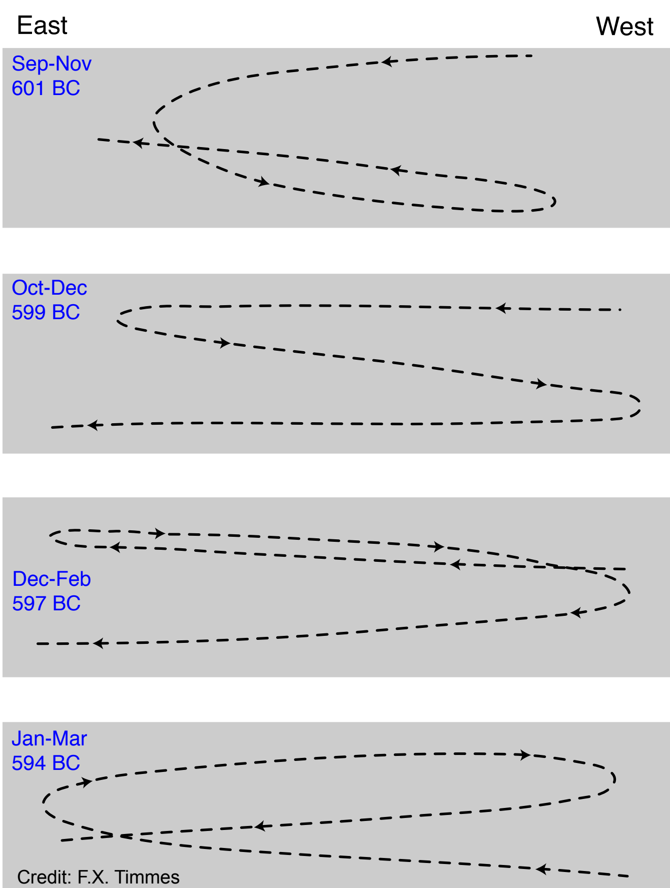
There are nights when the wolves are silent
and only the moon howls.
George Carlin

Planets Go Backwards

Hello AST 111. I feel great today. In this module we will explore the mystery of the planetary motion and why it was so difficult to explain.

Credit:Wikipedia Creative Commons

We've covered the motion, the appearance and motion of the stars, the Sun, and the moon in the sky. But the motion of the planets posed an ancient mystery that also played a critical role in the development of modern civilization. As evidence of that criticality, it's why since you were a young child, it's been drilled into your head that the Earth goes around the Sun, and not the other way around, with the Earth being the center. It was a fundamental shift to accept that the Earth was not the center of the universe.



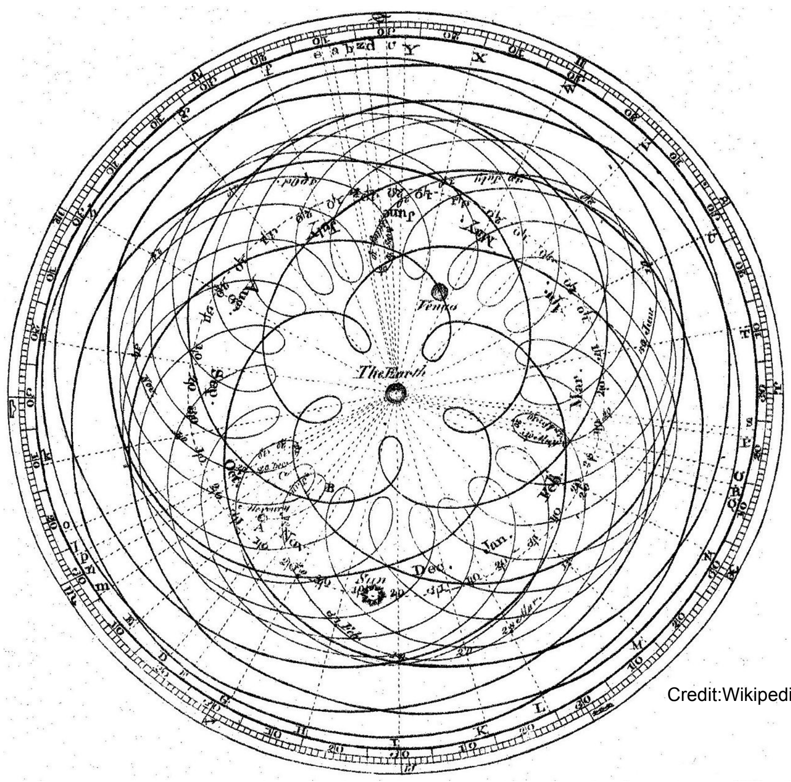
Credit: F.X. Timmes

Like all the other celestial objects on the celestial sphere, the seven known planets appear to move from east to west, no big surprise there. And just like the Sun, superimposed on that general east to west motion is a general shift of about one degree per day.So far, that's nothing mysterious. That was well understood, but on occasion, the planets' generally eastward motion slows, stops, and reverses itself.

The planets go backwards!

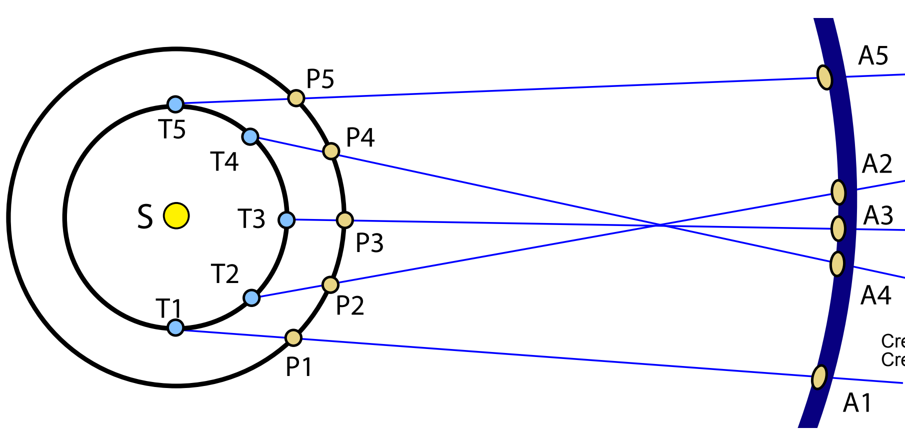
They continue to go westward against the stars before eventually reversing direction yet again, and continuing their travel East.

The image on the left shows what it would look like in Babylonian times, and this is for Mars, you can see that this motion, this going backward motion, comes in a variety of shapes. You can have loops big, loops small, sometimes it doesn't loop at all, it just zig zags back and forth. This bizarre backwards motion is called retrograde motions. Even stranger yet, not only does the planet go backwards, but when it goes backwards the planet looks brighter. Wow! It goes backwards and gets brighter at the same time. What could possibly be causing that?!



Credit:Wikipedia public domain

The Greeks came up with some very clever ways to explain this, which we are going to cover later. But ultimately, their explanations were complex and wrong. So the modern explanation of why planets undergo retrograde motion, and why they get brighter when they undergo retrograde motion, is that it's an illusion.



Credit:Wikipedia
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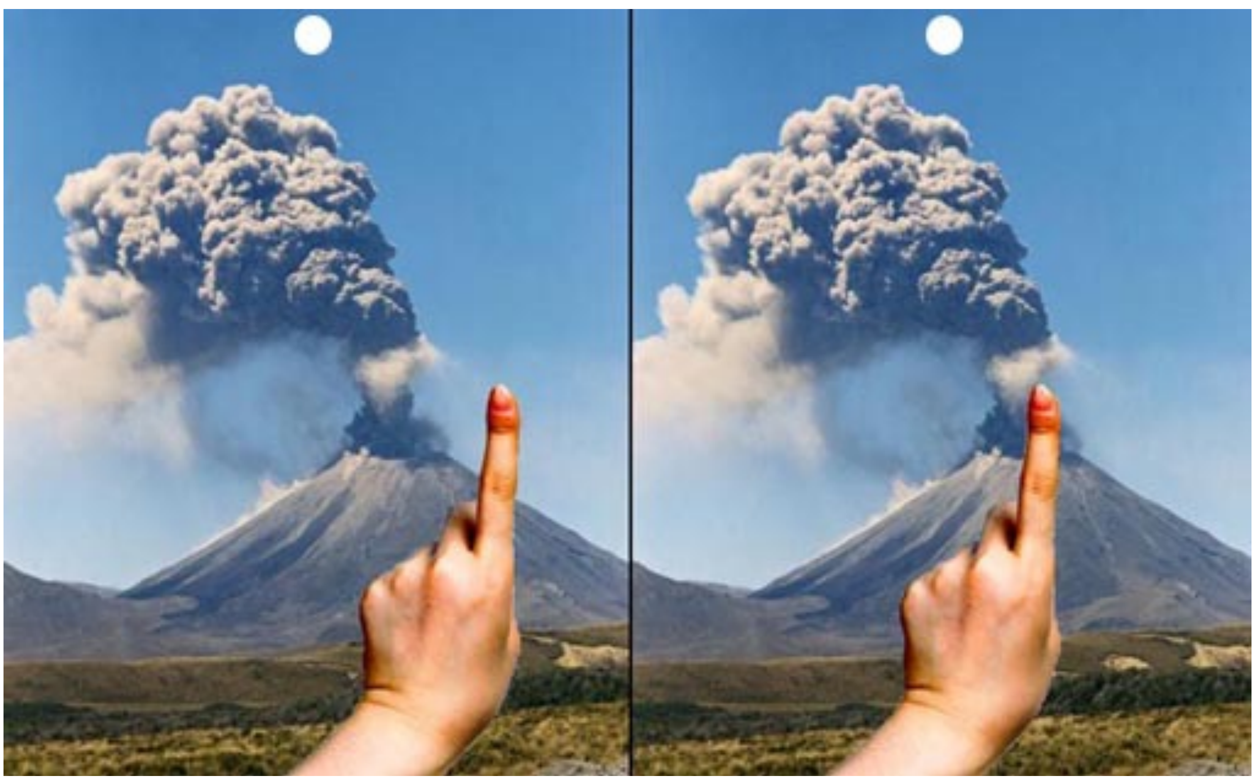
The image above shows the Sun and Earth and Mars. Both Earth and Mars orbit the Sun. So it's kind of like passing somebody on the freeway. Earth is in the fast lane of the freeway, so it's going around its circle faster. Mars is in the slow lane of the freeway, going around slower. so You know when you're in the fast lane on the freeway and you pass somebody, it looks like they're going backwards. It's not that they are actually going backwards; you're just going faster than they are. The same thing happens with Earth and Mars, for example. As Earth, going faster, speeds up, catches Mars and goes past it, it looks like Mars is going backwards. And … drum roll please … Mars appears brighter because its closer to Earth as Earth passes it!

So it's an illusion. So why did the ancient Greeks reject the real reason for planetary motion? If retrograde motion is so easily explained by the Earth orbiting the Sun, why wasn't this idea accepted by the Greeks? It was certainly known to the Greeks, the Greeks certainly considered the idea that the Earth was maybe going around the Sun, as opposed to the Earth being at the center, and the Sun going around it. It goes back to at least 260 BCE, Before Common Era, by the Greek astronomer Aristarchus.

But nevertheless, the idea of a Sun centered solar system, a Sun centered universe, a Sun centered cosmology, did not gain acceptance until almost 1700 years later. Although there were many reasons why the Greeks were reluctant to abandon an Earth centered universe, the most important was their inability to detect something called parallax.

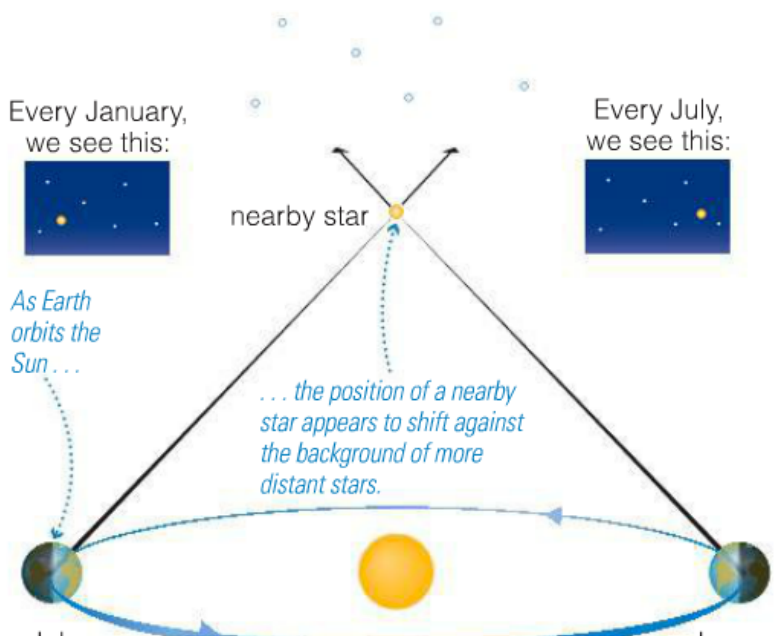


Credit: Ngā Whetū, public domain

Parallax is something that your brain intrinsically knows. Parallax is how we get depth perception, because we have a left eye and a right eye, so we see things in slightly different perspectives, and we turn that different perspective in that angle difference into a depth. Our magic computer up there knows how to turn an angle difference into a distance.

You can demonstrate this pretty easily to yourself. Hold your finger up in front of you. Go ahead, nobody's looking at you right now. So hold your finger up in front of you and look with your left eye keeping the right eye closed. Now look with your right eye keeping your left eye closed. Go back and forth like this between one eye and then the other. Back and forth, back and forth. You see the position of your finger jump because you're looking at it from two different perspectives. That's parallax. That's all there is to it. It's a different angle between two different viewing positions.

If you hold your finger even farther out, you'll find that the angle that it jumps is even smaller, and so we know that when that angle difference gets smaller, our brains tell us that thing is farther away. So parallax is how we get depth perception.



The idea for astronomy is exactly the same as two eyes, except now use the Earth going around the Sun. So July would be like the left eye and then six months later January would be the right eye. If you look at a nearby star you should be able to see a parallax as the image above shows. You should be able to see a jump in the position of the star relative to more distant background objects.

The Greeks could not find any detectable parallax. And so they concluded either 1) the Earth does orbit the Sun, but the stars are too far away to detect parallax, or 2), there is no parallax because the Earth is at the center of the universe.

They rejected the first answer in part because they couldn't imagine that the stars were that far away. In reality, yes they are far away. Very far away. In fact it wasn't until the 1800s that we got the first 3D glimpse of our neighborhood, when the first detection of parallax of nearby stars was measured.

Today we can detect parallax with relative ease. This also provides direct proof that the Earth orbits the Sun. In fact, parallax provides the most direct way of measuring distances because it's strictly a geometric thing. It's just a triangle.

Carpe Diem. Thanks. Bye bye!