BRIEF

CCD IMAGING
Air Mass

Overview

As discussed in the lesson: The Earth's Atmosphere, you learned that the atmosphere of our planet can impact imaging and science.

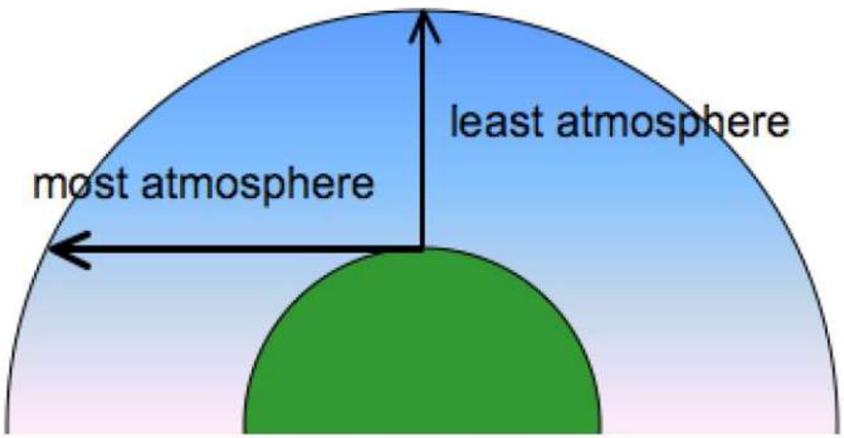
This lesson further discusses Air Mass which is another way to describe how much of the Earth's Atmosphere we are imaging an object through.

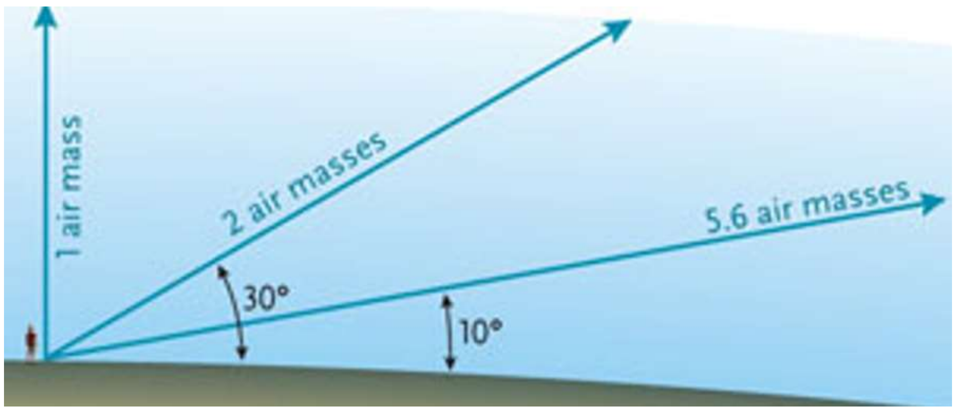
What is Air Mass

Air Mass: the path length for light from an astronomical object to pass through the Earth's Atmosphere.

The more atmosphere, the greater the Air Mass, and thus the greater light is attenuated/dimmed/reddened (through extinction) by scattering and absorption.

As a result, astronomical objects viewed near the horizon appear less bright than when at the zenith (directly overhead).



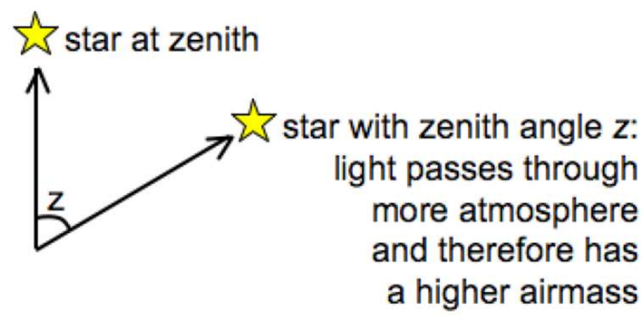


Measuring Air Mass

The angle between the zenith and where the object is located on the night sky is the amount of airmass.

It is mathematically defined as: $$\text{airmass} = \frac{1}{\cos z}$$

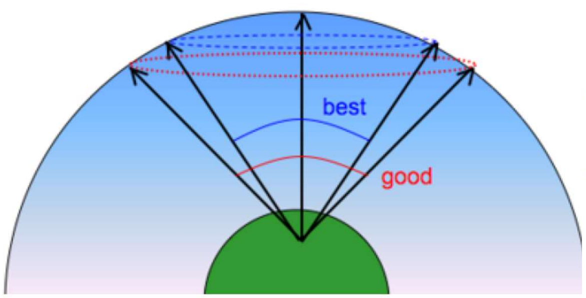
Where z is the angle between the two.

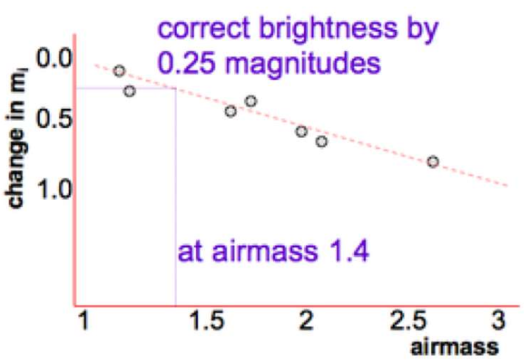


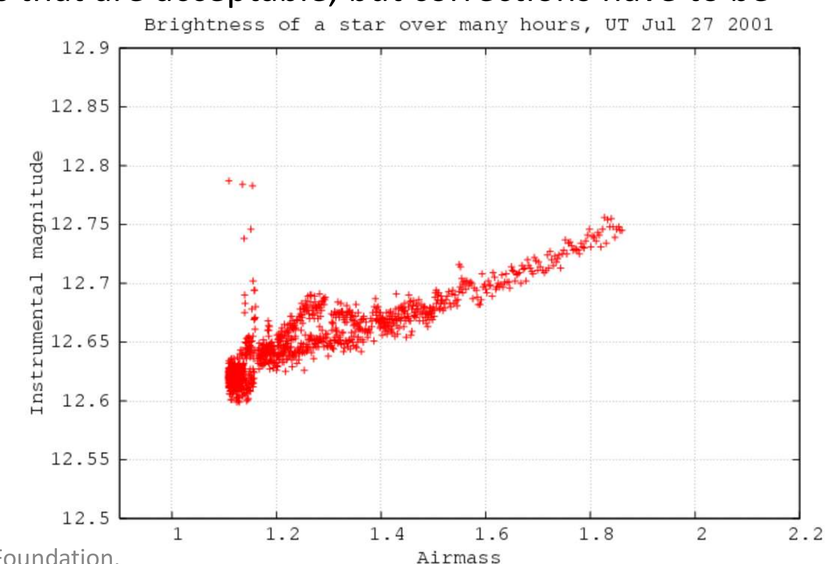
Imaging Through Air Mass

Observing at the zenith is the best way to minimize the effects of air mass. However, this is not always possible. For example: Times of an exoplanet transit, times of a variable star's phase entry/exit, or the object's position in the sky as not all objects pass through the zenith.

While an air mass of 1 is the best, there are other degrees of air mass that are acceptable, but corrections have to be made to the observed magnitude of the object.





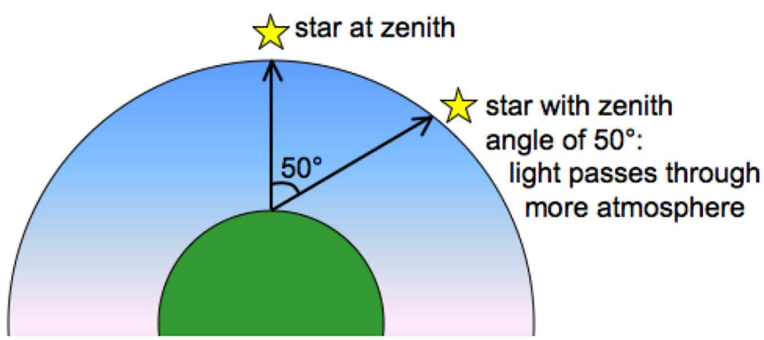


Observations at varying Air Masses

Observations made low on the horizon should also be avoided. Observations when the airmass is less than 2.5 (or altitude > ~23°) is best as the light from a star has to pass through the Earth's atmosphere to reach a CCD camera is lessened the lower the air mass.

Understanding that avoiding high air masses is not always possible, it is possible to apply corrections to your data to make up for imaging in these regions. Note, however, that the rate of extinction changes rapidly as you near the horizon. The effect also differs depending on the color of the stars you are measuring.

$$\text{airmass} = \frac{1}{\cos z}$$



Altitude (angle above horizon)	Zenith angle (angle from overhead)	Airmass
90°	0°	1.00
60°	30°	1.15
30°	60°	2.00
23°	67°	2.56
20°	70°	2.92
10°	80°	5.76

Atmospheric Extinction and Wavelength

This graph demonstrates the impact of atmospheric extinction on varying wavelengths as a product of Altitude/Airmass at an elevation of ~6,000’ MSL.

Note how the shorter wavelengths are affected the most.

Altitude	Airmass	3000 Å	3500 Å	4000 Å	4500 Å	5000 Å	5500 Å	6000 Å	6500 Å	7000 Å	8000 Å	9000 Å	10 000 Å
90	1.00	1.2	0.65	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
75	1.04	1.2	0.65	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1
60	1.15	1.3	0.75	0.5	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1
45	1.41	1.6	0.9	0.6	0.4	0.3	0.3	0.2	0.2	0.2	0.1	0.1	0.1
30	1.99	2.3	1.3	0.8	0.6	0.4	0.4	0.3	0.3	0.2	0.2	0.1	0.1
20	2.90	3.3	1.55	1.2	0.8	0.6	0.5	0.5	0.4	0.3	0.2	0.2	0.2
15	3.82	4.4	2.5	1.6	1.1	0.8	0.7	0.6	0.5	0.4	0.3	0.3	0.2
10	5.60	6.4	3.65	2.3	1.6	1.2	1.1	1.0	0.7	0.6	0.4	0.4	0.3
5	10.21	11.8	6.7	4.2	2.9	2.2	1.9	1.7	1.4	1.1	0.8	0.7	0.6

Air Mass

Summary

Effects of the Earth's atmosphere are, for the most part, a reality we have to deal with.

Thankfully, there are measures we can take to minimize the impacts. While it is best to observe at an Air Mass of 1, this is not always possible due to object position or timing of an exoplanet, or variable star event.

Questions?