EXTRA CREDIT: Going Observing

Name: ____________________

ASTR/PHYS 1060, The Universe, Dan Wik; Due Dec. 5th

Pack your bags, you're going to Hawaii! In this activity you and your colleagues will plan observations from Mauna Kea on the Big Island, one of the worlds top observatory sites. It hosts three of the worlds largest optical telescopes including the two Keck telescopes (with mirrors 10 meters in diameter) and the Gemini North telescope (8 meters). This activity will combine many of the topics we've discussed in the first part of this class.

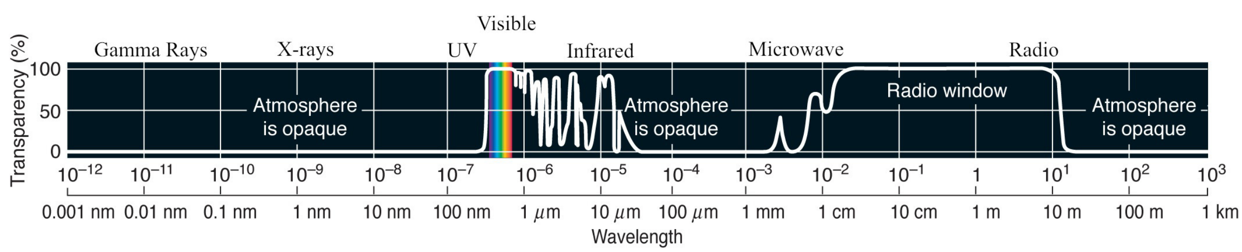
1) Target Selection: Before going to the telescope, you will need to determine what targets you can actually observe on the nights you will be on the mountain. Mauna Kea is at a latitude of 20°N. Based on the location of each object below, determine if it always, sometimes, or never observable and explain why.

A) A galaxy located very close to the north star.

B) An accreting black hole located on the celestial equator.

C) A faint star located near the south celestial pole.

2) Wavelength Selection:



Use the atmospheric transmission graph above to determine what wavelengths of light you could make your observations at. From Mauna Kea, could you observe:

A) (Y/N) A galaxy at X-ray wavelengths?

B) (Y/N) A star at visible wavelengths?

C) (Y/N) An accreting black hole at radio wavelengths?

D) Mauna Kea is almost 14,000 feet high, and its high elevation greatly reduces the amount of atmosphere above the telescopes there. Based on the graph above, at what wavelengths would this reduced atmosphere be most helpful for observing.

3) Detecting faint sources:

A) Once you get up to the telescope, you realize that you can see much fainter sources through the eye-piece of the telescope than with your naked eye. Why?

B) The amount of light you collect with a telescope is proportional to the *area* of the telescopes mirror. How much more light would you collect with the Keck telescope (10 meters in diameter) than you would with a 1 meter diameter telescope?

C) You're trying to view a distant, faint supernova. When you look through the eye-piece of your telescope, you don't see it. What could you do to detect the supernova with the same telescope?

D) You use a CCD camera to get an image of a galaxy and find that there is a faint stream of stars that wasn't visible from an old photograph of that galaxy that was taken on the same size telescope with the same exposure time. Why is this?

4) See More Detail: In addition to seeing fainter objects, telescopes can also help us separate or *resolve* two sources that are located close together. The best resolution a telescope can have depends both on the wavelength of light being observed and the diameter of the telescope. This maximum resolution is known as the diffraction limit and is given in arcseconds (1/3600th of a degree) by:
$\text{angular resolution of diffraction limit} = 2.06 \times 10^5 \frac{\text{wavelength of light}}{\text{diameter of telescope}}$

A) You want to measure the brightness of two stars separated by an angle of 0.3 arcseconds (this is about the angular size of a quarter held 1 mile away). From your backyard 10 cm telescope, you found that the closest stars you could resolve were 1 arcsecond apart. Using the formula above, should these stars be resolvable by the 10 meter Keck telescope (hint: you shouldn't need a calculator)?

B) When you get to the Keck telescope and observe the stars, you find that you still can only resolve objects separated by 1 arcsecond. What went wrong?

C) After failing to resolve the stars at the Keck telescope, you decide to apply for Hubble Space Telescope time. For the maximum resolution would it be better to propose to observe the stars visible or infrared light?