Assignment 2.

Due date: Noon Thursday 26th April. Submit to me by e-mail or on paper in my mailbox.

Question 1: What is the diffraction limit (in arcsec) of the Parkes radio telescope (64m dish) at a wavelength of 21cm?

Question 2: Imagine that you work at a radar installation. Every day, you pick up an average of 9.3 meteorites hitting the atmosphere far above your heads. But today, you haven't detected any. Never, in the year that you've been working here, have you failed to detect any meteorites. Should you start panicking, or could this just be a statistical fluke? Explain your reasoning.

Question 3: (the big one). NASA plans to launch a space telescope with a 1m diameter primary mirror. Its mission is to search for planets around other stars by looking for the dimming in their light when a planet passes in front of it. It will monitor 100,000 stars for five years, looking for the slight dimming caused by these planetary transits.

Imagine that you are trying to find planets the size of the Earth, in orbit around stars like the Sun. In particular, planets in edge-on, 5 day period orbits. You will observe in the V-band, using a CCD with 80% quantum efficiency (i.e. it detects 80% of the photons that fall on it at V-band wavelengths).

How faint can a target star be? It must be bright enough that you can clearly detect real transits, and not detect too many spurious transits.

To solve this puzzle, I would like you to do an end-to-end Monte-Carlo simulation. For a given V-band magnitude, you can calculate the number of photons which will hit the primary mirror. Assume that the detector is at a Cassegrain focus, and that you lose 10% of the light at each mirror reflection. You lose an additional 20% of the v-band light in the filter. Assume that the only photons you detect come from the star – i.e. ignore background light. The example program on the stats web page may be helpful.

The detector is a CCD camera. Basically it accumulates photons in the chip, until you read the chip out. The chip will be read out at regular time intervals: you can choose what this time interval is. Whenever you read it out, it tells you how many photons from the star were detected. But it adds Gaussian noise to this value, with a standard deviation of 5.3 counts.

Write a program to simulate the stream of data obtained. Put in one or more fake transits. Invent a statistic which you can apply to the data to detect transits. Then change the brightness of the star, and see how faint you can go and still get a good detection of your fake transits, without being swamped by spurious ones.

Submit your computer program, and a brief write-up giving your answer, and explaining and justifying the statistic you used, and how you assessed whether the results from a given simulation were acceptable.