Constellations Podcast

Episode 118 – Hot Jupiters, Super Earths and Sub-Neptunes

Speaker: Ian Stotesbury, Lead Systems Engineer and Dr. Billy Edwards, Project Scientist, Blue Skies Space– 27 minutes

John Gilroy: Welcome to Constellations the podcast from Kratos. My name is John Gilroy, and I'll be your moderator. Changing things up today, I'd like to open with a quote from a well known American astronaut, Buzz Lightyear. And the quote is. "To infinity and beyond." On the podcast episode today, we're going to exoplanets. That's what we're going to talk about today. We'll go beyond our solar system and discuss how satellites are conducting scientific research into exoplanets. Exoplanet research has been quietly going on for years, and today's guests will discuss how newer mini satellites and alternative business models can bring exoplanets scientific research to a much broader audience at significantly lower cost than is available.

John Gilroy: With us today is not one, but two guests who will take us through the technical issues involved in conducting research beyond the solar system, how the telescope on their satellite differs from those on earth orbit satellites and how their business model differs from others as well. Our guests today work at Blue Skies Space, a company based in the UK that provides space science facilities and is developing a new class of satellites to provide high quality data to the global scientific community. In this podcast, we will hear more about Twinkle their first satellite designed to create new opportunities for transformative scientific research. Welcome to Ian Stotesbury lead systems engineer and Dr. Billy Edwards, project scientist. Gentlemen, are you familiar with the academic work of buzz light year?

Ian Stotesbury: What a model citizen, John. Lovely to be here. Thanks for having us.

Billy Edwards: Yeah, I have to say maybe I've missed some of his work, but I'll look into it after the podcast. I obviously need do my homework.

John Gilroy: Go to the Oxford Library. There's a lot of big journals that he's written for and everything else. So Billy, you are the guy we're going to start off with here. I think the first question should be is okay, what is an exoplanet? How do they differ from the planets and our solar system?

Billy Edwards: Yeah, that's a really a good question to start with, I guess. So to give you the simple answer, essentially, an exoplanet is any planetary body that is outside of our own solar system. So our own solar system, we're all opting the sun. We have eight planets and a whole bunch of other things as well, but exoplanets, we're looking beyond the solar system to planets around other stars, but also some planets that are free floating in space as well, that have been kicked out of their systems. So all of these come under that bracket of, exoplanets. And in terms of how do they differ from the planets in our own solar system? The answer to that is greatly. They're really, really different so far in terms of what we've found. So the diversity there has been really, really staggering.

Billy Edwards: So within our own solar system, what we have is lots of smaller rocky planets, like the one we're all stood on or sat on today, kind of closer to the star. And then the big gaseous planets are much further out like Jupiter and Saturn and so on. But when we started to find planets around other stars, what we found is actually they seemed to be very, very different. And this is a little bit because of our kind of detection bias in terms of which planets are easier to find. But what we found is, for example, planets, we call hot Jupiters. So these are planets that are the size of Jupiter, big gaseous bodies, but they're on all bits of maybe just a couple of days around their stars. So they're really, really close to their stars.

Billy Edwards: They have temperatures exceeding 2000 degrees. You have metals that are gaseous at that point. So these are really hellish worlds, essentially, and a whole variety of other things as well. For instance, we found that some of the most common exoplanets out there are kind of in between the size of the earth and of Neptune. And we don't have any similar planets in our solar system. So this is quite an odd thing to have found that this most common type of planet is one we don't have in our own solar system. So what we've kind of discovered I guess, is that our solar system is really not the standard paradigm and there's a lot of bizarre stuff going on out there.

John Gilroy: So Ian, is this like a science fiction novel here? I mean, rogue planets, brown dwarfs. I mean, you making this stuff up?

Ian Stotesbury: Yeah. Well, I mean, I'm not the scientist, so as far as I know maybe they are.

John Gilroy: Maybe they are.

Ian Stotesbury: Maybe they are. I mean, but what is exciting about this, I mean, I say I'm not the scientist. I studied astrophysics at university, and now I get to work on a mission as the engineer that's trying to discover these things. And it's a really vastly, rapidly growing field of thousands of universities around the world starting to engage properly and seriously in exoplanet research. And we will see, I think it's one of those spaces where we do generally get to imagine, and it might be even crazier than that.

John Gilroy: So Billy, your company has been working on a project called Twinkle. I think it's a satellite set that's going to be launched here in a couple years, maybe 2024. From what I've read, it's going to focus on the study of exoplanets and asteroids. So tell us more about the mission of Twinkle and what you folks hope to accomplish.

Billy Edwards: Yeah, so that's right. So I mentioned that there's this kind of real diversity of systems out there that have been discovered. And kind of the original idea behind Twinkle is what we could do is go and study those planets that we found in more depth and use a method called transit and eclipse spectroscopy to study their atmospheres. So we can look at, for example, the molecules that are present. We can detect things like water or carbon dioxide in their atmospheres, and start to gain an idea of their chemistry and of kind of what's going on within the atmospheres that these planets look at their thermal structure, for example. So how does the temperature change with altitude? Like we have the ozone layer in our own atmosphere, which causes a massive increase in temperature over that land.

Billy Edwards: So looking for kind of similar structure in the atmospheres of these planets. This was the idea originally for twinkle was kind of just to do this. But what we've discovered since is that actually there's a whole host of other science that we could do as well that maybe had not been immediately obvious to us. So much of this is in again, the study of exoplanets and other stuff you could do there. And the study of their host stars as well trying to understand stars and how variable they are and how active they are and things like that, but also objects within our own solar system. And you mentioned asteroids, and that's a really good example of something we're able to study. And there we're looking for what are called reflection spectroscopy. So again, we're trying to understand the mineral composition of these asteroids, particularly look for what we call hydration features.

Billy Edwards: So these are due to water ice, and these are really difficult to detect from the ground because you're looking through an atmosphere that's just full of water. So it's hard to disentangle whether you are detecting our own atmosphere or the band on the asteroids. And this as well as studying asteroids and comets as well, maybe we'll be able to tell us, how did our solar system form and evolve, and how did water get delivered to the earth and those sort of questions that we're trying to answer.

John Gilroy: Ian, the engineer, got an engineering question for you. I assume this project is going to have a space-based telescope on it. So what is it designed to do and how does it differ from imaging or communication satellites?

Ian Stotesbury: Yeah. That's right. So we're an lower orbit mission. I think you're a space podcast, so I'm going to just say it as it is. So it's a lower orbit spacecraft. We're flying about 700 kilometers, sun synchronous orbit. Instead of looking at the ground, though, obviously we're looking out. And we're looking out across the visible and the near infrared wavelength. So from 0.5 microns, rather four to 4.5 microns, which means we have to have our telescope really well cooled. It needs to be cryo cooled down to a low enough temperature that its own mirrors and its own baffle doesn't radiate radiation onto our detector and swamp out what we're trying to look at in deep space. And that's part of the big engineering challenge is pointing out into deep space in a really stable way, but both from a pointing perspective, but also from a thermal perspective. And the telescope's not actually that large. It's about 0.5 meters across at the primary aperture, but it's that sensitivity that we really need to focus on.

John Gilroy: So Billy, I imagine these exoplanets are way beyond our solar system. So this must be a really powerful telescope or must be very sensitive. So maybe you can give us more details on this, please.

Billy Edwards: Yeah. I think the key thing was really highlighted by in there in terms of the sensitivity. Like you said, we're not necessarily the biggest satellite out there, but what is key is having precise measurements. And this is what we can achieve by having a very stable spacecraft. And actually because of some of these planets that I mentioned, these large gaseous planets that are close to their star, the signals that you're seeing from these are actually quite large. So you don't necessarily have to be the biggest telescope out there to be able to detect these and start to figure out what's going on. So there's this whole host of science that we can do with just a relatively modest spacecraft. And so that's why I'm really excited to get doing this and the same with asteroids as well. These are relatively bright and just by going to space and getting above the atmosphere and all the issues you have with trying to observe through that, you can actually get away with a kind of slightly smaller primary aperture.

John Gilroy: So Ian, I have two kids that are engineers. They always ask the engineering questions. So who's building it, and give us some details of who's building it. And why is it so different?

Ian Stotesbury: Yeah. Great. So engineering kids, that's great. They can go into space hopefully. But so yeah, we've got Airbus, which is main European prime for us. So they're developing the platform and payload. And then we're working with ABB in Canada who are developing the spectrometer. The spectrometer is sort of like the heart of the payload. That's where the spectroscopy is happening. So effectively, we're looking, we're sending this light down through the telescope optics and through a prism in effect to split the light into its spectra. And that's how we do the science. We're splitting up all this light into individual bands. And then we're looking at how out different transits, different planets, how their light is absorbed in different ways in these different bands, which allows Billy and the scientists to understand what the atmosphere must have been made of to see that absorption feature happen.

Ian Stotesbury: And I think the difference here really is probably the approach in how we're designing the craft. Traditionally science spacecraft are done by the big, international or national space agencies, NASA, ISA, et cetera. And they're incredible. We're all counting down to the days for James Webb. Depending on when this podcast goes out, we'll either have good news or bad news one way or the other, but James Webb is going to be this truly era defining mission, but it's designed to be pushing every possible boundary, scientific engineering, logistic, and so on. What we want to do is look pragmatically across the space industry and identify what high heritage components can we deliver great science with. Not necessarily push the engineering boundaries, but really push the science boundaries through heritage and pragmatic design and effectively bring that new space model to science.

John Gilroy: So, Billy, I want to ask you a question about astrophysics, but I'm more going to ask you a question about vocabulary in the English language. Boy, the words we're throwing around here today, we're going to impress some people this podcast. Spectroscopy, reflection spectroscopy. So maybe for the mere mortals, Billy, people down here closer to the earth, maybe you can describe what that word means.

Billy Edwards: Yeah, of course. Spectroscopy is a really key thing for Twinkle and is kind of what enables a lot of the science that we're doing as Ian was just mentioning. So by spectroscopy, we really simply mean taking light from any object, say the star in this case, and splitting up that light into different wavelengths, into different colors. So you might want to think back to your science classes back at school, where you took a prism and you put some white light through it, and it splits it out. And you get the rainbow. And it's exactly the same thing we're doing with Twinkle essentially. So we're looking at those visible wavelengths and dividing those up into the different colors and different wavelengths. And then we're also looking into the infrared as well, which is what we kind of perceive as heat and what's cooking of food and so on.

Billy Edwards: But the reason we're doing this is by splitting up the light, we can start to tell how much light we are receiving in each wavelength. And this allows us to be able to get these diagnostics of, okay, in this exoplanets atmosphere, what molecules are there. And this comes about from absorption and emission within that atmosphere and us detecting different levels of light, different wavelengths. And the contrast between these allows us to say, okay, well, this planet's atmosphere must have water or carbon dioxide. And you might also think about it like if people have seen the Fraunhofer lines. If you look at the sun, for example, you get this beautiful spectrum. And then there's black lines where you've got absorption. So it's kind of a very similar thing, except we're not resolving individual lines, but much more broader bands. But yeah, that's the kind of the key concept behind Twinkle and what gives us the ability to do this wonderful science.

John Gilroy: Ian, when Billy uses a phrase splitting light, I think more of a physicist than an engineer. And so you have to use a lot of physics skills in this too, don't you?

Ian Stotesbury: Yeah, absolutely. And that's why we are really careful with picking our industrial partners. So ABB is world renowned for this work, and we're really pondering with them to bring in their expertise. And that's what's quite exciting for me to join Blue Sky Space is that commercially minded approach of where's the world expert, how can we partner with them? What commercial framework and agreement can we get in place? So they're bringing that to the table. And my role as a system engineer is great fun. I get to work with engineers right across the world to deliver this mission.

John Gilroy: Ian and Billy, thousands of people from all over the world have listened to this podcast. Go to Google and type in "Constellations Podcast" to get to our show notes page. Here, you can get transcripts for all 100 plus interviews. Also, you can sign up for free email notifications for future episodes. Dr. Edwards, if you look at Twinkle, it looks like their founding members are renowned international universities. So is academia the primary market for the information you're going to gather here?

Billy Edwards: Yeah. That's exactly right. We've currently, I think, got 14 different institutions from all over the world. I think it's 10 different countries, all different time zones, which makes... We had a meeting a couple of days ago, and it makes scheduling in a time to get everyone online, really difficult, so we were all up at 1:00 AM having these discussions about how they want to use the spacecraft and that sort of thing, which was great, but obviously is always a bit of a challenge there. But yeah, so the idea behind Twinkle is really to provide data to scientists. And this came about because of kind of a lack of available data.

Billy Edwards: And certainly depending on where you come from as well, what region you are based in and what institution you are at. It can be very, very difficult to get access to cutting edge space based data. So the idea behind Twinkle was to really kind of broaden access to space and allow these scientists who have really wonderful ideas of how they would like use a mission like Twinkle and give them the opportunity to try and answer some of the questions that they're really interested in and try and understand more about these planets going forward.

John Gilroy: Ian, I have interviewed hundreds of CEOs of American companies, mostly technology companies. And it seems to be the theme is a lot of an engineering background, lots of EE background, a civil engineering background. So I got to ask the engineer on this podcast, the business question. And so it looks like that you're not the only folks that are researching exoplanet. So how will your technical approach or your business model differ from the exoplanet satellites and their business models, the ones currently being deployed?

Ian Stotesbury: Yeah, that's a great question. So I think really one of the key things to get across is we don't see this as a competitive market right now. We are trying to provide a pragmatic high heritage, new space solution to complement these large agency driven missions. We are going to be celebrating alongside everybody else. We've changed web successes in the near future. But what we hear from scientists right around the world is if I live in a certain region, it's hard to get access to data early. If I live in a certain region, it's hard to be part of the decision making process for what a spacecraft's going to use, going to be used for. And also wherever I am in the world, often the decision-making process of what the spacecraft's going to spend its time on is quite a closed group, and quite a difficult system and applications take a lot of time.

Ian Stotesbury: What we are doing here as a company is really going, we're cutting through that. And we're saying to scientists right around the world, if you come on board, if you join the mission, you're going to be part of a collaborative framework. We are building a big system behind Twinkle which is probably slightly less attractive to news in terms of what we're doing, but we're building this big collaboration platform for scientists to really collaborate together, to coordinate together. Often you'll see submissions to different spacecraft from right around the world that are really quite similar science cases that people are requesting to do. And we're trying to cut through that. We're saying, come on board, join the survey, and collaborate directly before we then made the decision on how those spacecrafts used so that we can really maximize science utilization.

Ian Stotesbury: As I said, just before, we're trying to bring that new space approach. We're trying to identify pragmatic engineering solutions that still deliver great science rather than have a fundamental of pushing engineering in all ways. And that allows us to be much more agile and much more cost combustive than these big flagships, which we do think we'll be collaborative with. Time on Twinkle will be significantly cheaper than time on James Web. That goes without saying, but research done with Twinkle will we think help refine how to use these big flagship missions as well. So hopefully an ecosystem of really positive returns.

John Gilroy: So Billy, when I think about this exoplanet research, it seems of course like an emerging endeavor. And I'm going to borrow a word from Ian. He used the word earlier heritage, and so will traditional heritage business models work? And if not, how will yours different from similar models?

Billy Edwards: Yeah, it's true that the exoplanet field is relatively young. I mean, I think people are theorized about planets around other stars since sort of the ancient Greeks, but when I was born, and this is not to make either you or Ian feel too old, but when I was born, we didn't know of a single exoplanet around other stars. And then over the last sort of 25, 30 years, we've discovered, I think it's now on four and a half-thousand of these. And that's rapidly increasing as we go forward. And what this means is that there's a lot of people working on this now. And it's also a field, I think that is very much in the public eye as well, and that a lot of people are very interested in and one they can engage with.

Billy Edwards: So it's a field that while it's kind of new and up and coming, I guess there's a lot of people working on this and a lot of resources going into this. And you can see this with, how James Webb is going to be dedicating a lot of time to exoplanets, and there are other missions being developed by ESA and NASA as well, focusing on this. So it's really a hot topic. And we can see that from how many people have got involved with Twinkle already and how many people we know are kind of interested in being involved as well. And, so the idea is the heritage component of Twinkle is coming from the engineering and from the instrumentation that's underlying it, but we are just using that for a slightly different purpose. So I guess, the business model that it's maybe most similar to is some of how earth observation is used, where you just kind of remake the same satellite and get data which you can then sell on. The idea, I guess, with Twinkle is kind of similar, but pointing outwards.

John Gilroy: So Billy, when you were talking about when you started your career, there didn't have many exoplanets. And so in America we would use the phrase, Ian, when I was your age, blah, blah, blah. And so I would use that phrase with Ian right now. Ian, when I was your age, we didn't have any software as a service going on, or infrastructure as a service or science as a service. And so some people describe your offering as science as a service. So what does that mean for our listeners?

Ian Stotesbury: Yeah, as far as I'm aware, we're the first mission to offer deep space science as a service. And basically the purpose here is we will take care of giving you easy access to the infrastructure of booking time on the spacecraft, easy access of getting the data down here. That will all be taken care of as part of our offering. And we'll be offering you collaboration tools, access to tools. We are developing the data processing pipelines to help our scientists get access to the data in a timely fashion. And this is also something we are really passionate about. Traditionally, it's been quite hard for scientists around the world who don't have expertise to get involved in fields like this. And we want to offer this collaboration platform and these tools to those scientists too, to remove some of those barriers to entries. There's the geographical, regional, almost political barrier to entry, but then there's also the expertise power entry.

Ian Stotesbury: And we want to try and remove those two through our service. And yeah, I mean, we said it earlier, but we've got nations from right around the world. We've got some really renowned institutions and some slightly less known institutions. And that for me has been really exciting. And we've seen it in those initial calls, and the collaboration's continually growing. Those initial calls where you have some scientists who really have never had the opportunity to collaborate with scientists in the states, for example and it's quite a thing actually. And we think of science as this truly incessant endeavor, and it is in many ways. But when it comes to access to some of these big scientific graphs, sometimes it's a bit less. So we're hoping we can help to remove those barriers too.

John Gilroy: Dr. Edwards, there are a lot of PhDs in the world who are smart like you and doing all kinds of research that's important. So the question that our listeners want to know is why is exoplanet research so important? And and what do we hope to learn from it?

Billy Edwards: Yeah, it's a very good question. I think, for each kind of researcher, I guess the answer to that question is probably slightly different. And everyone has different aims and goals and things they want to know. I think the underlying thing will always be curiosity what is out there. And I think, especially with exoplanets, that's always been one of the questions about are there planets out there? And our ancestors have always looked at the sky and asked questions. And we are now in an era where we can actually start to answer those, which is a wonderful time to be alive and be part of these things. So I think with exoplanet science and with solar system science as well, kind of the key aim I guess, is to really understand how do planetary systems form, and how do they evolve and what are the kind of underlying physical processes that shape our planets from birth right up to what we see today.

Billy Edwards: And I guess that helps us understand not only our own system, but also these are the ones that are out there in the galaxy. And I said earlier that our solar system is quite obviously not the standard paradigm. And so when they started to detect these first exoplanets, a lot of theories of planet formation kind of got thrown out the window. And now we're getting to the point where hopefully Twinkle and these other facilities that we've mentioned are going to start to unlock some of these processes and really give us an understanding of how did we get here and what else is out there as well in terms of planetary systems.

John Gilroy: Yes, Ian.

Ian Stotesbury: Yeah. I want to jump in. I want to add my spin on this. So I'm going to jump on the SpaceX bandwagon briefly. I think mankind, humanity rather should be a space fairing species. And this is a truly inspirational thing that is being done right now, breaking into exoplanet research. I'm not claiming that we'll be there anytime soon, but this is the beginning of foundations of a fundamentally different species. And we're doing that initial research into the future. And inspiration in itself is a wonderful thing. Science should celebrate that part of itself too. And I do outreach into schools and stuff. And this for me is one of the earliest and easiest things to get people engaged in science engineering. And every eye lights up when they first look through a telescope for the first time. Hopefully, every child will love hearing about all these wacky planets, the raining liquid led or whatever it is that Billy finds in the future.

John Gilroy: So, Ian, I'm going to ask you the science fiction lost in space question, I guess this is the 500 pound elephant that's sitting in the room with us here. So will this research lead us to earth 2.0? Is that where we're heading?

Ian Stotesbury: Well, exoplanet in general? I mean, humanity will find 2.0, that will happen. Will Twinkle find it? I think that's an edge case for us, probably best that that Billy takes on the detail there. But we will know so much more about how planets are made and formed as a result of Twinkle's work. And we'll start to understand. We already know we're fairly unique in terms of how our solar system looks. But how unique are these planets? How unique is the atmospheric composition of earth, Jupiter, et cetera? Billy, Earth 2.0, over to you.

Billy Edwards: To answer the question that you gave Ian of, is Twinkle going to find Earth 2.0? My response to that would be a definitive no, but maybe I'm overly cautious on that, just because of how difficult it is to find planets that are Earth-like. I said we found four and a half-thousand or so, but it's really, really difficult to find planets that are on orbits this far out, and that are this small. And we don't really have any good analogs for any planets within our solar system around other stars. So finding Earth 2.0 is a huge challenge, and you need a mission, more like the Kepler, which successfully found many planets or the upcoming Plato mission. So those missions will be more focused on the earth 2.0 direct detection, I guess.

Billy Edwards: But even those will only provide us really with, okay, this planet is roughly on the same orbit as earth, roughly orbiting a similar star, maybe the same radius and mass, same size, but they'll tell us nothing about the atmospheres and that key to the research behind. Twinkle is trying to understand atmospheres, and while we won't be characterizing Earth-like atmospheres, understanding these other atmospheres, as Ian said, is really going to help us sort of understand which planets retain atmospheres for example, and how do they evolve and that sort of thing. So it's not going to directly go towards it because I think the pursuit of Earth 2.0 is a very valiant cause, but it's a really, really tough challenge. I mean, the signals you're looking for, so infinitesimally small, and you have to look over such a long time period. So we'll get there. And this hopefully is a step towards that, along with all these other great missions and observations that are going on. And we are far closer than we were. And I expect over the coming years, we'll get closer, and we'll start to find things that really do seem Earth like.

John Gilroy: Gentlemen, you have given our audience a great perspective on exoplanets and the whole concept of infinity and beyond. I'd like to thank our guests, Ian Stotesbury lead systems engineer, and Dr. Billy Edwards project scientist, and they both work at Blue Skies Space. Thank you.

Ian Stotesbury: Thanks, John, have a great one.

Billy Edwards: Thank you for having us.