Lab #13c$_2$: Distance to the Moon (Apparent Size 2)

The distance from us to the Moon changes during the day as the Moon rises high up in the sky, as indicated on Fig. 1. This results in the Moon appearing to be somewhat *smaller* when it is rising, contrary to everyday perception. The difference can be measured in a photograph and can be used to determine the distance to the Moon, provided we know how large Earth is.

Fig. 1a. The rising Moon is farther from the observer than the moon that is high up in the sky.

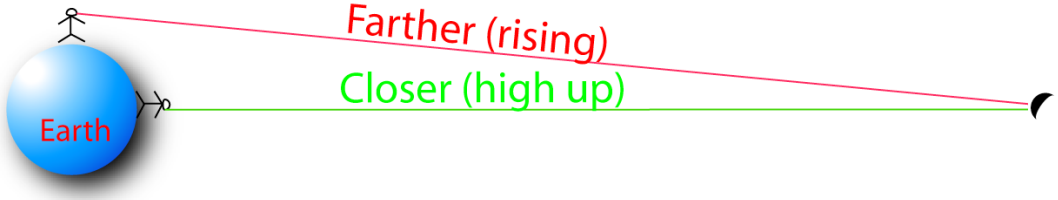
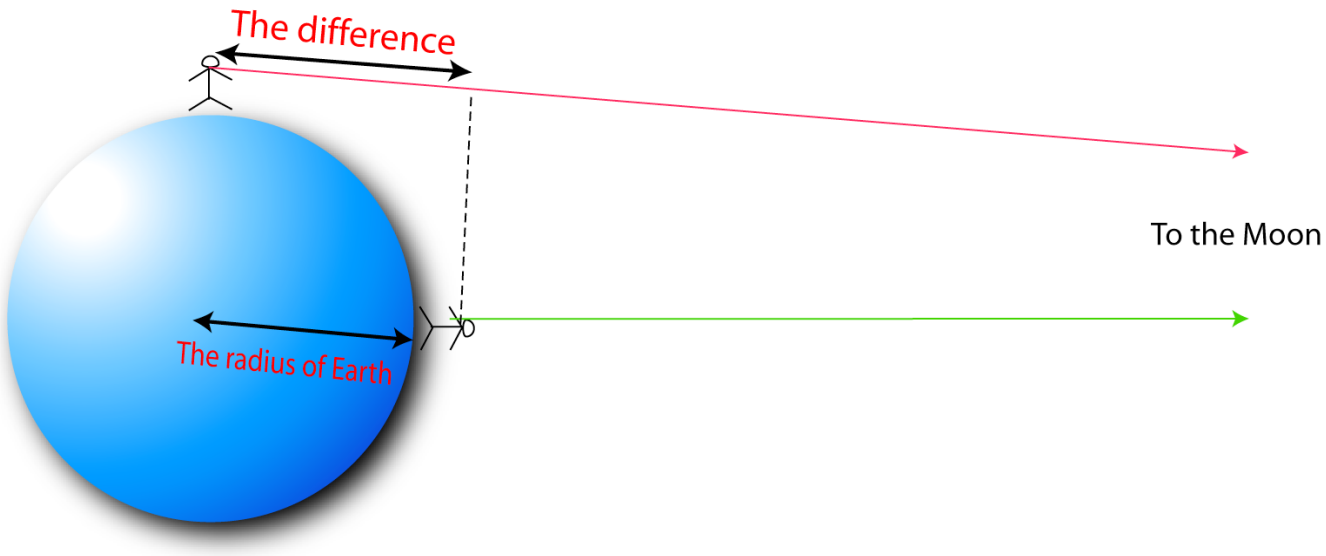


Fig. 1b. The difference in the distance is almost equal to the radius of Earth.



The two separately supplied laminated photographs of the Moon were taken October 27, 2004 by an amateur astronomer in Monterey, CA. The first one was taken of the eclipsed Moon at *7 pm*, just after moonrise, the other one was taken at *11 pm* when the Moon was high up in the sky. Comparing the size of the Moon on the two pictures, we can tell how far the Moon is.

A disturbing effect is what is called refraction. Light entering our atmosphere will be turned from its original direction. Any point on the Moon will appear to be higher up in the sky

than it really is by as much as a half a degree (Fig. 2). In addition, the bottom of the Moon is "raised" less than the top, and the shape of the Moon is distorted. The rising Moon looks as if someone hit its top and the vertical size is changed. In order to avoid the error this effect introduces into your measurement, you'll need to measure the horizontal diameter of the Moon, which is not affected by refraction.

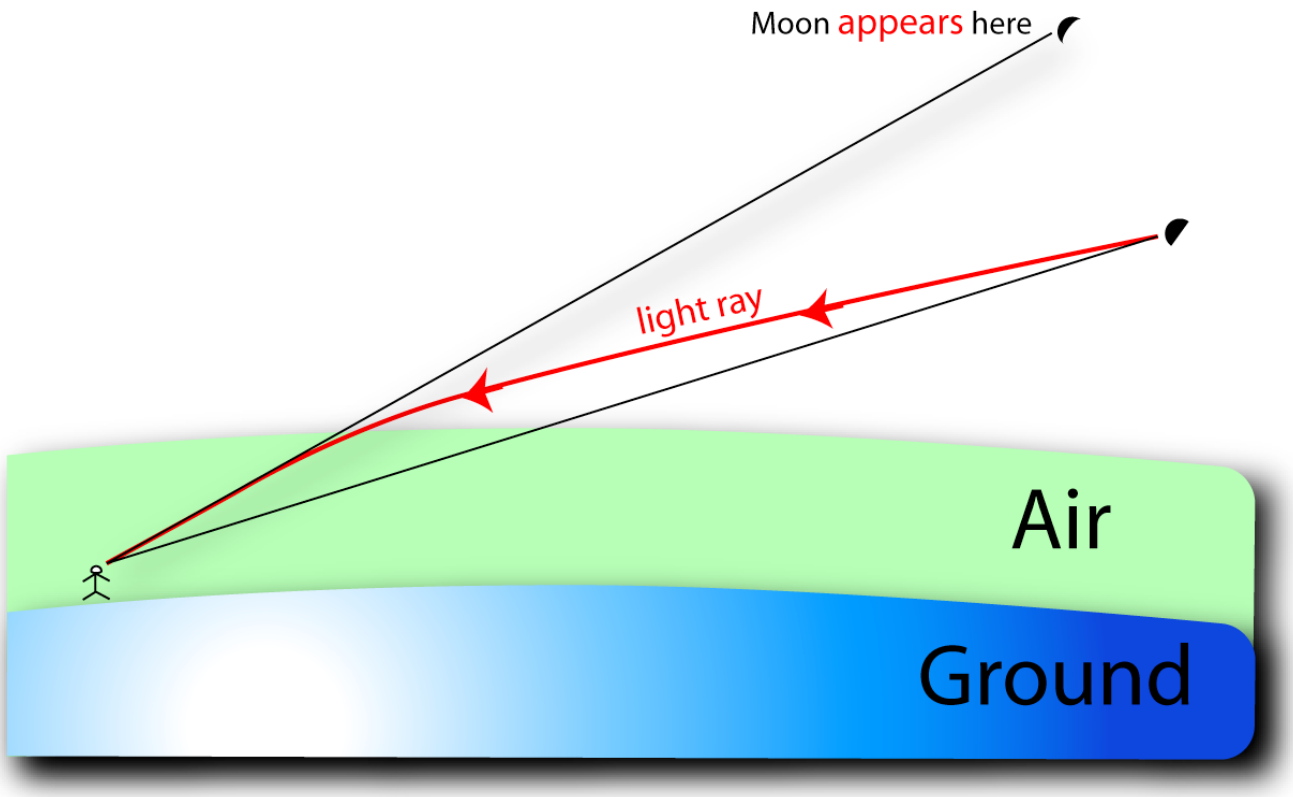


Fig. 2. Refraction: the rising Moon appears higher up from where it really is.

PROCEDURE AND LAB REPORT

Date:_____ Your name: _____Partner's name: _____ Section: ___/___

Maximum two students may work together as partners!

A. ***Read the review.***

B. ***Follow the steps of the calculation:***

(1) On the two pictures supplied, measure the size of the Moon with a ruler. You will need to do this very accurately, with the precision of a tenth of a millimeter. Your results are: the Moon is _____ *mm* in diameter on the picture when it is 67° up, and _____ *mm* in diameter on the picture when it is 6° up.

(2) Now calculate the difference. The Moon is _____ *mm* larger when it is high up. This is _____% of its diameter. The Moon is this many percent closer when it is high up.

(3) With a good approximation, the Moon is one Earth radius, 6340 *km*, closer to us when it is high up. Out of this, calculate the distance to the Moon: _____ *km*.

(4) Compare this result with the actual distance to the Moon, measured more accurately through the time delay of radio signals, to be 384,400 km. How accurate is your result, and what do you think is the main reason for the difference?

_____

(5) For a bonus point: Measure the percent change refraction causes in the apparent size of the Moon. Show your calculation on a separate sheet.