Stars and Galaxies

Observational Techniques Homework Set 2

1) Assume that the signal level in a CCD exposure is high enough such that the dark current and readout noise are negligable, so that the signal and background are the only sources of noise. The following table shows the output from a 5×5 pixel segment of the CCD, which has a gain of 1.

1030	970	986	994	992
983	952	1021	992	1030
941	1048	1100	992	986
961	994	1051	1005	1037
1061	1028	1020	922	973

(i) Calculate the probability that the reading from the central pixel is due to the presence of a star, and not just random occurence. [2 marks]

(ii) Imagine that the CCD had 1000 pixels with a mean of 999. How many pixels would you expect to have a value greater than 1100? [1 marks]

2) *(i)* Write down the equation relating the signal-to-noise (S / N) to the number of photons per second from the object and sky, exposure time, read-noise, dark current. [1 mark]

(ii) Describe what is meant if an observation is: **(a)** sky noise limited, **(b)** read-noise limited, **(c)** dark-noise limited. [1 mark]

(iii) You observe a 15^{th} magnitude star for 600 seconds with a 1-meter telescope on a night when the moon is 1/4 full, and hence there is some scattered light. The count rate from the star is 10 photons / second on a CCD with a gain of 1 photo-electron per ADU. Calculate the S / N in the sky-noise limited case if the sky background has a count rate of 20 photons / second [1 mark]

3) Becuase the stars and galaxies course is so exciting, you decide to persue a career in astronomical research. As your research project, you want to search for extra-solar planets around a nearby stars like the Sun. You hope that one day, you will take a spectrum of one of these planets to search for life, which will win you the Nobel prize.

You decide to use the FORS2 camera on the ESO Very Large Telescope and continually monitor the magnitude of the star over a period of 8 hours. Your goal is to search for and detect the small change in the apparent brightness as a planet transits in front of the star.

However, you have a catalog of 100,000 G-type stars with a range of observed magnitudes to choose from, and need to narrow the catalog down. Assuming you want 1% accurary in the photometry, what is the limiting magnitude of the star that you can choose? [4 marks]

[Hint: You will need to use the FORS2 expousre time calculator to answer this question: `https://www.eso.org/observing/etc/` and select "FORS2"). You will also need to decide on your observing conditions, and how often you need an new exposure for these observations].