ASTR469: Homework #2 Solutions.

1. A few questions regarding airmass...
   (a) (2 pt) What airmass does your sight line traverse for observations at an angle 30° above your horizon?
   \[ x = \sec(z) = \frac{1}{\cos(z)} \]
   \[ x = \frac{1}{\cos(60°)} = 2.0 \]

   (b) (3 pt) Now imagine that you have two stars, one observed at 30° elevation, and one observed 10° more toward the zenith. What is the difference in extinction (in magnitudes) due to our atmosphere for these two stars, assuming an extinction coefficient of \( k = 0.14 \) magnitudes per air mass?
   \[ m_1 = 60° \]
   \[ m_2 = 59.833° \]
   \[ \text{Observed extinction:} \quad X_1 = 2.0 \text{ (as above)} \]
   \[ kX_1 = 0.28 \]
   \[ kX_2 = 0.2736 \]
   \[ \text{Diff: } 0.004 \text{ mags} \]

2. (4 pt) At beach the barometric pressure is \( b = 780 \text{ mmHg} \) and it is 22°C outside. About how many minutes later in the day does the Sunset seem to occur due to atmospheric refraction as you watch it set behind a mountain at an altitude angle of 30°?

   \[ \Theta_R \approx 60.4 \left( \frac{b}{760} \right) \tan(z) \] \[ \text{works to} \quad z \approx 7.5° \]
   \[ b = 780 \text{ mmHg} \]
   \[ T = 22°C = 295.15K \]
   \[ z = 60° \]
   \[ \Theta_R \approx 99.3 \text{ arcsec} \]
   \[ \Theta_R = 1.66 \text{ arcmin} \] \[ \text{So refracted 1.66 arcmin but arcmin \_ minutes!} \]
   \[ \text{Sun does 360°/24h} \]
   \[ w = \frac{360° \text{deg}}{24 \text{hr}} \times \frac{60\text{min}}{1\text{deg}} \]
   \[ w = 15 \text{ arcmin per minute} \]
   \[ 1.66 \text{ arcmin takes} \]
   \[ \frac{1.66}{15} \min = 0.11 \min \approx 6.6 \text{sec} \]

3. Positions...
   (a) (2 pt) From Morgantown, what declinations are visible?
   \[ \text{Morgantown} \]
   \[ \text{lat} = 34.63° \text{N} \]
   \[ \text{lon} = 79.96° \text{W} \]
   \[ 90° - \text{lat} = 50.4° \] \[ \text{always visible} \]
   \[ \text{Decs } \delta > -50.4 \text{ never visible.} \]
   \[ \text{Decs } \delta > -50.4 \text{ always visible at some point} \]
   \[ \text{dropped - will discuss in class.} \]

   (b) (3 pt) From Morgantown, for how many hours in any given 24-hour period is a source of \( \delta = -10° \) visible?

   (c) (1 pt each) Using HEASARC:
   \[ \text{i. What is the RA and Dec of the Galactic center in J2000 coordinates?} \]
   \[ \text{J2000 RA } 17:45:37.2 \]
   \[ \text{Dec } -28:56:10.2 \] \[ (\text{degrees: } 266.4°, -28.9°) \]
   \[ \text{ii. What is the Galactic latitude and longitude (l, b) of the J2000 north pole?} \]
   \[ gl = 122.9° \]
   \[ gb = 29.1° \]
   \[ \text{iii. Mark the J2000 north pole position on this map of the sky:} \]
   \[ gl \text{ is galactic longitude} \]
   \[ gb \text{ is galactic latitude} \]
4. Let's make (and use) a color-magnitude diagram of the Pleides star cluster!

(a) (4 pt) Make a CMD plot, label axes, use apparent V-band magnitude and the B-V color (hotter stars on left, brighter stars on top). See attached.

(b) (1 pt) Determine the V-band magnitude and the $B-V$ color of the cluster turnoff point. Around $m_V = 6$ or 7, $B-V = 0$

(c) (2 pt) Pleides is 120 pc away. Derive the absolute V-band magnitude of the turnoff.

\[
m - M = 5 \log (d_{pc}) - 5 \quad \text{m} = 6 \quad \text{d} = 120 \text{pc}
\]

\[
M = -5 \log (120) + 5 + 6
\]

\[
M = +0.60
\]

(d) (3 pt) The lifetime of stars $t$ is proportional to stellar luminosity as approximately $t \propto L^{2.5}$. Given the magnitude of the turnoff, $M_V = 4.8$ for the Sun, and the Solar lifetime of $10^{10}$ years, how old is the Pleides star cluster?

\[
\left( \frac{t_{\text{Pleides}}}{t_{\text{Sun}}} \right) = \left( \frac{L_{\text{Pleides}}}{L_{\text{Sun}}} \right)^{2.5}
\]

\[
t_{\text{Sun}} \text{ given}, \quad \text{Luminosity ratio relates directly to absolute magnitudes}
\]

\[
t_{\text{Pleides}} \text{ unknown}
\]
Object Position Finder, Coordinate Converter, and Separation Calculator

Object Name or Coordinates: 0.0 0.0
(e.g., Cyg X-1 or 101.295, -16.699 or 6 45 10.8, -16 41 58)

Input Coordinate System: Galactic

Name Resolvers: GRB, then SIMBAD else VizieR (Sesame), then NED

Special Equinox: 

Find Target/Convert Coordinates  Reset

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<th>B1950</th>
<th>Galactic</th>
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Object Position Finder, Coordinate Converter, and Separation Calculator

Object Name or Coordinates: 0.0 90.0
(e.g., Cyg X-1 or 101.295, -16.699 or 6 45 10.8, -16 41 58)

Input Coordinate System: J2000

Name Resolvers: GRB, then SIMBAD else VizieR (Sesame), then NED
Use local caches

Special Equinox:

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V-band apparent magnitude

B-V

Main sequence

Turn-off point