

The phases of the Moon

If you have seen the Moon at night many times, you may have noticed that its shape is not fixed, but changes. The various shapes of the Moon are called "the phases of the Moon." In this article, we will explain why the phase of the Moon changes.

In the last article, we mentioned that the Earth orbits around the Sun. In this article, I need to additionally note that the Moon orbits around the Earth, which in turn orbits around the Sun. Actually, the Moon is much smaller than the Earth. Its diameter is about a quarter size of the diameter of the Earth. In the last article, we mentioned that the Sun is much bigger than the Earth, its diameter being 109 times the one of the Earth. However, when seen on the Earth, the apparent sizes of the Moon and the Sun are roughly the same. Why is it so? It's because the Moon is much closer to the Earth than the Sun is, about 400 times closer.

Anyhow, see Fig. 1. The Moon orbits around the Earth, and the sunlight is coming from the right. Again, the figure is not in scale. The white part in the Moon in its orbit denotes the bright part of the Moon. They are bright because the Sun is shining there. The black part in the Moon in its orbit denotes the dark part of the Moon. The Sun is not shining there. They are shadows.

When we see the Moon on the Earth, we can only see its white part, because the black part is invisible. Unlike the Sun, the Moon doesn't radiate the light on its own. The only reason we can see the Moon is because of the sunshine. The big pictures of the Moon in Fig. 1. denote the phases of the Moon that we see in the Northern hemisphere on the Earth. When the Moon is situated right on the side of the Sun, it is called "new moon" and is completely invisible. Then, the right part of the Moon waxes (i.e., getting bigger or growing). The Moon is called "waxing crescent." Then, at "first quarter," exactly the right half of the Moon is visible. It continues to wax (waxing gibbous). When the Moon is right on the opposite side of the Sun, we have a "full moon." Then, the Moon starts waning (i.e., getting smaller). The right part of the Moon starts being shadowed (waning gibbous). At the last quarter, exactly the left half of the Moon is visible, and the right half of the Moon is invisible. Then, even some of the left part starts being shadowed (waning crescent). Finally, the whole Moon is shadowed, and we have the new Moon again.

It takes about 29.5 days for the phases of the Moon to complete one cycle. In other words, it takes about 29.5 days from a new moon to the next new moon. As the phase of the Moon changes periodically (meaning it always takes the same 29.5 days every time), the change of the phase of the Moon is useful to keep track of the dates. Therefore, some countries or traditions use calendars based on the phase of the Moon. These are called "lunar calendars." In lunar calendars, a new month begins with a new moon. As it takes 29.5 days for the phases of the Moon to complete one cycle, a month is either 29 days or 30 days, depending on the months. So, on the 1st day of a month, we

have a new moon, and on the 15th day of a month, which is exactly the midway between two new moons, we have a full moon. In the Gregorian calendar, this doesn't happen. In other words, we can have a full moon on any day of a month. This is because an average year, which is 365.2425 days in the Gregorian calendar, is fixed to be exactly 12 months, which implies that a month is not 29.5 days, but about 30.4359 days ($=365.2425/12$).

Now, let's talk about the moonrise and the moonset. See Fig. 1 again. I marked the time of a day on the Earth. Let's talk about the sunrise and the sunset first. When you are facing the Sun, it is noon (12 am). When you are facing right opposite to the Sun, it is midnight (12 pm). You cannot see the Sun at midnight, because it is in the opposite direction. The Sun rises around 6 am, as this is when you see the Sun on the Eastern horizon. The Sun sets around 6 pm, as this is when you see the Sun on the Western horizon. Now, think about the full moon. You cannot see the full moon, when it is noon, because it is in the opposite direction. But, at midnight, you can definitely see it. Also, it is easy to see that you can see the full moon between around 6 pm and around 6 am. This means that the full moon rises around 6 pm and sets around 6 am. We can do a similar analysis for the first quarter moon. It rises at noon and sets at midnight. Of course, you won't be able to see the Moon at noon, because the Sun is so bright that all the other astronomical objects such as the Moon and stars are invisible. However, they are still there in the sky.

Problem 1. When does the last quarter moon rise? Choose one.

(1) around 6 am (2) around noon (3) around 6 pm (4) around midnight

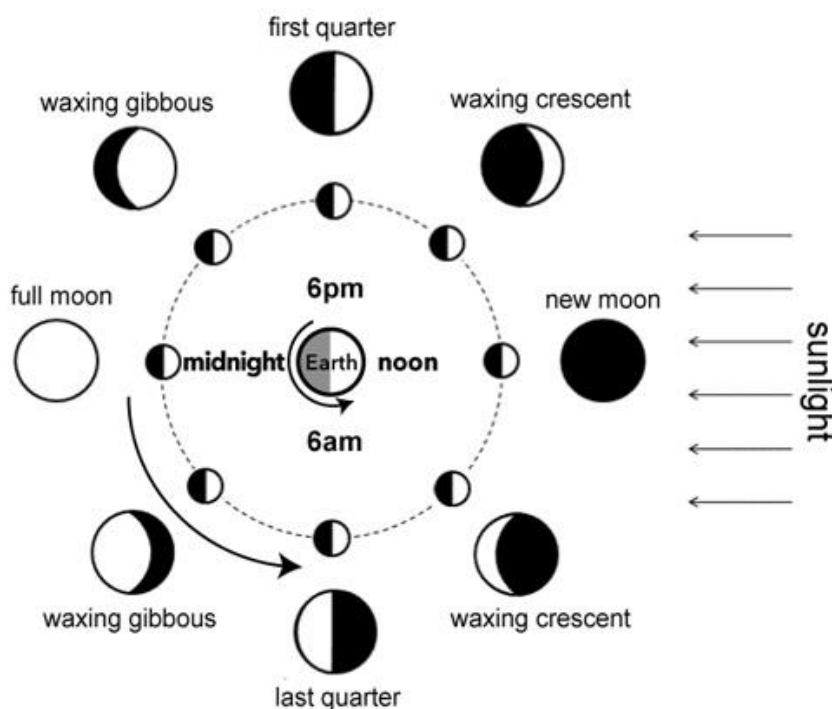


Fig. 1: The phases of the Moon

So, if a lunar month is 29.5 days, does it mean that it takes exactly 29.5 days for the Moon to orbit around the Earth once? No. It takes about 27.3 days. In Fig. 1, we implicitly assumed that the Earth is not moving, and the sunlight comes from a fixed direction. In reality, the Earth slightly changes its position, as it is orbiting around the Sun. Therefore, there is a small difference.

Summary

- The Moon changes its shape when seen on the Earth. The various shapes of the Moon are called "the phases of the Moon."
- The bright part of the Moon is where the sunlight is reflected, and the dark part of the Moon is where the sunlight is shadowed. The relative position of the Moon with respect to the sunlight changes, as the Moon orbits around the Sun. This is the reason why the phase of the Moon changes. It takes about a month for the phases of the Moon to take one cycle.

Fig. 1 is adapted from

https://commons.wikimedia.org/wiki/File:Moon_Phase_Diagram_for_Simple_English_Wikipedia.GIF