Saturn: Crash Course Astronomy #18

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So now weâ€™ve come to the last of the naked eye planets in the solar system: Saturn. Itâ€™s the second largest planet, but ironically the least dense. In fact, if you could find a bathtub big enough, Saturn would float in it! But it would leave a ring. OK, thatâ€™s the oldest joke in astronomy, but itâ€™s true. Saturn is a gas giant, which means it has a thick atmosphere. Like Jupiter, it probably has a rocky core several times the mass of Earth, surrounded by layers of ice and weird, metallic hydrogen. On top of all that is its atmosphere, hundreds of kilometers deep, composed mostly of hydrogen, with a smaller amount of helium and a whole bunch of trace gases like methane and ammonia. Overall, its density is about 2/3rds that of water. It wouldnâ€™t really float, though; its gravity would draw in all the water from the giant bathtubâ€¦ although, actually, come to think of it, a bathtub filled with water big enough to put Saturn in would have more mass than the planet, so the water would pull Saturn in. Astronomy is fun! Saturn spins really quickly, completing a day in just ten and a half hours. Its rapid rotation and low density means itâ€™s really oblate, or squished; itâ€™s 10% wider through the Equator than through the poles! Thatâ€™s really noticeable through a telescope. When we look at Saturn, we only see its cloud tops. Those clouds are mostly ammonia ices, with water clouds lower down. The atmosphere is banded, like Jupiterâ€™s, but the pattern is much fainter, probably due to Saturn being farther from the Sun and therefore colder, as well as the atmosphere being deeper than Jupiterâ€™s too. Thatâ€™s not to say Saturn doesnâ€™t have storms. Oval hurricanes pop up every now and again, and in 2010 a huge storm erupted in Saturnâ€™s northern hemisphere. It was discovered by an amateur astronomer, and Cassini spacecraft pictures showed it getting so big it literally wrapped around the planet, reaching a length of over 300,000 kilometers! Traces of it persisted for years. One of the most striking features on Saturn is a huge, hexagonal vortex at its north pole. Vortices like this are common on planets; Earth and Venus have them too. That well-defined six-sided shape is pretty freaky, but itâ€™s actually a natural outcome of a spinning fluidâ€"the air circulating Saturnâ€™s atmosphereâ€"which itself is in a spinning systemâ€"in this case, the planet itself. Itâ€™s not that different than Earthâ€™s jet stream, but itâ€™s a lot bigger, about 20,000 kilometers acrossâ€¦ wider than Earth. And right at its center, over Saturnâ€™s north pole, is a ridiculously beautiful storm system about 2000 kilometers across. Wind speeds there have been clocked at 500 kilometers per hour. Saturn as a planet is of course an amazing place, but câ€™mon. When you think Saturn, you think rings. As well you should. Saturnâ€™s rings were seen by Galileo, but his telescope lacked the resolution to really figure out what they wereâ€"he thought Saturn might be three objects in close proximity. Some decades later the Dutch scientist Christiaan Huygens correctly interpreted their appearance as a ring surrounding the planet. Theyâ€™re not solid. If they were theyâ€™d get torn apart, since the inner edge would orbit the planet way faster than the outer edge. Theyâ€™re actually made of countless small chunks of very nearly pure water ice. Each particle orbits the planet independentlyâ€¦ so I guess Saturn wins in the â€œwhich planet has the most moonsâ€• category. What really gets me about Saturnâ€™s rings is their scale. Theyâ€™re 250,000 kilometers across. If you put Saturn between the Earth and Moon, the rings would cover â…" that distance. And yet, despite their size, theyâ€™re incredibly thin: They average about ten meters thick. And no, I did not misspeak, I meant ten meters. Ten meters. Thatâ€™s amazing. Thatâ€™s thinner, to scale, than a sheet of paper. Way thinner: If you shrank Saturn down to the size of a piece of paper, that paper would be ten thousand times thicker than the rings. So yeah, Saturnâ€™s rings are flat. But why? Well thatâ€™s tied to their origin, though the specifics of how they came to be arenâ€™t exactly known. One idea is that they were originally an icy moon that got disrupted by a huge collision. The shattered moon particles would have spread around Saturn, and any of them that were on a tilted orbit would quickly collide with others, and in the end that would average out all their orbits to form a flattened ring. Or maybe there was once a large moon near Saturn, that was big enough to be differentiated; that means the rocky bits fell to the moonâ€™s core, while the ice stayed near the surface. As it plowed through the material around the proto-Saturn, the moonâ€™s icy layer got stripped off, forming the rings. And again, that would form a very flat disk. However they formed, collisions would quickly flatten the ring out. And remember, Saturn is oblate, so as the rings formed they wouldâ€™ve felt a gravitational tug from Saturnâ€™s equatorial bulge, centering them right over the planetâ€™s midline. Saturn has three main rings, give or take. In classic imaginative astronomer fashion, theyâ€™re given the names A, B, and Câ€"in order of their discovery. B is the broadest, roughly 26,000 kilometers wide. A is outside B, while the C ring is fainter and inside the B ring. When the rings were first observed, the A and B rings were thought to be one ring. But then the Italian astronomer Giovanni Domenico Cassini discovered a gap between them, and we now call that the Cassini Division. Itâ€™s about 5000 kilometers across, but itâ€™s not empty! There are quite a few very narrow rings inside of it. The gap is due to one of Saturnâ€™s moons, Mimas. If youâ€™re an ice particle in the Cassini division, you orbit Saturn twice for every one time Mimas goes around. This is called a resonance, and it means that the particles at that location get tugged repeatedly by the gravity of Mimas, which in essence yanks them out of their orbit. There are quite a few gaps in the rings caused by moons; in fact, there are hundreds of â€œringletsâ€• in the main rings. Even weirder, the F ring is outside the A ring, and is very narrow, just a few hundred kilometers across. Itâ€™s kept that way by two moons, Prometheus and Pandora, orbiting just inside and outside the ring. They tug on the ring particles in such a way that keeps them confined to very strict orbits; if a particle wanders out, the moonsâ€™ gravity drags it back in. As the moons and ring particles interact, they can also create weird rippling waves in the rings. And this is really cool: when small moons orbit Saturn on slightly inclined orbits; it can create waves in the rings, tremendous vertical excursions that can reach several kilometers high. Saturn is weird. And so are its moons. I already mentioned Mimas, an icy moon that carves out the Cassini Division with its gravity. It also suffered a massive impact long ago that created a single huge crater, making it look somehow familiar. But Saturn has two moons specifically you should know about. The first is Titan, a monster satellite thatâ€™s actually bigger than Mercury, not that much smaller than Mars, and second in moon size ranking only to Jupiterâ€™s moon Ganymede. Titan not only has a substantial atmosphereâ€"the only moon to have oneâ€"but itâ€™s thicker than our air on Earth! I wouldnâ€™t suggest breathing it, though: Itâ€™s mostly nitrogen, with a smattering of methane and hydrogen. Itâ€™s also a hundred and eighty below zero Celsius there. Definitely donâ€™t stick your tongue on a flagpole on Titan. Titanâ€™s atmosphere has a thick layer of haze that prevents us from seeing the surface using visible light. But using infrared and radar, though, the Cassini spacecraft, which has been orbiting Saturn since 2004, is able to map the surface. It also deployed a probe named Huygens to land on Titanâ€™s surface, the first time humanity had ever landed on an outer solar system moon. What they saw was an odd world, Earth-like in some ways, and very alien in many others. Titan has wind-sculpted dunes, but theyâ€™re made of hydrocarbon grains, not sand. There are hints of volcanoes that spew liquid water instead of lava. These are called cryovolcanoes, cold volcanoes, a term I love. This, together with measurements of Titanâ€™s gravitational field, have scientists thinking that Titan may have an underground ocean of liquid water. Intriguingly, Titan also has long, winding channels indicating flows of some kind of liquid on its surface. But it canâ€™t be water; itâ€™s far too cold on the surface for that. So what kind of liquid could it be? Well, Cassini also spotted quite a few flat regions near Titanâ€™s north and south poles. These have since been confirmed to be lakes of liquid methaneâ€"the first time any liquid has been seen on the surface of another world. The shorelines of the lakes appear to change over time, too, hinting very strongly that Titan has

weather, driven by methane as opposed to water here on Earth. Weather, atmosphere, surface liquids, and an abundance of organic, carbon-based moleculesâ€¦ could there be life on Titan? The conditions there areâ€¦interesting. We obviously donâ€™t know yet, but itâ€™s an exciting possibility. And itâ€™s not the only Saturnian moon scientists are looking at for signs of life. Enceladus is a smaller, icy moon about 500 km across: About the size of my home state of Colorado or the southern part of England. Enceladus is incredibly shiny, reflecting nearly all the light that hits it: a strong indicator itâ€™s covered in water ice. Parts of it are cratered, but other parts are very smooth, indicating some event resurfaced the moon. The surface also has an extensive series of cracks in it, much like Jupiterâ€™s moon Europa. Scientists suspected cryovolcanism, and that was confirmed quite dramatically in 2005 when Cassini spotted active geysers of water spewing from the south pole of Enceladus! The water is erupting from a series of cracks nicknamed â€œtiger stripesâ€•, and is coming from deep under the surface. Like Europa, Enceladus has an under-surface ocean, kept liquid by Saturnâ€™s ferocious tides, which squeeze the moon as it orbits the planet. The plumes reach several hundred kilometers from the moonâ€™s surface, and Cassini even flew directly through the plumes, and detected organic molecules. Could Enceladus be yet another harbor for life in the solar system? Again, no one knows, but Iâ€™d put it in the top three places to look, including Europa and Titan. Itâ€™s weird, isnâ€™t it? Weâ€™ve always looked for planets where conditions were like here on Earth, but it turns out extremely cold moons may be the best places to seek out new life. Saturn has a huge retinue of other moons, too, and theyâ€™re all pretty weird. Iapetus is shaped like a walnut, with a tall ridge of mountains encircling its equator; no oneâ€™s quite sure how that formed. Hyperion looks like a huge piece of Styrofoam thatâ€™s been hit repeatedly with a BB gunâ€”and thatâ€™s not a bad analogy, since it has such a low density itâ€™s likely to be extremely porous, like a sponge. A lot of Saturnâ€™s moons orbit the planet backwards, retrograde; similar to several moons of Jupiter. These may be captured asteroids, or even Kuiper Belt Objects, giant chunks of ice that weâ€™ll learn about very soon in a future episode. All in all, Saturn has over 60 moons weâ€™ve discovered so far. I want to add a personal note. When you ask astronomers or astronauts what got them started, what was the very first thing that happened to them to inspire them to do what they do, overwhelmingly they will tell you: â€œI saw Saturn through a telescope.â€• Itâ€™s true. Itâ€™s true for me; I remember my parents buying a cheap department store telescope when I was five or six, setting it up in our driveway, and aiming it at Saturn. I still remember seeing Saturn in the eyepiece, a perfect jewel, the rings small but vivid and sharp. Itâ€™s hard to believe itâ€™s real when you see it, and even after all these years, itâ€™s my favorite target when Iâ€™m stargazing. Iâ€™ll never get tired of watching peoplesâ€™ faces when they see it for the first time. They gasp, they their eyes get wide, their mouths drops openâ€”itâ€™s honestly one of the greatest joys of life. Saturn is the crown jewel of the solar system. Itâ€™s the best kind of astronomical object: Visually stunning, artistically gorgeous, and filled to overflowing with incredible science. Today you learned that Saturn is a gas giant, and has a broad set of rings made of ice particles. Moons create gaps in the rings via their gravity. Saturn has dozens of moons, including Titan, which is as big as Mercury and has a thick atmosphere and lakes of methane; and Enceladus which has an under-surface ocean and eruptions of water geysers. And, though we donâ€™t know for sure, itâ€™s possible either or both moons may support life. Crash Course Astronomy is produced in association with PBS Digital Studios. Head on over to their channel and discover more awesome videos. This episode was written by me, Phil Plait. The script was edited by Blake de Pastino, and our consultant is Dr. Michelle Thaller. It was directed by Nicholas Jenkins, edited by Nicole Sweeney, and the graphics team is Thought CafÃ©.