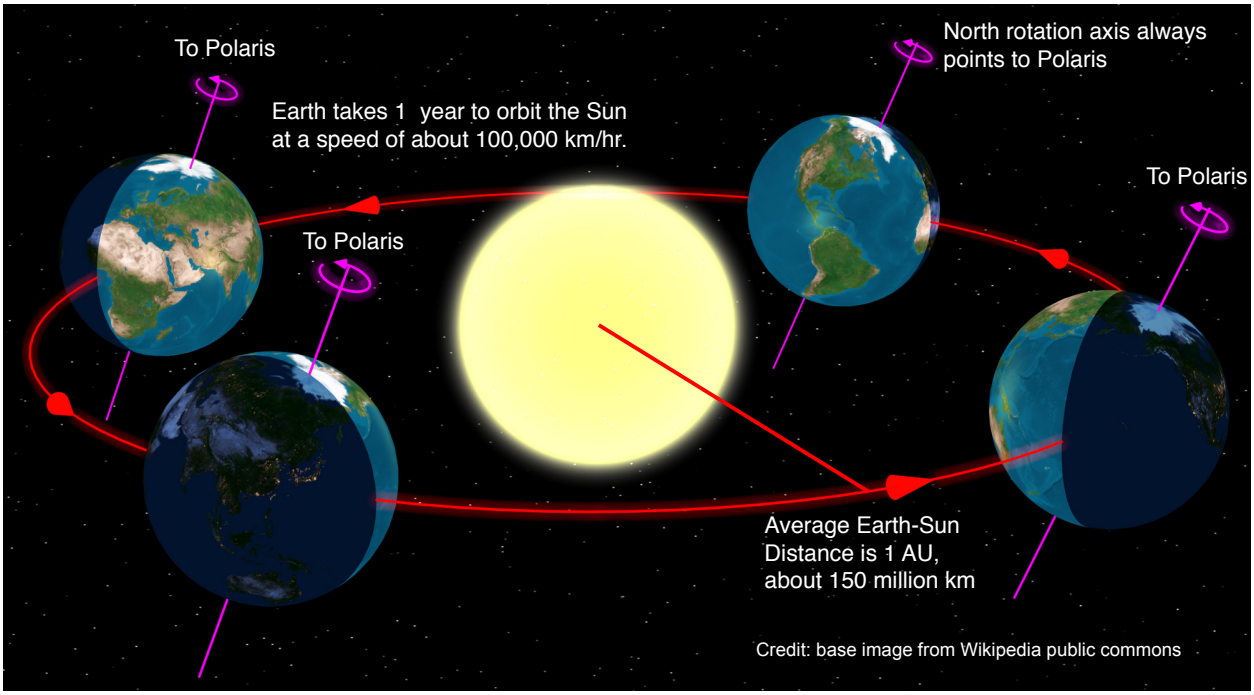
Spaceship Earth: The problem for the passengers is that there is no manual to identify all the parts, and no instructions on how to operate the spaceship.

Richard Buckminster Fuller

Space Station Earth

In this module we'll explore how things are moving around the Earth, Milky Way, and within the Universe.

So how is Earth moving in our solar system? Well, the Earth rotates on its axis once each day, which is not obvious.



Have you ever seen a Foucault pendulum? And so they line up dominoes or boxes or something in a circle. The pendulum begins to swing and knocks over the dominoes. That is proof that the Earth is rotating on its axis once each day! Because the plane of the pendulum always remains the same. If you took the pendulum, lined it up with a star of your choice, swung toward that particular star, the plane of the pendulum's swing would always line up with that star. Its the Earth underneath the pendulum that is turning.

This was proof that the Earth rotates on its axis. Done circa in the 1800s. Also the Earth orbits the Sun once each year, which again is not obvious. And that's partially why it's been drilled into your head since kindergarten that the Earth orbits the Sun, and

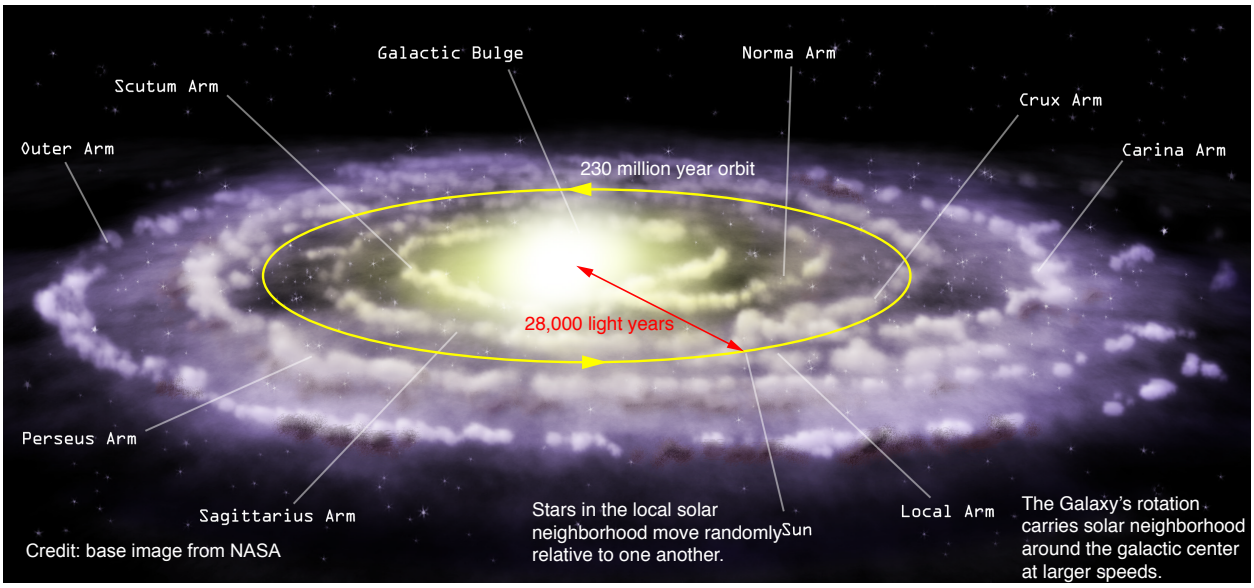
because it was a great revolution coming out of the Dark Ages that the Earth goes around the Sun.

So the Earth orbits the Sun at an average distance of 1 AU. A reminder that an AU is an astronomical unit, the average distance between the Earth and the Sun. So Earth orbits the Sun at at 1 AU.

The Sun and all the planets, more or less, are in a flat plane. That plane we call the ecliptics. The Earth is tilted at about 23 and 1/2 degrees relative to that plane, called the ecliptic, as it goes on around. As we'll talk about in a couple of mini-lectures from now, that's the reason for the seasons. It has nothing to do with the distance between the Earth and the Sun. And it has everything to do with whether the axis is pointed towards the Sun in summer or pointed away from the sun, in winter.

And so, in general, we are always spinning and orbiting around the Sun.

How is our solar system then, moving through the Milky Way?

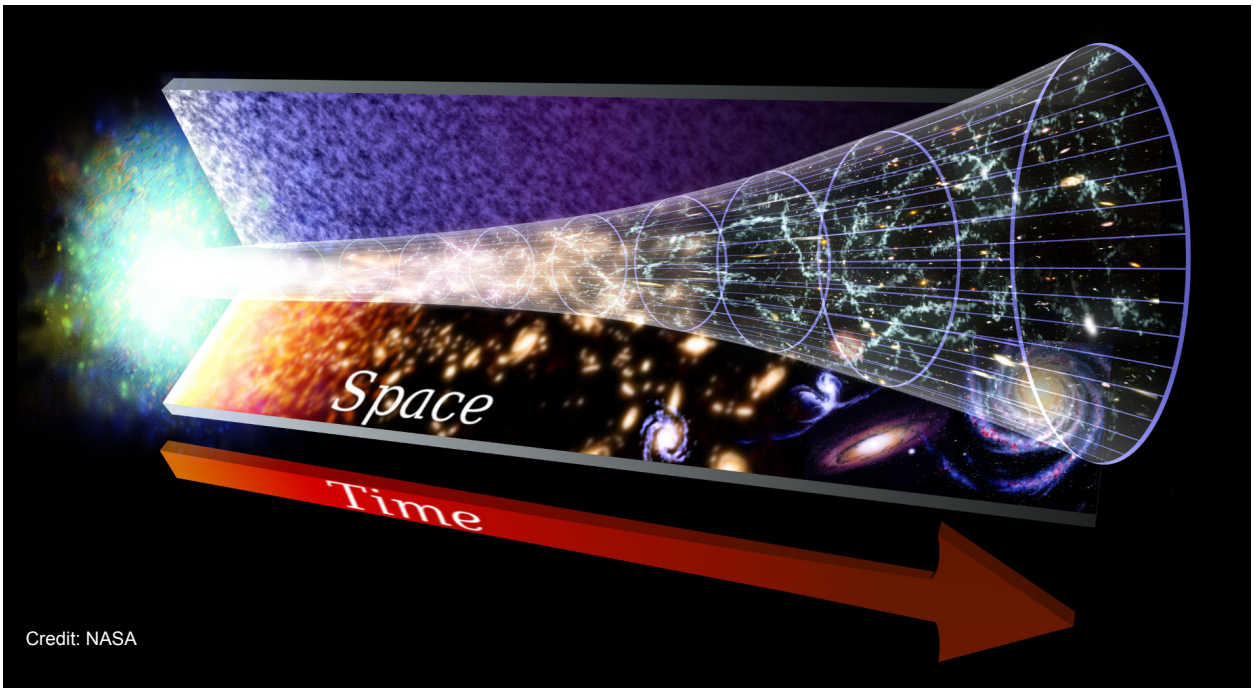


Well, we move essentially with random speeds relative to other stars on our local solar neighborhood. Within our local solar neighborhood, which is about 100 light years or so, stars kind of come this way and they go that way. It's random. But the stars are so far away that their motions are undetectable to the naked eye, particularly over the course of a night.

Now we can measure those motions - they are called proper motion-- but it takes about a human lifetime for those to become measurable with the technology that we have today.

So although there's this random motion of the nearby stars, in toto, the Sun and all the other stars in our neighborhood orbit the center of the galaxy about once every 230 million years or so. We're a comfortable out 28,000 light years from the center of the galaxy. Kind of out in the suburbs away from the big city. The last time that we were in this place in our orbit, dinosaurs ruled the Earth.

So how do galaxies, then, move within the universe?



Well, first, within our local group, which is basically us and the nearest large spiral galaxy to us - the Andromeda galaxy - plus a host of smaller what are called dwarf spheroidal galaxies and some irregular galaxies like the Magellanic clouds. Galaxies essentially move at random within the local group, much like the local stars around us sort of move in random.

But in toto, if you look at all the galaxies, all the galaxies are moving away from us faster. In other words, the universe is expanding. An analogy is a raisin cake model of the universe, where you have raisins, i.e., galaxies. And as that dough rises, i.e., as the universe expands, all those raisins get farther away from one another. Each raisin gets farther away from any other raisin uniformly. We live in an expanding universe. And that gives you an amazing conclusion. If the universe is expanding now, run the movie

backwards. And the conclusion is in escapable, that there was a beginning, that was the first moment when the movie started, that there was a big bang. And the universe had a beginning, about 14 billion years ago.

Are we always in motion? Well, I hope the answer is obvious by now.
The answer is yes:

We spin around Earth's axis at ~1000 km/hr.

We orbit the Sun at ~ 100,000 km/hr.

Our solar system moves randomly among the stars of the solar neighborhood at ~ 100,000 km/hr.

Our solar 'hood orbits the center of the Milky Way at ~ 1,000,000 km/hr.

Our galaxy moves randomly among the galaxies of the Local Group at ~ 300,000 km/hr.

All other galaxies move away from us at speeds depending on their distance.

Thanks for listening. Bye bye.