ASTR21200: Homework 2 (HW2)

1. **Astro Software:** For this question, read the wiki pages on Astronomy Software[1] and other Computing Resources

   (a) What is the name of the computer server where you download fits files from Stone Edge Observatory?

   (b) What software will we use to view images in fits format?

   (c) What software can you use to manipulate fits images?

   (d) The most distant galaxy in the Universe that we've detected water in was discovered by the South Pole Telescope. The object is called SPT-S J031132-5823.4 is about 12.8 billion light-years away. What website would you use to look up information about SPT-S J031132-5823.4?

   (e) Based on the information that you found on the website, what are the Galactic coordinates (Longitude and Latitude in degrees) of SPT-S J031132-5823.4?

2. **Magnitude to Flux:** What is the observed flux ratio between the faintest galaxies in the DES survey and the Sun? (Use the apparent magnitudes listed in the lecture slides.)

3. **Silicon CCDs**: At λ=950 nm Si has an index of refraction of 3.7 and an absorption coefficient alpha=0.005 μm^{-1}.

   (a) Estimate the quantum efficiency for a CCD that was 20 μm thick Si wafer at λ=950 nm?

   (b) Estimate the quantum efficiency for a CCD that was 250 μm thick Si wafer at λ=950 nm?

   (c) Given the properties of Silicon, at what wavelength will the absorption of Silicon drop off significantly, no matter the thickness? What property of the Silicon causes this?

[1] https://github.com/bradfordbenson/ASTR21200_2025/wiki/Astronomy-Software

4. **Photometry**: Observing on Magellan ($D = 6.5$m) with the Megacam CCD imager[2], the sky background in r-band varies between a magnitude of 21 to 20 per square arcsec during a new and full moon. Assume the following, the r-band is centered at λ=600 nm with a bandwidth $\Delta\lambda$=200 nm. The r-band magnitude, M_R, can be written as $M_R = -2.5 \log(f_R/f_0)$ where $f_0 = 3000$ Jy. The pixel scale is 0.08-arcsec per pixel, and the quantum efficiency of the detectors is about 0.8 at this wavelength. Note that 1 Jy = $1{\times}10^{-26}$ W m^{-2} Hz^{-1}.

   (a) Whats the ratio of photo-electrons per pixel that you expect to see for the new vs full moon?

   (b) Integrate for 180-sec. What is the average number of photo-electrons that you see per pixel during the new moon? You can either calculate this yourself (i.e., from first principles, given the above information), or use whatever information that you can find on the Magellan website (but cite your sources).

5. **Angular resolution**: Sagittarius A* (or SgrA*) is the black hole at the center of the Milky Way galaxy. SgrA* is about 26,000 light-years away, with a black hole mass of about 4.3×10^6 M_{Sun} (i.e., the mass of the Sun). Show your work for this calculation.

   (a) One way that we've measured the mass of SgrA* is to measure the orbits of stars moving around it, then using Kepler's laws of planetary motion, which Newton also used to measure the mass of Jupiter. The nearest star cluster that we've measured around SgrA* has an orbit of about 1000 AU. What angular resolution would you minimally need to measure the orbit of this star cluster? How does this compare to SEO's typical angular resolution?

   (b) A second way that we've measured the mass of SgrA* is to measure the diameter of the event horizon around it, using an Earth-sized virtual telescope called the Event Horizon Telescope (EHT), which primarily observes at 230 GHz. At 230 GHz, what would the best angular resolution of an Earth-sized telescope be at this observing frequency? How does this compare to the angular resolution in part-a to measure stellar orbits?

[2] https://www.lco.cl/magellan-instruments/