# Astronomy 350, Autumn 2002, Problem Set 6

Due Thursday, November 14 in class

## Problem 1

In the table below are the results of 10 observations of a star taken with a 2-aperture photoelectric photometer through a standard V-band filter. Each observation consisted of a 10-second integration with the star in one aperture and the sky on the other (i.e., the star and sky were measured simultaneously). Both apertures were 2-arcseconds in diameter. The units in the table below are counts/$10^{sec}$.

| Observation # | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Star Aperture | 111 | 108 | 106 | 113 | 111 | 105 | 112 | 111 | 113 | 104 |
| Sky Aperture | 21 | 20 | 22 | 19 | 23 | 21 | 20 | 21 | 22 | 20 |

a) Compute the mean counts and their uncertainties in each of the Star and Sky apertures, averaging over the 10 observations, and express your answer in units of **counts/sec** with the appropriate number of significant figures.

b) What is the sky-subtracted signal from the star alone, $S_*$, in units of *counts/sec* and its uncertainty?

c) A standard star with V=5.02±0.02 mag was observed with the same equipment before and after the observations of the target star. The observations were made at the same airmass, so effects of atmospheric absorption can be neglected. The mean sky-subtracted signal from the standard star was found to be $S_{std}$=4230±15 counts/sec.

   i. Using the stated V magnitude and the observed counts from the standard star, compute the zero-point magnitude, $V_0$, and its uncertainty for this instrument.

   ii. Using your estimated $V_0$, estimate the V magnitude of the target star and its uncertainty.

   iii. Given that the sky aperture was 2-arcsecond in diameter, estimate the V surface brightness of the night sky during these observations in magnitude/arcsec$^2$ and its uncertainty.

## Problem 2

The data table below lists observations of 4 infrared standard stars in the K band.

| Star | K | $\sigma_K$ | Counts/s | $\sigma_{counts}$ |
|---|---|---|---|---|
| 1 | 7.280 | 0.010 | 40346 | 228 |
| 2 | 7.535 | 0.015 | 31006 | 470 |
| 3 | 7.135 | 0.012 | 42578 | 237 |
| 4 | 7.315 | 0.010 | 38351 | 188 |

The second and third columns list the catalog K magnitudes of each of these stars and their uncertainties, while the 4th and 5th columns list the observed counts/second from the stars and their estimated uncertainties.

a) For each star, compute an "instrumental magnitude", $K_{inst}$, defined as follows:

$$K_{inst} = 26 - 2.5\log_{10}(Counts/s)$$

and its uncertainty.

b) Now estimate the zero-point magnitude and its uncertainty for each star, defined so that

$$K = K_0 + K_{inst}$$

where $K_0$ is the zero point, K is the true magnitude, and $K_{inst}$ is the instrumental magnitude as defined above.

c) Using your 4 estimates of the zero-point and their measurement uncertainties, compute the mean zero point, $\bar{K}_0$ and its uncertainty.

d) You now observe a faint galaxy with total K-band signal of 36000±180 counts in a 100 second integration. Convert this to units of counts/second, and estimate the galaxy's K-band magnitude and the uncertainty? Which contributes more to the uncertainty of the answer, the error in the zero-point or the error in the photometry of the galaxy? Please be quantitative in your assessment.

## Problem 3

$AB_\nu$ magnitudes are defined in terms of the flux, $f_\nu$, as follows:

$$AB_\nu = -48.60 - 2.5\log_{10}(f_\nu)$$

where $f_\nu$ is given in cgs units of erg/cm$^2$/s/Hz.

a) Using the table of the fluxes of a 0th magnitude A0v star in the UBVRI filters given in the notes, create a table giving the difference between the UBVRI magnitude and the AB magnitudes in those bands for an A0v star. Show your results as a table.

b) A common unit of energy flux per unit frequency interval in astronomy is the Jansky (Jy) which is defined as:

$$1\ \text{Jy} = 10^{-26}\ W\ m^{-2}\ Hz^{-1}$$

Rewrite the formula for $AB_\nu$ magnitudes above so that it now uses $f_{Jy}$ instead of $f_\nu$.

c) What is the flux in the center of the V band for a 15th magnitude star, expressed in units of mJy?

d) The surface brightness of a very dark night sky in B is about 22.5 mag/arcsec$^2$. What is this surface brightness in μJy/arcsec$^2$?