Venus: Crash Course Astronomy #14

Crash Course: Astronomy
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This episode of Crash Course is brought to you by SquareSpace Venus was the Roman goddess of love, and honestly, if youâ€™ve ever seen it after sunset, hanging like a diamond in the twilight, the planet Venus is stunningly beautiful. The only problem? Venus is hell. Venus is the second rock from the Sun, closer to the Sun than Earth is. Itâ€™s the third brightest natural object in the sky after the Sun and Moon, and itâ€™s shockingly bright when you see it, in fact, a lot of the time when people see it they think itâ€™s an airplane. Some folksâ€"and this is trueâ€"even report it as a UFO. Like Mercury, it never gets far from the Sun; at best it can reach about 45Â° away. If you want to see it, the best time to look is after sunset or before sunrise. Through a telescope, Venus can be seen to undergo phases just like the Moon and Mercury do, too. When itâ€™s on the far side of its orbit from Earth, we see the illuminated face, so it looks full. As it rounds the Sun and approaches Earth in its orbit, it gets bigger from our point of view, because itâ€™s getting closer, but it also wanes; itâ€™s gibbous, then half full, then a crescent. When it gets between the Sun and Earth, itâ€™s as close as it can get to us, about 45 million kilometers away. Itâ€™s a very thin crescent at that point, but close enough to us that you can see the phase easily with just binoculars. Ironically, even though we see only a small portion of it illuminated then, it appears so big that itâ€™s actually brighter than when itâ€™s full but far away. The orbit of Venus around the Sun is tipped with respect to the Earthâ€™s by a little over 3Â°. So, like the Moon as seen from Earth, Venus usually passes above or below the Sun in the sky as it laps the Earth and pulls ahead in its orbit. But again, just like with the Moon, sometimes things line up just right and Venus passes directly across the Sunâ€™s face. This event is called a transit. During a solar eclipse the Moon can completely block the Sun, but Venus is much farther away, so it can only block about a tenth of a percent of the Sun. We see the planet as an inky black circle against the Sunâ€™s face. Transits were very important centuries ago. Scientists realized that by precisely timing the start and end of a Venus transit, and applying a little geometry, they could figure out how far away Venus was, and use that like a meter stick to measure the size of the entire solar system. Grand expeditions were sent to remote parts of the Earth where the transits were visible, but it turns out Earthâ€™s atmosphere blurs the disk of Venus just enough that exact timing of the transit isnâ€™t possible. Scientists had to wait until we could use radar and other methods to get the exact distances to planets in the solar system, but transits are still pretty amazing to watch. Theyâ€™re very rare: the way the orbits of Venus and Earth align, they happen in pairs separated by eight years, but then donâ€™t happen again for over a century. The last pair of Venus transits happened in 2004 and 2012. I was fortunate enough to see both the 2004 and 2012 transits and they were totally cool. But the next one? December 10, 2117. If you missed the last two, sorry about that. Venus is actually so bright sometimes that it can be seen in broad daylight; Iâ€™ve done this myself. So hereâ€™s an obvious question: Why is Venus so bright? Telescopic observations show it to be a nearly featureless white disk, completely covered in a thick cloud layer, reflecting almost all of the sunlight that falls on it. OK, great, so thatâ€™s why itâ€™s bright, but then why are its clouds so thick? Well, it turns out that Venus might be nice to look at from a distance, but up close, yikes. In some ways, Venus is the planet in the solar system most similar to Earth. Itâ€™s only a wee bit smaller â€" 12,100 kilometers across, about 95% the width of the Earth â€" and has 80% the Earthâ€™s mass. But if itâ€™s a twin of Earth, itâ€™s the evil twin. Venus is closer to the Sun. At a distance of about 110 million kilometers, 2/3rds the distance of the Earth from the Sun, youâ€™d expect it to be warmer. What you might not expect is that its surface temperature is 460Â° Celsiusâ€" thatâ€™s 860Â° F, hot enough to melt lead. And it gets worse. Its air is almost entirely composed of carbon dioxide, and atmospheric pressure on Venus is a crushing 90 times that of Earthâ€™s! As if thatâ€™s not bad enough, it rains sulfuric acid, too, but itâ€™s so hot the drops evaporate before hitting the ground. Yep. Venus is hell. Why? How did it get so hot? It turns out Venus is a victim of a runaway greenhouse effect. A long time ago, Venus may have been more temperate, and might have even had liquid water oceans. But the Sun was cooler when it was younger, and as it aged it got hotter. At some point, the thinking goes, the Sun warmed Venus enough that its oceans started to evaporate. Water vapor is an excellent greenhouse gas, so Venusâ€™s heating accelerated. It got so hot the oceans boiled away. Any carbon dioxide dissolved in the water was released to the atmosphere, heating the planet even further, and thickening the atmosphere hugely. It got so hot that the CO2 even got baked out of the rocks, which was like, well, throwing gasoline on a raging fire. The greenhouse effect raged out of control at that point. Venus lacks a magnetic field, so it has no protection from the solar wind blasting past it. Over billions of years, this stripped a lot of the lighter elements from the atmosphere, as well as all of the water. The resulting atmospheric chemistry is pretty screwy compared to Earth. Sulfur dioxide is a popular molecule there, and clouds form from sulfuric acid. Those clouds are high off of the surface, and very white and reflective. Itâ€™s pretty incredible to think about. The Sun warmed, so Venus warmed, and then a cascading series of events lead to it being a ridiculously hostile environment due to the runaway greenhouse effect. Even though Mercury is closer to the Sun, Venus is way hotter! Given that, the last thing you might expect on Venus isâ€¦ snow. Well, possibly; observations show that thereâ€™s something shiny on the mountaintops, and snow fits the bill. But itâ€™s not water ice like on Earth. As the thinking goes, at lower elevations, minerals like bismuthinite and galena would be vaporized by the heat. Theyâ€™d then circulate up into the atmosphere and deposit onto the surface at mountaintops where itâ€™s cooler. If this is correct, then Venus is so bizarre it literally snows metal there! Thereâ€™s other weird stuff going on at Venus, too. For one thing, it has an incredibly slow rotation rate: One day on Venus is about 243 Earth days! It rotates so slowly that at its equator, you could jog faster than the planet spins. Its slow spin is probably why it has no magnetic field, too, since rotation is critical in generating the magnetic fields of objects like the Earth and the Sun. Not only that, but the planet spins backwards! This is called retrograde motion, and in a sense it means Venusâ€™s north pole got swapped with its south pole: It flipped over. Itâ€™s not clear why that happened. A lot of ideas have been proposed, including a giant collision that skidded the planetâ€™s spin to a halt, but as of right now, Venusâ€™s lazy rotation is still not completely understood. If you could survive it, living on Venus would be really odd. The thick clouds mean itâ€™s about as bright as twilight on Earth, despite being closer to the Sun. The thick atmosphere also means surface temperature is about the same everywhere on the planet, pole to equator. Due to its backwards rotation, the Sun would rise in the west, and due to the slow rotation its day is actually longer than its year! Calendars on Venus would be a mess. But calendars would probably be the least of your worries if you had to live there. Incidentally, Venus has no moon. Being closer to the Sun, itâ€™s possible that any moon it may have once had would have been perturbed by the Sunâ€™s gravity, and was eventually tossed out of Venusâ€™s grasp. Itâ€™s also possible it simply never had one to begin with. And hereâ€™s another fun fact: Venus is the most spherical of all the planets. Because it rotates so slowly, it doesnâ€™t bulge out at the equator from centrifugal force like Earth does. The diameter from pole to pole is almost exactly the same as it is through the equator. We donâ€™t have a lot of data about the interior of Venus, though given its similar composition and size to Earth, itâ€™s not too crazy to think it has a core, mantle, and crust like we do. But even given the weird atmosphere, the surface of Venus is really different than ours. Venus doesnâ€™t have tectonic activity like Earth does; itâ€™s thought that water helps drive that, and Venus long ago lost its water to the greenhouse effect. Still, the surface appears to be very young; about a thousand impact craters have been found, and theyâ€™re evenly distributed around the planet. The majority appear to be in pretty good shape, they havenâ€™t been eroded much, indicating they arenâ€™t terribly old.

Not only that, but the erosion we do see seems to be about the same for all these craters, indicating theyâ€™re all roughly the same age! Thatâ€™s weird! This all points to some sort of catastrophic event that resurfaced the planet roughly half a billion years ago. Any features older than that were wiped out, and then big impacts over time created the craters we see now. But what could repave an entire planet? A big clue can be found by counting volcanoes on Venus: There are 167 bigger than 100 kilometers in diameter, a huge number. These volcanoes could, over time, pump out enough lava to cover the entire surface of Venus. Thereâ€™s also a lot of indirect evidence that volcanic activity is ongoing, now, today: One mountain on Venus, called Idunn Mons, is seen to be abnormally warm, for example, indicating it might have magma under its peak. Also, sulfur dioxide levels dropped a lot in the 1980s, which may indicate a big volcanic event happened in the 1970s, blasting out lots of the gas, which then subsided. Itâ€™s possible, though somewhat speculative, that the entire planet is a supervolcano, a ginormous pressure cooker of barely-constrained magma. Every few hundred million years, the whole surface lets go in a colossal eruption, covering everything in lava. Yikes. Some volcanic features on Venus are different than on Earth. Without tectonics, slow bubbling leaks of lava from the interior of the planet can continue in one spot for a long time. This creates what are called â€œpancake domesâ€•: huge, flat, low domes. Many are dozens of kilometers across, but less than a kilometer high. The lava that formed them was probably really viscous, which is why the domes are flattened and spread out. The searing surface temperature of Venus probably kept the lava hot and helped it spread out more, too. Oh, and one final note: under international agreement, surface features on Venusâ€" mountains, plains, craters, and so onâ€"are all named after women or goddesses of various cultures. This is an homage to the planet itself being named after a goddess, of course, but also? Itâ€™s just cool. Today you learned that Venus is the same size as Earth, but with a super thick atmosphere. A runaway greenhouse effect makes it the hottest planet in the solar system. It has the slowest rotation of any planet, and spins backwards. Tremendous volcanic activity ages ago resurfaced the entire planet, and it still may be active today. Crash Course Astronomy is produced in association with PBS Digital Studios. Head to their channel to 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 co-directed by Nicholas Jenkins and Michael Aranda, edited by Nicole Sweeney, and the graphics team is Thought CafÃ©.