Midterm 1 Practice Problems

Midterm 1 on September 30 from 10:45am-12:05 pm, in class

Exam Instructions:
Please show all work, writing solutions/explanations clearly, or no credit will be given. If you get stuck or don't know how to solve a problem, write down what you do know about the topic. Reference to an $8.5 \times 11''$ equation sheet (both sides usable) and a calculator is allowed. Use of the textbook, notes, homeworks, internet, or other online sources is **not** allowed. The exam represents your individual work; do not copy from others.

1. Consider a star with a right ascension α and declination δ of $(\alpha, \delta) = (180°, -20°)$.

   (a) Where on the Earth would this star never be visible?

   (b) From Salt Lake City ($\ell \approx +40°$N), what is the maximum altitude the star will reach?

   (c) On the vernal (spring) equinox, at approximately what time will the star cross the local meridian (i.e., reach its highest altitude)? (HINT: Use true local time, e.g., noon is when the Sun crosses your meridan; ignore time zones and daylight saving time.)

   (d) Will this star always have these celestial coordinates? Explain why or why not.

2. In 2017, the comet 'Oumuamua showed up in lots of news stories, some of which contained speculations that the object was actually an interstellar spaceship or probe, even though there was no conclusive evidence it had active propulsion (i.e., the object's motion was dictated entirely by the Sun's gravity).

   (a) Given that the comet is almost certainly of interstellar origin, and is now returning to interstellar space, what can you say about the shape of its orbit? Explain.

   (b) At the perihelion of its orbit, its distance from the Sun was 0.255 AU. What can you say about its velocity when it was that close to the Sun? Please provide a qualitative description.

   (c) Also give a quantitative [numerical] answer.

3. Imagine that you plan to observe a star known to have a smooth, blackbody-like spectrum.

   (a) If there is a hydrogen gas cloud (that has a cooler temperature than the star) between you and the star, what will the spectrum you observe look like? Draw a plot of the spectrum (wavelength on the x-axis, relative flux on the y-axis).

   (b) What specific emission and/or absorption processes are at work that modify the star's spectrum?

   (c) You see a series of lines from hydrogen in your spectrum, and you measure the lowest energy Balmer line (between the $n = 3$ and $n = 2$ states) to have a wavelength $\lambda = 655.0$ nm. What does this tell you (quantitatively), either about the star or the gas cloud?

4. Imagine that you make observations of 2 stars, determining their bolometric (total, integrated over all wavelengths) fluxes to be 10^{-16} J m−2 s^{-1} and 2×10^{-18} J m−2 s^{-1}.

   (a) If star 2 is measured to have a parallax of 5 milli-arcseconds, how far away is it from us?

   (b) What is the luminosity of star 2?

   (c) If star 1 is twice as hot and twice the size (in radius) of star 2, how far away is it?

   (d) If you want to observe star 1 with a telescope that has an effective collecting area of 2 m^2 and a CCD with quantum efficiency of 80%, how long of an exposure time do you need to reach a $S/N > 20$, assuming the background is negligible and that all photons are emitted with wavelengths of 500 nm?