RioTinto

Transcript

Things You Can’t Live Without

Episode 9 - Dr Leah Alconcel’s lasers

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Dr Anna Ploszajski [00:00]
Hello, and welcome to Things You Can't Live Without, the podcast in which I, materials scientist, Dr Anna Ploszajski, ask a special guest, what's the one thing they can't live without? Then we interrogate experts on this stuff, how it's made, who made it, and where its constituent components come from. This is because we all know that our stuff has an impact on the planet.

Dr Anna Ploszajski [00:26]
So we want to find out what needs to change in order for us to keep living with these objects in a sustainable future. Joining me today is a spacecraft engineer with over 17 years’ experience working on planetary exploration missions throughout our solar system, including the Cassini mission spacecraft around Saturn, which frankly puts my parallel parking to shame.

Dr Anna Ploszajski [00:47]
She's worked on the full life cycle of space missions from concept and design through to build, launch, operation, and end of life. I'm certain her thing that she can't live without will be out of this world, and I can't wait to find out more. Welcome to the podcast, Dr Leah Alcancel.

Dr Leah Alconcel [01:02]
Thank you very much.

Dr Anna Ploszajski [01:04]
So Leah, tell us, what is the one thing that you can't live without?

Dr Leah Alconcel [01:08]
It's lasers.

Dr Anna Ploszajski [01:09]
It's lasers! A suitably scientific object for someone such as yourself. But as always, we need an expert to take us through the processes, people and raw materials that make up our favourite things. And that expert today is Rio Tinto's Chief Scientist Nigel Steward.

Dr Anna Ploszajski [01:24]
Welcome back to the podcast, Nigel.

Nigel Steward [01:25]
Hi Anna, good to see you again and nice to see you too, Leah.

Dr Leah Alconcel [01:28]
Nice to see you, Nigel. Nice to meet you.

Dr Anna Ploszajski [01:35]
So first, Leah, tell us about your lasers and why you can't live without them.

Dr Leah Alconcel [01:39]
So, lasers have been part of my scientific journey since I was a postgraduate student. I used them then to, they're very big lasers, I used them then as a base component of the experiments that I was doing.

Dr Leah Alconcel [01:49]
So, I used a custom built ND YAG laser, which is neodymium dope yttrium aluminum garnet laser, and also a titanium sapphire laser, which was provided by a company. But it was the, the custom built one that I really loved because you could actually take that apart. You could actually take the rod from the laser out of that.

Dr Leah Alconcel [02:11]
It was water cooled and I only had to do that a couple of times when I, when I was a post grad, but, but when I did get to do it, it was very exciting. And then once I did start working in space, I discovered it. They were pretty much everywhere on, in spacecraft and experiments. Obviously, they're a big part of computer equipment, CD ROMs, DVD ROMs, and, and other components of computer equipment as well as being on spacecraft.

Dr Leah Alconcel [02:36]
So they, they, they're, large and small lasers have been sort of part of my life since, since I started being a scientist.

Dr Anna Ploszajski [02:45]
What are the main uses for lasers?

Dr Leah Alconcel [02:45]
So for the kind of experiments that I was doing when I did my PhD, they were used to break apart molecules. So, we would create a beam of negatively charged ions, and we would fire the laser at the beam.

Dr Leah Alconcel [03:02]
The laser would intersect with the molecules and it would break them apart. And that would help us to understand how different molecules interacted with the light in the atmosphere. So, two examples that I would give are from the Cassini mission.

Dr Anna Ploszajski [03:21]
Tell us more…

Dr Leah Alconcel [03:22]
So in 2017, the Cassini spacecraft, came to an end in Saturn's atmosphere. It, it burned up in Saturn's atmosphere. And the reason for this is that it was running out of fuel, was running out of propellant, and it was considered to be the safest way to dispose of it because Cassini was nuclear powered. So, it was necessary to, to dispose of this radioactive material by burning it up in the atmosphere.

Dr Leah Alconcel [03:42]
And on the JUICE mission, so JUICE is a mission to Jupiter, it's the Jupiter Icy Moons Explorer, that is, well, it's on its way to Jupiter. It was launched last year, almost, almost exactly a year ago. It's, it's still traveling around the inner solar system, picking up speed to try and get, get itself to, to Jupiter.

Dr Leah Alconcel [04:01]
But the magnetometer, which measures the magnetic field, which is not necessarily an instrument that you think that should have a laser on it. But one of the sensors on it is called a coupled dark state magnetometer, which is, and please don't ask me how it works because that is the, the, the one sensor on the, on, on the magnetometer that I, I must admit, I don't fully understand.

Dr Anna Ploszajski [04:25]
It's good to know that even scientists like you need to have a bit of bit of faith sometimes in the instruments that you're working with.

Dr Leah Alconcel [04:30]
Yes. Yeah. But that, that magnetometer, uses, also uses lasers. And again, they're really small. There's these little diode lasers.

Dr Anna Ploszajski [04:38]
I just wanted to ask you about the JUICE mission.

Dr Leah Alconcel [04:40]
So you mentioned that it was launched last year and it's currently whizzing around the inner solar system, picking up speed. Are you going to, at some point, going to slingshot it off the inner solar system and point it at Jupiter?

Dr Leah Alconcel [04:52]
Yes, Yeah. Yeah. So I think it has a couple of swingbys to do of Earth and Venus.

Dr Leah Alconcel [04:56]
And then after that it will start its journey out, out to Jupiter.

Dr Anna Ploszajski [05:00]
How does it feel to have your work out there in space?

Dr Leah Alconcel [05:04]
Oh, pretty good, I have to say. When you, when you see the culmination of, of that, that many years of work. So, the first meeting that I ever attended was in 2010 and launch was last year, 2023.

Dr Leah Alconcel [05:17]
So it's, it's definitely not a game for the impatient, but certainly if you are patient enough, it's, it's really satisfying when you see the end result.

Dr Anna Ploszajski [05:25]
How did you first get into space? You know, what was it that attracted you in the first place?

Dr Leah Alconcel [05:30]
Well, I think I have to blame doing a postdoc at the Jet Propulsion Lab.

Dr Leah Alconcel [05:33]
The Jet Propulsion Lab is in Pasadena, California. It's one of the NASA research centres. While I was there, I was still being a physical chemist, using lasers, to make measurements of chemical reactions. But that is Earth science, which is what the division that I was in is only about 10 per cent of what the Jet Propulsion Lab does.

Dr Leah Alconcel [05:52]
The other 90 per cent is space. And, so, I got to know a lot of people who worked on various missions, including Mars rovers, and I'm talking about Spirit and Opportunity because I'm old. And, you know, I had the chance to see them doing their test drives and, and that sort of thing. And I, visited mission control while I was there, that that was really what got me interested.

[music interlude]

Dr Anna Ploszajski [06:14]
So on this podcast, we're really interested in where stuff comes from and how things are made, but also how things work. And I wonder Leah, if you could do us the honours of taking us through how lasers work.

Dr Leah Alconcel [06:25]
So, I guess the most, the simplest way to think about it is when you, when you switch on a light, you get a bunch of rays of light and they come out sort of in all different directions.

Dr Leah Alconcel [06:34]
There's no, there's no ,control over kind of where they go. You get a, a lovely bright light that you can, you know, you can read by, and, and it helps you see at night, things like that. Whereas when you switch on a laser, what you get is a really focused beam of light. All the little, light rays are going in the same direction.

Dr Leah Alconcel [06:52]
And you can make a tremendously powerful beam in that way. You can make a beam so powerful, it can cut through solid materials. So that's kind of the difference, I think, between what we think of as a normal source of light and a laser source of light.

Dr Anna Ploszajski [07:07]
Okay. And, so this, the colour of light that you get out of a laser is related to the specific material that's, that, that's the core of the laser, right?

Dr Leah Alconcel [07:13]
Yes.

Dr Anna Ploszajski [07:14]
And you mentioned one of those materials earlier. What was the one that you were working on?

Dr Leah Alconcel [07:18]
So the, the main laser that I used was an ND YAG. So that's neodymium doped yttrium aluminum garnet. It was a very lovely sort of coral pink, the little laser rod.

Dr Anna Ploszajski [07:30]
Oh, very nice. I wouldn't have guessed that.

Dr Anna Ploszajski [07:33]
And we'll come on to some of those elements that you just mentioned because that's the theme of our episode. There's one family of elements that are critical to lasers that I want us to particularly focus our conversation on today. And that is the family called the rare earth elements. These sit in the kind of murky corner of the periodic table that you'd be forgiven if you'd never heard of them because we don't tend to come across them in everyday life.

Dr Anna Ploszajski [07:57]
There's 17 rare earth elements in total, including elements like scandium, yttrium that you just mentioned, lanthanum, cerium, praseodymium, neodymium, which you also just mentioned, samarium, terbium, and dysprosium amongst others. A bit of a tongue twister as well. And lots of these are used in these kinds of applications in lasers.

Dr Anna Ploszajski [08:19]
Can either of you tell me why are they particularly useful in these applications? Nigel?

Nigel Steward [08:19]
Well, they allow us to, you know, control the frequency and the type of light that's generated by the laser. So that's their, their, their function, their, they modify the, the type of host material to achieve the frequency and the power of the laser.

Dr Anna Ploszajski [08:38]
Because what we want to get out of it is a specific colour of light. So, we can kind of play around with what the atoms and the electrons are doing inside the materials so that as they generate that light, it's the right colour for the use that we want.

Nigel Steward [08:52]
Exactly.

Dr Anna Ploszajski [08:53]
The name suggests something that they are relatively hard to come by.

Dr Anna Ploszajski [08:57]
And of course, we're really interested on this podcast in where stuff comes from. So, Nigel, I'd love to turn to you now to tell us more about rare earth elements. Firstly, are they actually rare?

Nigel Steward [09:09]
Well, I think the, the, the rarity aspect comes from the fact that, you know, we, we, you know, when we talked about the neodymium yttrium aluminium garnet laser earlier on, aluminium, we're very familiar with.

Nigel Steward [09:21]
But we're not very familiar with these other elements, but they're actually very prolific in our lives, just that we don't hear about them. We hear about aluminium, copper, iron, titanium, elements like that, but less so about the rare earths. So, it's rare in that sense. They're all around us, but we don't see them. They were discovered in the late 1700s.

Dr Anna Ploszajski [09:42]
Okay, so actually quite a long time ago, relatively speaking.

Nigel Steward [09:45]
Quite a long time ago, yeah. And some of them aren't that rare. For example, cerium is about as proliferant as copper is.

Dr Anna Ploszajski [09:52]
Oh, wow.

Nigel Steward [09:53]
But I think what's really made them rare was that despite being discovered a long time ago, they've been very, very difficult to extract chemically.

Nigel Steward [10:00]
So it really wasn't until the late 1940s, early 1950s with the creation of ion exchange technologies that we were actually able to separate all of those rare earths out into their individual elements.

Dr Anna Ploszajski [10:14]
Ah, okay.

Nigel Steward [10:15]
So, the, the, the rarity, maybe it came from the fact that they were just difficult to separate out and extract, but since the 1950s, 1960s, we've been able to extract them very successfully using ion exchange technology.

Dr Anna Ploszajski [10:25]
Okay. So, these are sort of liquid processes and we're talking about ions, not irons, right? It's a bit of a confusing terminology.

Nigel Steward [10:33]
It's an element with a few electrons missing. Yes.

Dr Anna Ploszajski [10:36]
And how do those processes work and how do they compare to other processes of extraction?

Nigel Steward [10:42]
Well, what happens is you digest a rock and you extract all of the rare earths into solution.

Nigel Steward [10:49]
And then what an ion exchange resin does, it captures a particular ion of a particular size. So, all of these individual elements, they have slightly different sizes and characteristics, so you can pick them out one by one. So the only the ion that you want goes into that ion exchange resin. Then you take the resin out and you, you flush it to bring that element back out into solution. And that's the way we extract them.

Dr Anna Ploszajski [11:13]
And, and they form when you, when you effectively dissolve the rock into, is it sort of, what sort of chemicals are you dissolving it into?

Nigel Steward [11:20]
Oh, these are things like, you know, acids, sulfuric acids, things like that, hydrochloric acids.

Dr Anna Ploszajski [11:25]
Leah, did you have a, when you were developing your lasers or working on them, did you ever think about where the materials came from?

Dr Leah Alconcel [11:31]
Not really, no. I think I have to say, I think we kind of, at least when I was a student, I took that stuff for granted. You know, you, you, you bought what you needed in order to, to run an experiment and, and, as long as it was available, you know, that was, that was enough. I did have a sense of how valuable the core, those core elements, were.

Dr Leah Alconcel [11:52]
So the, for example, the rods that were used in the, in the YAG laser, those were very expensive and fragile. And so handling them was non trivial. I remember the first time I ever had to take apart the laser head and actually remove the rod, I was sweating bullets because I really didn't want to break it. I didn't want to have that.

Dr Anna Ploszajski [12:11]
Don't drop it. Don't drop it.

Dr Leah Alconcel [12:12]
So, so I did, I did have a sense of the, of the value of, not necessarily the process by which the elements themselves were extracted, but of how difficult it was to create this sort of crystal matrix to capture them.

Dr Anna Ploszajski [12:28]
Nigel, in terms of the economics of extraction, are rare earth elements, especially valuable? Expensive?

Nigel Steward [12:36]
Yes, they, they command a very high price. Some of them in particular which, which, which are very rare. So, we, we find rare earths in two principal mineral sources. You have to mine, or you extract them from mineral sands. What we tend to find is that cerium is actually quite prolific.

Nigel Steward [12:54]
So you can extract a lot of cerium, but you need to extract a lot of cerium to get some of the other elements, things like dysprosium. So, in the end, because we need to meet dysprosium or neodymium needs, we end up overproducing, you know, the amount of cerium. So, there's usually a cerium and lanthanum surplus to get all of these important rare earths that we need in lasers and for many other uses as well.

Dr Anna Ploszajski [13:17]
And where does that excess go?

Nigel Steward [13:20]
It goes into, it tends to go into stockpiles and the price of cerium, because the supply is high, is very low. So, your cerium is actually relatively inexpensive, whereas elements like dysprosium are very expensive to buy.

Dr Anna Ploszajski [13:32]
Leah, did you have any other questions for Nigel about rare earth elements, where they come from, how we're extracting them?

Dr Leah Alconcel [13:39]
I'd be interested to know the two, mineral, the two ores that you get, the rare earths from. What does, what does it look like when you take it out of the ground, I guess?

Nigel Steward [13:49]
Well, they're just rocks.

Dr Leah Alconcel [13:50]
They're just rocks. Okay. There's nothing special about them. There's nothing unique about their appearance.

Nigel Steward [13:55]
No, what's special about them is that they contain rare earths. Yeah.

Dr Leah Alconcel [13:59]
Wow. Okay. So how do you find where they are?

Nigel Steward [14:03]
That's a really interesting question. You have to drill a lot of holes. And we kind of roughly know where things are, things are found and you can use indicators and we use a lot of indicators, what we call exploration vectors to try and find and identify resources.

Nigel Steward [14:19]
It's not easy, but this is the world of exploration geology. One of the things that we have used in the past is, you know, radioactive tracing because these rare earths are often associated with uranium and thorium and you can scan the surface and identify radioactive hotspots using very, very sensitive pieces of equipment.

Nigel Steward [14:38]
So, that gives you a lead indicator as to where you can find some of these rarer earth ore deposits like the monazites and the basinazites.

Dr Leah Alconcel [14:46]
I'm having visions now of a slightly more serious version of the detectorists going around looking for these very fake radioactive signals to find, to find the ores.

Dr Leah Alconcel [14:58]
So it, the detectorist was about a couple of, amateur metal detectorists who go around and looking for treasure as a detectorist do, but in, in the process they end up finding an awful lot of other stuff and making some very funny jokes.

Dr Anna Ploszajski [15:12]
And are those detectors by any chance based on laser technology to take us back to our topic?

Nigel Steward [15:18]
Well, sometimes we use, you know, LiDAR.

Dr Anna Ploszajski [15:21]
There you go. Another use for lasers.

[music interlude]

Dr Anna Ploszajski [15:26]
Now, Leah, On this podcast, we do try and give people hope for the future, that's for sure, particularly a sustainable future, but we're under no illusion that this transition to a more sustainable future is going to be plain sailing the whole way.

Dr Anna Ploszajski [15:39]
There may well be a version of the future in which we've, you know, either used up all our rare earth minerals or it becomes too expensive or costly energy wise to mine and process them, in which case you may be without your beloved lasers. In that imagined future, how will you cope as a scientist?

Dr Leah Alconcel [15:59]
I don't know.

Dr Leah Alconcel [16:00]
Probably quite badly. We're really very dependent on them. And also it's one of the, it's one of the hopes for the future for space communications. So, as we put more and more satellites into earth orbit. And as we start to look at potentially establishing remote habitation on, on other planets, or, or even if it's not humans, having robotic exploration outposts in, in other, other parts of the solar system, laser communication is, is considered to be kind of, one of the, one of the ways of the future.

Dr Leah Alconcel [16:31]
The, the volume of, of data that you can communicate is much higher using lasers than it is using conventional radar. And if you don't have the obstruction of an atmosphere, then, then certainly, optical communication can, can, between laser based optical communication can travel a really long way in near vacuum with no obstruction.

Dr Anna Ploszajski [16:53]
But if we don't have that, then we won't be able to talk to all of the different spacecraft that are out there. And, you know, potentially even the other, yeah, the other kind of people that might be living elsewhere in the solar system. And of course, through fibre optics, our internet is light based these days.

Dr Anna Ploszajski [17:08]
So would you effectively be able to get Wi Fi on Saturn from the Earth if there were lasers? Would that work?

Dr Leah Alconcel [17:16]
Yes. I mean, that's kind of, yeah. It would be. Yeah.

Dr Anna Ploszajski [17:22]
I love that. I love that idea that you could, yeah, you could watch all your TikTok videos on Saturn if you were chilling out there.

Nigel Steward [17:29]
It's interesting listening to, it's interesting listening to you just describing space and, and, you know, all those technologies that were developed for space have actually been brought to Earth and we use them every day as well today.

Nigel Steward [17:42]
I'm, I'm, you know, I'm thinking about, you know, laser scanners that you have when you go to the supermarket and shop. You think about all the optical cables that that, that are serving the internet, and they all have lasers, basically, communicating down those optical cables. Many of the things that you've talked about with the analysis of lasers, that's the way we, you know, we've been analysing core samples when we when we're searching for new minerals, we use laser induced breakdown spectroscopy to do that.

Nigel Steward [18:14]
And it greatly speeds up, you know, our rate of discovery, using that particular technology. So, there are many things that, that have been brought from space and the development of space technology to sort of Earth that we use every day and, and, take for granted.

Dr Anna Ploszajski [18:28]
Yeah, absolutely. Nigel, that's really interesting that you mentioned, the work of Rio Tinto and discovery and working out what materials are there and how to process them that that uses lasers as well. They clearly are much more ubiquitous than most of us realise.

Nigel Steward [18:45]
Yeah, exactly. You know, in mining, I mentioned the exploration side of things, but we deployed autonomous haul trucks in some of our mines a few, about 12 years ago now. And of course they use LiDAR systems. That's the way the truck navigates.

Nigel Steward [18:58]
That's the way it knows what's around it. You know, and in just our everyday work because lasers are so accurate. We use them to position things within our processes very, very accurately. So, we use lasers there and of course we track things as we go through our process. So, things like spare parts, they all have barcodes or QR codes.

Nigel Steward [19:17]
We scan them. We, we, we, we track them. That goes into information systems. So, we track what's going on and then, you know, we have to communicate with everybody around the world. We're a global company and we use all of these optical fibres and which are powered by lasers, essentially. So, it's a very, very important part of our business, but also a very, very important part of our day to day life.

Dr Anna Ploszajski [19:38]
Life as we know it wouldn't be the same without lasers. And, and we, they may be hidden. We may not realise it, but all of our data and technology, it really relies on this stuff. So, we can't really face a future that would be recognisable without these rare earth elements. They really are the key, the key to that.

Dr Anna Ploszajski [19:56] And so if we want to live in a sustainable future where this stuff is still available that we are extracting and processing it sustainably, Nigel, can you paint a picture for us? What's the current state of play of the impact perhaps on the planet and of the people of mining these rare earth elements?

Nigel Steward [20:16]
Well, I think the main challenge is that they are, you know, found in relatively low concentrations. You know, the exception is cerium, but the rest of them are found in very, very low concentrations. So, when you extract a rare earth element, you do naturally generate an awful lot of waste. The second thing is, as I mentioned earlier, some of these ore deposits, they're associated with uranium and thorium.

Nigel Steward [20:35]
So you end up concentrating uranium and thorium. So, you have to find a use for that in the nuclear industry. So those are the, probably the biggest challenges that we face with respect to, you know, to rare earths. And I think this is why people are starting to think about, well, how do we recycle more? A great example in the digital world.

Nigel Steward [20:53]
I mean, we're all used to our computers, our iPads, our iPhones, you know, and we stare at these screens, our TVs and those, those phosphors. They create the red, green, and the blue europium, terbium, and yttrium, they're rare earths. So, literally when you look at your screen on your phone, your computer, the TV, you're staring at rare earths.

Nigel Steward [21:15]
So they're kind of ubiquitous, they're everywhere, not just in lasers. The rate at which kind of we're growing as a society will always need to produce more. So, the other, the other thing that we can do is start to, as I mentioned earlier, start to look at whether we find rare earths in our existing ore bodies that we're using to produce other elements.

Nigel Steward [21:35]
And that way we can we can recover a lot more from an ore body without mining. I think those are the pathways that we are looking at to, to try and address this problem.

Dr Anna Ploszajski [21:45]
So, Leah, Nigel mentioned recycling, particularly of electronic components that contain these rare earth elements. Your spacecraft clearly contain a lot of these rare earth elements.

Dr Anna Ploszajski [21:56]
Is there any talk about recycling of spacecraft or satellites or stuff that is out in space that contains a lot of valuable materials that we maybe originally didn't think of bringing back to Earth to recycle?

Dr Leah Alconcel [22:07]
There's a lot of concept work going on to try and work out how to recycle materials, spacecraft in space and what that might look like, particularly aluminum because most spacecraft structures are made of aluminum and it's relatively easy to repurpose aluminum.

Dr Leah Alconcel [22:23]
But the other components of, of, spacecraft tend to be things like printed circuit boards, which are, you know, have, are really complicated, they're layered structures, they have lots of different types of materials in them, and would, would be quite difficult to say, strip down into their constituent components.

Dr Leah Alconcel [22:39]
But there would, there might be other ways of repurposing the whole PCB, for example, on its own, and, and, and certainly other, other larger structures. So almost all spacecraft, for example, are wrapped in blankets of multilayer insulation that can be cut into sections and, and reused, and we should be able to do that.

Dr Leah Alconcel [22:57]
If, if even if we can't break down rare earth containing items in spacecraft to their constituent elements, we should be able to, to, to reuse them because it's most spacecraft need, robotic spacecraft need the same kind of systems in order to operate. So, it should be able to take them from one spacecraft to another.

Dr Anna Ploszajski [23:18]
Nigel, do you have any questions for Leah about what we've talked about space junk or otherwise?

Nigel Steward [23:23]
No, maybe I think in the, in the laser world, what's the, the space community working on in terms of the next generation of, of lasers?

Dr Leah Alconcel [23:30]
There's a lot of work going on to, to do what I talked about before, free space optical communication between spacecraft.

Dr Leah Alconcel [23:36]
But there's also a fair amount of work into understanding how the upper atmosphere behaves. a bit better. And by upper atmosphere, I mean beyond the clouds kind of thing.

[music interlude]

Dr Anna Ploszajski [23:49]
So Leah, what's next for you personally? What missions or work are you excited about that you've got coming up?

Dr Leah Alconcel [23:55]
One of the things that I started working on is working with the quantum technologies hub in Birmingham.

Dr Leah Alconcel [24:01]
So the quantum technologies hub for sensors and timing, which is going to, I think, hopefully continue. They are interested in basically doing atom interferometry in space, which will involve lasers. And, so, it will be exciting to see where that goes.

Dr Anna Ploszajski [24:19]
Nigel, my final question for you. We mentioned the rare earth elements as a family, some of them are very rare, some of them are rare because they're difficult to extract, but some of them are not rare at all.

Dr Anna Ploszajski [24:29]
And I wondered if you, if you were going to act as rebrand manager for, for the rare earth elements, how might they better be described as a family?

Nigel Steward [24:39]
You know, when you describe their uses and where they get used in our everyday digital life, in supporting the energy transition, particularly with, you know, with electric motors and things like that, and with, their importance in medicine and medical devices, you start to think of them as the essential materials.

Nigel Steward [24:57]
They're not rare materials. They're the invisible. But essential materials that we don't talk about very much. I think that would probably be the best way I would describe them.

Dr Anna Ploszajski [25:07]
Invisible, but essential, definitely.

Dr Leah Alconcel [25:09]
Earths also has the advantage of alliteration. It sounds quite nice.

Dr Anna Ploszajski [25:14]
It's true. I like it. Right. We'll start the campaign then to rebrand. These essential elements then are crucial for modern life in our device screens, in communications, and in the energy transition. A huge thank you to both of my guests today for taking us through the rare earth elements, Dr Leah Alcancel and Nigel Steward.

Nigel Steward [25:31]
Yeah, thanks very much, Leah. It was great to meet you and good to see you again, Anna.

Dr Leah Alconcel [25:35]
Thank you very much, Anna, and thank you, Nigel.

Dr Anna Ploszajski [25:37]
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