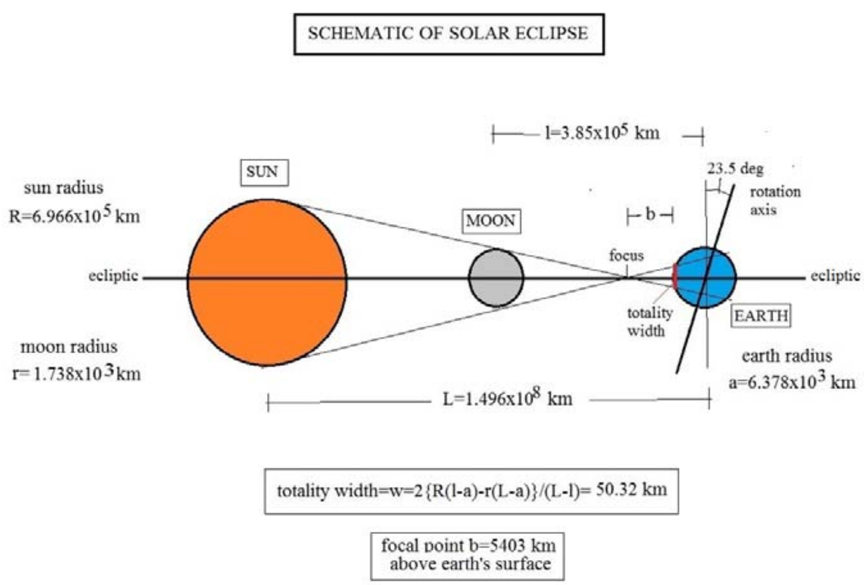
PROPERTIES OF A SOLAR ECLIPSE

Yesterday the nation was treated to a once in a lifetime solar eclipse whose totality traced a forty mile wide strip across the US from the Oregon coast-line to Charleston, South Carolina. Even here in Gainesville we were treated to a partial eclipse with about 85% of the sun's disc covered by the moon. Although millions watched the event, very few actually understood the details of the astronomy behind such an event. We want here to help clarify this situation.

First of all we start with the basic definition of a solar eclipse:

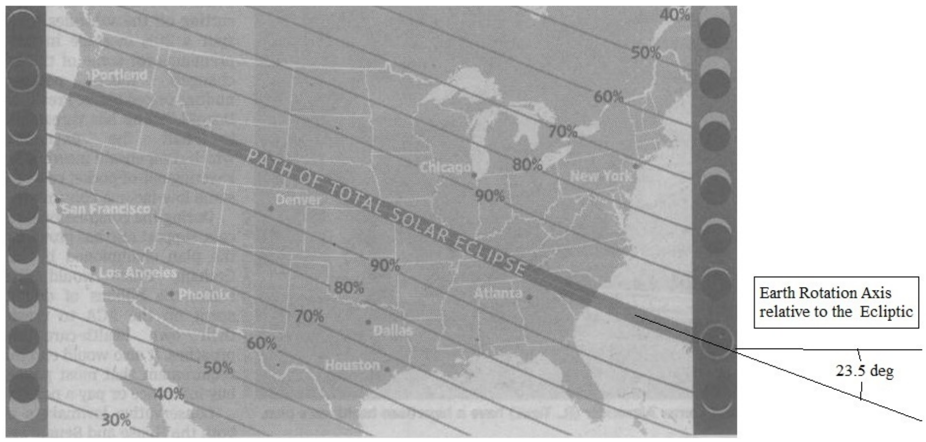
**A Solar Eclipse is an Astronomical event where the Moon aligns itself between the Sun and the Earth along a straight line lying in the Ecliptic Plane**

A schematic of the phenomenon is shown in the following sketch-




We show there an un-scaled side-view of the phenomenon. The moon is seen to block out the sun along a path along the Earth's surface inclined at 23.5 degrees to the normal to the ecliptic plane because of the Earth's rotation axis orientation. The totality strip followed in yesterday's solar eclipse extended as a diagonal across the entire country as shown-

PATH OF SOLAR ECLIPSE ACROSS THE UNITED STATES- AUGUST 21, 2017




(map from Wall Street Journal)

Coast Line , Oregon
1:16 pm
LAT=45N, LONG=124W

Charleston,South Carolina
2:47 pm
LAT=33N, LONG=80W

Here in Gainesville we were in the pen-umbra of the path with about 85% of the Sun obscured at about the time of total eclipse at Charleston. To observe the partial eclipse here I constructed a primitive camera consisting of a 2.5 ft long cardboard box of about one square foot cross-section. In one end of the closed box I put a pin-hole while at the opposite side I closed the box with a solid surface into which I cut a large centered hole covered with tracing paper. The resultant circular image of the Sun seen on the tracing paper was about ¼ inch in diameter and during the partial eclipse the disc exhibited a large scallop taken out of the solar image.

To make some specific calculations concerning totality width and other characteristics, I began with a collection of astronomical data available on the internet. Here is the data-

R=Sun radius=$6.955 \times 10^5$ km

L=Earth-Sun distance=$1.496 \times 10^8$ km

r=Moon radius=$1.738 \times 10^3$ km

l=Moon-Earth distance=$3.844 \times 10^5$ km

a=Earth radius=$6.371 \times 10^3$ km

With this information we were able to carry out several different astronomical calculations. Referring to the first figure above, a similar triangle evaluation shows that-

$$\frac{r}{l-a-b}=\frac{R}{L-a-b}$$

*and*

$$w=\frac{2rb}{l-a-b}$$

, where b is the distance above the earth to the focal point and w the totality width (the umbra). Solving these equations we have-

$$b=\frac{R(l-a)-r(L-a)}{R-r}=5403km$$

*and*

$$w=\frac{2}{(L-l)}\{R(l-a)-r(L-a)\}=50.32km$$

This totality width is very close to that which was found in yesterday's solar eclipse. Viewing the sun from the focal point above the earth's surface, shows that the sun and the moon subtend the same angle of-

$\theta$=arctan[2r/(l-a-b)]=0.5345 deg

On the Earth's surface the angle subtended by the Moon and Sun differ slightly from each other. They are-

2arctan(6.966/1496)=0.533 deg  for the  Sun

and-

2arcftan (1.738/385)=0.517 deg for the Moon.

For the Earth to rotate about its axis from the longitude of 80 deg in South Carolina to 124 deg at the Oregon coastline is-

$$\tau=\frac{(124-80)}{360}24(60)=176\,\text{min}$$

In actuality the eclipse cross the US started at 1hr 16 min EST and ended at 2hr 47 min EST. That is, it took only 91min. This discrepancy is due to the movements of the Moon and the Earth in their respective orbits during the eclipse duration. This is not taken into account by simply looking just at the Earth's rotation.

In case you missed yesterday's eclipse you can see the next one in the US in 2024. I remember seeing my last solar eclipse before yesterday's in March 1970 shortly after I started working here at the University of Florida.

U.H.Kurzweg
August 22, 2017