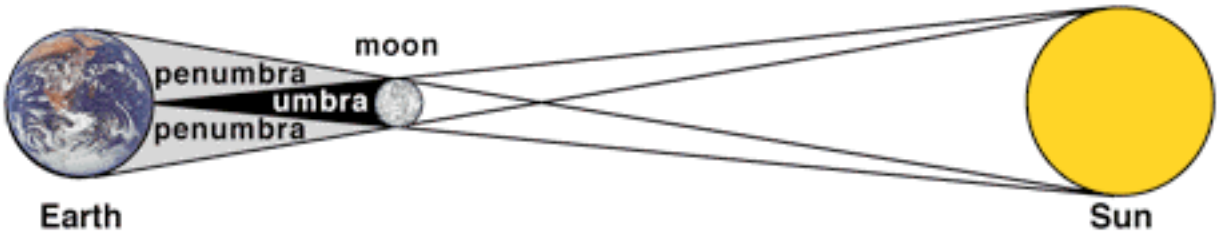
[Why Eclipses Happen]

by Ron Hipschman

This coming February 26th, we will be treated to another celestial event in the unending dance of the planets. On that day, the moon will move exactly between the earth and the sun. The moon's shadow will fall across the earth, and a few lucky people in the right places will see a total solar eclipse. Those of us not lucky enough to live in these places will travel thousands of miles to see this event. It's certainly one of the most awe-inspiring alignments that can happen. Let's take a closer look at the mechanics of solar eclipses, and see what makes the celestial clock tick.

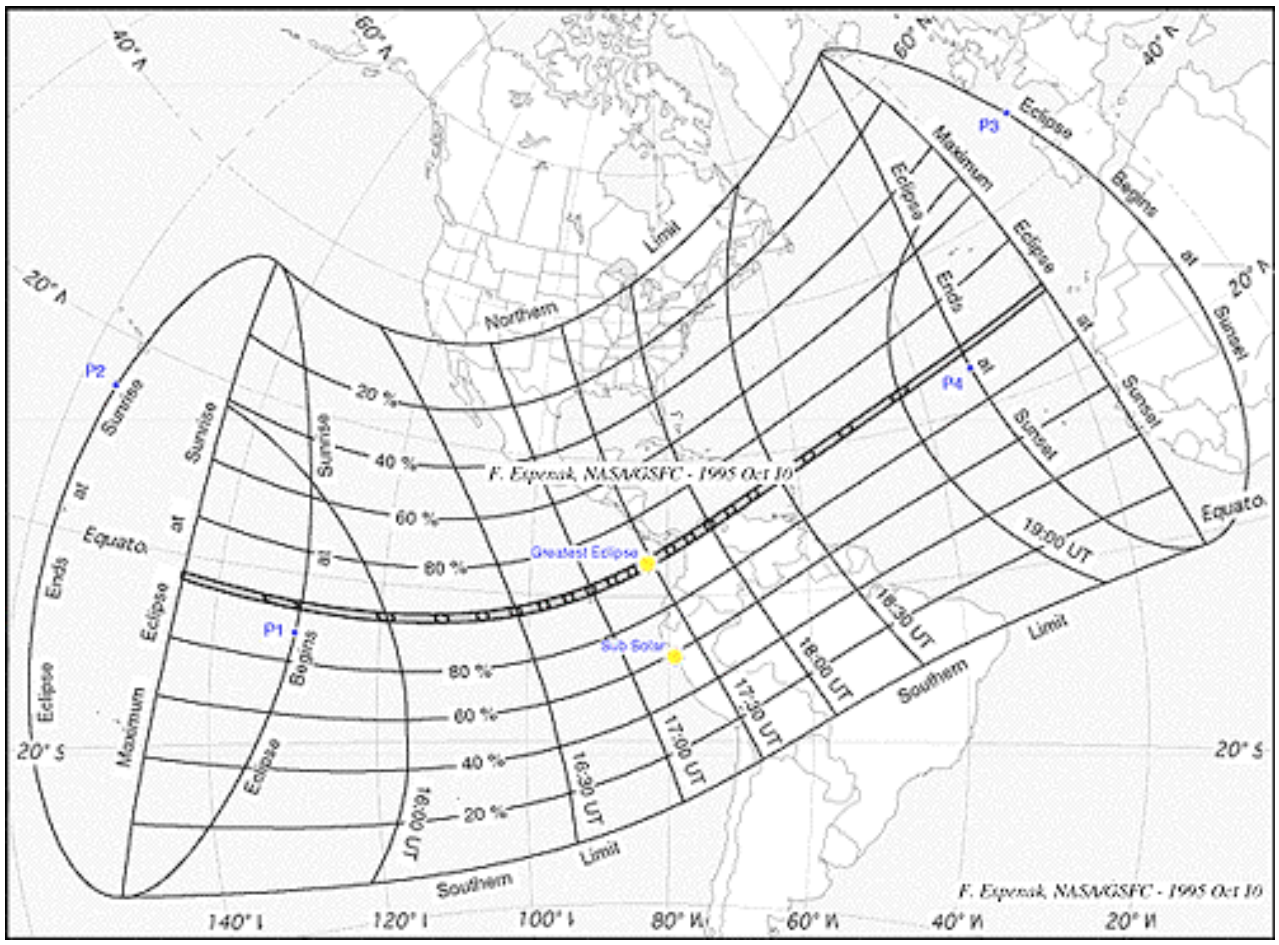
[Alignments]

To see a total solar eclipse, you have to be in just the right spot on the earth. When you look up in the sky at the sun and the moon, you notice a strange coincidence--both look the same size in the sky. Both the sun and the moon look about one-half degree in diameter. Now, they're not really the same size. The sun's diameter is actually 400 times the moon's diameter. But, you must also take into account that the sun is also 400 times further away from the earth, reducing its apparent size to the same as the moon's. Because of this relationship, when you are standing on the earth, looking up at the two, you must be in a very limited zone to see the moon cover the entire face of the sun. If you were to move a little north, the sun would peek out over the top of the moon; a little south, and the sun shines past the southern limb of the moon. The match is so good that the "path of totality" is never more than 167 miles in diameter, and is usually less. This means that very few people have seen a total eclipse because the shadow only covers a very small area on the earth.



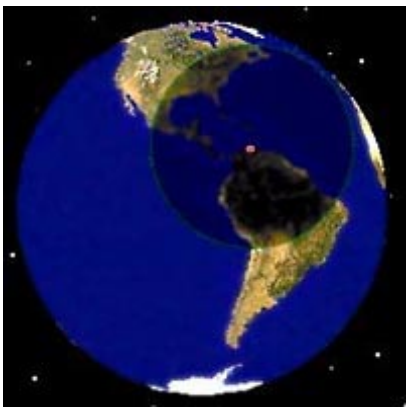
This diagram (wildly out of scale) shows a side view of the alignment. From anywhere in the grey penumbra, you will see some part of the sun shining from behind the moon. The penumbra is the area of partial eclipse. Only from within the tiny area where the dark umbra touches the earth will you see the sun completely covered and witness a total eclipse.

The earth and the moon are not fixed objects. The moon is busy orbiting the earth. The earth is busy orbiting the sun and additionally rotating on its axis. This means that the spot on the earth where the umbra falls is always in motion and actually traces out a path.



This diagram shows the path of the umbra for the eclipse on February 26th, 1998. Only the central lines mark out the path of the umbra. The much wider area shows the path of the larger penumbra, where a partial eclipse can be seen. (Note the percentages of total in the penumbral regions.)

The shadow first touches down near the equator out in the Pacific Ocean. It travels eastward and first sees land at the Galapagos Islands, where it brushes past the northen-most of those famous Darwinian outposts. Continental landfall occurs in Panama and Colombia, where the eclipse passes over the cities of Montería, Sincelejo, Magangué, Valledupar, and Maracaibo. The path nicks northern Venezuela and then heads out into the Carribean, where it will pass over the islands of Aruba, Curaçao, Montserrat, Antigua, and Guadeloupe. From there, the shadow sweeps out into the Atlantic Ocean before it takes off into space.



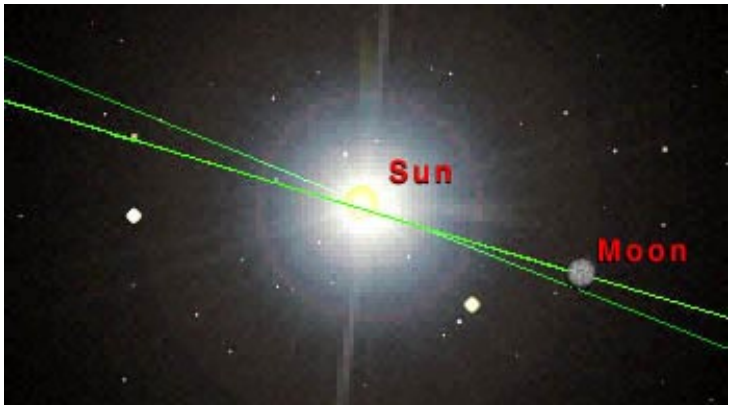
Seen from the moon, the moon's shadow will look like this when we are in total eclipse in Aruba. The large grey circle is the penumbra from which only a partial eclipse will be seen; the small circle in the center is the tiny umbra from which the total eclipse will be seen.

[Orbits]

Total eclipses seem to happen infrequently. Why doesn't the moon get between the sun and the earth every month at new moon and produce an eclipse? Because, I've over-simplified matters. The real situation is a little more complicated. We need to discuss the orbit of the earth around the sun and the orbit of the moon around the earth. The orbits of both are not circles, but rather slightly oval-shaped ellipses. Also, these orbits do not lie parallel to each other in the same plane.

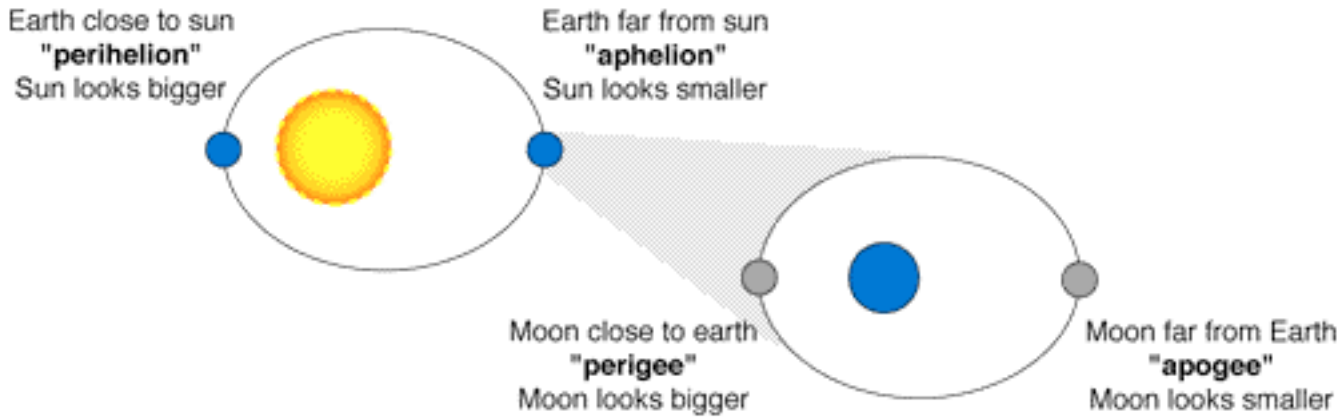
As the earth orbits the sun, taking one year to complete one circuit, it appears to us on earth that the sun moves around our sky once against the background of stars. Here's an analogy--If you walk around a campfire (the sun) looking at your friends on the other side (the stars), to you it would look like the campfire moves past your friends. Likewise, from earth, it looks like the sun moves against the background of stars, making one circuit of the sky in one year.

If the sun could draw a line as it moved against the stars, we would see a great circle called the ecliptic. If we could ask the moon to also draw a line in the sky as it orbited the earth, we'd notice that the two lines would be close to each other, but the moon's path is tilted about 5 degrees to the path of the sun. This is why the moon doesn't eclipse the sun every month. Most of the time, the moon passes over or under the sun. An eclipse can happen only when both the sun and the moon arrive near one of the crossing points (these are called nodes). There are two of these nodes on opposite sides of the sky, one where the moon crosses from south to north, and one where the moon passes from north to south. Since there are two crossing points in the sky, eclipses happen during two "eclipse seasons" separated by about six months.



The sun does not have to be exactly on the node when the moon arrives there, only close enough for the moon to block some portion of the sun. This leaves a "window" of about 18.75 days before and after the sun gets to the nodes. During this 37.5-day period, the moon can cause an eclipse. Since the moon takes 29.5 days to go from new moon to new moon, this means that an eclipse of some kind is guaranteed about every six months.

The type of eclipse that *does* occur depends on several things. First, if the eclipse happens when the sun is further from the node, it is more likely that the eclipse will be a partial. In this type of eclipse, the dark umbra passes above the North Pole or below the South Pole, never touching the earth. All we ever see is part of the sun covered.



There's another variable, though. Remember that the orbits of the earth and moon are not perfect circles, but rather ellipses. Note that in the diagram above (again wildly out of scale), the earth is sometimes closer to the sun and sometimes further. The same is true for the moon--sometimes it's closer to the earth and sometimes it's further. See the table below:

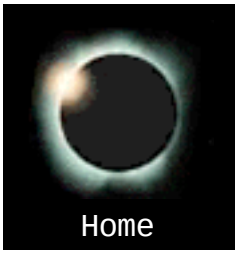
	Close Distance	**Far Distance**
Sun	147,101,455 km	152,098,155 km
Moon	356,749 km	406,282 km

As you can see, both the sun and the moon change their distances quite significantly. The moon changes by about 14 per cent, and we vary our distance to the sun by about 3 per cent. Because of this, the sun and moon look bigger sometimes and smaller at other times. If we're far from the sun so that it looks smaller, and close to the moon so it looks bigger, the moon will be able to cover over the entire face of the sun as seen from earth, and we'll see a total eclipse. If the opposite is true and we're close to the sun and far from the moon, the moon will appear too small to cover the face of the sun.

In this case, it's like trying to cover a penny with a dime. You would see a ring of copper penny sticking out on all sides of the dime. This happens with the sun amd moon. You see a ring of the sun shining around the edges of the moon. This is called an "annular" eclipse (annular comes from the Latin *annulus* or ring). In an annular eclipse, you don't get to see any of the "special effects" of a total eclipse, such as the corona, or diamond ring effect. The thin sliver peeking around the moon is far too bright to allow this.

More on this in another section "What to see..."

[All Photos unless otherwise noted, by Ron Hipschman]



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