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0:00:21.4 Jordan: Hi, I'm Jordan.

0:00:24.2 Kit: And I'm Kit.

0:00:25.5 Jordan: Welcome to Starry Time, where stars, plus lines.

0:00:29.6 Kit: Equal stories.

0:00:31.4 Jordan: For this month, we will be exploring The constellation Andromeda the Chained Lady.

0:00:38.1 Kit: This week's episode will be focused on the astronomy and other cosmic background of this constellation. Andromeda the Chained Woman, or the Chained Maiden, is one of Ptolemy's great constellations.

0:01:00.4 Jordan: Like the other constellations we've covered so far, it is also one of the IAU recognized constellations. It's a rather large constellation at 722 square degrees, which makes it the 19th largest of the 88 IAU recognized constellations.

0:01:16.4 Kit: Yeah. Top 20 is pretty good. It's definitely the largest constellation we've discussed this season.

0:01:21.6 Jordan: But unlike other constellations like Pisces or Taurus that we discussed in season one, Andromeda is a constellation that emerges in the ancient Greek era.

0:01:32.2 Kit: Yeah, and we'll definitely talk about this more in our Myths and etcon episode because Andromeda is the daughter of Cassiopeia and Cepheus, and that whole family is part of Greek mythology. But the stars in Andromeda have been associated with other women figures as well as just completely other things in other cultures.

0:01:52.5 Jordan: You got to stay tuned for next week's episode.

0:01:55.6 Kit: Exactly.

0:01:56.6 Jordan: So let's talk about how to go about finding this constellation in the night sky. When you were looking at it Kit, what were your first impressions?

0:02:04.8 Kit: Well, so I like to start by looking at the IAU official constellation with the lines. And so I did that first and it was so busy and there were so many lines. I felt overwhelmed. And so then I looked for other more simple or like ones without all the other stuff going on. And I guess I kind of could see like a stick figure upside down or on their side and maybe holding like those little devices that you can get to like grab things from high shelves. I don't know. I know this is a bigger constellation than Cassiopeia, but there really wasn't that much distinctive to me when I was looking at it. How about you? Were you able to get to Chained Lady or?

0:02:56.6 Jordan: My first impressions were like I was looking at a subway map, but of a very

uncomplicated city not Chicago or New York, closer to Boston, maybe Seattle, Portland, a light rail system. Yeah. Besides that, it looked again like maybe a taxonomical chart or like some sort of a caterpillar ancestor sort of diagram. But no, I didn't see Chained Lady. I didn't see anything anthropomorphic. I didn't see the lady at all. I saw a lot of points. I saw a central perpendicular and a lot of things extending from it. But besides that, no, there wasn't anything about it that I was like, "Oh, yeah, this is definitely a constellation." And yeah, there's some of them we talk about where you go like, "Okay, I can get it why they form this constellation." This one, it seemed pretty arbitrary to me.

0:03:54.8 Kit: So those probably those descriptions don't help. But Andromeda is a northern hemisphere constellation. It's visible between +90 and -40 latitudes. But unlike Cassiopeia, Andromeda does set. So the best time to see it for northern hemisphere folks is August through January.

0:04:16.1 Jordan: Since we're talking latitudes already for people who wanna know the celestial longitude and latitude, that's also known, of course, as a right ascension and declination. Andromeda's right ascension is one hour and its declination is 40 degrees.

0:04:31.5 Kit: So Andromeda is close to Cassiopeia, as well as the Great Square of Pegasus. So if you're familiar with those more notable constellations, you can kind of find your way to Andromeda in that way.

0:04:41.9 Jordan: Excellent. And as we both mentioned in our first impressions, there are a lot of main stars in this constellation.

0:04:50.1 Kit: 16 of them that make up the sort of humanish non-human figure.

0:04:55.2 Jordan: Yeah, if you're lucky, you can see a human. I see 16 random stars. But yes, we can compare that to the six main stars in Corona Australis, or the five main stars in the W of Cassiopeia from last month. 16? That's a lot.

0:05:13.9 Kit: Yeah. So does there being more stars give you more or less confidence in Bayer's designation being right? I guess is my question.

0:05:23.5 Jordan: I think it gives me more confidence. Hopefully that means there's a greater variability and the brightest star is like 10x brighter than the least bright star. And it makes the differences between them very obvious. I'm hoping for you, Bayer, that's the case.

0:05:43.1 Kit: All right, let's find out. The brightest star in this constellation is Alpha Andromedae.

0:05:53.4 Jordan: Yes, thesis, hypothesis, correct. Me and Bayer, we are on the same page. The more stars, the better. It is easier to find the brightest one in those parameters. Okay, great. Well, tell me more.

0:06:06.4 Kit: Yeah. It's incredible. He's on a real streak. So Alpha Andromedae is also known by the official name Alpheratz, which comes from an Arabic phrase meaning navel of the horse.

0:06:18.2 Jordan: Navel of the horse?

0:06:21.0 Kit: Mm-hmm.

0:06:21.8 Jordan: Wait, we were just talking about a Chained lady. There isn't a horse in this story here, is there?

0:06:29.8 Kit: Not that I'm aware of, but there is a reason, and it brings us back to our very good friend Ptolemy. So when we're thinking back about the Almagest, Ptolemy considered Alpha Andromedae to be shared with the constellation Pegasus, which of course the winged horse, which I mentioned before, that Andromeda is close to that constellation Pegasus. And so this being a shared star, so a star that belonged to both constellations, it was pretty much standard until the IAU began standardizing and separating the constellations more clearly, but it was pretty much just accepted. Yes, this star exists in both constellations.

0:07:11.8 Jordan: Oh, the IAU, so powerful, able to make these hard decisions and separate the star charts and determine where the horse ends and the chained lady begins.

0:07:23.3 Kit: That's important. Great power, great responsibility. So for his part, Bayer gave this star system two designations, Alpha Andromedae and Delta Pegasi, and it also has a series of other non-official Arabic names that were used by medieval astronomers, which have to do with the Chained Women rather than the Winged Horse Pegasus.

0:07:46.8 Jordan: This is a star that's had a lot of names.

0:07:49.6 Kit: Yeah. So Alpha Andromedae is a binary star system with an apparent magnitude of +2.06.

0:07:58.7 Jordan: +2.06, that means it's definitely visible to the unaided eye and pretty bright.

0:08:05.1 Kit: Yeah. It's actually the 54th brightest star in all of the night sky.

0:08:09.3 Jordan: Alpha Andromedae coming in pretty strong here.

0:08:13.8 Kit: Yeah. So both components of the binary system are on the main sequence. The primary or bigger star is a blue B8 subgiant star, and the companion is a smaller A-type star, but both of these stars are more massive and hotter than our sun.

0:08:30.5 Jordan: And our sun, of course, is a G-type main sequence star.

0:08:34.2 Kit: The primary star has also been identified as a mercury-manganese star.

0:08:39.1 Jordan: Well, let me guess, a mercury-manganese star, these seem to be identifying characteristics. Maybe that means the star has more than the expected level of mercury or manganese.

0:08:52.3 Kit: Exactly. It might also have an excess of Phosphorus or Gallium I don't know how to say that. I'm so sorry for all the chemists or people that know these things that I don't. So, yeah, so the primary star does, in fact, have an excess of manganese and xenon. And it earns, then, as a

result, this designation of a chemically peculiar star.

0:09:17.7 Jordan: Slow clap for my co-host Kit, who nailed not only Gallium but also Manganese. As far as chemically peculiar stars go, that's a great name. I can't argue with that.

0:09:32.4 Kit: This designation is just used for main sequence stars. And it's, again, related to the high or low levels of particular metals in their surface layers. Astronomers estimate that between 5% and 10% of main sequence stars have these sort of chemical peculiarities. So they're not completely unusual, but nor are they particularly abundant. So yeah, so chemically peculiar stars can include ones like the primary star in Alpha Andromedae, as well as other kinds of peculiarities.

0:10:03.2 Jordan: And do we know what causes these peculiarities yet?

0:10:07.1 Kit: Well, it seems like astronomers have some hypotheses based on what I read. They seem to think it has to do with diffusion or magnetic effects that happened after the star is formed. So the idea is that these processes, diffusion or magnetic effects, move around elements and deposit them in higher or lower places in the surface layers than expected but underneath it, they're just normal. They're normal main sequence stars at their cores. They're just totally normal.

0:10:39.8 Jordan: Well, to be fair, we all find camouflage, disguise, costume. But at the end of the day. Yeah, it's not surprising that they might just be normal underneath.

0:10:50.2 Kit: So that's the brightest star in the constellation. Now let's move on to our segment, Bayer's Variable Star, where we follow the Greek alphabet to learn more about the Bayer-designated stars in the night sky.

0:11:02.5 Jordan: Well, I'll be honest with you, Kit. I'm a little, well, I'm a lot of meh about the star because there are a lot of interesting Bayer-designated stars in Andromeda. But this one that we happen to have landed on, Theta Andromedae. This star is a binary star system with a primary star that is an A-type main sequence star, which means it is more massive, hotter, and brighter than our sun.

0:11:30.5 Kit: To add to this star being maybe a little boring, I also read the primary star has an abundance of iron, which makes it a chemically peculiar star like Alpha Andromedae but we just we literally just talked about it.

0:11:45.5 Jordan: Yeah. See, Theta, you're not that exciting.

0:11:49.5 Kit: Yeah, not wrong.

0:11:51.3 Jordan: Well, don't worry. I'm gonna come back strong with something really good for Gold Star.

0:11:56.2 Kit: All right. Let's take a quick break and then we'll overshadow Theta Andromedae with something more exciting. Welcome back. This segment is called Gold Star. In this segment, we alternate picking the star or space object in the constellation of the month that captures our mind, our heart, and our soul. So what was your illustrious pick this month, Jordan?

0:12:29.6 Jordan: Kit, it is my great honor to induct into the Gold Star of the month club, Messier 31. Our nearest galactic neighbor, a source of much significance in science fiction, as well as astronomy. Of course, I'm talking about the one, the only the Andromeda galaxy.

0:12:56.1 Kit: Yes, yes. One of the most famous deep sky objects I think out there, for sure.

0:13:01.6 Jordan: And with good reason. The Andromeda galaxy is a barred spiral galaxy, which is much like our own Milky Way. There's just so much information about the Andromeda galaxy out there. So I'll just summarize a few of the things I thought were most interesting about this particular galaxy. And then we can link to some additional places for deep dives in our show notes and on our socials. Does that sound all right?

0:13:27.3 Kit: Yeah. I think that makes so much sense. And that means now is such a good time to follow us on our socials if you haven't already. We're at starrytimepod on the Universeodon server on Mastodon. We are at starrytimepod on Twitter still for the time being. And you can always check out our show notes on our website, which is [www dot starrytimepodcast dot com](http://www.dottstarrytimepodcast.com). And I will definitely link Dr. McTier's book, *The Autobiography of the Milky Way*, because there's a whole arc connected to the Andromeda galaxy where she actually frames, she talks a lot about the science of it, but also frames the Andromeda galaxy as a love story with the Milky Way, and it's really, really good. It's like a beautiful blend of like storytelling and astronomy, so I will also be sure to link that in the relevant places.

0:14:17.6 Jordan: Excellent. So, here's what I think is cool about the Andromeda Galaxy. First, at 2.48 light years away, it is the closest complete galaxy to the Milky Way. If we ignore, of course, smaller, dwarf galaxies that orbit the Milky Way.

0:14:33.8 Kit: Which we do.

0:14:34.9 Jordan: I mean, they're just smaller dwarf galaxies orbiting our galaxy. They're like parasite galaxies. Should we count them? I don't know. Second, in about 4 billion years, something exciting is going to happen whether we like it or not. And that is that the Andromeda and the Milky Way galaxy will collide and form one galaxy. And it might turn out to be a giant elliptical galaxy, or it might turn out to be a lenticular galaxy, or maybe even what's called a super spiral galaxy.

0:15:08.4 Kit: That's scary.

0:15:10.0 Jordan: Well, yes and no. I mean, intersection in astronomical terms is complicated. On the one hand, it's unlikely that many stars will actually collide. Just because when we look at outer space, well, there's a lot of empty space. And on the other hand, things will certainly be ejected out of this new galaxy. So yes, there will be consequences. And a paper modeling the collision suggests that there's a 12% chance that our very own solar system is gonna get the boot during this collision.

0:15:46.4 Kit: Oh, no.

0:15:47.1 Jordan: Will get ejected. The same paper suggests that there's a 50% chance that the solar system would just get cast way further out from the galactic center, but still remain part of this new super galaxy that has been formed.

0:16:02.8 Kit: Yeah, but we're talking four billion years out. So by the time this happens, our sun will be well on its way/a red giant, meaning the earth, if not engulfed in flames, will be very warm, very warm.

0:16:17.8 Jordan: Yeah. We might be grateful to be kicked out from the Galactic Center at that point. It might be like getting put in the freezer for a little while. There are some proposed names for this future super galaxy, such as Milkomeda or Milkdromeda. But I think these all need a little bit of work.

0:16:38.1 Kit: I think that it should just be called Andromeda Way. I feel like that's a place I want to live.

0:16:43.8 Jordan: Same. Yeah, it sounds pretty bougie, actually.

0:16:46.6 Kit: Yeah.

0:16:47.7 Jordan: Alright. A third fun fact about the Andromeda galaxy is that it is more massive than the Milky Way. In fact, much more massive with some one trillion stars. In our Milky Way, it has somewhere between 100 to 400 billion stars. So the Andromeda Galaxy is at least twice as big, if not 10 times as big. This galaxy has a visible magnitude of 3.44, which makes it visible to the naked eye, and a popular astrophotography target.

0:17:23.8 Kit: Yeah. I see tons of pictures of it on Mastodon and there are some truly breathtaking images of it from Hubble.

0:17:31.2 Jordan: And I can't wait to see what the Webb camera shows going forward. Just like our Milky Way has dwarf galaxies orbiting around it. The Andromeda galaxy has 14 or more dwarf galaxies orbiting it. And it also has, like our Milky Way galaxy, a super massive black hole at its center. However, the one at the center of the Andromeda Galaxy is approximately 140 million solar masses. Or maybe even higher by some calculations of the ESA.

0:18:10.1 Kit: Oh my gosh. So Sag A-Star, which is our supermassive black hole, is a measly 4.3 million solar masses. So whoa, that's a big black hole.

0:18:24.1 Jordan: So in everywhere we can think, Andromeda is going big. Which brings me to a last fun fact. Back in 1999, scientists believed that they may have detected an exoplanet with a mass of about six times that of Jupiter, which would be in the star system of Andromeda. And though the results are and still remain speculative, if this discovery were to be confirmed, this would be the first detection of a planet outside of our Milky Way.

0:18:54.3 Kit: Yeah. That is a really interesting finding. It's like all the things we've seen so far have been in our galaxy. So yeah, maybe one day we'll find out amazing stuff from our friend, the Andromeda Galaxy, a illustrious and amazing addition to the Gold Star Club. I mean, I think that the club's reputation would be highly questioned if the Andromeda galaxy was not a member.

0:19:28.4 Jordan: Thanks for joining us today as we explored the cosmic background of the constellation Andromeda. Next week, we'll start retelling and reconstellating the myths of this constellation.

0:19:42.4 Kit: This has been Kit.

0:19:44.3 Jordan: And Jordan.

0:19:49.4 Kit: Sisters. Lovers of stars and stories.

0:19:49.5 Jordan: And we'll see you next time.

0:19:50.9 Kit: On Starry Time.