PHY466

RJP- 4.5

DETERMINING APPARENT MAGNITUDES

1. Introduction

The apparent magnitude of any object is defined to be:

$$\mathbf{m = C - 2.5 \log (b),}$$

where C is a calibration constant that characterizes the instrumental system used for measuring the brightness b. The brightness b may be expressed in various units, even a relative number on some arbitrary scale, such as the one to be used in this exercise. The calibration constant C is found by measuring values of b for many different stars that have magnitudes already defined in some system. Since m and b are then known for each star, we can solve the above equation for C in each case. One then computes an average value for C from all of the determinations. This is what you are going to do in this exercise. In reality, this is a simplistic approach. One must also account for the color index of the star. In this case $C = k_1 + k_2(B\text{-}V)$. The constants k_1 and k_2 must be found by a least squares solution of data for many stars that have a variety of values of B-V. In addition was must account for extinction effects in the Earth's atmosphere for each observation. We shall forgo these complications for this project.

The most widely accepted standard system of magnitudes is the **U, B, V, R,** and **I** color magnitude system that was established by H. L. Johnson in the middle of the 20th century. These are magnitudes measured with filters that isolate ultraviolet (**U**), blue (**B**), yellow-green (**V**), red (**R**), and infrared (**I**) portions of the spectrum. There are two different ways to express such color magnitudes, either as $m_v = 3.23$, or V = 3.23.

On the pages of a separate document are photocopies of strip-chart recordings of relative brightness for several stars and the background readings for the sky near each star. These measurements were made using a photometric system consisting of an 8" diameter refracting telescope, a photoelectric photometer containing a 1P21 photomultiplier tube, and color filters that closely match those used by H. L. Johnson. The strip-chart recorder consists of a small motor that moves a long roll of graph paper from one reel to another at a precise rate so that time may be indicated on the chart. The recorder also has a pen that constantly monitors the output of the photometric system. After a star is centered in the field of view of the telescope, a small window is opened to allow the star's light to enter the electronic photomultiplier tube. The tube responds to the light by generating an electric current proportional to the brightness of the light. This electric current is amplified and then causes the recording pen to deflect in proportion to the brightness of the star.

2. Assignment

Examine the charts given to you. These are to be downloaded as the file "MagChrts". Notice that each page has brightness deflections for one star. The name of the star is written near one or more of the deflections. Each of the deflections is labeled with the filter used to isolate a bandpass, and an amplifier setting. On the same page with the star readings are deflections for the brightness of the sky located near the star. The pen deflections are noisy due to several causes, but mainly atmospheric turbulence. One must imagine that the chatter or noise in the deflection is centered on some average value. It is this average value that you must determine. Each reading must be done to one decimal place precision. For example, look at the yellow or V deflection for ζ Hyd on the first chart. An estimate for the average value of this deflection may be 41.7. This is a bogus number; you must determine the actual value.

Now follow the following steps:

1. For a given star, estimate an average value for each deflection and also for the sky for each filter. Enter these values in Table 2 on the first two lines in the appropriate boxes for the filters (bandpasses).

2. Subtract the sky reading from the star reading for each filter and enter the net reading on the 3rd line in the appropriate boxes.

3. Enter the amplifier settings on the next line in the appropriate places. Be sure to account for the power of ten.

4. Multiply the net readings by the amplifier settings and record on the next line in the appropriate boxes for each filter. These are the values of b.

5. Use your calculator to find the log (base 10) of each of the above values and enter on the next line.

6. Repeat the above for each of the stars for which you have data.

7. For the standard stars, use the value of V, B, or U from Table 1 as m and your value of log b for that star to calculate the value of C from **C = m + 2.5 log (b).** Enter these values of C in the appropriate boxes in Table 3. You can not do this for the star V834 Ori or θ Hyd, because these are not standard stars and their color magnitudes are unknown at this point.

The values of C that you will get for the 3 different standard stars will be slightly different due to errors of measurement and many other factors, such as variation in the extinction coefficient of the Earth's atmosphere, which has been ignored. These errors can be reduced by taking a mean value for each filter.

8. For each column in Table 3, find the average or mean value of C and enter on the last line of the Table.

9. Now take the mean value of C in Table 3 for each filter and the corresponding values of log b for the star V834 Ori and use the magnitude equation to compute values of V, B, and U for this star. Enter these values on the last line of Table 4 labeled “magnitudes.”

10. Repeat step 9 for the star θ Hyd.

11. Submit Tables 2, 3, and 4 with a cover page stapled together.

Table 1

Color Magnitudes for Standard Stars

Star	V	B	U
ζ Hyd	3.10	4.11	4.91
ρ Hyd	4.37	4.32	4.27
ε Tau	3.53	4.54	5.41

DETERMINING STELLAR MAGNITUDES

Table 2

Data from Charts for Standard Stars of Known Magnitudes

ζ Hyd				ρ Hyd			
Filters	V	B	U	Filters	V	B	U
Star Reading				Star Reading			
Sky Reading				Sky Reading			
Net Reading				Net Reading			
Amp. Setting				Amp. Setting			
b= NR x Amp. Set				b= NR x Amp. Set			
log b				log b			
ε Tau							
Filters	V	B	U				
Star Reading							
Sky Reading							
Net Read							
Amp. Setting							
b= NR x Amp. Set							
log b							

Table 3

Calculated Values of Calibration Constants

Star	C_v	C_b	C_u
ζ Hyd			
ρ Hyd			
ε Tau			
Mean Value			

Table 4

Data for Stars of Unknown Magnitudes

V834 Ori			
Filters	V	B	U
Star Reading			
Sky Reading			
Net Reading			
Amp. Setting			
b = NR x Amp. Set			
log b			
magnitude			

θ Hyd			
Filters	V	B	U
Star Reading			
Sky Reading			
Net Read			
Amp. Setting			
b = NR x Amp. Set			
log b			
magnitude			