Appendix B

Signal to Noise Ratio

When observing a celestial source with an apparent magnitude M_s and a background sky flux B in e^-/s/pix, we can calculate the Signal to Noise Ratio (S/N) for a given exposure as

$$S/N = \frac{I_o A\eta T t * 10^{-(M_s - M_o)/2.5}}{\sqrt{\pi r_{source}^2 (Bt + Dt + R_n/\sqrt{N}) + I_o A\eta T t * 10^{-(M_s - M_o)/2.5}}}, \tag{B.1}$$

where

- M_o is a magnitude of zero that corresponds to a flux of $I_o = 10^6$ photons/s/cm^2/band
- A is the area of the telescope in cm^2
- D is the dark current in e^-/s/pix
- R_n is the CDS read noise of a given pixel. Note that this can be decreased by the factor $1/\sqrt{N}$ by sampling the pixel N times during the integration. The floor of $R_n/\sqrt{N}$ will likely be limited by $1/f$ noise and not zero.
- r_{source} is the approximate radius subtended by the source on the detector
- T is the transmitted fraction of light through the atmosphere and optical system
- η is the quantum efficiency of the detector

To obtain a signal to noise of S, then, we should expose for a time t given by

$$t = \frac{(S/N)^2 (I_o A\eta T * 10^{-(M_s - M_o)/2.5} + \pi r_{source}^2 (B + D))}{I_o^2 A^2 \eta^2 T^2 * 10^{-2(M_s - M_o)/2.5}}, \tag{B.2}$$

where we have neglected the contribution of R_n since it becomes negligible in comparison to B and D in the limit of large t.