\Delta X)^2)}$

The errors in instrumental magnitudes of field stars combined with errors in instrumental magnitudes of standard stars Δm_{is}, have been propagated to give errors in calibrated magnitudes or actual magnitudes Δm_c as shown within first brackets (Table 4.2 to 4.10) These errors so propagated to the final stage of results are shown in Table 4.11.