

# **S3\_E13\_Asterism\_MoonsofJupiter**

## **Intro**

Jordan: Hi, I'm Jordan.

Kit: And I'm Kit.

Jordan: Welcome to Starry Time

Kit: Asterisms Edition,

Jordan: where stars plus lines equal stories

Kit: with an asterisk.

Jordan: In these episodes we explore ideas, concepts or people that didn't make it into the main show or items that we just want to talk about a little bit more.

## **Background & History**

Kit: And this week we're going to discuss the astronomy of Jupiter's four largest moons.

Jordan: Also known as the Galilean satellites.

Kit: Jupiter actually has 95 IAU recognized moons, but Io Europa, Ganymede and Callisto are the largest and most well known

Kit: with. our myths and ret constellations episode on Ursa Major and Ursa Minor to kick off season three, we met the final of these characters from Greek myth. So we decided now is the right time to discuss their astronomical forms.

Kit: If you want to know more about their mythological stories and think more about how messed up it is that Jupiter's moons have been named after these people whose lives Zeus, AKA Jupiter ruined, you're just going to have to listen to the following, uh, episodes.

Jordan: Can listen to season one's episode on Aquarius and Taurus to learn about Ganymede and Europa and season two's episode on Cepheus to learn about Io

Kit: Yes, uh, it's not intuitive, but our Cepheus myth episode is about Io and if you're like why? Well you have to listen to the podcast.

Jordan: No further questions will be answered until you do the pre work.

Kit: Yeah, our reason was extremely compelling and uh, you'll have to get into the back catalog to find out. The so called Galilean moons were discovered in late 1609 or early 1610 by the one and the only Galileo Galilei. So using one of his new telescopes, he initially identified three of the moons and thought they were actually fixed stars. Through observation over time, however, he could see that they were moving and orbiting Jupiter. And then he found the fourth object.

Jordan: Which of course was pretty controversial at the time due to the belief that not only did everything orbit around Earth.

Kit: Not true.

Jordan: Well, it's a good guess. Or a guess. And the belief that things could only orbit around Earth.

Kit: Again, false.

Jordan: Well, you know, they're getting started. We should also note here that around the same time in 1609, the records of a much less famous astronomer from Germany called Simon Marius also is recorded as identifying these moons.

Kit: I don't think these guys got along because Galileo accused Marius of plagiarism.

Jordan: Marius. Other claims to fame were identifying what he called the Andromeda Nebula, which we now know is our nearest galactic neighbor In 1612

Kit: shout out to our episodes on Andromeda and again to Dr. Moya McTier's excellent read. The Milky Way in Autobiography of Our Galaxy. So good.

Jordan: Well, in the end we give Marius some dubious credit having named these moons with their current names.

Kit: Yeah, Galileo was much more of a suck up. He wanted to name these moons after Cosmo de Medici because he was looking to get some cash,

Jordan: got run over by a lexus Galileo was working the system, that's all we're trying to say. Other names were proposed in the wild before times before the IAU, including those who wanted to call them Circulatores Jovis or the Jovus Cometis by Johannes Hevelius who we met in our constellation episode Lynx.

Kit: Jaques Ozanam, who was a French mathematician, proposed calling them gardes or satellites. But in the end Simon went out with his proposal in 1614 which he reported came from Johannes Kepler. So he didn't actually even come up with them but, but um, our guy Kepler did.

Jordan: All right, well let's do a quick roundup of each of these large moons, starting with Callisto and then working our way backwards through our podverse.

Kit: Yeah, that sounds great. And we're going to keep these descriptions relatively short and focused on our favorite fun facts because we probably could have done an entire episode on each one of these Galilean moons.

Jordan: And who knows, maybe after we finish the 88 IAU constellations, we'll come back around and do just that.

## **Callisto**

Kit: Uh, our most recent encounter on the pod has been with Callisto so we're going to start here. As you just mentioned,

Jordan: the too long didn't listen background

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Jordan: for Callisto is that Zeus pretended he was Artemis and seduced her. Cool guy Zeus doing his thing. She got pregnant and was then kicked out of Artemis's squad and was turned into a bear when Hera decided to enter the chat.

Kit: And you can head on over to our side Myths and Ret Constellations episode to learn more. The moon Callisto is sometimes called Jupiter 4 because it is the outermost of the four moons. It's the second largest moon of Jupiter and is the third largest moon in our entire solar system at large.

Jordan: To put it into perspective, this moon Callisto is about a third the size of our moon and uh, about the diameter of Mercury.

Kit: Though Mercury is actually more massive than Callisto because Callisto is about 50% ice with some metals and silicates, while Mercury is about 70% metal and 30% silicate.

Jordan: ice you say? Okay, ice suggests maybe water. Water maybe.

Kit: Yes, ice does suggest water. And so Callisto is actually expected to have a salty and likely ammonia filled ocean beneath its very thick icy surface. But other of these moons that we're going to talk about also have water. But this one is the most likely to potentially have life because it's way, way far out, orbiting Jupiter at about five times the moon's orbit around the Earth. And so it's, um, further from the sort of, uh, radiation and magnetosphere of Jupiter.

Jordan: Yeah. Orbits about 1.8 million kilometers away from Jupiter, which of course is very important. We want to stay as far away from the toxic vibes of Zeus, Jupiter as possible.

Kit: Yeah. So obviously Callisto's potential for life is my favorite fun fact about this moon. But there are two others that I want to just throw out there before we move on. So the first is that Callisto has seen some, um, stuff it's heavily cratered in. The cratering on the surface is pretty much the only surface feature of the moon. So astronomers were able to use these craters to estimate the age of Callisto at about 4.5 billion years old. My second fun fact is that a 2003 NASA study called Human Outer Planets Exploration

Jordan: Hope.

Jordan: Yep. Suggested that Callisto was the most viable target for potential human habitation out of all of the Jovian moons. But I got, I got to tell you, the mean surface temperature is -218, 18.5 degrees Fahrenheit. And so I'm gonna go ahead and, uh, pass.

Jordan: Better bundle up. Gonna need a lot of hand warmers, maybe some foot warmers, but. All right, Very, very cold. Callisto we see you.

## **Io**

Let's move on now to Io

Kit: The too long didn't listen for this myth of Io is basically just another mortal woman

Zeus wanted to have an affair with and Hera found out and she turned Io into a cow and harassed her with gadflies. Um, alternatively, Zeus turned Io into a cow to hide her from Hera. But either way, beautiful princess turned into cow is the myth.

Jordan: And you can head over to our episode Cepheus Myths and Ret constellations for more, including what Io has to do with King Cepheus, the husband of Cassiopeia. And the father of Andromeda.

Kit: We have the entire family saga for you in season two.

Jordan: So if you're keeping track though, so far we have turned into a bear, turned into a cow, and we're only halfway done. These four moons, Io is about the same size as our moon, but unlike other moons of Jupiter, it is mostly silicate rock and an iron or iron sulfide core. Its Surface is covered in frozen sulfur. Neat. Or sulfur dioxide, which contributes to this very yellowish, orangish, brownish hue.

Kit: Yum.

Jordan: I, um, mean, it probably doesn't smell great, let's be honest. But that's not gonna be your number one problem if you find yourself on Io So while you're plugging your nose, you should also be on the lookout for the fact There are over 400 active volcanoes and lakes of molten silicate lava on its surface, including a lava Lake that's 126 miles in diameter called Loki Patera.

Kit: Okay, we're getting those Norse gods into the mix. All right. Um, do we know why Io is so volcanically active?

Jordan: Well, Kit, it's actually the result of its location as the innermost of the Galilean moons, which gives it the designation Jupiter 1. It's being pulled on not only by the mass of

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Jordan: Jupiter, but also Ganymede and Europa. The result of this location, and therefore the interactions it has with all these other bodies, is tidal heating, which is what fuels the internal heat and results, luckily, in all these volcanoes, that is.

Kit: Different from what fuels the sort of volcanoes and what's going on in the Earth's core, which is radioactive isotopic decay. But, um, Yikes. Definitely too close to Big Z for my liking. Sorry, Io

Jordan: If the volcanoes are any indication, I don't think Io is too happy being this close to Zeus either.

## **Europa**

Kit: I know that there's actually a lot more we could say about Io but it's time to turn our attention to Europa.

Jordan: Here's the rundown. We got another princess. We got Zeus. In this case, we have Europa, princess of Phoenicia, who Zeus, of course, instantly falls in love with. So what does Zeus do? You know, he's got all the power in the universe. Daddy Z becomes a white bull and mingles among Europa's father's herd. And, um, somehow

gets Europa to climb on his back, where he promptly takes off with her. But, you know, all's well that ends well because she goes on to become, you know, the first queen of Crete. So worth it.

Kit: So it worked out great. And if you have questions about this, um, we did, too. We. We explored this myth in depth in our episode from season one on Taurus, so you can find out more there. The moon Europa, by contrast, is the smallest of the Galilean moons of Jupiter, but it's the sixth largest moon in the solar system. If you've seen any of the Galilean moons, if you've ever seen a picture of one, you've probably seen this one. It's the one that seems to have red brown scrapes across the surface. Despite looking like it's carved with lines, the surface of Europa is really smooth, which is likely due to an enormous saltwater ocean beneath the icy surface. Potentially this ocean has as much as twice the water we have on planet Earth.

Jordan: But what causes the reddish streaks, Kit?

Kit: So it's not 100% known. Scientists believe that maybe they're created in the same kind of processes that create oceanic ridges on Earth.

Jordan: Right. So on Earth, this is caused by, you know, the tectonic plates. As they move apart, magma from the center of the planet will bubble up, cool, harden into rock, which then creates these underwater mountain ranges.

Kit: Exactly. So the idea here is that tidal flexing due to Jupiter's gravity might be causing the crust of Europa to be pulled apart and then maybe water kind of bubbles up. But the question is why these marks seem to be reddish brown. And that still seems to be an open question. We don't seem to have a similar chemical compound on Earth.

So it's hypothesized that it could be the result of hydrated salt or minerals from below the surface. And a recent study from researchers at the University of Washington proposed that it was indeed some kind of salt hydrate. But it's different from what we see on Earth, probably due to that cold, high pressure condition on Europa, but we don't have that condition here. And so I'll be sure to post some more about what folks think it is, um, for anyone who wants to deep dive further. But it's not 100% known at this time what, what causes it.

Jordan: Surprisingly complicated.

Kit: Um, and probably the last and most important mystery of Europa is whether or not it has life.

Jordan: Yes, this is the question that we've been coming back to for the past 20 or 30 years. In general, three components or ingredients for life are liquid water. Ever heard of it? Organic molecules like carbon, hydrogen, nitrogen, oxygen, phosphorus, sulfur, some of our favorites, as well as energy. So we think Europa has liquid water, but what about the other components?

Kit: Well, scientists think that Europa will have the key organic molecules, in part due to when it was formed, as well as via asteroids and comets.

Jordan: All right, tentative check two thirds of the way there.

Kit: So, as for energy, this would be something really different from what we see on planet Earth.

Jordan: So most of the energy here on Earth comes from our sun. And, well, sunlight is something like 25 times fainter at Jupiter and Europa.

Kit: Yeah. So the sun is much fainter and it would have to penetrate that icy Crust. So there's two potential sources of energy on Europa, and the first is radiation from Jupiter.

Jordan: We're lucky we have that icy crust, because it would kill pretty much anything on the surface.

Kit: Exactly. But if the radiation breaks down the ice it could release oxygen, which could be implicated in chemical reactions and energy. All right, so Source 2 could be Tidal flexing due to Jupiter's

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Kit: gravity. If Europa has a metallic core, which is if we don't know, then the interior may be warmed up by this tidal flexing, which would then suggest a rocky mantle in a warm interior where energy could be generated.

## **Ganymede**

Jordan: For now, though, let's turn our attention to the final Galilean moon, Ganymede.

Kit: So too long didn't listen. Ganymede was a mortal youth, by which I'm saying like a teenager who Zeus abducted because he was beautiful. He took Ganymede as a lover, gave him eternal youth, and made him a cup bearer to the gods.

Jordan: For more about Ganymede, check out our episode on Aquarius from season one. The moon Ganymede is the largest Galilean moon and in fact, the largest moon in our solar system. Ganymede has a metallic iron core, a rocky mantle, and an icy shell. It is suspected that it also, like Europa, may have an ocean beneath its icy surface. One of the ways scientists came to this conclusion was by studying its aurorae.

Kit: Yeah, so if you listen to our episode on the science and folklore of Aurora, you know that aurora are caused by a magnetosphere, and, um, most moons don't have one.

Jordan: Ganymede is the only moon in our solar system with a known magnetosphere. And it's a product of its iron core that stays molten due to the gravity of Jupiter, causing tidal heating. When scientists were looking at the aurorae on Ganymede, they weren't wiggling as much as they predicted, based on the interaction between Ganymede and Jupiter's magnetic fields. Which suggested to the scientists that perhaps there was a counterbalancing effect through some kind of conductive body, perhaps

Kit: a, uh, salty ocean. Perhaps

Jordan: there might be six to eight times as much salty water on Ganymede than here on Earth. But scientists aren't sure quite yet. Similar to Europa, Ganymede could also have the conditions for life. But since it's further away from Jupiter and it's bigger, it means there'll be even less energy to create those chemical processes we just talked about with Europa. But again, we'll be learning more when the European Space Agency's Jupiter Icy Moons Explorer, AKA Juice, does its close flybys Of Ganymede in the summer of 2031. One other thing that I thought was fascinating about Ganymede is its relationship with Europa and Io. They are in a 1:2:4 orbital resonance with each other, meaning that for every one orbit Ganymede makes, Europa makes two orbits

around Jupiter and Io makes four.

Kit: Is it science or is it witchcraft?

Jordan: Why not both? Spooky scary. No, no, just kidding. It's science. In this case, what's happening is that as each of these moons orbits Jupiter, they are influenced by both Jupiter's mass, but periodically also by the mass of the other two bodies, which results in this sort of alignment of orbits. Or the 1:2:4 orbital resonance science and Callisto Uh, well, it's orbiting far enough away that it's not locked in this pattern. But a paper published in 2020 suggests that due to tidal dissipation, the inner moons moving out, it will get trapped in, you know, uh, one and a half billion years or so.

Kit: That's something else to look forward to.

## **Outro**

Jordan: And on that note, we definitely covered both a lot and kind of just the icy surface of these moons. But that's what Asterism Edition is for. If we missed your favorite Galilean moon facts, please be sure to let us know over on our socials at starrytimepod on the Universeodon server of Mastodon, which is linked in the show notes.

Kit: There's so much more to say and learn about these moons, and I'm really looking forward to revisiting them again, especially when we get new data from the Europa Clipper or Juice projects. This has been Kit

Jordan: and Jordan,

Kit: sisters, who love stars and stories.

Jordan: And we'll see you next time

Jordan: on Starry Time.

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