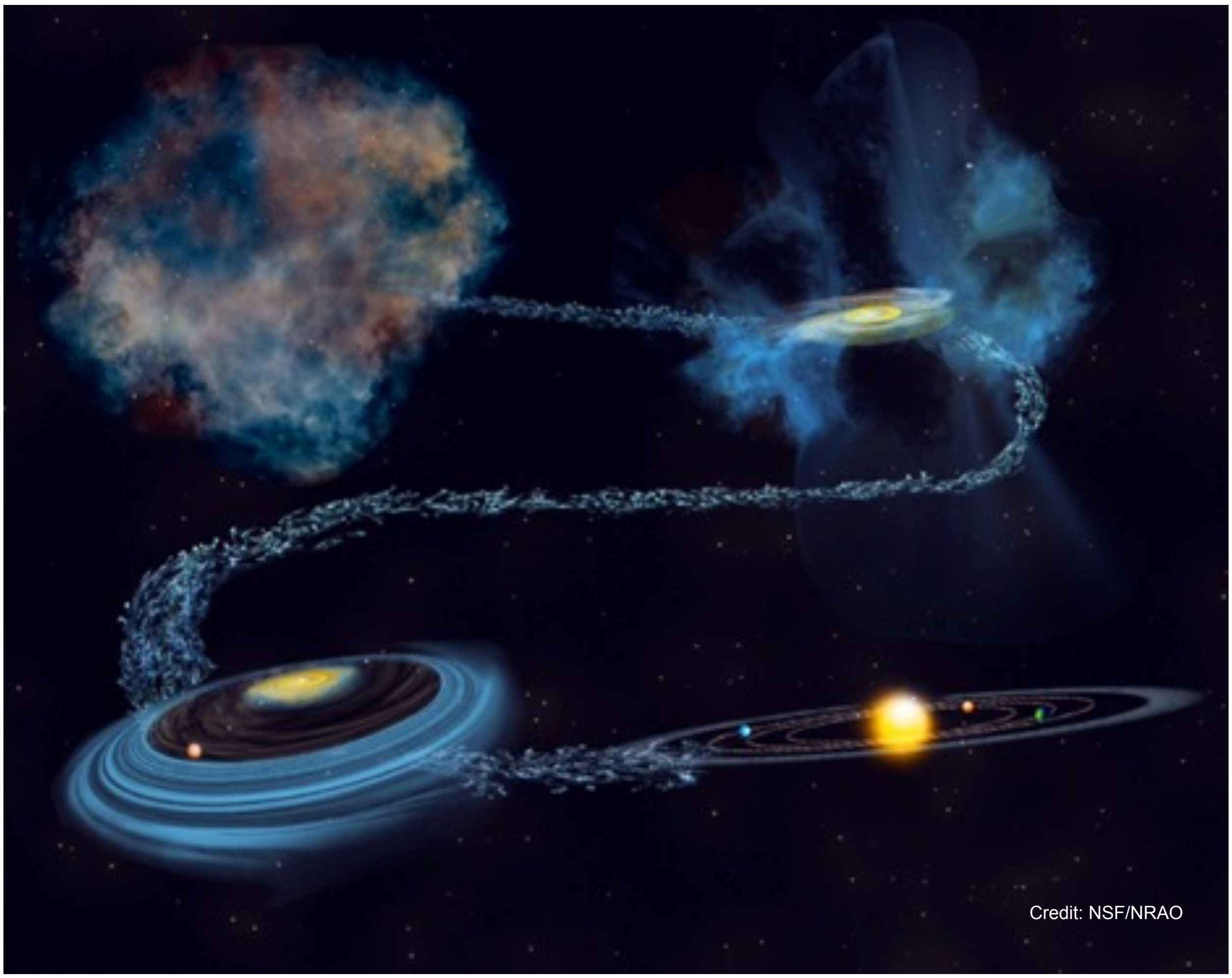
In outer space you develop an instant global consciousness, a people orientation, an intense dissatisfaction with the state of the world, and a compulsion to do something about it. From out there on the moon, international politics look so petty. You want to grab a politician by the scruff of the neck and drag him a quarter of a million miles out and say, "Look at that, you &*^%$."

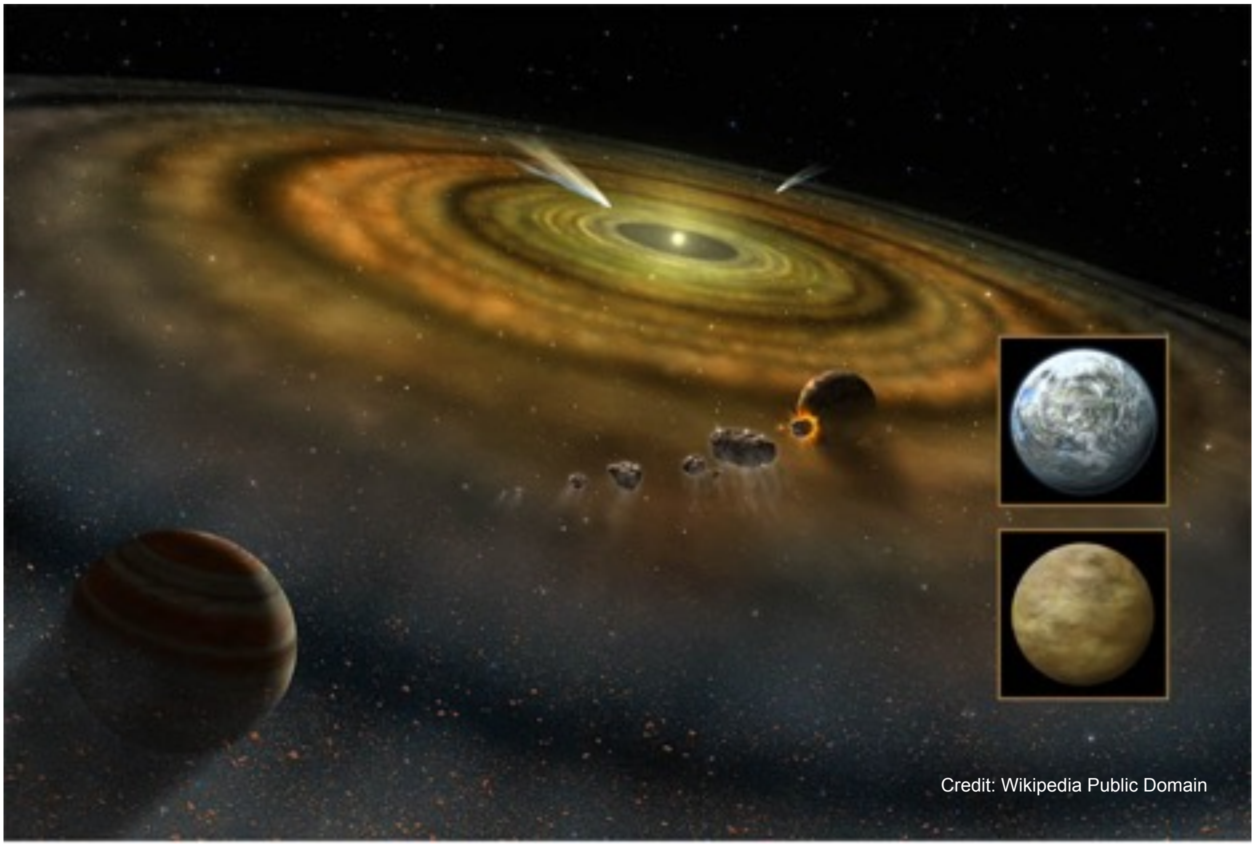
Edgar Mitchell

Heating, Spinning, Colliding

Hi everyone! In this module we'll explore how our theory of solar system formation explains the orderly pattern of motion in our solar system.



A large, collapsing cloud starts to heat up, spin faster, and flatten out as it shrinks. That's shown in the upper part of the illustration above. This is what we'll focus on in this module.



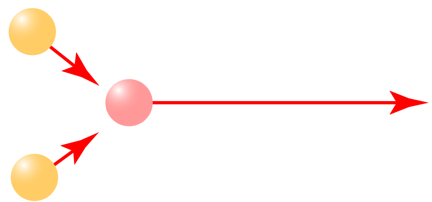
So as the cloud falls inwards, it converts its gravitational potential energy into the energy of motion, the kinetic energy, of the gas particles. These particles are going to crash into one another, now converting their energy of motion into the random motions of thermal energy. This heating -- getting hotter as it falls down-- is just energy conservation in action. In total, you're converting gravitational energy into heat energy as the cloud collapses.

Whatever spin the initial large cloud had, its going to keep the angular momentum as it collapses on down because of the conservation of angular momentum, which we covered early on in this course. Remember an angular momentum is a mass times distance times speed and that product must always equal the same number no matter what happens. Its a a constant, its conserved.

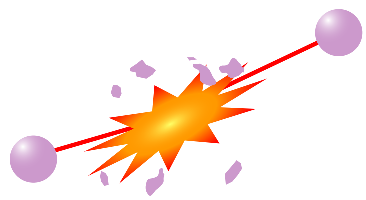
The spinning also helps spread out the material into the disk, like what happens when you spin a ball of pizza dough. This spreading out helps ensure that not all of the material of the solar nebula end up in the the protosun. Why? Well, what does gravity want to do? Gravity wants to smash everything into a point- - create a black hole, so to speak. If gravity was the only actor, the whole entire solar nebula would collapse down to a point. That’s no fun. So it's this spinning, this conservation of angular momentum, that ensures that not all of the material goes into the middle.

That middle part where it is the hottest is ultimately going to turn into the Sun, where it’ll burn hydrogen to helium for most of its life. But it's not quite there yet. It's still just kind of a warmish spherical blob as the material is raining on down to it. So we refer to this stage as a "protosun" , as in “before a Sun”.

Why a disk?



Oblique collisions -> regular orbits



Head-on collisions -> smaller object

Credit: F.X. Timmes

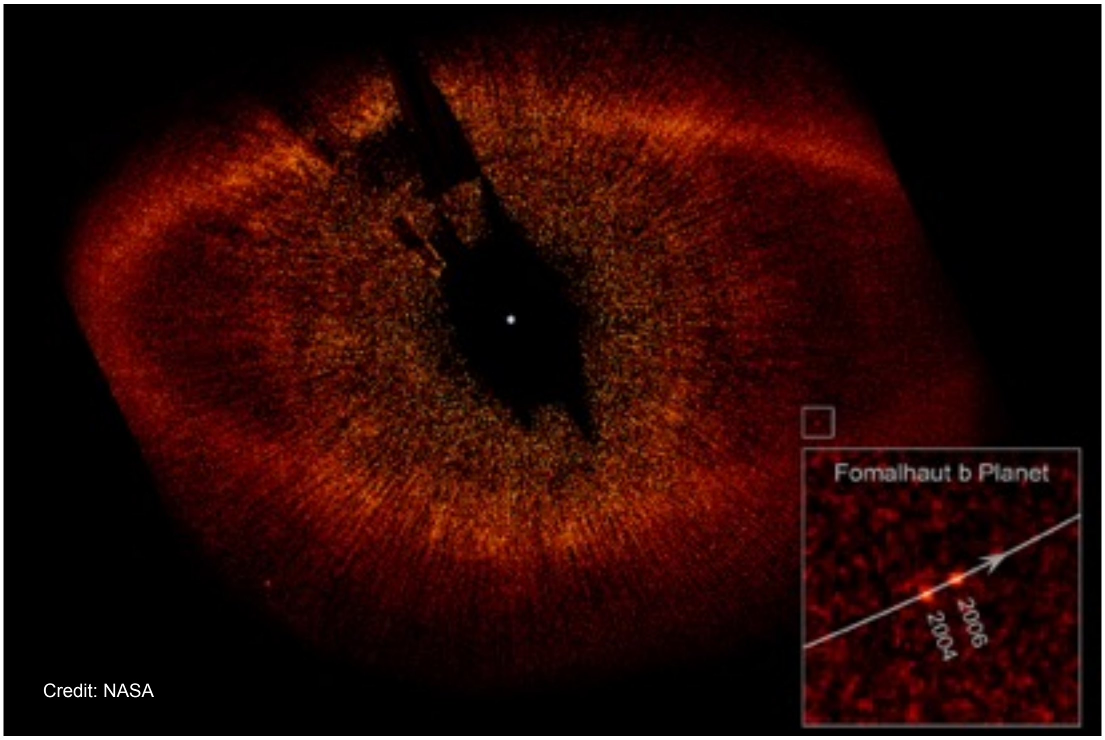
So a cloud can generally start with any shape you like, with different clumps moving in different, random directions at random speeds. As the cloud collapses these clumps collide. When they collide, the new clumps obtain the average of the old speeds. This is just our friend conservation of momentum. Collisions helps circularize the orbits. Collisions sort of averaging out the energy, averaging out the speeds. Its what starts producing order as the cloud collapses. Random motions become more orderly, changing the cloud's original lumpy shape into a rotating, flattened disk.

Flattening of the disk explains why all the planets orbit in nearly the same plane, because it's from within this flattened disk that you're going to form planets.

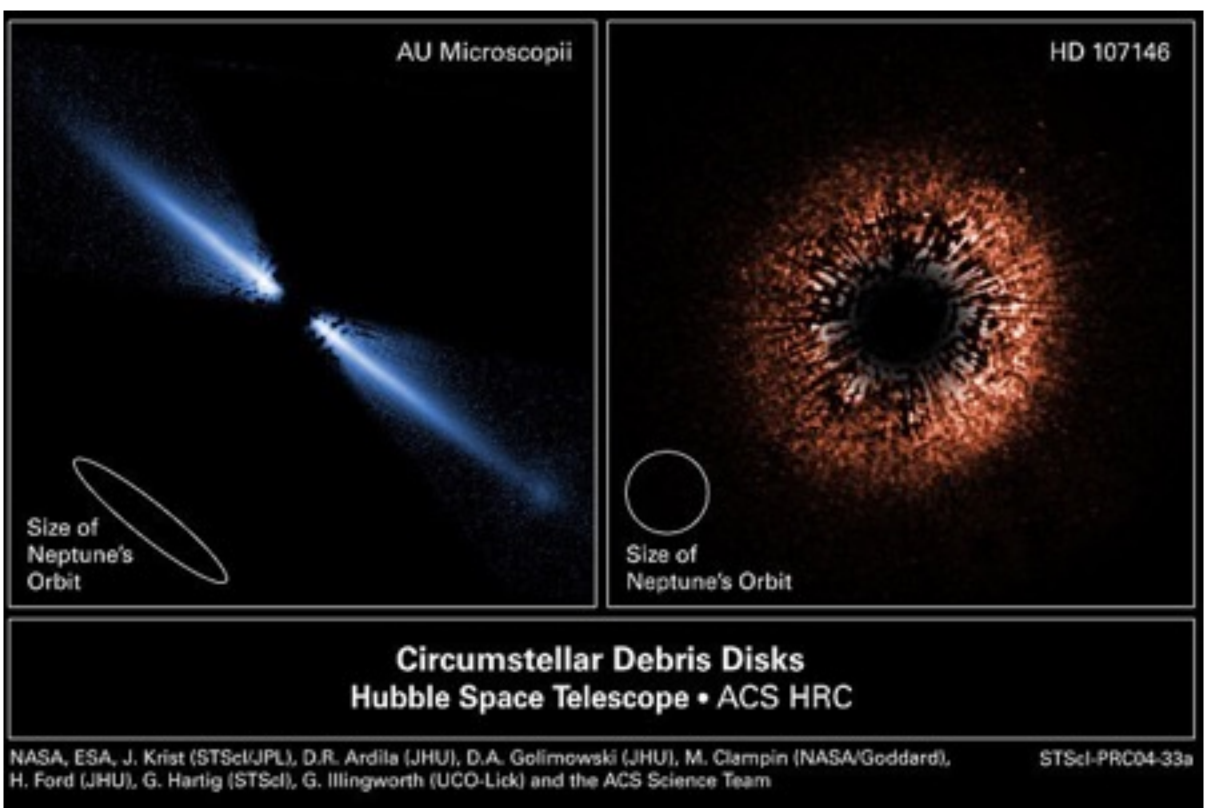
Spinning explains why all the planets orbit in the same direction. It plays a large role in making most of the planets rotate in the same direction as they orbit.

Colliding explains why most planets have nearly circular orbits.

The combination of heating, spinning, flattening, and colliding thus explain the overall orderly pattern of motion that we see in our solar system. Its not just our solar system. You can go and observe other solar systems in formation. Particularly these days, when we have thousands of exoplanets known. You can start taking a look at their disks and the environment in which they're forming, and check if you get what expect to get from our solar nebular theory. The image below is an example. Not only can you image the planet (wow!) but you can see some evidence of a disk of material around the host star.



The image below shows more direct evidence of disks around other new stars forming solar systems. You see a disk of material in various states of evolution both from the side (left) and almost face-on (right). Such images offer confirmation that heating, spinning, flattening, and colliding can be sen in other newly forming solar systems.



Thanks for listening. Bye Bye.