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| Jon Spooner: | 00:02 | Hello and welcome to Live from The Space Shed, a podcast all about space and science hosted by me, Jon Spooner and me |
| Mini Jon: | 00:12 | You mean me. |
| Jon Spooner: | 00:12 | Sorry. Yeah, I mean you. |
| Mini Jon: | 00:13 | Mini Jon! |
| Jon Spooner: | 00:16 | Mini Jon! Long story short, a few years ago, I accidentally set up my own space agency based out of the shed at the bottom of my garden. Turns out if you go around telling people you're the Director of Human Space Flight Operations for the Unlimited Space Agency, wearing an orange space suit, more people than you might think want to play along. And now the British astronaut,Tim Peake is our patron and he took me with him to space. |
| Mini Jon: | 00:37 | He took *me* with him to space! |
| Jon Spooner: | 00:37 | Yeah, yeah. Alright. He took *you* with him to space. So Mini Jon became UNSA's first astronaut. |
| Mini Jon: | 00:47 | Woohoo! |
| Jon Spooner: | 00:47 | Since then we've been touring in UNSA's mobile headquarters, The Space Shed to festivals like Latitude and Blue Dot, telling stories, talking to some super cool space and science people, and we've recorded our chats so you can find out about their amazing work as well. |
| Jon Spooner: | 01:07 | MJ? |
| Mini Jon: | 01:08 | Yes, Jon? |
| Jon Spooner: | 01:09 | Guess what? |
| Mini Jon: | 01:12 | What? |
| Jon Spooner: | 01:12 | The Space Shed has only been shortlisted for Shed of the Year! |
| Mini Jon: | 01:18 | Really!? |
| Jon Spooner: | 01:18 | I know right! But we need all of our listeners help to vote for it. |
| Mini Jon: | 01:25 | Come on! |

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| Jon Spooner: | 01:25 | Just go to the homepage of our website thespaceshed.com - the links are all there. It will literally take you 30 seconds to click and make your vote, and it would be mine and Mini Jon's literal dream come true if we could win. |
| Mini Jon: | 01:41 | Yeah! |
| Jon Spooner: | 01:41 | Voting is open until the 29th August, so please get voting. |
| Mini Jon: | 01:47 | Who's in the Shed this week? |
| Jon Spooner: | 01:47 | Oh yeah, the podcast. Right, this week we're talking to cosmologist and dark matter explorer Dr Alexandra Amon. |
| Mini Jon: | 01:56 | Dark matter explorer? |
| Jon Spooner: | 01:56 | Yeah, dark matter explorer. That would make a good band name. "Dark Matter Explorer" |
| Mini Jon: | 02:02 | What is dark matter? |
| Jon Spooner: | 02:05 | I don't know what dark matter is, but "Dark Matter Explorer" would be the heaviest metal band in the universe. You can play drums. |
| Mini Jon: | 02:15 | I want to sing |
| Jon Spooner: | 02:15 | I'm the singer. It was my idea. |
| Mini Jon: | 02:18 | I quit! |
| Jon Spooner: | 02:18 | What do you mean you quit? You haven't even joined. |
| Mini Jon: | 02:22 | You're on your own! |
| Jon Spooner: | 02:22 | Fine. I'll play all the instruments AND sing. |
| Mini Jon: | 02:26 | Sad |
| Jon Spooner: | 02:26 | It's not sad. I get on with me really well. I bet I'd have great musical chemistry with myself. |
| Mini Jon: | 02:38 | Get on with it, Jon. |
| Jon Spooner: | 02:38 | Oh right. Yeah. Sorry. Let's find out what dark matter is with Dr Alexandra Amon, and don't forget to vote for us in the Shed of the Year. Enjoy this episode of Live from The Space Shed. |

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| Jon Spooner: | 03:07 | Hey!! Hello. My name is Jon, Jon Spooner. I'm the Director of Human Space Flight Operations here at the Unlimited Space Agency. Welcome to UNSA's HQ, The Space Shed. Give it up for The Space Shedddddd! I love space. You'd never know, would you? We've been here all weekend. It's been a real joy. It's been beautiful being in your beautiful sunny city. It's always like that here, right? Yep. One of my favourite things about working with Unlimited Space Agency is I get to meet loads of very, very cool, very interesting people, space scientists. And today I'm joined by a brilliant one. Would you please give a lovely Space Agency Newcastle welcome to Alex Amon. [clapping] Alex, hi. |
| Alex Amon: | 03:58 | Hello. |
| Jon Spooner: | 03:58 | Welcome to The Space Shed. Thanks very much for coming today. |
| Alex Amon: | 04:02 | Hi everyone. |
| Jon Spooner: | 04:03 | You are an astrophysicist. |
| Alex Amon: | 04:06 | Yes. |
| Jon Spooner: | 04:06 | Which is just like the coolest job title, right? And you've come down today from the Royal Observatory in Edinburgh. |
| Alex Amon: | 04:12 | Exactly. Yeah. |
| Jon Spooner: | 04:13 | Yeah. And you can answer all the questions that any of us have about anything? |
| Alex Amon: | 04:17 | Everything. |
| Jon Spooner: | 04:17 | Excellent. Okay. But you specialise in a particularly cool thing, right? Which is, you look at the dark side of our universe. So you're like, you're basically like Darth Vader. |
| Alex Amon: | 04:28 | Kind of... |
| Jon Spooner: | 04:30 | You're- It's not a Jedi thing, is it? |
| Alex Amon: | 04:32 | No. So basically everything that we know, our bodies or buildings and books or even stars and planets, they only make up 4% of our universe, 4%, the rest of it is dark. We have no idea really what it is, but we're working hard to try and figure it out. We know that it's called dark matter, 26% of it, and the |

other 70% is called dark energy. But those are just names for things that we don't really understand.

Jon Spooner: 05:03 [Laughs] I mean they're cool names, astrophysicist, dark energy, dark matter, we don't know anything is what you're saying.

Alex Amon: 05:08 Exactly.

Jon Spooner: 05:09 But you're trying to work it out.

Alex Amon: 05:11 Yeah, we're trying, we're working really hard trying to study as much as we can and figure it out.

Jon Spooner: 05:15 And how, how are you doing that? I mean, given that I can't work out how to get into the Shed sometimes and you're trying to work out what 95% of the universe is, how'd you do that?

Alex Amon: 05:25 So we use this technique called weak gravitational lensing. Uh, and that sounds really, really fancy, but the idea is quite simple. So how many of you wear glasses? I can see quite a few of you. So you can't see very well without your glasses, but the glasses work because the light goes through the lens and gets bent just a little bit so that when it hits your eyes you can, your eyes can figure it out better. So that means something is bending the light. It's pretty much the same in space. So we have lots of stuff in space, like big galaxies and clusters of galaxies and they have a lot of dark matter in them. So they're quite massive. And when light from far away galaxies travels all the way to our telescopes for hundreds and hundreds of light years, it gets bent by these structures. So they call it, that's why it's called lensing cause it works just like your glasses lenses. And because the light gets bent, it means that every single picture we take of space is a little bit funny. It's a little bit distorted. So whenever we take a picture of a galaxy, they, they look more, um, their shapes are more elongated so they're less circular. And that's because their light has been lensed by all of the dark matter and dark energy.

Jon Spooner: 06:40 So you have to make a lens that un-lenses the distortion on them.

Alex Amon: 06:44 So what we do is we, this is a really tiny effect, so we measure the shapes, I mean you would think that an astrophysicist has better things to do than measuring shapes, but that's literally all we do. We measure the shapes of lots of galaxies. And I don't mean like 10 or 20. We measured the shapes of hundreds of millions of galaxies across the sky. And by measuring how

distorted their shapes are, it tells us a lot about what the light traveled through. So it tells us about this mysterious dark universe.

Jon Spooner: 07:14 And what's the coolest thing that you've found out about the dark universe? I think from here on in whenever- it shouldn't be dark energy, it should be [said in deeper tone of voice] "Dark Energy". What's the coolest thing about the "Dark Universe"?

Alex Amon: 07:26 [Laughs] So there are two things that we try to figure out, we try to figure out how much dark matter there is and then we try to figure out how clumpy it is. So it's quite interesting because if we use other techniques to study the universe, like the early universe, if we look at that probe of the universe, it gives us slightly different results to what weak lensing shows us. So weak lensing tells us that our universe, it's quite clumpy, when you zoom out it forms like a web of this dark matter and all our galaxies live in the web.

Jon Spooner: 07:54 Wow. I mean it's great language, isn't it? Dark matter, energy, webs, clumpiness, out there, sounds a little bit scary. So this is what you're doing. You're looking out into the universe trying to work it out using telescopes. Do you hang out curled up under a telescope- that's how I like to imagine you, in the observatory, in Edinburgh, curled up with a blanket and a mug of cocoa, staring out of the universe, looking at the webs.

Alex Amon: 08:17 So if anybody here has been to Edinburgh, it's quite like Newcastle where you don't often see the sky. So we don't actually sit under telescopes at all. All our telescopes are based in Chile, which is in South America and down there they have really clear clear skies and it's not as humid as it is here. So we just get the data from them and we actually spend all our days sitting at a laptop coding. So if anybody's learning computer science in school, you want to pay attention.

Jon Spooner: 08:45 You do a lot of coding?

Alex Amon: 08:46 Yeah. So that's all- that's what we spend most of our time doing. It's very rare on days that we, that we sit and look at a nice picture of a galaxy.

Jon Spooner: 08:54 You see to me, that's taken a little bit of the magic away. This is the danger of talking to the scientists.

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| Alex Amon: | 08:59 | I mean we do go to telescopes sometimes, so about once a year you get to go, but most of the time you can just wire that, that uh, those pictures over. |
| Jon Spooner: | 09:08 | I mean that is very cool. I guess that rather than have to move to Chile, or to go and live in, or just to visit, it's a rubbish commute from Edinburgh to Chile. |
| Alex Amon: | 09:15 | Yeah. It'd be pretty long. |
| Jon Spooner: | 09:17 | That you can just be at home. Can you work from home? |
| Alex Amon: | 09:19 | Yeah, exactly. I can just work from home and log on to my laptop and look at all these beautiful pictures of galaxies that no one has really looked at before. |
| Jon Spooner: | 09:27 | That is cool. Who thinks Alex has got a cool job? Yeah! How do we get a job like yours, Alex? |
| Alex Amon: | 09:32 | So you just have to study really hard and sc- [laughs]. Pay attention in computer science and physics and math. |
| Jon Spooner: | 09:39 | Okay, so study. People always say the same thing. |
| Alex Amon: | 09:42 | Yeah. |
| Jon Spooner: | 09:42 | I wish someone had told me this when I was six. Rather than a Space Shed I could be sat under a telescope in Chile looking at the stars. |
| Alex Amon: | 09:49 | Or sitting at home on your laptop [laughs]. |
| Jon Spooner: | 09:52 | Or sitting at home looking at the stars. Can I do that? |
| Alex Amon: | 09:54 | You can! |
| Jon Spooner: | 09:54 | Can I look at? Can I get on the Internet and look at- |
| Alex Amon: | 09:56 | Yeah, you can. You can go onto NASA or the European Space Agency's website and you can see all the images there. |
| Jon Spooner: | 10:03 | Really? So- |
| Alex Amon: | 10:05 | Yeah. So, all of the data that we use, the survey that I'm part of is a European survey called KiDS at the Kilo Degree Survey, and all their data is public because it's European Space Agency data. |

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| | | So you can actually just log on and always look at these beautiful pictures that we measure the shapes of all the time. |
| Jon Spooner: | 10:22 | Okay, well that's something that we can all do when we get home then. |
| Alex Amon: | 10:25 | Yeah, if you have spare time, just flick through those 10 million galaxies and- [laughs]. |
| Jon Spooner: | 10:29 | Or just scroll mindlessly through Twitter, looking at tweets about the football. Or look at the universe, for free! |
| Alex Amon: | 10:37 | Yeah! |
| Jon Spooner: | 10:37 | There's very cool things. The other thing that I really love as well, there's, um, I didn't know this until recently, there's two satellites that sit either side of the sun that are constantly filming the sun. And if you go to I think the Met Office website or certainly the NASA website where you just look up sun live space, you'll go to a website and you can see live footage of the sun. It's really, really cool. |
| Alex Amon: | 10:58 | It is really cool. Yeah. |
| Jon Spooner: | 11:00 | Now, you are working on a very cool project. So I've got, I've written it down because I had to write it down. This is the Large Synoptic, oh look, I pressed a button, Large Synoptic Survey Telescope. |
| Alex Amon: | 11:09 | Yeah. |
| Jon Spooner: | 11:09 | So a less cool name than all the other things. |
| Alex Amon: | 11:11 | Yeah. So, we've upgraded from that one called KiDS. So the new one is going to be called LSST and it hasn't started yet but we get first light, so that's when it first opens its domes in Chile to start observing the universe, and that's happening in about a year. And this one's really cool because it's not really for weak lensing, the people who designed the telescope, don't really care about the dark, about dark energy and dark matter, don't know what's wrong with them. But they're looking for killer asteroids that might obliterate earth. So that's a bit more important arguably. But because of that, they're just going to map, they're just going to keep surveying the southern sky, the entire sky. So the bit of gap, the bit of sky that we've looked at in KiDS is about 10 of your hands on the sky, 10 of your palms. So that's not very big, but it's taken us four years and even that |

amount contains about 15 million galaxies, which is just an unimaginable amount because we live in our own galaxy, the Milky Way. So to think that there's so many others. But the LSST, LSST telescope, will just keep looping over the entire sky every three nights so that we pick up these asteroids, but people like me will grab on to their data and use it to figure out the dark universe.

Jon Spooner: 12:24 Oh, that is very cool. So the research benefits everyone in lots of different fields.

Alex Amon: 12:28 Exactly. It'll just change the entire-

Jon Spooner: 12:31 Will I be able to watch that one? Because that is something that I could definitely spend all my evenings doing because my, I think the seventh best film ever made is Armageddon, which is, which is about how miners go into space to save the planet from an asteroid. Some of you are a bit young for it right now, but as soon as you hit the right age range, I would recommend it.

Alex Amon: 12:51 That's the movie that got me into space.

Jon Spooner: 12:52 Don't, yeah, don't listen to the people that tell you that it's a rubbish film. It's not, it's the seventh best film ever made. But I could look at, could I look at that telescope, the LSST and watch out for asteroids and then I could be like Bruce Willis!

Alex Amon: 13:03 Technically, you can. There's a small problem in that because it keeps going over the sky, it's such an amazing big telescope, it has quite a lot of data. So I don't know if there are any techies in here, but, um, usually when you, your computer will hold about a terabyte of data. Well, LSST will take three terabytes of data every night. So we're still working out, um, how to [laughs], how to manipulate this data so that we can get the information we want.

Jon Spooner: 13:28 Well, thank you for making- for protecting us from asteriods.

Alex Amon: 13:32 But hopefully you can, um, you can download it.

Jon Spooner: 13:34 So this is cool. Computers to study computer science at school, get a job as an astrophysicist, save the world from asteroids and work out what dark energy is in the process.

Alex Amon: 13:44 Pretty much, yeah!

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| Jon Spooner: | 13:44 | [Laughs] Great job. Who's got a question for Alex? Something that you might've always- straight up, yes. What's your, oh, hang on Flight Commander has got a megaphone, high tech piece of kit. |
| Audience: | 13:53 | What would you do if there actually was an asteroid? |
| Alex Amon: | 13:58 | Um, that's not really my job luckily, but I get that, um, I assume that all the governments will have to work pretty quickly to understand what would happen. But we have research projects in place looking for them, so we're pretty sure we're okay for now. |
| Jon Spooner: | 14:13 | It's not unlikely though, is it? |
| Alex Amon: | 14:15 | No, it's, I mean we're probably okay in our lifetime, but for future generations, we need to have the ability to keep surveying the sky to make sure- |
| Jon Spooner: | 14:23 | Anyone with young children, sleep well tonight. |
| Alex Amon: | 14:29 | Sorry [laughter]. |
| Jon Spooner: | 14:29 | But the, the answer is, the answer is as well, a big rock coming from space, unless like in Armageddon, we can send some oil rig workers into space to bury a nuclear missile inside it and explode it, and apparently that's not a very realistic scenario. The Earth's pro- let's not worry about that. |
| Alex Amon: | 14:48 | Moving on. |
| Jon Spooner: | 14:49 | You've already brought everything down. Thanks for that question. Does anyone have, um, I mean we're talking about the dark universe, so this is good actually. What are the really dark questions you've got about the universe? |
| Alex Amon: | 15:02 | Yeah. What's your question? |
| Audience: | 15:04 | How many galaxies have you found so far? |
| Jon Spooner: | 15:06 | Oh, good question. |
| Alex Amon: | 15:06 | That's a really good question actually. So we've looked at, my team has looked at 15 million so far. I mean, I don't even, I can't even count that much to be honest. So it's a pretty big number. Let's put it that way. |

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| Jon Spooner: | 15:20 | When, when you asked that question, were you expecting the answer to be 15 million? |
| Audience: | 15:26 | We were expecting more! |
| Jon Spooner: | 15:26 | More! Love your ambition. |
| Alex Amon: | 15:28 | But that's all that we've looked at. I mean, there are plenty more out there. |
| Jon Spooner: | 15:33 | I like it. Maybe you can join in this experiment. |
| Alex Amon: | 15:35 | Do you know the name of Eric Galaxy. [Audience member answers] Ah, very good. |
| Jon Spooner: | 15:40 | And the next closest galaxy? I learnt this yesterday. |
| Audience: | 15:43 | I don't know the name of that one but I do know it's going to collide. |
| Alex Amon: | 15:47 | Yeah, but not for a long long time. [Laughs]. |
| Jon Spooner: | 15:49 | It's good. We're back on the dark stuff. I like it very much. Yeah. |
| Alex Amon: | 15:52 | That one's called Andromeda. That one's my favorite. |
| Jon Spooner: | 15:55 | Tell us the, tell us about the collision. This is, I think this is really cool, since we're on doing dark side stuff, our Milky Way Galaxy, the Andromeda Galaxy, the next nearest one, they are going to- |
| Alex Amon: | 16:04 | Colide |
| Jon Spooner: | 16:04 | Smash together. |
| Alex Amon: | 16:04 | In a million, I mean in lots and lots of years. But that's quite funny because they're moving together just the same way that we stay around our sun because of gravity, because gravity attracts us. But what I didn't say was what dark matter and dark energy do. So dark energy is actually making our universe expand. And that's a bit strange because we know that gravity keeps things together. So while gravity pulls things, towards each other and keeps them attracted, dark energy is making our universe expand and all the galaxies are getting further and further apart. |
| Jon Spooner: | 16:37 | Thats, thats- How do you know? I mean, we don't know what it is, but we know that it's doing this. How do we know that? |

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| Alex Amon: | 16:40 | We know that it's doing that because we can look at things called supernovae. So that's when, when a star gets really old and dies, like our sun will do in, again, in millions and millions of years- |
| Jon Spooner: | 16:53 | Keep it dark Alex, keep it dark. |
| Alex Amon: | 16:53 | [Laughs] It will explode in this beautiful explosion called a supernova. Uh, and if we look at enough supernova from far away, they are further away than we expect. So it tells us that our universe is expanding and we know that quite well. But it was only discovered in 1990 that that was happening. |
| Jon Spooner: | 17:11 | That's very cool. So we know the universe is expanding- |
| Alex Amon: | 17:14 | Due to some mysterious thing called dark energy. But that's all we got. |
| Jon Spooner: | 17:17 | And that's how we know that the universes, our galaxies, sorry, are going to collide. |
| Alex Amon: | 17:21 | So the galaxies are colliding against that, just because of gravity. |
| Jon Spooner: | 17:23 | So the funny thing to me is, what will happen when the galaxies collide? |
| Alex Amon: | 17:27 | We die. [Laughter] Uh, no, we will be, uh, this will be millions of years from now, so none of us will, um, will be alive anymore. [Laughs]. |
| Jon Spooner: | 17:38 | I heard, I'm loving it so much, I heard that we wouldn't- I mean if we were around, which we won't be because- |
| Alex Amon: | 17:47 | Our sun will die before. |
| Jon Spooner: | 17:48 | Yeah, before that happens. But I was told that actually because everything's so far apart from each other, there would actually be very little noticeable change. |
| Alex Amon: | 17:56 | Yeah. So that's true, cause all the stars are quite far apart. So it's, it's like if you all, if two of you stood far apart from each other and had a bunch of little balls in your hand and threw them at each other, it's quite rare that the balls actually hit each other cause there's so much room in between them. So it'd be quite like that. |

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| Jon Spooner: | 18:11 | So that's okay. We've, we've saved that one, I think. It's not going to happen in any of our life- anybody's lifetime. |
| Alex Amon: | 18:17 | But we'd be fine if it did. |
| Jon Spooner: | 18:18 | Yeah. Excellent. What happens, "we die". Like it. Excellent. Who's got another question for Alex? You have? Hi. |
| Alex Amon: | 18:25 | Hi. |
| Audience: | 18:28 | What's the Milky Way? |
| Alex Amon: | 18:28 | What's the Milky Way? The Milky Way is our galaxy. So we live on a planet, uh, and our planet is one of eight that goes around the sun, and the funny thing is there are lots of suns. The sun is just a normal star. So when you look up at night and you see the stars twinkling, our sun is just like that. It's not any more, it's not any bigger, it's not any more special. It's just that it's much closer to us. So that's why it looked so big. But there are lots and lots of stars and the stars swirl around and they're held together just like our planet goes around the sun every day, which is why we have days and years. The stars swirl around and form a galaxy. It's like a cloud of galaxies. But they swirl in a really nice pattern. You should go home and look, and look one up and see pictures of them. |
| Jon Spooner: | 19:10 | We were told recently, so you can see, so the, all the stars in our galaxy that swirl around, that's the Milky Way, and you can see the Milky Way really clearly from somewhere near here. There's a dark sky somewhere. |
| Alex Amon: | 19:20 | Yeah. So if you go somewhere really dark, so the stars swirl around so that they form like a flat disc that rotates. And so because of that, when it's really, really dark, you can see the disc of stars. We're looking out along the disc, so you can see all the stars in a line along the sky. It's like a strip along the sky. And that's our own Milky Way. Those are just the other stars in our Milky Way. |
| Jon Spooner: | 19:41 | It's very, very super cool. Uh, does anyone know? Is it, I can't remember the name, it's about 60 miles from here it's a dark- [audience member shouts] Kielder? Yes. Kielder. So apparently, if you go to Kielder in the winter and get a clear sky, then you can see the Milky Way really clearly. It's one of the few dark sky sites in the- |
| Alex Amon: | 19:56 | So that's what the Milky Way chocolate is named after. |

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| Jon Spooner: | 19:59 | I think that answered your question. |
| Alex Amon: | 20:00 | Yeah. Chocolate bar, home galaxy. |
| Jon Spooner: | 20:02 | Bit weirded out by the idea that we're in a galaxy. Yeah. [Laughs] Brilliant. I'm glad- but these are some of the assumptions we make, right? Everyone knows what a galaxy is. No. Because how old are you? You're like six. Yeah. And there's no reason why. It's like I found out, um, when I was 33 that uh, I exist in many different places at the same moment in time because of quantum physics. |
| Alex Amon: | 20:25 | Yeah. Let's not go into that one. |
| Jon Spooner: | 20:26 | No, no, we won't go into that, but the thing, the thing that I thought was why didn't anyone tell me that when I was six? Because instead of being really freaked out by it, I'd have just gone, 'oh, well that's, that's an interesting thing to know'. Like gravity, gravity is weird, right? But if you were to- but you're told about gravity when you're really young and the answer is 'why?' And you go 'because that's how it is'. |
| Alex Amon: | 20:44 | Yeah. |
| Jon Spooner: | 20:44 | So you know multiverses. |
| Alex Amon: | 20:46 | My mum still thinks I measure the shape of stars, not galaxies. So it's okay. |
| Jon Spooner: | 20:53 | Who needs to know something about the universe? |
| Alex Amon: | 20:54 | You have another one? Okay. |
| Audience: | 20:59 | How many stars have you found so far? |
| Alex Amon: | 21:00 | So we don't really care about style. Well, I don't really care about style. So style are made of the same things that we're of, which is quite funny. So all the, all the, um, the iron that's in our blood, all the things that were made of that, our bodies are made of, were formed in stars, in the cores of stars. So all of that stuff, we kind of understand. It's a bit boring for cosmologists, which is what, which is the field that I work in. We care about the other stuff. The dark, the dark universe. |
| Jon Spooner: | 21:28 | So you're looking at- so you don't know the answer because you're not even looking for stars. Stars are boring. |

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| Alex Amon: | 21:33 | So, yeah. Well, we found galaxies and each galaxy has stars in it, has a billion stars in it. [audience member shouts] Yes, so many, so many. Lots of stars. Let's just stick with lots. |
| Jon Spooner: | 21:47 | Well yeah, this is the conversation we had yesterday, or earlier today actually. The answer to how many stars are there in our galaxy is 'loads'. |
| Alex Amon: | 21:53 | It's supposed to be more than all the grains of sand on the earth. So if you've ever went, if you ever went to the beach, that's a lot of sand. And that's just on one beach. So if you think of all the sand on our planet, there are more stars than that in our universe. |
| Jon Spooner: | 22:08 | Loads. |
| Audience: | 22:12 | Well I know lots about the universe from [inaudible] books and things like that. |
| Jon Spooner: | 22:17 | And from, and from this conversation today, although actually no, you know all the stuff already, so.[Laughter] Lets, someone ask a question that Joe would find something new out from. |
| Audience: | 22:27 | Do you think dark matter would make like life on another planet? |
| Jon Spooner: | 22:31 | Oh I like it. |
| Alex Amon: | 22:31 | So if we didn't have, so dark matter and dark energy, they have, dark matter is 25% and the dark energy is 70% and if we didn't have that really precise mixture, that exact mixture. So let's say, we had 40% dark matter or only 50, 40% dark energy, whatever that is, then um, the universe wouldn't have evolved in such a way that life could form because dark matter keeps things together. So without dark matter you can't have structures like galaxies and without galaxies then you wouldn't have stars and planets like what we live on. So yeah. |
| Jon Spooner: | 23:08 | So yes. |
| Alex Amon: | 23:09 | Yes. |
| Jon Spooner: | 23:10 | Basically, yes. Dark matter would create, can create life because that's the stuff that's out there. |
| Alex Amon: | 23:16 | Well, without that- it doesn't create life, but without dark matter we wouldn't have life. That's for sure. |

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| Jon Spooner: | 23:21 | It's an important distinction to make. Listen to Alex, not me. |
| Alex Amon: | 23:24 | If you've got dark matter in a jar, you can just whip some life up [laughs]. |
| Jon Spooner: | 23:28 | Although you, that would sell. |
| Alex Amon: | 23:31 | That would sell |
| Jon Spooner: | 23:31 | But that's the sort of thing that would help you with, maybe, another source of income or the work that you're doing. |
| Alex Amon: | 23:37 | [inaudible]. |
| Jon Spooner: | 23:37 | I think you could grow it into something, right? |
| Alex Amon: | 23:39 | Something. Anything. |
| Jon Spooner: | 23:40 | Yeah, yeah. Hands up who would buy some dark en- dark matter in a jar? There you go, look. There's definitely a market for it. |
| Alex Amon: | 23:46 | Yeah, I'll try and work on that. [Laughter]. |
| Jon Spooner: | 23:49 | I'm full of great ideas though, I should be working for you. [laughter] Anything else, anyone would like to? Yes. Yeah. Hi. |
| Audience: | 23:57 | So how do you, how do you know it's 25% and 70%, how would you know the difference between dark energy and dark matter? |
| Jon Spooner: | 24:03 | Good question. |
| Alex Amon: | 24:04 | It's a good question. So dark matter and dark energy. We know what the difference because they, they're, they're very different. Their names put them to sound similar, but dark matter lives around galaxies. So when we, so weak lensing tells you where the mass is in the universe, where all the stuff is. So because the light gets bent around it, if you do weak lensing over a patch of sky, you can make a map of where all the stuff is on that map. Uh, and so that tells us that where the galaxies are, there's a big blob of dark matter around it. This- that just means that there's a big blob of mass around it that we can, it's not like normal mass, it's not like mass that we can measure. It doesn't react with light, so we can't see it. Whereas dark energy is even more mysterious, we also can't see it, which is why we put the dark in the name, but it lives everywhere and it's just driving this expansion of space. Uh, and if we, if we use a |

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| | | combination of, of techniques to study the universe. So if we use weak lensing, um, so by itself weak lensing tells you where the mass is and it tells you if the mass is clumpy. Whereas if we combine that with a study of the early universe, so I don't know what kind of astrophysicist you had yesterday, but we can see if we have, um, a certain type of telescope, so Radio Telescope, then we can see the first light that the universe ever emitted. And that's called the cosmic microwave background. And if you measure that as well as lensing and do your analysis together, you can find out, you can distinguish between the two. [laughs] |
| Jon Spooner: | 25:40 | It's like, it's great, it's like well it's slightly complicated, but- you did a great job there. |
| Alex Amon: | 25:46 | [Laughs] I really tried. |
| Jon Spooner: | 25:47 | We don't know, you trust Alex, that this is the case now, right? |
| Audience: | 25:50 | Yeah, could be complete lie [inaudible] |
| Jon Spooner: | 25:53 | It's not though, is it? |
| Alex Amon: | 25:53 | It's not a lie. So when you turn on your radio and you get static, that's like leftover radiation. Uh, so lots of it is noise, but if you, if you cleaned it of noise, you would still get this leftover radiation. And that's actually left over radiation from the start of the universe that we can still detect. Yeah, called the cosmic microwave background. |
| Jon Spooner: | 26:15 | That's like on old television sets when you turn them on and it's like oh, people moan about it, oh there's nothing ever on tele. Well turn it on and have a look at The Big Bang. There's the beginning of the universe. |
| Alex Amon: | 26:26 | The discovery of that was super cool because people that, the astronomers, I don't remember when, I don't know when it was not the date, but they were trying to clean and clean their telescopes cause they kept getting this background fuzz and they were like, what is this? And they had a pigeon problem near their telescopes. So they thought that it was pigeon poo just contaminating their, their signature. So they kept cleaning the telescope, trying to get all the pigeon poo off. And then only like a few years after when a theorist realised that their observations were actually observing the first light ever emitted by the universe. Not pigeon poo. |

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| Jon Spooner: | 26:58 | Which is cool and there was people, wasn't there- there was a group at MIT or something just down the road that had been properly searching for the beginning of the universe for years and years. And then just down the road there was these two guys going- |
| Alex Amon: | 27:09 | They were like 'what's the pigeon poo?'. |
| Jon Spooner: | 27:09 | 'Oh it's not pigeon poo... It's the beginning of the universe' and the guys down the road were like 'ARGH'. |
| Alex Amon: | 27:15 | If only they had WhatsApp, they could have been telling each other what the, what they were finding and figured it out a lot sooner. |
| Jon Spooner: | 27:20 | I love that story, it's a really good one. Um, does anyone have anything else to ask Alex? Excellent. |
| Alex Amon: | 27:27 | Yes! Question from a girl |
| Audience: | 27:32 | How does the light bend? |
| Alex Amon: | 27:33 | How does the light bend? That is a cracking question. So light just travels along, whatever it can travel. So in the air it travels in straight lines, but then if you wear glasses it does, that is proof that it bends, right? Cause it does fix your vision for you and it's not fixing your eyes, it's just bending the light so that it goes into your eyes the right way. And you can also do this, if you have a glass at home and you shine a light through it, you can see that it makes a circle. So the light just bends. Um, I don't know how it bends, but it just gets distorted because, because if it travels through something made of a different thing. So if it's traveling in the air, it goes in one direction and then it hits your glasses, which are made of glass or if you shine a light through a pool, for example, which is made of water, then it follows a different path because it has something, a different thing to travel through. So whether it's traveling through air or glasses or water or dark energy, then it gets bent a little bit. |
| Jon Spooner: | 28:36 | Cool, right? Yeah. Now you know how light bends, which is a great thing to learn on a Sunday afternoon, I think. Yeah, you look pleased. Excellent. Look, like I say, Alex isn't going to be running away. So if you didn't get a chance to ask a question and you want to then uh, she'll be here. Thank you very much for joining us this afternoon. If you want to find out how to join the Unlimited Space Agency, it is free even though I was begging for money- it's free. Um, there's loads of really fun activities you |

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| | | can do. You can sign up, become a cadet at the Agency and there's loads of uh, Tim Peake is our patron. There's loads of cool activities, free apps to download, that sorta stuff. Just get a card from any of the guys- any of the ground crew with the high vis vests on, they've got cards you can take away. Thank you very much for having us in Newcastle. Could I ask you please to give an excellent Newcastle Unlimited Space Agency round of applause to Alex Amon! |
| Alex Amon: | 29:26 | Thank you. |
| Jon Spooner: | 29:26 | Thank you, Alex. |
| Mini Jon: | 29:30 | Dark matter is weird |
| Jon Spooner: | 29:30 | Dark matter is weird, MJ. Still, at least we know what it is now. |
| Mini Jon: | 29:37 | Alex is cool. |
| Jon Spooner: | 29:37 | Alex is cool. I bet she'd play drums in my band. |
| Mini Jon: | 29:41 | Hmmm... |
| Jon Spooner: | 29:41 | You wait, you'll see. This time next year, Dark Matter Explorer will be headlining the main stage at Latitude while you're stuck in this silly - little - Space Shed. I love the Space Shed. |
| Mini Jon: | 30:00 | Ok... |
| Jon Spooner: | 30:00 | Thanks for listening to this episode - if you enjoyed it please subscribe to Live from The Space Shed on Apple Podcasts, Spotify, Google Play, wherever you get your podcasts. And please if you can spare a moment to vote for us as Shed of the Year you'd be making us all very happy. You can find full details and social links at our website thespaceshed.com. Live from The Space Shed is an Unlimited Theatre production with season one brought to you in association with the Science & Technologies Facilities Council, the Cockcroft Institute, The Space and Arts Council England. With special thanks to Dr Rob Appleby of Manchester University. Our theme music is "Go!" by Public Service Broadcasting used with their extremely kind permission. Our sound engineer and editor is Andy Wood, with additional sound design by Elena Pena. The show is produced by Jon Spooner and Alice Massey with support from our friends at Storythings. Live from The Space Shed is an Unlimited Theatre production on behalf of the Unlimited Space Agency. See you for more |

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| Mini Jon: | 30:51 | Live from The Space Shed! |
| Jon Spooner: | 30:53 | Live from The Space Shed soon! |