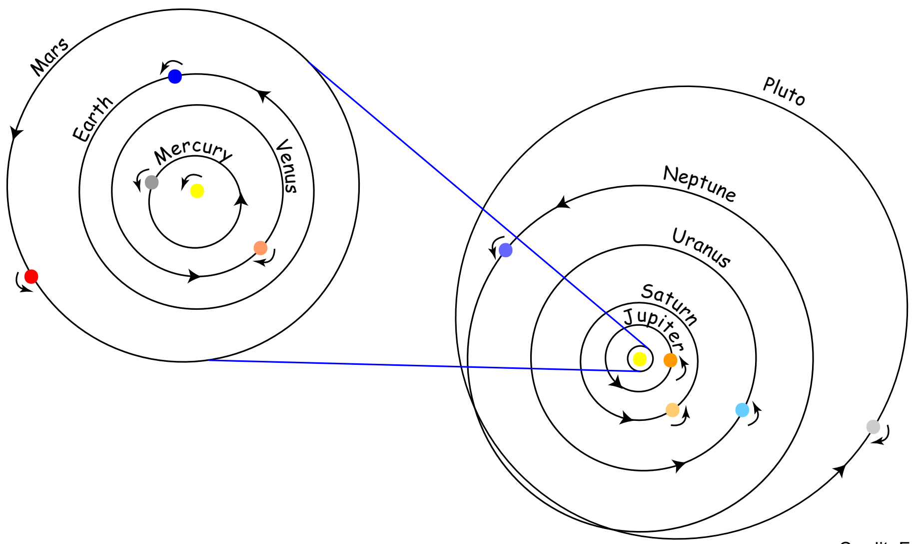
It suddenly struck me that that tiny pea, pretty and blue, was the Earth. I put up my thumb and shut one eye, and my thumb blotted out the planet Earth. I didn't feel like a giant. I felt very, very small.

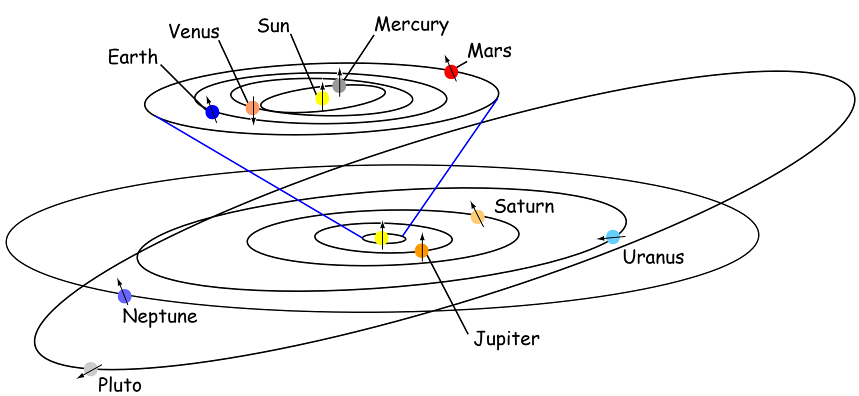
Neil Armstrong

Solar Nebula

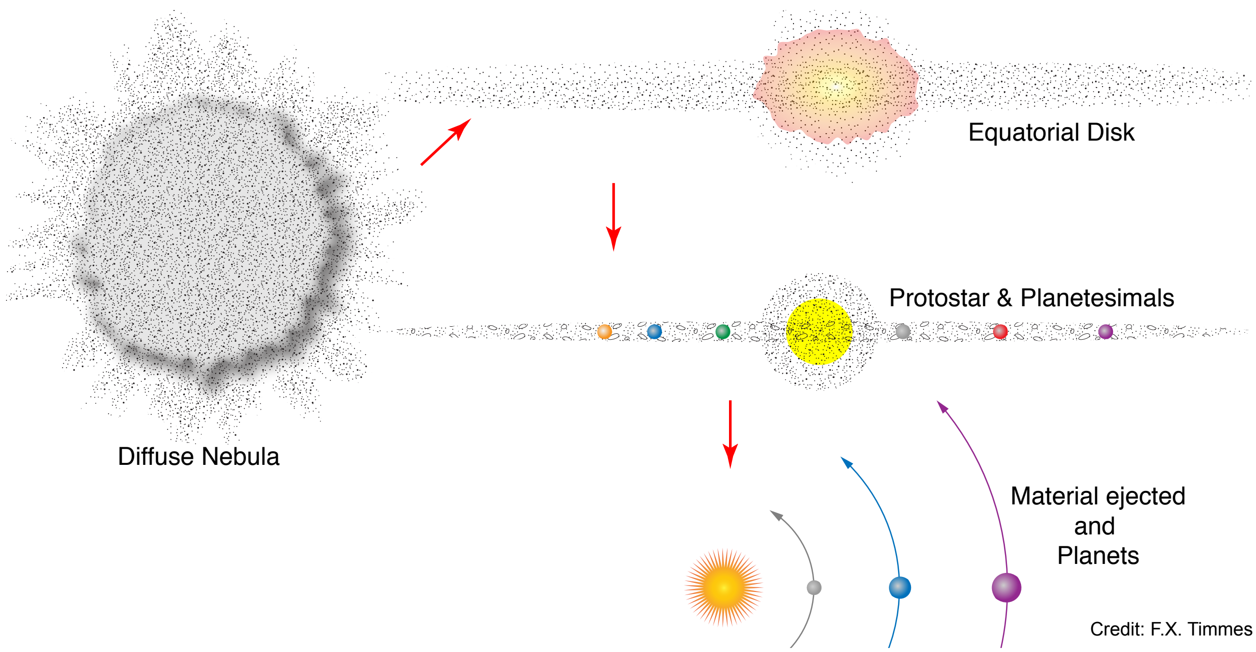
Hey there! In this short module we'll review the four main challenges that we like our theory of solar system formation to explain and introduce the "solar nebula theory".



Credit: F.X. Timmes



We found four features that we would like our solar system theory to explain. One was the the great amount of order in the orbits shown in the image above. Everybody orbiting in the same direction, most rotating in the same direction. Two as explaining why planets break into basically two groups so cleanly, the terrestrials and the jovians. Number three was explaining why there is so many asteroids and comets in distinct reservoirs. Number four was explaining why here are exceptions to the patterns.



Of course a theory can't just postdict -- explain what's already there. A good theory must be able to predict something. To predict things that are subsequently confirmed by new observations or experiments.

The standard paradigm theory of the day, the solar nebula theory, holds that the solar system formed from the gravitational collapse of a large cloud of gas and dust. It successfully is going to explain our four features, along with predicting new features that people can go after and observe.

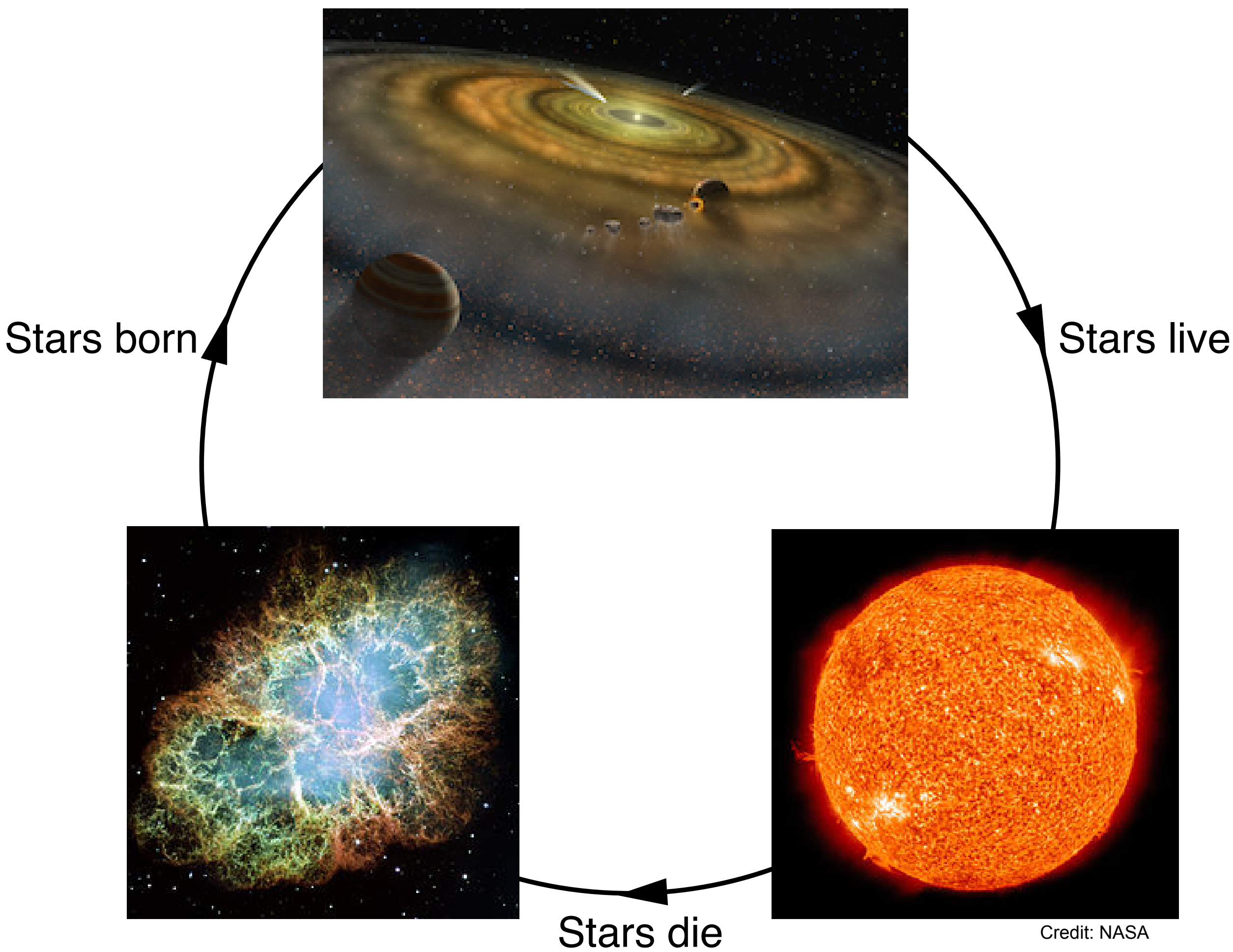
This wasn't always the theory on how the solar system formed. Probably, oh, up until about the 1940s, the prevailing standard paradigm was the close encounter theory, which held we had an interloper that came by and zipped by the young Sun. As it zipped by it pulled off blobs of gas. And those blobs of gas then condensed into the planets that we see today. This theory died out as new observations became harder and harder to explain under that theory.

So the illustration above shows, we're going to see several renditions of this figure as we go progress, you start with a large, roughly spherical, diffuse cloud of gas and dust. As the cloud collapses, conservation of energy, momentum and angular momentum assure it’s going to flatten out into a disk. This is why disks are very common in the universe. So you get this spinning disk with a protosun at the middle.

It's hotter toward the center, where the protosun is, colder on the outside. This determines what kind of snowflakes you are going to get. Snowflakes of rock and metal closer in. Snowflakes of ice and hydrogen compounds farther out. This is generally going to be why you have terrestrial planets on the inside, gas giants on the outside.

Then there's an era when the Sun finally turns on by igniting its nuclear fuels. The strong wind from “first burners” is going to clear away the disc. The amount of time that you have to form protoplanets is relatively short. After the Sun turns on and blows away all the extra loose material, there's a period of great consolidation. great violence, where at the end you are left with the planets we have now.

So that's the solar nebula theory in general terms. We're going to each piece in a little more detail as we go on.



Let’s start that with that large diffuse cloud of gas. This cloud that gave birth to the solar system was the product of gas recycled through many, many generations of stars. This could, our cloud, consists of about 98% hydrogen and helium and 2% of all the good stuff that makes, for example, you and me -- carbon, oxygen, calcium, iron, silver, gold, and so on.

So let’s walk through the scenario from the beginning. When the universe began, in the Big Bang, the only thing that the Big Bang made was hydrogen and helium. There was no carbon. There was no oxygen. There was no calcium. None of this stuff.

It's stars that are the element factories. It's stars that make the periodic table of the elements. So a star is born. And a star dies. When the star dies, it spits out new elements that it created through the nuclear furnaces in its interior. These new elements go out into interstellar space, becoming gas and dust. That gas and dust then gets reincorporated into a new generation of stars. And the gas-star-gas cycle continues. Every time you go around that cycle, you enrich the galaxy, the cosmos, with a bit of more carbon. A bit more oxygen. A bit more of the elements heavier than hydrogen and helium. You go around the cycle enough times until when the cloud that became the solar system you have about 2% the heavier elements. So stars are the element factories. In a very real sense, we are star stuff. I know that sounds really ooey gooey. And it might be — if it wasn't so true.

The image above is of the Orion Nebula. Its a location where new stars, new solar systems, are being born from the collapse of large diffuse clouds of gas and dust. Orion is a constellation located on the celestial equator and this visible thought the world. It was named after Orion, a hunter in Greek mythology. Its got two stars for the shoulders, three stars for the waist, and two stars for the feet. Below the waist, the belt, is a fuzzy patch of sky sometimes said to represent a sword in the belt. Its this fuzzy patch that is the Orion Nebula. Compare what you can see with you naked eye to the image above. Wow!

Thanks. Bye Bye.