



Variety | Personality | Companionship



Stars Over Surrey. A monthly guide to astronomy and developments in space with Graham Laycock and Rachel Dutton of Guildford Astronomical Society.

And welcome to the second special edition of Stars Over Surrey. Following the Artemis one mission and with me, I have two fellows of the Royal Astronomical Society, as usual is Rachel Dutton.

Hello Rachel. Hi Graham, how are you? Alright, thank you very much. Still recovering from watching it all and Mary McIntyre.

Hello Mary. Hello everyone. Right. Well it's been quite a mission, hasn't it? An amazing event with the man going furthest from the earth. A new record there, wasn't it? It was amazing. I could speak for most of my fellow space nerds at how emotional we got, seeing, especially people going around the moon and then the landing again, Mary, I don't know how you felt.

All of it was just so emotional. It's been just incredible hearing them, talking about what they were seeing. Just the launch, the splash down, all of it has just been incredible. And what an awesome team they were. And they were so eloquent in their descriptions, weren't they? They were excellent. I mean, there's some so heart wrenching moments like coming around the dark side and getting the communication back after those 40 minutes.

Then I guess the next thing was really, which I was concerned about, was the reentry. Mm-hmm. I think all of us were quite concerned about that. So I'll start talking about why, with Artemis one that was unmanned. We did have two human phantoms on. There was also a space Snoopy representing NASA and a Shawn the sheep representing Issa on board, but originally, the whole thing looked fine.

And then when they took that Artemis one capsule back to Kennedy Space Centre and looked at it in the vehicle assembly building there, they noticed that there was a crack in the heat shield. Although everything inside was safe and. Nothing appeared to be damaged.

There didn't appear to be any problems with the interior. This was a big concern. Heat shields are something we've been struggling with recently. So SpaceX have been struggling with heat shields and Starship. We've been talking about the different tiles that they've had to test, the heat resistance and things like that.

The Apollo heat shields, which was avcoat. Didn't have issues because they were designed as a single large piece with like a honeycomb structure allowing even consistent showering and ablation during lunar returns. But the Artemis heat shields use larger, less permeable blocks that cracked under the unexpected pressure during a new skip reentry method.

So a report back in 2024 by NASA's office of. The Inspector General found that the heat shield failure was caused at least in part by the buildup of hot gases beneath the avcoat during reentry. So for Artemis two, the agency used a different, more porous avcoat formulation that would allow the gases to escape.

Engineers. Then verified in lab tests that a modified skip reentry one with initial dip into the upper atmosphere, followed by a shorter duration climb out, would allow the AV coat to sort of. Breathe, as they called it, preventing the formation of. Cracks and trap gas. And one NASA astronaut, John Oliver, who did two shuttle missions, said that back in January.

He did read all the reports very thoroughly and had very frank and open conversations, not just with the NASA engineers who were working on the heatshield, but also with the four Artemis crew members and. They considered that in their decisions to fly, but he did say that wasn't a warning to them. He was very satisfied with the reports and the data, and he was impressed about how much and how thoroughly NASA had investigated the heat shield.

So it wasn't a warning to them, it was just a full briefing so that they could make up their own minds. Um. And he said that he was around watching the Columbia disaster, and for him it was more of a, I'm a third party astronaut, I've got nothing but their safety in mind. I want to know for myself that this is gonna be safe and then report on my findings one way or another to them.

So these days, NASA, is very safety conscious and Jared Isaacman has even said after the Boeing Starliner incident that he is changing their approach to safety even more, and making sure that they are super conscious throughout the whole decision making process. This was even seen sort of back in February when they made that no-go decision, that they would always say no and err on the side of caution rather than take a risk.

So that was the big concern. Obviously things worked out well for the crew and they splashed down, but we won't know how that heat shield performed until they actually take it back and examine it. So Mary, do you wanna take us through what happened with the landing sequence?

Yeah, certainly. So they, as you said, they were skipping a kind of down and back up out of the atmosphere on the reentry. So first of all, the service module had to separate, and they did that at, 00:33 BST. And then we started the reentry at 00:53 BST. And during that communication blackout, seeing the infrared camera view of what the capsule was going through had me holding my breath, and I, I kind of, it was beautiful to see the infrared view, but also seeing the ablation going on.

You realize just how violent an event this actually is and how important that heat shield actually is. I've never been more relieved in my life as I was when we got the signal back and they started talking again.

Then they were falling so quickly and the two drug shoots opened. There were like a pre parachute, parachute, if you will, two smaller ones to try to slow them down. So they deployed and it felt like so much longer before the main parachutes deployed, even though it was only like a minute or two later, they just seemed to be falling so quickly.

And I was like, please open the big parachutes. They did, and everyone's likening them to the Tunnocks tea cakes, which is one of my husband's favourite treats. And they really are very like that. So Tunnocks need to get on the advertising with that one. So then they splashed down into the sea and everything was okay.

They then had to go through that process of inflating the helium balloons and inflating the raft and going through the, the helicopters coming and winching them up. And this is an area that I feel like. I dunno, we need to, it feels very old school to be doing that there, there has to be a better way of getting them out of that capsule.

It was really, it was just awful. The long wait for them to actually inflate that and get them all out. But the astronauts were amazing, despite all those days in space. They were safe, they were able to walk and the whole thing was just incredible. So it was great to see them come back and when they left the capsule.

They were supposed to leave the plushy behind Rise, and he was like, no, we're not leaving our fifth crew member behind. And he clipped into his belt and brought Rise back out with him, which I think is amazing. I thought that too. And what you were saying about the retrieval, actually I was looking into that a bit more because I was thinking the same thing.

I know they said, look, they're safe, so we're gonna go slowly and make sure that we do it right. But I think it's a mixture of because they went through a lot more of the atmosphere. So the

modules built differently compared to like the SpaceX splash downs on the Dragon capsules because those are a lot faster.

They have hypergolic gasses, whereas it was different gases coming off the Orion module. And also the I module heated up far more than the dragon capsules heat up. So they have to wait long for it to cool down. But like with the dragon retrievals, I dunno if you spotted those boats, they were sort of spiralling in really slowly.

Yeah. So, it looked like they were holding weird devices up, so they were taking the temperature and they had sniffer devices for the fumes. So they had to wait for the fumes to dissipate and the temperature to go down. And then mission control were doing, you know, in flights they have their engine checklists for closing down the engines.

Yeah. They, they were doing the same before they powered down the module. But I did find, I thought it was a bit odd, they put the cuff around to keep the mod, the module inflated, and then put a raft for the front porch, as they called it. But it looked so small. I was like, how are they all standing there?

And they've got four astronauts lying down and it felt very delicate. Then having, Graham, you mentioned earlier, the helicopters sort of coming in, you could see like all the waves coming out around it. Yes. Yeah, I, I was just thinking. It feels very delicate that it might get blown away. Yeah. and I, I wouldn't, I wouldn't enjoy being winched up like that.

No. But we did see the, no, I thought, I thought the worst part for the astronauts was the winch section. I, I think so. That's gonna be really uncomfortable because the webbing attaches to the winch would just be sort of digging in, but it was quite a short journey. And then we saw the helicopters on the flight deck.

We saw them slowly wind down, and then we saw the astronauts sort of sat on with their legs, sort of dangling out the sides, with the helmets off. And they could breathe earth air there the first time in 10 days, which must feel nice to have. The, the sort of sensation of like the wind against your skin and everything.

They were all smiles. They were giving out hugs. We saw the NASA administrator, Jared Isaacman, go over to them. He's done two, space flights himself, and he's a very accomplished pilot. He has his own fighter pilot planes that he flies himself in. The, the latest employee of the month scheme from NASA is that he takes you up on a flight with him, which sounds pretty cool to me.

So, he knows what it's like to hit into the water at rate speeds, although not quite in, the same way. And he's obviously very knowledgeable about aviation safety. So, he went and greeted them rather than do the big press conference. And then we saw them stand up. They had gurneys behind them, but all of them sort of made their way on their own two feet with people either side of them, just to make sure they didn't fall.

But there were big smiles on their faces. They looked to be really happy and in good spirits, so that was really nice to see. After that they were taken to San Diego on the ship. They had a two hour medical assessment, and then they went to sleep and then they have more thorough assessments on land, then they fly back to Houston.

They had even more, medical assessments when they were reunited with their families before they did the press conference on Saturday evening.

## **Rise Mascot**

And what about that mascot rise? Yeah, so Rise was designed by an 8-year-old, uh, from California. It is adorable. And they kept it under wraps. It was secret until the day of the launch, I believe.

Mm-hmm. So he is got a hat on that looks like the earth, and he is got a constellation on the peak of his hat That looks like Orion. It is, yeah. Yeah, it, it's so adorable and I think there's now a huge demand for people to buy these. Like he has really won the hearts of everybody. The plushie went viral, which is amazing.

It must be so incredibly awesome for the person that designed it, that everybody loves Rise as much as we do. Yeah, it's, it's absolutely adorable. So if anyone doesn't know, it's a little moon plushy, but inside there is a chip with about 5.6 million names, including mine. 'cause you could apply to get your input in it, so that would fly to space.

That chip alone has approximately 150 times the total computer storage of the Apollo eight mission, which I thought was pretty cool. But it is absolutely adorable. And apparently the visor was supposed to represent the mystery of deep space and that there's also like an Apollo rocket and an Artemis rocket on the peak as well.

So I thought it was adorable and I, I loved that they brought it back with them rather than left it on the integrity module. So on that note, actually, should we talk about, some of the other items they took in space with them? So the Smithsonian put together like a generic flight kit with them.

And in that, and this is super cool, the crew carried a small piece of the original 1903 Wright Brothers plane on their mission. So this was a one inch square swatch of Muslim fabric on loan from the Smithsonian National Air and Space Museum. And that was from their original flight, and I believe it was on the Apollo Missions two.

And then Artemis one. On that uncrewed flight back in 2022 that carried the tree seeds around the moon. Similar as how Apollo 14 did in 1971. So we've got Artemis moon trees. Mary, I don't know if you've heard about the Apollo moon trees. I haven't. No. So the Apollo missions took seeds around the moon and then distributed them.

So there'd be moon trees and. The Royal Astronomical Society said on one of their podcasts that they're looking to find out what happened to these moon trees. So if anyone knows, do contact either, you know, stars over Surrey or the Astronomical Society because they're really keen on tracing these.

But they carried on that tradition on the Artemis one flight. But on Artemis two, they flew soil samples collected from the base of the Artemis Moon trees that were planted at the agency's 10 centres. And the packets of Earth are representing the full cycle exploration. So launch flight growth, return to space again, as explained by NASA and the Canadian Space Agency will restart that cycle with the tree seeds that it we're flying around on Artemis two to be planted in Canada, which I thought was a really nice sort of legacy thing for them to do.

There's also a copy of a photo taken by the NASA Ranger 7 mission, which was the first NASA successful landing on the lunar surface. They've also got shavings from the SLS system whilst it was being manufactured for luck, although, I dunno about YouTube, but I was a bit concerned about 'em taking metal shavings into space.

Yeah, it seems to be strange. Yeah, a bit risky. I'm hoping in a very well fielded packet. Yeah. Because that's just imagining those floating off and causing problems and then they like all the mission patches and badges and similar things and then personal items. Reid Wiseman took a note down a note card to take thoughts during.

Flights. So like a diary, Victor Glover took a Bible and heirlooms for his wife and children, and then a collection of inspirational quotes compiled by Apollo nine astronaut. Rusty, I can never say his last name, is it? Looks kart, I think. Yeah. Yeah. And then Christina Cook, she took handwritten notes from people that she loves to serve as like a tactile connection between her and them that she could read.

And Jeremy Hanson, the Canadian astronaut, took four moon pendants for his wife and his three children. So I thought that was quite nice. I like the fact they took a remnant of an early aircraft, because you forget how short a period of time there was between the very first aircraft through to.

Going to the moon and supersonic aircraft like Concord, like the period of time is so tiny for how quick that evolved.

Yeah. And it's just such an amazing achievement. So it's great that they, they took that nod to the first flight. Takes me back to, I did go and see where the Wright brothers first, flew Kitty hawk and then there's, you know, did little, I think stones or something in the ground every so often, their first flight.

Then it went a bit further on the second and third flight, and look where we are now, I think. So it is pretty amazing.

## **Space Toilets**

Now, the most important issue of the whole flight, as I understood it, was the non-operating of the toilets. Oh yes. Do you know what, this is the thing people have asked me about the most, and for some reason during outreach events, the people, the thing people ask me about, about space flight is how do astronauts go to the toilet and space?

So one of my favourite facts that I quote a lot is that if you, if you ever see a shooting star that appears to come from the ISS overhead, then you are wishing on astronaut poop. so the initial fault. Almost immediately after launch, the crew reported a blinking light on the toilet, which was found to have a jammed fan used to manage the waste management in microgravity, and Christina decided to become the space plumber.

And as a veteran of previous space flights took on the role of improvising and receiving instructions from mission control on how to fix the system, and then. Later on day two, the crew discovered a separate, more serious issue where the vent line for the wastewater became clogged with experts suspecting a buildup of frozen urine.

So to fix the frozen pipe, the mission controllers instructed the crew to rotate the spacecraft, to allow the sunlight, to hit the vent, to melt the blockage, which I thought was a very innovative solution to toilet problems. And by the fifth, they announced that the toilet was fully functional again.

Whilst the toilet was broken, they did have backup, urine collection devices, so that wasn't the end of the world, but obviously a toilet's far more comfortable. Yes, indeed. Indeed. The first crude, lunar mission that had a toilet, wasn't it? Yeah. So this is why we test Ah, right. And why it had to be a manned mission.

One of the many reasons. Yeah. So, if anyone wants to know more about toilets on various different stages of human space flight are covered up that in the first Artemis special, so you can go back and since the replay, it's just amazing how everything else though just worked perfectly. It is and that was the one thing that, made the news for so many interesting reasons. Well, you can understand it if it's the first time they've had a toilet, uh, in a spacecraft.

## **Yeah. Now, the first ever space to space call took place between humans.**

Yes. So I put between humans as a kind of joke there because obviously we don't know if other space to space calls have happened with other civilizations.

I kind of hope so for any sort of fellow aliens out there, but, you know, I say fellow aliens because obviously we're aliens to them. So on the 7th of April, Houston patched through a call between integrity and the ISS for the first base to space call that we know of, but definitely the first one between humans.

I was super excited about this and you could see their excitement as well. So, on the ISS. Side of the call, they had astronauts, Jessica Meir, Chris Williams, Jack Hathaway, and ESA astronaut. Sophie Adenot. And it was an audio only call, but the ISS did watch the NASA live feed to integrity that we could all see.

So they could see them, but integrity couldn't see them. And when, the ISS astronauts Jessica Meir started talking, there is a slight delay in the feedback that you could hear. You could see their reactions as soon as they, heard her speak. Because they got really happy and excited to speak to their colleagues.

So, they had a 10 minute call. They discussed, Christina and Jessica, they were part of the first ever all female EVA or spacewalk on the ISS back in 2019. And they'd flown together on the ISS before. So, Christina referred to her as my astro sister, space sister, and she'd always wanted to, work with her again.

And she never imagined that they'd fly together in this way. She was really excited about it and she remarked how she missed the views from the ISS every day. The ISS crew asked about the difference in the overview effect. When seeing the earth even further away. So all the astronauts, even people who just go into low Earth orbit for a few minutes and come back, talk about the overview effect and the impact it has on them when they realise there is no true boundaries.

It's just political ones that we draw up between us. And they, the Artemis crew did mention that. When seeing it from further away with all the black space around it, it really highlighted how beautiful the earth is and, how fragile it is, and when you realise that it is literally the only thing like that that we know of in that bar space, how fragile and lucky and special we are to live on such a beautiful planet.

That was a thing that came back throughout the whole mission quite a lot. The integrity crew were asking the ISS crew what they had eaten today and that they were going to match the same thing. Because the, the menu choices they have available is the same. So, one of them had said that they had eaten spicy beans and another one said that they eaten a mango salad, so they were going to do the same.

So that was just quite a nice sort of chat for them to talk to their peers a bit and sort of exchange quips and talk shop a bit about what's going on. And, whilst they knew they were being watched, I think it, it's a bit different to sort of having to perform to speak to a different audience because they were sort of peers talking on the same level as each other.

But it was really lovely to witness. I loved seeing that call between them, but one of the things that really stood out is that. The view of the earth being so fragile. I once got asked a question from somebody that was a bit snippy about space tourism for millionaires and every single person that has ever been on any of the space tourist missions gets a view of earth from high up and gets that sense of how fragile the planet is.

And the more people that get that view, particularly people that have money and potentially power. The better it is for our planet. So space tourism, I know some people are a bit snippy about it, but everybody coming back with that view of earth cannot be anything but a good thing in my opinion. So it's really great that we have a new Earthrise picture and we can all see just how fragile and borderless our planet actually is.

Yeah, good point. Good point. And those pictures are just amazing.

Of course, **one of them was that eclipse.**

Yeah. So. Back on the 6th of April, they had an eclipse that is due to the effect of their position between the moon and the sun. They got 54 minutes of totality. We get like four on earth if we're lucky.

So as a person that's seen solar eclipses, and a full total eclipse, Mary, I was wondering if you could talk us through that a bit more and why they would be studying the Corona and. A bit more about that? Yeah. Well, the Corona is something we can only study during an eclipse. it's so faint and you need the moon to be completely blocking out the sun's light.

This was amazing. There were three planets visible. Uh, we weren't sure whether they would show up, but they did. The three planets showed up on camera. There was Mercury. I believe Venus and

Jupiter were visible. so they were really awesome and there were a couple of other stars in the background as well because of the relative sizes.

A lot of the Corona near to the sun's edges were not visible, but those really faint streamers coming out were. Just gorgeous. And the Sun's Corona is so tenuous and it's a fascination because it's so hot and we don't understand why it's hot. But to see it as such a tenuous it, it was just gorgeous. Like you couldn't see all of the.

Deep lines that you get during an eclipse where you can see the bit, a bit nearer to the sun's limb. So it was a really unique eclipse. It looked very different from any photographs of an eclipse that I've seen before. But the other thing that was a bit odd is that you could see earth shine on the moon because the moon was the phase.

It was, so there's earth shine on one limb, but the rest of the, the moon surface was completely black. So it was. The moon itself looked different during this eclipse because it wasn't a conventional eclipse. So my brain was hurting a little bit, trying to understand the dynamics of exactly what I was seeing.

But it was beautiful. And to get that long and solar eclipse is unbelievably unique. Uh, the normally, like you say, between a few seconds up to about seven minutes maximum. So to have had that long to study the Corona, just incredible. Yeah. And one of the things. One of the reasons why people are really keen to find out more about the Corona is.

It, it is extending so far out, away from the sun and they're still trying to figure out the physics of it and the temperature gradients and things like that. But, astronaut Victor Glover described the streamers, as baby hair that appeared to reach out towards Venus and Earth, and then later he, followed up with, it was like a spotlight at night and then compared it to the crow.

The light at top of the Luxor Hotel in Las Vegas saying it looked like, what that wants to be when it grows up, which, made me giggle and then the other descriptions were bright white glow and a soft ethereal halo. So I implore people to go and take a look at those photos.

Something else I noticed on the eclipse images, these ones, they had the stars and the planets in the background. We don't get that with eclipse images on earth. I got a photograph of Regulus with my eclipse in 2017, but that's the only star that I saw historically. When people have observed eclipses, they have noted some bright planets, but you don't see it very often.

And I think part of the reason for that is that we take such closeup pictures of the Corona. Yeah. So very often it's the zoom lens. You so you are seen a bit in the immediate vicinity of the sun. Yeah. And unless you just happen to have a planet right by the limb, you just wouldn't see those things. But we did see res and it is in my photograph, that's the only star that I remember seeing that day.

But it's an overwhelming experience I so much to see and talk about. I couldn't find the words to describe what I was seeing. I was crying. I was all of the things and there's loads that I probably missed during that experience. I can only imagine how that must have felt then with the Artemis crew. Yeah.

An amazing record they've got there now, haven't they? Yes. I'm sure they'll be pouring over that, uh, back on earth. And we're gonna take a short break and we'll be back with more about Artemis two stars over, sorry. Your monthly guide to astronomy and developments in space on Brooklands Radio.

Stars Over Surrey. Your monthly Guide to Astronomy and developments in space.

Welcome back to Stars Over Surrey, and we're going be talking more about the Artemis two mission with Rachel and Mary.

The lunar observations themselves were dramatic.

Yeah, so part of the reason why, Mary joining me on this call is I don't know anyone who is as familiar very intimately with the surface of the moon as Mary is because she does sketching workshops.

You can go to the Guildford Astronomical Society YouTube page and see one that she did, with us, but, you measure lunar craters for fun. The amount of lunar photography you've done and sketching you've done of the various different aspects of the moon and the talks that you've done on the moon surface.

It makes you the perfect person to talk through, these lunar observations. So I was wondering if, first of all, you could talk us through why humans and being able to choose where they put their camera and how they use their camera is. So important versus something like the lunar reconnaissance orbiter images.

Yeah, so the lunar reconnaissance orbiter is phenomenal. I love the high res pictures that we get from it, but a camera is not a human eye. It's very good at some things, but if you've ever. Got your phone camera out to take a picture of a sunset and realise how different your picture looks from what your eye is seeing.

The human eye is an incredibly well adapted machine that has a dynamic range way beyond anything that a camera can do at this time, technology wise. So while you can get these high res pictures, you don't. The, the same colour. You don't get to change the exposures. The, satellite in orbit is taking its pictures and doing its thing, but you're not getting stuff from the different angles necessarily from the different lighting angles and being able to zoom in on certain features and get the colour balance correct, and just hearing the astronauts describing what they were seeing.

I was emotional, like my heart was just bursting with the way that they were describing these features. And I love the lunar reconnaissance orbiter. I've done so many drawings based on the photographs of it, and not one of them has affected me the way that hearing those human descriptions of them did last week as amazing.

It was, it really affected me as well. And you could hear the excitement and the emotion in the background, of the operational room. Because they had scientists in there. So they did a lot of training on, as part of their mission preparation on, learning different areas of the moon to be able to navigate to the areas that they wanted them to find, and also what they were looking for and how to describe things in.

Human terms, not scientific terms, so that they could just freely describe what they were seeing, but they actually had the scientists in the room with them. So if they were stuck trying to work out what they could see, they could describe what they thought they could see and that would then be validated or the scientists would say, actually, I think you're looking at this crater.

And then they could go to the maps and sort of recalibrate what they were looking at, but they were feeding back their responses and emotions and the excitement. And a lot of Luna scientists were immediately going and taking what was being said straight back and starting to do research on it immediately.

And then also a bit later on. Once they came back from the moon, bearing in mind this was like seven hours of solid observation, they took over 10,000 images. A bit later on they sort of had a further debrief with the scientists where they were asked many more questions whilst it was all fresh in their head.

So, let's talk a little bit about what the things they were looking at and why. So we know the near side of the moon has more mare on it. The far side is very cratered. There's lots of questions about the formation of the moon and what it tells us about the formation of the solar system. So Mary, I was wondering if you can tell us a bit more about what the different colour and albedo brightness, they were looking for.

Yeah, so the mare is basically lava that has flooded certain areas. So the Lunar Seas, as they were called, because in ancient astronomers thought it looked like water because they're much

smoother, they're less crated because it's a newer surface, and all the low line areas. Mostly on the near side. There were very few mare on the fire side.

They flooded with this lava and some of it has a different composition. So the stuff that's very orange is richer in iron. The stuff that has a bluer colour to it is richer in titanium. And then in between that there are some bits that are, are paler blue. There are some bits that are yellow that maybe have some more sulfurous.

Stuff in it. So all of those compositions are are very different and seeing photos up close that have had the colour saturation boosted really gives you a sense of where all those different patches of lava are and all those different compositions. The albedo is a really interesting one because solar, wind actually.

Kind of causes erosion on the lunar surface. It changes how bright features actually are over time. So the craters that are much, much brighter in albedo, they are newer, they haven't had time for the sun's energy to actually diminish those colours. So one that really stood out for me was looking at Aristacus because it is one of the brightest craters and we know that that is a much younger crater and hasn't had time yet for the the solar wind to actually degrade it in any way.

And it was just amazing seeing these craters up close, but also the, the craters were so familiar with on the near side, seeing them on the horizon, like seeing a side view of Copernicus, the really bright regions around the centre of Copernicus being on the moon's limb. It was just breathtaking.

The other thing as well is up close like that. I was seeing these really prominent, brighter ejecta rays that you just can't see as easily from Earth. It was, none of my photographs show ejecta rays in quite the way that I was seen on the pictures from this mission. I, I've got so many pictures that I want to draw.

I've got a massive, massive folder of pictures that I wanna create pastoral drawings of. Yeah. Um. Could you just quickly also explain what the ejector rays are, just in case people don't what that is? Yeah, so when something is impacted the moon, it will obviously cause the crater, but all of the material that was subsurface gets flung out and it forms these, the ejecta blanket immediately around the crater.

And then you get these kind of ribbons of material that gets. Flung out the moon doesn't have an atmosphere, so any impacts are much more violent because things aren't slowed down. And that means that some of the material ejected from a crater can extend all the way up the whole side of the moon. Some of them, it just go hundreds of miles.

They are lighter when they first get ejected. There's a really good experiment you can do to mimic this, by the way. Fill a tray with flour, put cocoa powder on top of it, and then just throw things at it, and you'll see that the stuff underneath that's lighter will get flung out and float down on top of the cocoa powder and completely mimic what a Lunar crater looks like.

And that's exactly what's going on. The subsurface stuff is lighter in colour, has a higher albedo, and that's what we see extending out from the craters. That's one of my favourite outreach experiments to do. Kids love it. actually, whilst we're talking about what those object arrays are, could you talk us through the features of a crater that you look at when you are drawing?

The crater walls are different on almost every crater. Some of them are very smooth, others of them are much bigger and have slumped terraces, and we certainly saw some of that up close. It's a bit like if you dig a hole on the beach and the tide comes in, it's unstable and starts to slump down in layers, so you see that on the larger craters.

Some of the impacts are so violent that it. Liquefies the rock underneath and you get a rebound, which causes a little mountain in the centre of the crater. And seeing some of those up close was pretty awesome. And some of the lunar reconnaissance orbiter pictures of those are breathtaking. So that's the features immediate within the crater.

And then the crater wall is usually higher than the surrounding area. So generally the rule on the moon is anything that is brighter in colour is high ground that's catching more sunlight. So usually crater rims are much lighter and then the ejector blanket comes out and that's not as bright as the crater walls, but is lighter than the surrounding area that the crater's been formed in.

Yeah. So one of the things they were asking them to do, was to look at the photometric changes, the differences, since they were last, sort of imaged up close. And now why would they ask them to do that? They're probably trying to model the erosion that's taking place. There's micro meteorite erosion taking place constantly on the moon, but they're also looking at what the solar wind is doing that causes that this change.

It causes everything to just darken it down by weathering. So there will be looking at the time period, it's taken for it to change albedo by a certain amount, and that will help us date craters more accurately. And just thinking about that as well. They would, they have newer craters. Those would appear on the top, wouldn't they?

So you can date craters that way too. You can. So obviously the Luna Maria, when that area flooded, there would've been no craters in it. And then over time, more and more have appeared. And one thing you can do to. Calculate the age of a surface of the moon or any other planet or moon in the solar system is to look at a particular size block and count how many craters there are because there is a formula that you can work out to find out how old the surface is based on how often it's been hit.

Because impacts happen all the time within our solar system. So you sometimes get craters on top of ejector rays. You get craters inside of other craters. You sometimes get chains of craters caused by the same impact. And the far side is really interesting because there are no Maria. So we've got so many more creators to, to look at.

And actually the one that they named, Carroll, is a very, very new crater that wasn't even on the moon maps, that they took with them. Yeah. Uh, we'll come back to that one in a minute. I was gonna ask you as well about, observations around the terminators, the line between night and day. Because I know that's one of your favourites when you're looking at LRO images to sketch, that's some of your favourite material to mind.

Can you tell us why that is? Yeah. When you ever look at a full moon, when it's illuminated fully from above, you have absolutely no information about the topography of the surface because it's just too brightly illuminated. But where the boundary between night and day is on the moon, that is where you've got the low sun angle, and that gives you the big, long shadows being cast by mountains and crater walls, and you get to see.

All of the different topography. You get to see the wrinkle ridges. You can see lava domes. You can see all of that detail that you just cannot see when it's fully illuminated. One of my favourite things to do is to take loads of photographs or drawings and then repeat it a couple of hours later and see how quickly that landscape changes and it changes remarkably fast.

So it was really interesting seeing what they were looking at around the Terminator and how that changed over time as they were doing their observations. Yeah. I've noticed that as well when I'm looking at the LRO images, it can completely give you a different feel and I, I think you've seen the sketches I did of Plato at Sunrise and sunset essentially, and it just changes the crater completely.

Because you see the different features and the shadows give you a feel for the different heights of the features as well. So it's just breathtaking. it really is. So I wanted to ask you about Lunar Swirls. And there was a particular feature that I know you are, you are very fond of that they, that they mentioned.

So, please take it away on Lunar Swirls, and I'm gonna guess which feature. Anyone who knows me knows I'm slightly obsessed with Reiner Gamma Luna Swirls are very interesting. So as I said before, anything that's lighter in colour generally is high lying. So when you observe it, when the Terminator is nearby under a low sun angle, it is usually casting shadows because it's areas that lie a bit higher.

Reiner Gamma is one of the most prominent areas. It looks like a squiggly tadpole, and it's on the left hand side of the moon. As you are looking at it, it's near the edge, so sometimes it's better viewed depending on vibration. When the terminator is nearby, that thing does not cast any shadows at all.

It's completely flush with the lunar surface, and yet it is incredibly bright. So people were really. Unsure about what this actually was, and we have done magnetic measurements. The moon does not have an iron core that can create a magnetic field, but the magnetic field around Luna Swirls light, Reiner Gamma is much, much higher in that local area.

And we don't fully understand why. it's believed that whatever caused this magnetism is deflecting the solar wind so that the weathering isn't taking place. So it's remaining very high albedo. There's lots of theories about what could cause this. It could be subsurface lava tubes that are kind of solidifying with a magnetic field there, it could have been a common impact.

The reality is we don't know, and the Luna Vertex mission was actually planned last year to go to the moon, land a rover to actually fully inspect these regions and try and answer some of those questions. There's obviously been some issues with NASA funding recent.

For that mission is currently paused, but I first became aware of it because the, the one of the project guys asked me to help with outreach on this mission because they had no budget for that. And I was more than happy to talk about lunar swirls because I love them. So Reiner Gamma isn't the only one, but there is a spectacular photograph with it in the foreground with Aristarchus off to the side.

And it's still my favourite picture from the whole of the Artemis two mission. And I will be creating a pastoral drawing of it, like they're just so fascinating. So Reiner Gamma is about 70 kilometers long, so it's like a wiggly line, 70 kilometers long with like a tad pole's head that has a shape that mimics the D pole magnet field if you put iron filings in a bar magnet.

So it's very, very interesting. There are lots of other lunar swirls as well as that one, but that's the most prominent and the one that we can more easily observe. And you also mentioned Aristarchus. That's a crater that I've drawn with you. so how. Did you feel, and what were your thoughts when they started describing that as well?

The brightness of this crater is incredible, so they believe it's only about 450 million years old, which in astronomical terms is very recent space weathering just hasn't darkened it yet, and those ejector rays from the photographs from Artemis are way more prominent than anything that I've seen. Herodotus is right next to it and the difference between the two is marked.

So Herodotus must have been there a lot longer and some of the eject rays have actually come out and extended over parts of Aristarchus. But the sun rises over the two of them very close together. So I often draw the pair and they're just so beautiful. And the photographs up closed. There's a real bluish hue to those in initial ejector regions. Mm.

It's so bright that it's hard to actually see the features in the centre of it. It has a central peak, but it's really hard to see because everything is so bright. It was so fascinating seeing those sites that we're familiar with just looking so different. Yeah. My brain took a while to sort of really process everything that they were saying.

## **Crater Naming**

So we've mentioned as well, about their suggested names. So there were two new craters and Jeremy Hanson requested, uh, two potential names for them. Now, the IAU are the official people that named Luna Craters, and they requested, one was named after Integrity, their capsule, and one was named after Reed Wiseman's, late wife who passed away in 2020.

Unfortunately after a battle with cancer and. They did say that she was a member of their team. What I really liked about that was the fact that they acknowledged that the families are as much

part of the crew as the actual. Prime crew members because they're there supporting them through the journey.

But Mary, you talk a lot about sort of the names of Luna creators and how many of them and what they're named after. I was just wondering if you could touch on that a bit more for us. Most of the creators are named after prominent men. Unfortunately, there are only about 1.8% of Luna CRA are named after women, so it's really nice.

We now have another one, I believe it's now 32, that are named after women. So the IAU will have had people proposing those names. There were prominent scientists or inventors. There's actually a book that came out last year called *Who's Who in the Moon* that talks about all those people and who they are and what they did and why the creators were named after them.

So the IAU hopefully will approve those. And Carroll was not on the lunar maps. It's a crater that is very new. I was talking to somebody at an astronomy society last night who actually measures Luna craters for fun. He believes looking at the area that this is a very new crater that was only produced about 20 million years ago, which is very recent in astronomy terms.

So it's a very high albedo crater and I really hope that they go with that name because it's awesome. And there is precedent for that before. So they've had, creators named after astronauts, including the Apollo astronauts that never made it to the moon. So hopefully they, they'll take that on board.

But that, that was a really emotional, hard hitting moment. I was sobbing. I was too. And if anyone's curious, Reid did say after they landed that. The rest of the crew had decided that before they even flew, that if they spotted any new craters, that's what they wanted to do. And they asked him if he was okay with that, so that they didn't surprise him.

Whilst he has to keep his, like, professionalism at the hottest and all the rest of it. So, they did ask him in advance, and he said yes, but he couldn't be the one to make the request, as he didn't think he'd be able to hold it in. So I thought that was very sweet and Jeremy made that request for him.

So that shows the very human aspect, and the emotional aspect as well of the mission as well. I'm getting choked up again just thinking about it. I know. We do have some questions from listeners. Before we do, is there any other sort of big things, Mary, that you wanted to mention about either the observations or the overall mission?

I think it's amazing that this mission seems to have captivated the public eye. Again, it's made people interested in NASA again, that they, NASA didn't have an account on threads. They set it up and within 24 hours had 11 million followers. It's been a long time since we've had that popularity around space.

Mm-hmm. And that's only a good thing. You need public support with space missions and this seems to have captivated public support, which is amazing. The photographs are gonna keep people busy for years. The pictures I'm still trying to process all the pictures that I'm seeing, like Oriental Basin, being able to see that up close on a low lighting angle, like all of it is just so much to take in.

And it's gonna keep me busy with my pastorals for quite a long time. And I know everyone will have their own personal angle on why this mission's been amazing. But the, the teamwork between the four of them is just beautiful as well. What an amazing team they were. The outreach has been great and being able to live stream the capsule all the time has been really good.

We feel like we've been there with them and really invested in the mission. So that's just, they've really done that. Right. And it's about time that we have people on board again with space. Because I feel like interest has waned a lot in recent years and I'm glad that that's changing. I think we really felt like we were taken along with them and we were part of their journey too, which was a really warm feeling for me.

Anyway. Well, it's been a fascinating, uh, discussion there, Rachel and Mary.

**Perhaps we can go now to some questions we've had in from listeners.**

**So we'll start with Noah, age 10. How do astronauts sleep? And who looks after the spaceship?**

This one is quite easy one to answer. So they have these sleeping bags that are velcroed and attached to walls in various different places They strap themselves in.

The first couple of times it feels a bit weird because they can't quite figure out what they're doing in space and their, their ears and all the fluids in their body are readjusting. But after about two or three nights, they, they start getting used to it. and who looks after the spaceship? Well.

Mission control, monitoring everything from the ground. And if you go online, you can see, some of the footage of the monitoring, everything that's going on on the ground whilst the astronauts are asleep.

Right now, **Ed from Kingston, he says, given all the Apollo experience and all the ISS experience, why is the mission manned?**

We know how to keep astronauts alive. What's, uh, actual science or engineering has been accomplished by having passengers on the spacecraft? This could be a really long answer, so I'll try and keep it brief. So one we've covered with the lunar observations. Two, it's a test flight. So not only are they checking that the systems work, but they also want to check that humans can monitor the systems.

So a bit like we've got autopilots, but we wouldn't want planes to just be off doing their own thing without pilots there. You want to pilot there to be able to intervene and monitor when necessary they need to train up. Their astronauts to be able to do the same. And thirdly, all these astronauts have different monitors attached to them at all times, giving a lot of data about how they fare in different regimes of space travel, just like they do on the ISS.

And that data is essential for space medicine for us to be able to work out the safest ways for humans to travel around in space. I guess different astronauts have different reactions to a degree. Yep. And project I was affiliated with, we were looking at a difference, in how males and female astronauts were affected by radiation.

So that there is a lot of differences between individual astronauts.

Right. We got **Glen from Kensworth when they were on the dark side of the moon. Did they see any anomalies, where they weren't expecting?**

So when we've got a really good mapping from the orbiters about what all of the sides of the moon looked like.

So first of it's. The far side rather than the dark side. They get equal amounts of sunlight. But when they were looking at the bit that was in shadow, they had a really brief window where they were able to study this theory about whether there were micrometeorite impacts happening all the time, looking for these tiny white flashes that we.

Believed to be taking place and they did in fact find those. So that was amazing. The cameras were not good enough, equipment to actually capture them. They were very brief, very fast, but it just cements that theory of the micro meteorite thing that's constantly happening on the moon. Everything else was just a better of view of things that we've already seen from orbiters.

So as far as I'm aware, there was nothing untoward other than the odd new crater that hadn't been mapped. Right. No little green men. No. Or yellow men for that matter. Yeah.

Right. Uh, **Phil from Dorking, uh, on the ISS, the astronauts exercise every day to maintain their muscle and bone mass. Did the Artemis crew do the same?**

And how do they weigh, how do you weigh yourself in space. It's a good one. It is. So the Artemis crew did. So the ISS crew, they do two hours of exercise a day. The Artemis crew did 30 minutes because it was a much shorter duration trip. they just had the one device on which to do their exercise. And weighing yourself in space.

Obviously when you step onto the weighing scales on earth, you are weighing your mass and the gravity that is pulling your mass down towards the earth. So instead in space, because you can't do that. They have springs and those springs have a certain number of coils that is known, they're made out of a certain material, they calibrate, putting different things on the springs, sort of push them up and down and heavier things cause the springs to oscillate up and down slower than lighter things so they can calibrate the weight based on that clever stuff.

Indeed. Well it's been a fascinating hour. Thank you so much Rachel and Mary, and uh, we look forward to the next Artemis mission. Yes. thank you everyone for listening and wishing you all clear skies and happy star gazing and happy pouring over Artemis Two images and happy, uh, drawing your pastoral shades there, Mary.

Yes, I'm gonna be very busy for the next few months. That was Rachel Dutton and Mary McIntyre, who are both fellows of the Royal Astronomical Society. And there'll be another stars over Surrey on Tuesday the 28th of April at 8:00 PM So do join us then Stars over Surrey on Brooklands Radio. Join us on the last Tuesday, the month at 8:00 PM for the monthly guide to astronomy and developments in space.

## About

Rachel Dutton FRAS is an astronomer and cellist and she looks after outreach at the Guildford Astronomical Society. She presents Stars Over Surrey bringing a monthly review of space news, astronomical matters including a review of the past month's discoveries, events and space missions, Astrocast what to look for in the night sky over the coming month, forthcoming talks and events.

If you want a reminder of when the show is on, and links to the images discussed, [you can sign up here for notifications from Rachel.](#)

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