Assignment 4

Due in by mid-day Thursday 10^{th} May.

Question 1.

You measure the B and V magnitudes of a galaxy. B=21.3±0.22 and V=21.7±0.41. What is the error on the B-V colour?

Question 2.

You can measure the distance to any given type 1a supernova with 7% (rms) precision. How many supernovae would you need to observe in a given galaxy cluster to measure the distance to that cluster to 1% precision?

Question 3.

A theory suggests that a certain sub-class of gamma-ray bursts all have the same absolute magnitude. This theory was based on the following sample of gamma-ray burst absolute magnitudes:
-9.33 -9.51 -9.40 -9.77 -10.16 -9.13 -9.56 -9.32 -8.98 -9.45 -9.56 -9.77

A paper has recently been published reporting the discovery of a gamma-ray bursts with an absolute magnitude of -8.56. The author claims that this absolute magnitude is so different from that in the previous sample that this must belong to a new sub-class of gamma-ray bursts.

Do you believe this claim? Justify your reasoning.

Question 4.

In the near-IR, imaging observations are typically limited by sky noise. What is this? The sky is so bright at these wavelengths that in every pixel of your image, sky counts typically swamp object counts. The noise therefore comes from the Poisson noise in these sky counts.
With the IRIS2 camera on the Anglo-Australian Telescope, it is possible to reach K=18.0 in a ten minute exposure, with a signal-to-noise ratio of 5.0.
How long would you need to expose for to find a 23^{rd} K magnitude source with a signal-to-noise ratio of 7?

Question 5.

An astronomer is trying to work out whether you could use quasars as standard candles, to study the cosmology of the universe. To do this, there needs to be some feature in their spectra which correlates with their absolute magnitude.

She obtained the spectra of 5,000 quasars from the SDSS and 2QZ survey databases. She then measured 50 different spectra parameters (line widths, line fluxes, line asymmetries, continuum slopes etc) from each spectrum.

Finally, she correlated each of these 50 parameters against the absolute magnitude of the quasar. The significance of each correlation was estimated by working out what the standard deviation in the correlation coefficient would be if there was no correlation. The measured correlation coefficients were then compared with this standard deviation to see how many sigma they were away from this null value.

She found that two spectral parameters (the flux in the CIV line and the width of the Ly-alpha line) showed fairly strong correlation with the absolute magnitude: both were slightly more than 2 standard deviations (2 σ) away from zero correlation. Another 30 parameters showed weaker correlations (more than 1σ but less than 2).

What could she deduce from all this?

Question 6

Let's revisit a question from Assignment 2. Consider a telescope which is continually monitoring a star, looking for transits due to planets orbiting this star.

Let us assume that this telescope reads out the brightness of this star once per minute. The average number of photons recorded per minute is 30. The only source of noise is the Poisson noise due to the photons from the star. Each star will be observed continuously for 10 days.

I would like you to work out how deep a transit needs to be, to be detected. As a function of how long the transit it. What I want is a graph showing minimum detectable transit depth, against length of transit (in minutes). For simplicity sake, you may assume that transits are perfectly aligned with the one minute exposures – i.e. that a 7 minute transit will cause 7 one-minute exposures to show a low flux. So no need to worry about what would happen if a transit started mid-way through an exposure.

You should work this out in two different ways, and compare/contrast the results. One way is to use this week's notes, and do it using your understanding of Gaussian statistics and uncertainty addition.

The other way is to write a computer program to simulate this. You should be able to modify the program you used for Assignment 2.

In both cases, you need to think carefully about what it means for a given transit to be detectable. Describe and justify your choice in the write-up. The write-up should show the relationship between detectable transit depth and transit length, and describe whether the analytic and computer approaches give similar results.