Errors and error propagation

1. **If you observe a source that emits, on average, 10 photons per second, and take a 10 second exposure, how many counts will you observe on average, and what will be expected standard deviation if you make a series of measurements? What is the signal-to-noise of each observation?**

2. **If you combine multiple observations, you need to propogate the errors on each individual observation to get an error estimate on your combined quantity. If you average together 10 of the 10s exposures, what is the expected error on this average?**

3. **If you take a single observation and count 1000 photons, what is the expected error? What is the expected error (in magnitudes) if you convert the counts into a magnitude?**

4. **If you observe a source in the B passband and get 500 photons, and observe it in the V passband and get 1000 photons, what is the expected error in the flux ratio, F(B)/F(V)? What is the expected error in the color difference (in magnitudes), mB - mV?**

5. **In many situations, however, one receives photons not only from the astronomical source, but also "background" photons emitted by the night sky. To measure the source brightness, one needs to subtract the background, e.g. by measuring it separately from the source. This is not generally difficult. However, when initially counting photons from source and background combined, both of these contribute to the noise in the measurement.**

   (a) **If one observes an object that produces 1000 photons in a ten minute exposure, and in that same time, the sky produces 500 photons, how many total photons will be measured? What is the expected error on this total from Poisson statistics?**

   (b) **If you assume that you can subtract the sky perfectly (usually you can come close), then the only effect that the extra background has is in the increased noise. For the 1000 source photons + 500 background photons, what will be your expected signal to noise?**

   (c) **When the noise from the object is the dominant noise source, this is called signal-limited. When the noise from the background is the dominant noise source, this is called background-limited. Derive how signal-to-noise depends on exposure time for both the signal-limited and background-limited cases.**