An interview with Associate Professor Andrew Peele

Transcript X-Ray Science

Andrew Peele
a.peele@latrobe.edu.au

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Transcript

Matt de Neef: Hello and welcome to the La Trobe University Podcast series. My name is Matt de Neef and today I'm speaking with Dr. Andrew Peele. He's an associate professor and reader in the physics department here at La Trobe and a program manager in the Australian Research Council Centre of Excellence for Coherent X-ray Science. Thanks for your time, Andrew.

Andrew Peele: No problem. Hi.

Matt de Neef: All right, so before we talk about what the Centre has been doing, I wonder if you could give us a brief sense of why X-rays are so valuable and why they're so valuable when doing imaging work compared to regular light sources?

Andrew Peele: Well, x-rays are kind of fun because, as everybody knows, they go through things. And that's really one of the things that make them very valuable for us. And what we're about is trying to take three-dimensional pictures of really small objects and to do that, you need

to have a source of light that will pass right through the object. And that's where the x-rays come in. The other aspect of x-rays is their wavelength is very short. So, in principle, that allows you to look down to the really smallest scales of whatever structure you're investigating.

Matt de Neef: So, of course, most people's experience of x-rays is when they've broken their arm, for example, and headed to the doctor's and get x-ray that way. Are the medical uses of x-ray much different from the sort of imaging you guys are doing in the Centre?

Andrew Peele: A little different although we do use what you'll find in every hospital, which is a CAT scanner - we use something very, very similar. Where we take our x-rays we rotate our sample, usually in a hospital we keep the sample - which is you - stationary and they rotate the x-rays and the detector around that. Because we're looking at very, very small things, we are concerned about how to mount them and move them. We put them on a very small, fine stage and spin them around. But the technique is basically the same.

Matt de Neef: As we touched on there in the introduction, you're the program manager of the experimental methods team at the Centre. What are some of the projects your team is currently involved in?

Andrew Peele: Lots. One of the things about having a well-funded centre is that you get to push out on lots of different fronts. So, where our group comes from, in fact, our group in La Trobe is really all about imaging using x-rays and using this process of tomography and so on and using different ways of making the x-rays give you contrast.

And in the Centre, what we're really doing is pushing that down to the really smallest scales, so looking inside cells, looking down even smaller right down to protein structures. And so, to do that, within the Centre we need to have people looking at theory of how x-rays interact with materials; looking at coherence - which is a property of the wave field that gives you a way to understand the images - looking at the equipment side of things and that goes from building things like vacuum chambers to cryogenic cooling systems to remote manipulation stages, people who build microfabricated structures. So, we need really small holders to hold these small devices. So, we have a whole microfabrication laboratory as well.

And then, on top of that, we do a lot of hard work at synchrotron facilities mainly overseas. So,

we then have to build equipment that goes overseas and we have people who run experiments for one or two weeks at a time several times a year. So, there's lots of different fronts that we're busy on.

Matt de Neef: So, you said before about modelling cells, so obviously, low-level imaging – what are some of the practical applications of this?

Andrew Peele: One of the big things that pushes what we do in the Centre is our close collaboration with biochemistry here at La Trobe and their interest in a number of systems, one of which is malaria, which I think we've probably heard about in a previous podcast. We're wanting to look inside the structure of the cells, seeing how the parasite evolves in the cell and the various shapes and forms that it takes. Looking down on a slightly smaller scale, we're also working slightly longer-term with people looking at mitochondria, which are the power plants within the cells, and looking at the structures that are related to those as well.

So, for us, it's all from the physics side. It's all about the imaging and the structures and looking at those features and for the biologist that's saying, 'once you've got those pictures for us, how come we interpret that in terms of function of the cell?'

Matt de Neef: As you touched on there, you were actually in a podcast about this time last year with Leann Tilley from biochemistry here at La Trobe. Can you give us a bit of an update about where the project is at now and where you've come in the last year?

Andrew Peele: Within my group, we've done an awful lot on building the equipment that will let us do this work. And we've done lots of work with much easier systems in malaria that don't fall apart when you zap them with too much of an x-ray beam and so on and showing how the technique works.

Now, to make it work for malaria - which is a bit more fragile and prone to radiation damage - we need to have very specialized equipment to hold it, to rotate it, to keep it stable and ultimately, actually, to put cooling effect, freezing onto the sample because when you can do that, you can delay the onset of damage from the radiation a bit longer.

So, we've gone a long way towards making all of that equipment. In fact, we're just about to go on another run in December for two weeks, where we will be testing how we can do those rotations of really small devices mounted in very tiny capillary tips and so on and line the x-rays up with those and take a tomographic series.

Matt de Neef: Is that a problem you run across a lot, the samples that you're testing do disintegrate under x-rays?

Andrew Peele: It's the perennial problem for really small devices, really small objects, particularly biological things. The dose that you have to put on of x-rays in order to get the image is the same sort as those that damage them and break them down. So, if you look at them too long, you can end up with a blob.

Matt de Neef: The Centre's website talks about an experimental laser research laboratory, where you're able to simulate x-rays using visible sources. Besides the fact that you can't see x-rays, how different are lasers from x-rays? And by using lasers to simulate x-rays, are you able to get around some of the problem of samples disintegrating, for example?

Andrew Peele: That's actually a really good question. In terms of visible lasers, one big difference is that the wavelength of the light is about 1000 times longer. So, the way they scatter, the way they interact with things is quite different. The other property that I talked about earlier, which is coherence, is actually the hallmark of a laser. A laser beam is actually coherent, which means that the light is, to put it into general terms, is well behaved. With the light coming out of the laser, you can predict from when it's coming out to what it's going to be doing quite a long time later or quite a big distance away.

With x-rays, your typical sources are much less coherent. So, the way the waves propagate, the way the direction of those waves take, the wavelength for those waves, you slightly randomize. And that gives you slightly different pictures each time when you're probing the same sample with them.

So, the lasers in some way are too good for us to do the simulation work. And you have to actually downgrade some of their properties to make them behave a little bit more like x-rays. But in terms of actually looking at the structures, they can't look at the things we're interested in

because of the wavelength problem. So, we use them for testing things that are 1000 times bigger. So, we might make a fake cell that's 1000 times bigger than the cells we're interested in.

Matt de Neef: A scale model sort of thing?

Andrew Peele: Yeah, basically.

Matt de Neef: You touched before on doing work in synchrotrons, especially overseas. And of course, the Australian Synchrotron has been open since 2007 down near Monash University which has provided research opportunities across a number of fields. How closely has the Centre been working with the Australian Synchrotron? And how hard is it to get in there to get projects done?

Andrew Peele: We're actually working very closely because the equipment that we're building in Chicago, the long-term plan - but it's not so long term now - in a couple of years, the plan is to bring that equipment back and put it in place at the Australian synchrotron. So, we're learning all of the lessons at a fully developed beam line already in Chicago. And then, we'll be able to bring it to the Australian Synchrotron and put it in place and use it there. So, that has involved a very close collaboration.

At the same time, we've been doing work at the synchrotron on other aspects related to the project, doing experiment testing for coherence and issues with the beams that we use and so on. So, it has been a really good proving ground for us.

Matt de Neef: I was having a bit of a look at your research project's web page and I noticed there's a section that talks about lobster-eye telescopes. I wonder if you could tell me what lobster eyes have to do with physics and how it's related to the research you've done over the years?

Andrew Peele: That's actually a bit of a blast from the past. They're fantastic devices. The optics of a lobster eye is really interesting. If you look really closely at them as I had to do - that was a terrible sacrifice we had to buy them and get the eyes - but if you look at them under the

microscope, they're square. So, they're full of lots of little square channels and what happens is the light bounces down the square channels and it does it in such a way that the light is condensed into a central point. In fact, the focal spot that you get from a lobster eye optic is a central point with the bright cross - cruciform arms on top of it.

And the use that they have for x-rays is that the way that the light bounces down the channels, it's like skipping a stone across the water, a little bit like playing Ducks and Drakes and x-rays will do a very similar thing. They'll skip across the surface of things and reflect very well. So, as long as the rays are coming in on what's known as a grazing incidence, they'll bounce down these channels and rattle down them and end up in this cruciform focus.

So, the nice thing about it is if you're looking at a star, an x-ray star, the light will be condensed into this bright point and give you a stronger signal so you can detect the x-rays. So, the idea was to make a telescope based on these optics and use it to look across the entire sky. It's a very wide field of view telescope. That's basically how it all hangs together.

Matt de Neef: So did it get built, the telescope?

Andrew Peele: The optics have been built; they're being tested from various time to time - we've had agreements and arrangements to actually put it up on a satellite. In fact, it was going to go on the international space station. The problem with satellite projects is as things change, these plans come and go. In fact, we had a berth on the space station and the launch was going to be the shuttle and then there was shuttle disaster, if you may recall. And that basically stopped projects like ours, to put a small-scale experiments up. So, then from there, that sort of morphed into several different things. And at the moment, we actually haven't gotten a way to get it into space, which is a real drag.

Matt de Neef: As we talked about before, the project with Leann Tilley in biochemistry, it's obviously a collaborative project between physics and biochem. And the Centre of Excellence for Coherent X-ray Science is a collaborative project between La Trobe and other universities. How important is this sort of collaboration in large-scale projects?

Andrew Peele: I think it's certainly for things like a Centre, it all depends on almost everything that we do because there are so many aspects to a complicated project. You need to bring in

people who have got expertise in different areas. And particularly, things like what we're doing, which is pushing these boundaries of imaging in biological systems. You need a physicist to do the technical developments and understand the fundamental physics of the interactions. You need a biologist to tell us what we're seeing when we do see things. So, it's absolutely imperative.

Of course, the interesting thing that comes out of all that is learning to talk to colleagues from different backgrounds. And that's where the fun really starts.

Matt de Neef: That would seem to be a problem there where you've got people trained in physics and people trained in biochemistry. What happens at the interface there? Is there a certain amount of give and take where people need to learn other's people's disciplines? Or is there someone that accessed an intermediary between the two parties?

Andrew Peele: A little bit of both, but the first one mainly. So, basically it's a lot of time just spending time with each other, working on projects, learning the language, learning what's important to different people. So, what I as a physicist might think as important, which is usually something cool and some shiny equipment, is really fairly unimportant to a biologist, who is much more interested in what's going on with the fundamental processes inside cells.

So, that give and take is definitely important. You need to learn that language. And we've done a lot of things over the years, holding various styles of workshop to try and get that knowledge across. We've held a really interesting series of workshops, what we called Talking Backwards and the idea here was we would get a couple of physicists, and they had to give a seminar on biology and a couple of the biologists had to give a seminar on physics and it was really interesting to see what impressions people had of other people's disciplines when they had to put it together that way.

Matt de Neef: So, how well was that received? Was there sort of laughter in the seminar room? Is it sort of a sense of being impressed by how much research is being done?

Andrew Peele: There's always a scope for a bit of laughter. But actually, people were really impressed at how well people from one discipline can actually master and communicate with another discipline. I think part of it might be because when you come from outside, you get rid of

a lot of the extraneous baggage and you just go straight to what's important. So, it actually ended up being a really, really good seminar series, in fact, one of the most popular that we've done.

Matt de Neef: If you'd like to leave a message about this or any other podcast in the series, you can get in touch with us at podcasts@latrobe.edu.au Dr. Andrew Peele, thanks for your time today.

Andrew Peele: No problem.