



University of Auckland  
**Scientific**

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May 2021

Volume 1 No.1

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# EDITORS' NOTE

Welcome to the inaugural edition of the *University of Auckland Scientific*.

The motivation behind this publication is simple: we noticed a disconnect between undergraduate science students and actual science currently being done – even research happening here at the University of Auckland is simply not visible to students. Unless you take part in a summer research project, chances are you will go through university learning all about scientific ideas but relatively little about where they are used. If you pursued a science degree because of a passion for brilliant science, it can be disheartening.

That is where we come in. Our goal is to communicate ideas at the frontiers of science, to provide a connection with the edge of the known world and beyond. Herein you will find informative articles, interviews, opinion pieces, and fun stuff that reminds us not to take ourselves too seriously. As fellow students, we want to engage with these topics and to bring you along for the ride.

We hope you enjoy reading about everything from dark matter to seabirds and beyond. Though this is only our genesis, we look forward to many more editions to come.

**Yours faithfully,**

**The *University of Auckland Scientific* team**

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A white-faced storm petrel.  
Photo by Annette Taylor on Unsplash.

# Seabird Sensory Ecology

INTERVIEW WITH  
ARIEL - MICHAIAH  
HESWELL

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By Louisa Ren

*Ariel is a postgraduate student in Marine Biology who recently completed her BSc(Hons) project on seabird sensory ecology with her supervisors Dr Anne Gaskett and Dr Megan Frieshen. The results of this project are expected to be published soon. Currently, she is working on her PhD where she will be studying seabird sensory ecology even further.*

***Tell us a bit about yourself! How did you get involved with your honours project?***

I was born and raised in Brunei, which was a very diverse environment and had very diverse animals. I loved animals and conservation, and when I moved to New Zealand, I took the Bachelors in Marine Science program and absolutely adored animal behaviour. The marine science department did not really focus on the particular animal behaviour I wanted to study for my postgrad, so I changed my major for my PhD to Biological Sciences to study the behaviour of seabirds from a sensory perspective. My supervisor and lecturer at the time was giving a presentation on seabird sensory ecology, which I got really into. Then I

did an honours project on it looking at whether certain types of sensory systems and seabirds are more vulnerable to bycatch, why they are more vulnerable to bycatch, and we looked at it from a sensory point of view. It did turn out that actually those seabirds that had a greater and larger sensory system relative to their body size, were more likely to be attracted to fishing vessels, which then increased mortality rate—these were amazing findings. And so I was continuing along the lines of bycatch by adding new avenues into it for conservation of seabirds, including plastics and lights. Right now for a PhD, I'm looking at different types of colours, plastics, and lights, seeing if certain seabirds are more or less likely to become attracted to the plastic. Looking at that from a sensory perspective, why are they being attracted? Is it the size of their sensory system? I'm looking at it from that point of view—I've just started and I'm seven months into my PhD.

***That's fascinating! What exactly is meant by seabird sensory ecology?***

Ecology is the study of animals and the interactions in their environment; how

they interact with things—which can be other animals, or it can be fauna and flora. Sensory is just how they view the world—like from their eyes, their hearing, their sense of smell and vision. So how they interact with their environment using these sensory systems.

### ***Why exactly are seabirds attracted to fishing vessels?***

So that question is actually really hard to answer. There can be multiple factors and variables as to why they are attracted.

There could be just a sense that they're in the same area, so the fishing vessel and seabirds are competing with each other for the same prize, which is fish or squid or something like that. When the fishing vessels are in the same area as seabirds, there's an increase in interaction rate, therefore they're more likely to be attracted to the fishing vessel. However, the actual studies have shown that sometimes the seabird diverts away from its normal migratory route and foraging area to go directly towards the fishing vessels. There is also the potential that because the fishing vessels are after the same prey as the seabird, as well as the bait and the awful discharges the fishing vessel emits, the chemicals and smells resemble the same odours as the seabirds' prey and diet. All these good smells for the bird that make them think, "I love the smells, I'm going to go towards it." Maybe they see that as their chum—which is their diet, and so they're like, "I want to try to grab something off that."

As for why they're attracted to lights, it is possibly because some of their prey is bioluminescent and lights up, so they're attracted thinking it's food. Another possibility is the seabirds are attracted because they use the celestial bodies such as the moon in the stars for navigation. They may see the light and think, "Oh, I should use that for navigation," and then collide with the fishing vessel instead.

### ***Were there any particular bird species that were found to be particularly attracted to fishing vessels?***

Yes. So there were some studies which have been done in the Hauraki Gulf in New Zealand when they've got MPI (Ministry of Primary Industries) reports, and they found that the black petrel was a high risk species to being attracted towards the boat—this is different from light attraction.

For the bycatch, the highest was once again black petrels and some flesh-footed shearwaters, and I believe some albatross species—I can't remember, but I think it could be the Buller's albatross or something like that. There were definitely seabirds which had less bycatch risk as well, such as the common diving petrel, the fluttering shearwater and the Buller's shearwater.

With the light attraction, it's interesting because the common diving petrel—which was less caught in fishing gear—was actually more likely to be attracted to the lights,

and they were actually caught as deckstrike when they just ram into the boat. And so common diving petrels are one of the highest, and also lots of Cook's petrels, whereas something like the black petrel is less often attracted towards the light.

### ***How was the research done? Was it all observational or were there experiments involved?***

For the honours project looking at bycatch, I went to museums and measured the skull and the wing lengths, and a bunch of body sizes of six different types of seabird species. We had three that were more likely to be at a higher risk of bycatch, and three that had a lower risk of bycatch. I just did a whole ton of measurements of their eye socket sides, nostril socket size, and did some brain scans to look at their olfactory bulbs and their optic tecta. Then I did a morphometric and sensory comparison of the different species to get a correlation of that. For the lighting experiments, I had a lot more range (because we had some permits) to do experimental designs. We went to the outer islands of the Hauraki Gulf, like the Mokohinau Islands, the Little Barrier Island, Tapanui, and Tiritiri Matangi, and we shone different types of lights into the sky; for example, red light, green light, white light, halogen fluoro, and a huge flood light. We counted the number of seabirds that we saw, and we weren't really looking at any particular species, but the species which were most likely attracted to the lights had burrows nearby.

### ***Was there anything that surprised you from your findings?***

Hm... something which surprised me, especially with the lights is that so far, we actually haven't found any statistical significance between different colours and attraction towards lights. When we did some more research beforehand into it, it looks like it also depends on other variables, such as the location. If you look at that specific location, there were differences between the lights, but when you combine them, there were no differences—so it's to do with the location as well as the moon phase. We definitely found significant results for the moon phase, which was that when it was a full moon and fully bright, there was less attraction towards the seabird—towards the light by the seabirds, whereas during a new moon and it is completely dark the lights were a lot brighter in comparison and less conspicuous, they were more likely to be attracted.

### ***Did you look into how birds see colour and whether that would affect their attraction to colours and lights?***

Yes, that is a very valuable point. Unfortunately, when we want to do that sort of thing and see how the bird sees the colour, the experiment to do that would involve dissecting the eyeball and looking at their rods, cones, and oil droplets—that's only now been done for two species of seabirds. One has just been done in Hawaii, and so [that researcher] is going to publish her work very soon; and another one has been done in Australia. It's really, really hard to do because

you need a freshly killed seabird in order to do it, and the ethics and permit to kill a seabird? Really difficult. Unless it's about to die (because of something else), you're not really going to be able to cut the eyeball and get everything done in time. The [researcher in Hawaii] has been doing this for a very long time so she knows what she's doing and managed to do it, but it's just going to be really hard to do for us as we're just starting out.

***Did this lead to any new questions?***

Yes. So in terms of questions of the moon phase, it also looked at why as well—most likely we would have to do the eyeball [dissection]. But also, the basic [study] we could do is just looking at their sensory size, and what the size of the visual system is. It won't help us with what the bird can actually see, but we can get an idea that if some eyeballs are bigger than the others, maybe that's related as well. It also opens an avenue of what other colours they are attracted to; for example: plastics. Are they attracted to certain colours or types of plastics? So yeah, just looking into that sort of thing as well.

***What else did you do during your project?***

When I did the honours project I was only able to do one CT scan sample per species, so I only got six. Because it was an honours project and was restricted on cash and time, I could only get a year to do everything, including coursework. I would like to do more of it this year, and I've actually been sending emails to museums in order to do some more CT scans. What I found was very restricting with the CT scan, is that if I try to go to a hospital or clinic to try to get CT scans they all ask, "Why do you want to do that?" Then they just say, "No, I'm not really interested." And if I go to the bioengineering place it's great because they understand the scientific research, but at the same time, I'm very restricted with the skull sizes I can scan. I can only give small samples because they can only fit a max. of about 10 to 11 centimeters, and some seabirds are much bigger—they can have about 15 centimeters. For those seabirds like the black petrel and the shearwater, the fluttering shearwater and the common diving petrel—those are really small. But bigger birds, which I want to test in comparison, are much bigger so they can't fit, so I am attempting to look at other places I can do the CT scans on. And yeah, so I found that very challenging as part of the research for the honours, and I'm probably going to find it challenging in that six month time to a year time [with further research].

***So you're hoping to do more CT scans later on?***

Yeah, because I would like to look at the olfactory bulb, and optic tectum. There is a potential way around it—I'm going to do dissections on the brains of the seabirds. That is a potential in case the micro CT scans fail. But I did enjoy doing the micro CT scans, because you actually get a 3D image of the brain and it's really cool to look at and do measurements.

***What kind of people did you work with during this project?***

I worked with museum curators, I worked with people who love to go out to remote islands and do [research]. I worked with rangers from the Auckland Council, the Department of Conservation, as well as my supervisors who know a lot of spectral and colour measurement things—just a variety of different people.

***What kind of impact do you hope your research will have in your field?***

I'm hoping that I can do some more publications and presentations at conferences, and things that could potentially give some more light to understanding these topics, especially since not many people look at it from a sensory perspective. Not many studies have delved into this sort of area, especially in New Zealand and Australia. Very little is done on plastic ingestion in seabirds in New Zealand, and it's so strange, given how many seabirds we have here. Nothing has been done on plastic ingestion and seabirds—maybe the odd observation but no one's actually done any experiments or published papers on it. It'd be good to actually give [these findings] to the MPI and the primary industries (especially for fisheries) and for example, going to cruise vessels and saying, "Oh, potentially you can use these colours of lights to reduce the attraction rate of seabirds," especially if you're passing through an island that is known to have burrows. You could dim or change the colour of the lights, or maybe discuss with cruise ships and fishing vessels, as well as with plastic companies.

I haven't done any experiments on this yet but in the next year or so, looking at the plastic and potentially going to people who do the plastic side of things and suggest maybe changing to this certain colour to try and reduce consumption by seabirds and turtles and things like that.

***Research aside, did you learn anything else from doing this project?***

It really taught me how to manage time to that next level; I did some other projects before, and I thought, "Oh, yeah, I can manage my time alright," but doing an honours project really teaches you that because you've got to balance your actual coursework, and other papers you're taking, as well as your research, as well as trying to find time for your friends and family. Then there's also your own time, so you have to go find that balance. It really teaches you to find a balance for your mental health as well as all of your physical health—like going out, doing some exercise, hanging out with some friends as well, going back to see your parents.

It also teaches you a lot more about taking control of the research, because I was very, very scared when I first started. I was like, "Oh, shoot, I don't know, if I'm gonna be able to do this in terms of what if I do it all wrong?" I felt like I needed to ask my supervisor about everything I was



Gulls gathering at a boatyard.  
Photo by Keith Hardy on Unsplash.

doing and I really needed guidance [starting off]. That was the beauty of my supervisor—she was always there to fall back on and guide me. As for my honours project, that really taught me to become more independent and I can now actually design my own [experiments]. Now for the research of this PhD project, I've actually started doing a lot more designing of other projects. I was doing some reading, and I decided that I want to do some experiments with colours and penguins. I brought forth a proposal to my supervisor and she loved it. So yeah, it teaches you how to become a bit more independent in your thinking and if you're like me, you can start off extremely dependent and super scared and nervous about what to do but in the end, you will grow in confidence.

***Do you have any advice for anyone who is hoping to go into research in this field?***

You don't have to be a seabird lover at first—I certainly wasn't. I had no idea there were so many different types of seabirds around, like the main albatrosses, cormorants, seagulls and penguins, and then you just open a new research area. Trust me when I say seabirds will grow on you and you'll end up loving them so much.

You also don't have to be someone who loves hiking or is very into getting out to the field to get into seabird research. Sometimes there are things in terms of going out to remote islands, going up and down sheer cliffs. I am personally terrified of heights, so I let some other researchers go up a sheer vertical cliff and I'll just wait down here, and that's all. You don't have to do that in order to do this seabird research because although a lot of fieldwork does involve going out to remote islands, you can also do other things like examining what colours they're attracted to, looking at their digestive tracts or something like that, and looking at their morphology; there are a variety of other things you can do if you're interested in conservation and things. Or if you really do enjoy going remotely and going up vertical cliffs, then yeah, go for it if you enjoy the thrill of that, but there's so many different

pathways and avenues you can take. Just be creative, and you and your supervisor will find a project.

***What is your favourite seabird?***

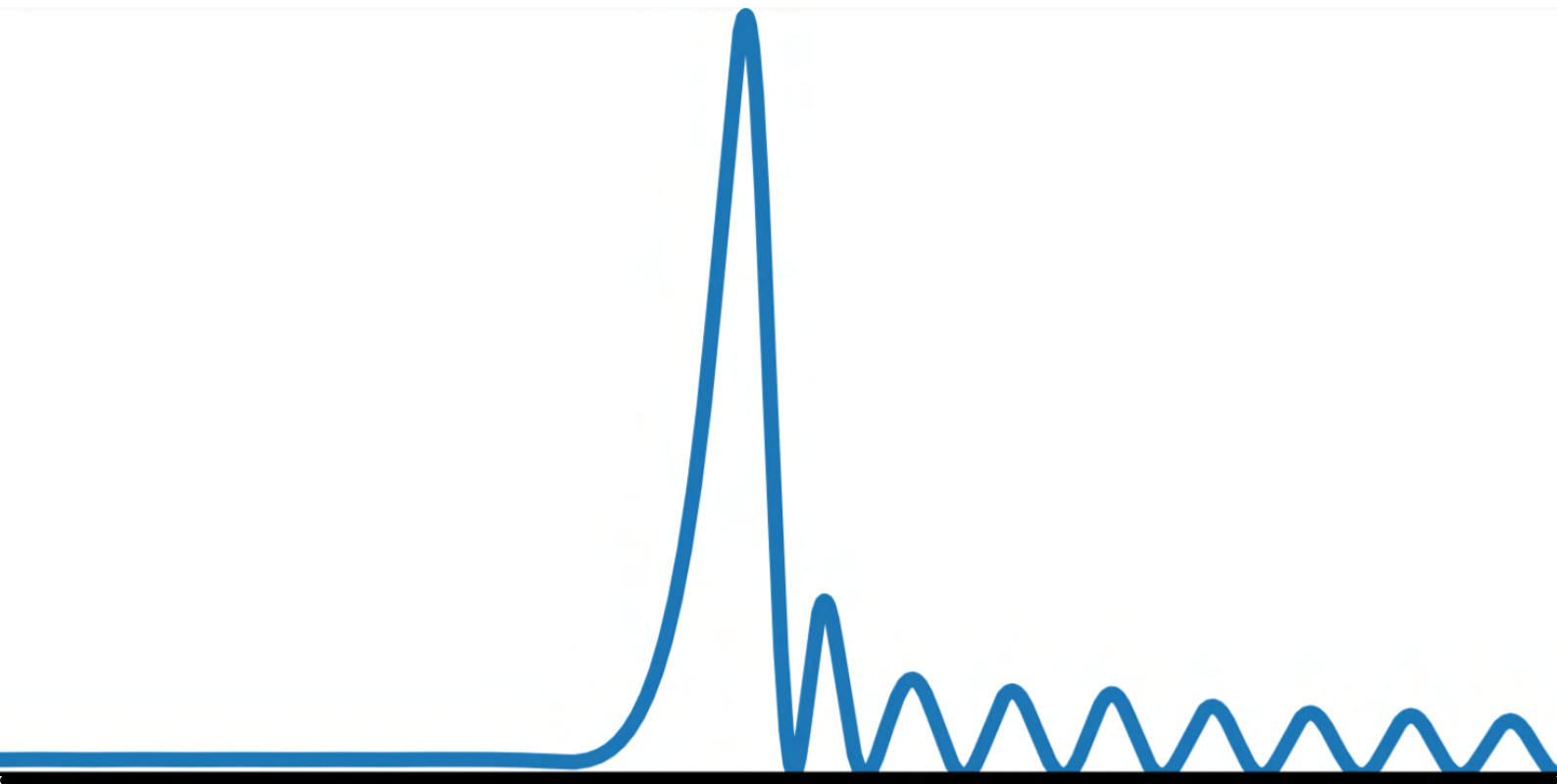
I love the New Zealand storm petrel. It's such a little cutie and any white-faced storm petrel as well. If you look up a picture, you'll see why they're just so cute. When they skip the surface of the water, the little pitter patter of their feet and fluttering around is so adorable. Also the New Zealand storm petrel, which was actually thought to be extinct until either the late 90's or early 2000's when it was rediscovered in Little Barrier Island.

***Do we have many of those?***

[Their population] is still really small but they are definitely around as you can see them in the Hauraki Gulf just fluttering around—they're tiny and probably around the size of a dove. Just picture that little thing, skimming the surface, barely touching the surface with their feet and then hopping off again.

***Overall, how was your experience while doing this project?***

I really enjoyed the seabird research. It's definitely been a journey and adventure and it has definitely given me a greater love for seabirds, as well as for research and showing that I actually really want to do research. For anyone interested in continuing on with research and if you're into this sort of thing, it's really fun. It gives you a sense that, "Oh, I discovered that," you know? I like that it gives you a sense that you're helping contribute to the scientific world, that you're actually helping your community. So you're actually helping with research and findings to understand how the world works. It's actually real and it's real fun, you'll meet so many interesting people. I've definitely met a whole ton of eccentric people and they've been great to work with. It's been a real fun time, definitely challenging. But overall, it's very rewarding.



# SOLITONS

By Caleb Todd

Last summer, I underwent a research project in the department of physics at the University of Auckland. One of the department's most active fields of research is optics, and my supervisor, Associate Professor Miro Erkintalo, specialises in nonlinear photonics, which is the study of high-intensity light. A host of rich dynamics and structures can be observed in this regime; it balances theoretical interest and practical applications and has something which everyone can engage with. Since the mathematics that underpins nonlinear light maps closely to other physical systems, it also provides a convenient testing ground for the behaviour of phenomena that manifest in all fields of physics. One such phenomenon is the soliton.

Solitons are localised pulses that propagate without changing shape. A ubiquitous wave phenomenon, they were first identified by John Scott Russell when he noticed that water displaced by a boat in a canal continued to move through the channel at a constant speed and without flattening or otherwise dissipating. This is in contrast to ordinary waves, which broaden, narrow, or break, given time. For nearly a century, this discovery's importance was not fully appreciated; it was a curiosity with little to no use. However, solitons have become a hot topic in recent years and one of their uses won the 2005 Nobel prize in physics.

The solitons we will consider are not pulses of water, but light. If you take a stretch of optical fibre and join its ends to form a loop, you have what is known as a fibre ring resonator. Any light you send in will circulate for a long time before it is lost. If the light within the resonator is sufficiently intense, it can experience nonlinear effects that are not present with low-intensity light. For our purposes, we only need to know about one of these effects: the nonlinear refractive index.

The refractive index of a material determines the speed at which light propagates through it. A Nonlinear refractive index refers to a material's tendency to change its refractive index as the light's intensity changes. Pulses of light are more intense where their size is greatest (the peak of the pulse). So, across the profile (i.e. shape) of the pulse, the refractive index of the material will be changing. This intensity-dependent refractive index, also known as the Kerr effect, causes nonlinear self-focusing, where the pulse is contracted due to the variation in speed across its profile. Usually, the wavelength of a pulse is constant throughout, but the Kerr effect also shifts the pulse's leading edge towards higher (blue) frequencies and the trailing edge towards lower (red) frequencies. This is depicted in the graphic on the next page.



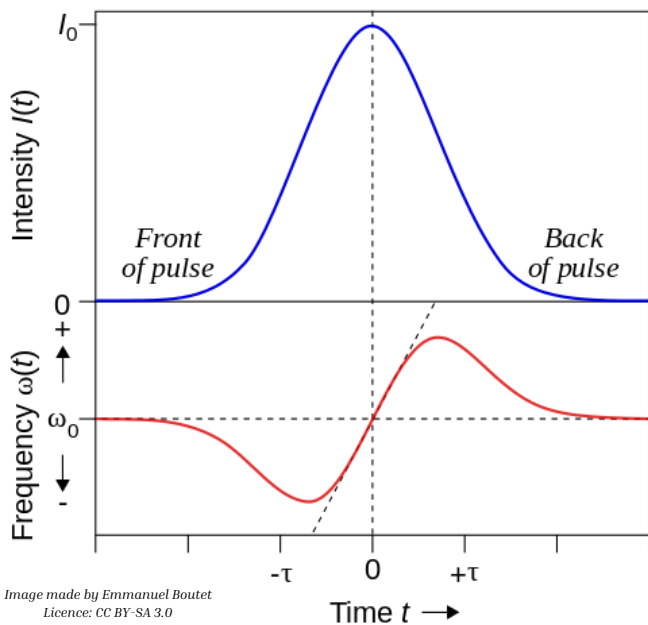


Image made by Emmanuel Boutet  
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A double balance maintains a soliton's constant shape. On the one hand, driving must offset lost energy: a laser will continually send light into the resonator to compensate for the light which escapes. On the other hand, the width/shape of the soliton arises through a balance between nonlinear self-focusing and dispersive spread.

Dispersion refers to the way the speed of a wave changes as the frequency of the wave changes. If higher frequencies move slower, the material is called 'normally dispersive', and if lower frequencies move slower, it is called 'anomalously dispersive'. In the anomalous dispersion regime, the leading (blue-shifted) edge of the pulse will move faster than the trailing (red-shifted) edge, causing the pulse to spread out. This dispersive spread compensates for nonlinear self-focusing, and the overall width of the soliton remains constant.

Solitons formed by this double balance in fibre ring resonators are known as Kerr cavity solitons. They have been studied extensively by research groups around the world, including the nonlinear photonics group here in the University of Auckland's physics department. One reason they have garnered so much interest is their use in generating optical frequency combs (light made up of a series of equally spaced frequencies). These frequency combs, whose development was awarded the Nobel prize in 2005, are used as high-precision tools in spectroscopy, optical clocks, metrology, and GPS technology.

One of the severe limitations, though, on solitons is the requirement to operate in the anomalously dispersive regime. Referring back to the double balance, the dispersive spread can only compensate the nonlinear self-

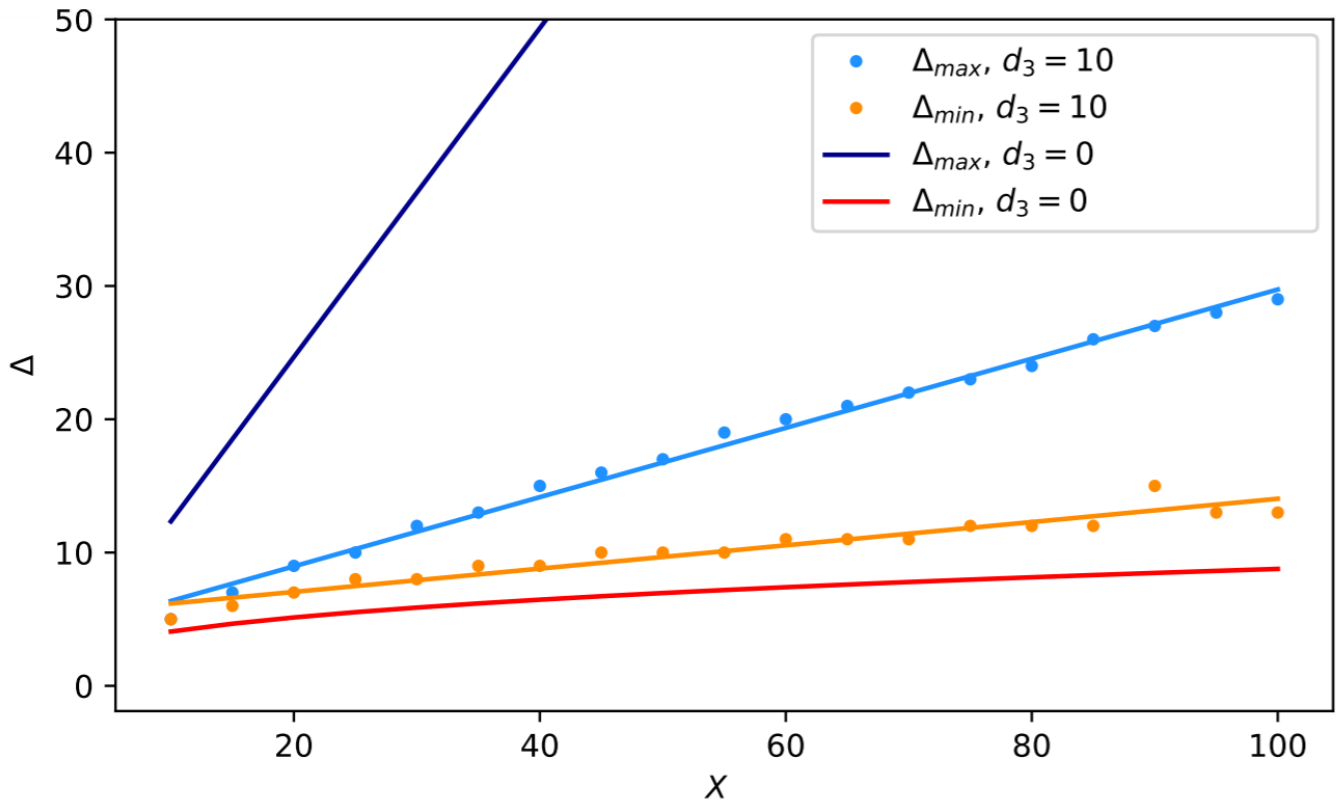
focusing if the blue-shifted leading edge of the pulse moves faster than the red-shifted trailing edge. If we are in the normal dispersion regime, the situation is reversed, and the dispersion helps the self-focusing rather than hinders it. There is no balance. The issue is that optical fibre is only anomalously dispersive at specific wavelengths. For example, light in the visible spectrum is normally dispersive in optical fibre. So, if you want an optical frequency comb at wavelengths of light in the visible region, you won't be able to use a fibre ring resonator soliton. There is a way around this, though, which was the focus of my research project.

Kerr cavity solitons can be made to exist in the normal dispersion regime by exploiting higher-order dispersive effects. Whether we are in the normal or anomalous dispersion regime is determined by the second-order dispersion coefficient. That's the coefficient on the second-derivative term in the dispersion's Taylor series if that means anything to you\*. In general, the coefficients at all orders will modify the soliton's behaviour, but the effects of coefficients beyond the second-order are usually inconsequentially small. However, it is possible to operate at wavelengths where the third-order coefficient is as significant or even more so than the second-order coefficient. This is useful because the effect of third-order dispersion on a soliton is to shift its centre frequency away from the frequency of the driving laser. In particular, with sufficiently strong third-order dispersion, the soliton can be pumped in the normal regime but have an anomalous centre frequency. This allows the double balance to be restored, even with normally dispersive pumping.

There are complications, though. The dispersion parameters are not the only factors in the behaviour of light within fibre ring resonators. Two other central parameters are the driving power (which we will call  $X$ ) and the detuning of the driving frequency from the resonator's nearest resonant frequency (which we will call  $\Delta$ ). Solitons do not exist at every pair of  $X$  and  $\Delta$ , and these parameters also determine their shape. In particular, larger values of  $\Delta$  give rise to taller, narrower solitons, which is favourable in producing optical frequency combs because a narrower pulse is comprised of a broader frequency profile. Ideally, we would be able to increase  $\Delta$  arbitrarily, but there is an upper limit in  $\Delta$  of soliton existence at any given driving power.

When third-order dispersion can be neglected, there are well-understood bounds on soliton existence. An approximate upper limit in  $\Delta$  can be determined for any given value of  $X$ . My project was to probe the existence range of solitons when the third-order dispersion cannot be neglected.

\*If it doesn't, don't worry. For interest's sake, though, a Taylor series is among the most important tools in a physicist's kit. It describes the fact that pretty much any function  $f(x)$  you're interested in (in this case, frequency as a function of wavenumber) can be represented by a polynomial. In general, the polynomial will have an infinite number of terms, with each term being of the form  $f^{(n)}(0) x^n$ ; (the  $n$ th derivative of  $f$  at 0 multiplied by  $x$  to the power of  $n$ ). However, close to  $x=0$  the terms with larger exponents will quickly approach zero and can be safely ignored. If we are left with only a few terms, our job is greatly simplified because polynomials are much easier to analyse in general than arbitrary functions.



A plot depicting the upper and lower limits of the detunings at which solitons may exist. The purple and red curves are for when third-order dispersion is not accounted for. The blue and orange points are the upper and lower limits which I found for a given, non-negligible strength of third-order of dispersion. Linear fits for my data have been presented to guide the eye.

To do this requires us to turn to computers. The canonical model of light within fibre ring resonators is an extended form of the so-called Lugiato-Lefever equation. Solitons are pulsed solutions to this equation that maintain a constant shape in time. When third-order dispersion is included in the model, it is difficult to obtain analytical results which describe soliton characteristics as  $\Delta$  and  $X$  change. However, we can use code on computers to simulate the Lugiato-Lefever equation, and by changing the parameters we can observe how the solitons change. In particular, you can pick values of  $X$ ,  $\Delta$ , and the third-order dispersion strength, generate a soliton, then increase  $\Delta$  until the soliton no longer exists to find an existence upper limit in  $\Delta$ .

I found that third-order dispersion drastically reduces that upper bound in  $\Delta$ . The graph above shows how substantial the decrease in the upper limit is, even for a moderate third-order dispersion strength. This limits the usefulness of a third-order dispersion approach to introducing normally dispersive soliton frequency combs because large  $\Delta$ 's enable more efficient energy conversion from the driving laser into the frequency comb. Nonetheless, third-order dispersion solitons still comprise useful tools for producing frequency combs at new wavelengths.

One of solitons' most useful features is how their position and number can be precisely controlled by rapidly modulating the driving over time. Again, this is well-understood when third-order dispersion is negligible, but including third-order effects complicates things substantially. My summer research's natural progression is to investigate how third-order dispersion affects the manipulation of solitons when the driving is modulated. This is the focus of my BSc (Hons) research project.

If the properties of solitons with third-order dispersion can be quantified, we will be able to reliably access soliton regimes traditionally not accessible. Kerr cavity solitons underpin a substantial range of technologies, some of whose limitations can be reduced by the promising features which these new solitons possess. I look forward to seeing how this research develops, particularly the breadth of its impact on fields of science, from biology to chemistry to astronomy. The capacity for nonlinear optical systems which support solitons to be scaled down to micrometre sizes means that whatever advances are made could easily seep into everyday use. It is very possible that future generations of ubiquitous technologies like phones and computers will rely on Kerr cavity solitons.



Beech forest in Te Urewera, which was given legal personhood status in 2014. Photo by David Tip on Unsplash (2019)

# Rights for Nature in Aotearoa

## Interview with Dr Brad Coombes

By Nina de Jong

**D**r Brad Coombes is a Senior Lecturer in the School of Environment at the University of Auckland. His research focuses on indigenous peoples' participation in environmental management. He has worked on Te Tiriti o Waitangi/Treaty of Waitangi environmental claims of several iwi, including Ngāi Tūhoe and Ngāti Tūwharetoa. Brad's recent work, "Nature's rights as Indigenous rights? Mis/recognition through personhood for Te Urewera", criticises the "personhood" or "Rights for Nature" environmental management approach. This approach recognises landscapes as sentient entities, and in some cases legal people, that have their own rights. It has been employed both internationally and in Aotearoa to protect nature in a way that is intended to align more with indigenous values. In this interview, Brad discusses how he became involved with this work, the main shortcomings of the personhood approach to environmental management, and how we should proceed into the future.

**How did you come to be a researcher in environmental management and indigenous rights?**

Probably the more important story goes back to where I was raised. Kāti Māmoe used to have quite a bit of land in the South Island. When the government redirected and extended the main trunk railway line back in 1888, they compulsorily acquired a corridor right through the middle of that Kāti Māmoe land. Unfortunately, there was what looked to be a simple clerical mistake. Rather than taking 20 yards on either side of the rail, which was the legal maximum that you took for a railway, they managed to somehow take 800 yards on either side. Despite a lot of acknowledgement that it was illegal, we still couldn't make the court system give our land back. And this included Moponui, which is the maunga tapu or sacred mountain for our hapū. The railway department had no use for the forested lands on either side of the railway, including the whole of Moponui. Eventually, it gave the land to the Department of Tourist and Health Resorts to become a scenic reserve in 1912. We were left with a tiny bit of land down by the sea and a tiny bit of land up past the railway. Neither of these could be used for the purposes that it was used for before. So, the idea of losing your forested rohe, including your important mountains, is definitely not

foreign to me. The battle to try and get some of that back influenced a lot of my childhood. Of the 6,500 hectares lost to the railway, the tribe eventually received 420 hectares in reserves and 128 hectares as freehold land because my grandfather just bought it back, and went on to live there. The mixture of, on the one hand, land rights, and on the other hand, somebody else's vision of what conservation should be, is a personal thing. I was sent off to university with the idea of contributing to the fight to get some of it back.

***You worked in the Urewera inquiry district, where a personhood approach for Te Urewera was taken. What was your role in that settlement?***

I have been involved with Te Urewera since the year 2000. When I came to this university, the Crown Forestry Rental Trust and the Waitangi Tribunal approached me to research environmental claims that had been brought before the Tribunal. I did environmental history reports for the Gisborne Inquiry District, Te Urewera, Wairoa and Tongariro National Park. The Tribunal gets very specific on land loss issues, but it can't afford to research everything, so it lumps together all of the environmental claims within an inquiry district and gets one or two people to research them. You basically look at every environmental issue that tangata whenua have been unhappy with since 1840! For Te Urewera, clearly, with the national park overlapping so much of their home territory, conservation management was the number one issue. They wanted to have a clear picture of how it became a national park and how it was managed, with emphasis on how a preservationist style of management alienated Tūhoe rights.

***What do you think are the most important merits of a personhood/Rights for Nature approach?***

It's been very hard in Te Urewera, and throughout the rest of New Zealand, for the public to see forests as anything other than forests, and to see mountains as anything other than mountains. One side of the debate has seen them solely as resources to be developed. Another side of the debate has seen them as environmental assets to be protected. And the strength of those two lobbies is so strong that any other view of forests, mountains, landscapes, rivers, is lost on the public. Personalising these spaces through personhood rights might at least prompt some discussion that may, over time, balance that debate so that it's not so dualistic. However, has it done so yet? I don't think so. Probably not at all.

The Treaty settlement process, especially where it involves national parks and conservation spaces, has been stalled. It has been fractious, and it wasn't really going anywhere. And I'm not sure I would argue this, but others certainly would, that anything that can accelerate that process is likely a good thing. I personally tend to stick to the idea that justice always takes time. If you're trying to speed up a tricky process, it's always going to backfire. But I am sympathetic to the idea that where Treaty settlement processes apply to the conservation estate, progress has

been very slow, and that's doing nobody any favours. If you can find an innovative, left-field solution that people sign up to, it's considered a success.

But it's what is missing from that list of benefits that's probably more interesting. I try to keep out of the Whanganui River example, just because it's one of the few that I haven't been involved with. But I look at what's happening in the Kaipara Harbour, or the Waikato River, or the Rotorua Lakes, all areas where instead of personhood rights, a different strategy has been utilised. And I see some positive progress. The substantial difference between, say, the Waikato and Whanganui cases is not so much that one has person rights, and the other doesn't. The idea of a river ancestor was acknowledged with the Waikato case, but it wasn't made a person. The substantial difference was the investment of money. Investments and clean-up efforts have been made, with federal money coming into the local and regional scales. And Māori are being heavily involved in deciding how that money is spent. The model that seems to be working most in New Zealand is state investment in co-managed restoration. That's what's happening in Kaipara, Waikato, and the Rotorua lakes. Where is the investment at Whanganui? And you could also say, where is the collaborative decision-making that goes into it? Because the Whanganui guardians are more champions than they are actual decision-makers. I think that's indicative – where progress is being made in decolonising freshwater management in New Zealand is not where person rights are being trialled.

***Leading on from that, what are your main criticisms of the Personhood approach to environmental management?***

When you research your own iwi claim or another iwi claim, you get to know the claimants as people. It's very long-term research. Whenever a third party or the government presented an option for National Park or Te Urewera, I think about how those particular people I became quite close to would react to it. It's significant that the reaction that comes up is always surprising, when person rights are suggested. In both of the inquiry districts where personhood came up, in Te Urewera and Tongariro National Park, it was well after the research, after the bulk of negotiations and the hearings, before the idea of personhood came up at all. It's a belated afterthought, to be honest. The earliest mention was in 2012. At that point, there were just a few idle mentions of what had happened in Ecuador and Bolivia, and was it relevant to treaty settlements in New Zealand? And, originally, Tūhoe were one of the strongest voices saying, "Well no. That's obviously not relevant to us at all." Things changed between then and 2014, when Te Urewera was given person rights, but it's not something that Tūhoe ever demanded. And even if personhood was a good thing, constantly giving indigenous communities something that they didn't ask for, and denying them what they did ask for, will eventually cause problems. My big fear is that this will backfire because there was no Māori demand for it in the first instance.

The second one is to go back to that duality. New Zealanders think the land is either wholly degraded or perfect and can't quite come up with a solution for the majority of the country, which is somewhere in the middle. That's about finding an honourable, sustainable solution that finds a balance between conservation and development. And are we any closer to that, having adopted person rights as our "go to" for Treaty settlements and conservation estate? I think we're further from it than we ever have been before. We still have that need that's unresolved, and we're focusing on the wrong thing by focusing on person rights.

The concern that these rights are easily manipulated has come up in many other parts of the world. When you look at the countries that have written Pachamama into their constitutions, especially Bolivia and Ecuador, it's been a horrible time of resource extractivism, especially in the petrochemical industries. That means that the award of person rights coincides completely with resource degradation, environmental loss, and the trampling on certain rights for different people. It was supposed to be done in the name of indigenous peoples, but instead it's enabled the petrochemical industries and mining industries to degrade indigenous territories. It's the way that these industries have framed nature as, "Well, now that we're accepting it's animate, we accept that it can heal itself. So there's nothing wrong with putting a few cuts and bruises into her." It's argued in the north-eastern states of the US that since localised ordinances around person rights have come into place, the mining industry and the fracking industries have found it easier to get around those rights compared to what was there before. And those ordinances were brought in explicitly to rein in those industries.

*Tongariro National Park is currently being involved in Treaty Settlement negotiations for multiple iwi, including Ngāti Tūwharetoa. Personhood rights, similar to what was applied to Te Urewera, is being considered for these negotiations. Photo by Yulia Gadalina on Unsplash (2019).*

These issues exist along with the multitude of social justice concerns that personhood raises, like, what is an indigenous right to development in a place that's now a person? What does this do to forestall indigenous demands into the future? And the quote from one of the interviews I did about slavery: "We still want to own Te Urewera, so are we now slavers because we want to own the land?" What that stands for is how personhood might forestall any future approach to historical justice in these places. Personhood will prevent questions of ownership from being addressed properly in the future.

The lack of balance between conservation and development, and the perpetuation of preservationism is my main academic concern. We need to find a more sustainable-use approach, and personhood rights have set us back on that.

*A criticism that you have of personhood and rights for nature is that it is not a concept from te ao Māori. In some ways, it is shoehorned into the New Zealand context. In 2001, a prison in Northland was being built at Ngāwhā springs. It had opposition from Ngāpuhi and Ngāti Rangī, who said the taniwha Takauere would be desecrated by the prison construction. Taniwha may in some ways be analogous to a personhood concept, and in contrast to personhood, taniwha are embedded in te ao Māori. Do you think legislation that centred around existing taniwha, for example, might have different consequences to conservation in Aotearoa than a personhood approach?*

Well, there are a whole lot of things beyond taniwha at stake there. The pools at Ngāwhā are a wonderful community development project, and they've become a



site of cultural resurgence in some ways. There was also a deal done with Top Energy, where the company would buy some of the former mined area right beside the springs and give it back to the local hapū. In return, tangata whenua accepted the extension of Top Energy's works. Tangata whenua have big aspirations for community development on that site. Even back in 2001, there was an essentialisation of the taniwha being the only issue, when many other things were going on. Not the least being the reason for the prison being built in the first place. Around 75% of the inmates are Māori, many from local tribes. There were some Māori that were saying "Yeah, go ahead and build it, we need to be close to those people who are going to be rehabilitated". Others were saying, "Well this is just a kick in the guts to the concept of community, to put a prison right on what is an important place for us." I'm not downplaying the narrative of the taniwha, but it wasn't as central to the whole story as history made it out to be.

As to how it may be more relevant to the New Zealand context, I think: What is personhood? Is it part, or not part, of what you've called "te ao Māori"? I personally don't like thinking about it in those terms. I have a sneaking suspicion that the phrase "te ao Māori" is invented. There's a truckload of very different cultural perspectives going on for different iwi and hapū, and to singularise that is counterproductive. The starting point is to say, "What's important to this tribe?" One reason why I would never rule out personhood, for, say, Te Urewera or Tongariro, is that for the tribes involved there, there were elements of personhood in what they do. For my own tribe, Kāti Māmoe? There's nothing about personhood for us at all. But we are widely held up to be sacrilegious, early victims of colonialism that have lost our way, whereas Tūhoe are often considered to be staunchly defensive of their culture. The "mountains marrying the mist" in Tūhoe's case, and the "I am the mountain, the mountain is me," understanding of Te Heuheu's relationship with Tongariro, suggests to me that there is something endemic about personhood for those particular tribes. So, I think too much gets lost at the "te ao Māori" scale. It's less of a cultural imposition if you look at what was specifically important to Tūhoe, and specifically important to Tūwharetoa.

Taniwha can be an important focusing aid to draw attention to otherwise hidden issues in environmental management. When State Highway One was in the works, the famous taniwha down towards Mercer came into the media. Previously, there had been no way of getting cultural values on the agenda for environmental impact reporting on building motorways. The public was so transfixed with building motorways that it was very difficult to say, "Well, what should be protected in these landscapes? Where should we spend extra money to go around significant sites?"

I think personhood is no more or less real for Māori, than taniwha. At times, the relevance of both has been exaggerated for Māori, and at times underplayed. But I don't think either concept and their use in resource management are any more genuine or disingenuous.

**Personhood and a Rights for Nature approach in Aotearoa embodies the tension between crown governance and Māori sovereignty. Wai 262 has the potential to change the way conservation and environmental management occurs in Aotearoa. Wai 262 outlines a partnership, 'in which the Crown is entitled to govern but Māori retain tino rangatiratanga (full authority) over their taonga (treasures). Do you think this is going to be a workable vision for environmental management? [The Wai 262 claim, also known as the "Flora and Fauna Claim", was a Waitangi Tribunal claim lodged in 1991, and was one of the largest and most complex in the Waitangi Tribunal's history.]**

It's notable that it's been a long time since the reports, and I don't think we're much closer to anything tangible coming out of it. Our track record speaks for itself there.

The Tribunal reports do quite a good job of saying that resources are inseparable from their metaphysical properties. It makes clear that we've got to start putting those metaphysical properties first, rather than ignoring them. And that is quite a fundamental shift for New Zealand. It's not that long ago that a judge in court said that Nganeko Minhinnick and her Ngāti Te Ata people's objections to the Waiuku Steel Works – the taking of freshwater from the Waikato, bringing it to the steelworks, transforming it in terms of heat and chemical pollutants, and then transferring into the Manukau Harbour was "a purely metaphysical objection", and that was reason for it to be dismissed. That it had no substance because it was "purely metaphysical". To frame it like that is incredibly insulting. That was in the late seventies, early eighties. If we can capture what's been said in reports and research for Wai 262, and ensure that the metaphysical properties of nature are realised in courts and tribunals, that will be a great thing. I just don't quite see what the mechanism for that is. The intent is there, but it's not like the various parties of Wai 262 have actually come up with mechanisms for getting to that point.

**Do you have any ideas of mechanisms that might work for this vision of Wai 262?**

I don't know if I should admit to being a bit of an anarchist, but academic anarchy is a little different to populist anarchy! I'm a big believer in flax-roots approaches that involve local expressions of leadership. And that's particularly relevant to the sorts of issues that personhood has been used to address, because giving a landscape personhood is not a local solution. It's actually a globalised rights discourse that's trampling on local expressions of personhood and culture. Hopefully, you got that distinction I made earlier between there being something meaningful for Tūhoe and Tūwharetoa to their relations of mountains and forests that may look like personhood is relevant. But it's not, because personhood doesn't build on what's there; it imposes on top of what is there. I would rather find solutions within the community. The relationship between metaphysical properties and physical nature is a very fine tuned thing. It can't be understood or well managed from a



*Rotoiti, which is one of the lakes in the Rotorua Lakes District. In this region, personhood has not been the focus of environmental issues in treaty settlements. Instead, there has been investment into lake restoration, and an attempt to give a larger role to Te Arawa in environmental decision making. This approach more closely aligns with locally based leadership than personhood rights approaches. Photo by Nicholas Rean on Unsplash (2014).*

distance. In academic understandings of anarchy there's still a role for the state, but it's an enabling role. To make local decision making and local control work in an ever globalised world, we need the state to be actively supporting it. But the initiative has to come from below.

We don't have a lot of scope for local control in New Zealand. Our particular style of doing things has always been against letting local people take control of their circumstances. A lot of the opportunities for local control have been taken away by the Think Big mentality that we've had in New Zealand for a long time, that lead to Tiwai Point smelter near Invercargill, and the Tasman Pulp and Paper Mill in Kawerau.

I think probably the worst thing was the National Development Act in the eighties, which said any major development that is in the national interest can be decided in court in Wellington, rather than at site. It meant that all the local activists were bankrupted by having to go to Wellington to protest, and most of them just dropped out because it's too expensive. New Zealand's conception of being a small underdog means we think we will fall behind the rest of the world unless we take a national development perspective.

Local expressions of environmental interest need to flourish for many Māori interests in the environment to be realised. It's when the local gets enabled, that we'll be in a position to more honourably and effectively deal with Māori environmental claims.



Photo by Brett Ritchie on Unsplash

# Explained: Dark Matter

By Caleb Todd

Chances are, you've heard of dark matter. Whether in popular science articles or the technobabble of your favourite sci-fi show, it pops up pretty much everywhere, and no wonder. Learning that what we think of as 'normal' matter only makes up 15% of the matter in the universe, and that the remaining 85% is comprised of some mysterious substance which we can't touch or interact with in normal ways is quite the bombshell. It makes perfect sense that it would occupy so much of our science consciousness; it's a concept at the very boundaries of what we know and understand, whose absurdity is easy to explain, and which has a catchy name and pub-quiz-style facts associated with it.

Perhaps the strangest part of dark matter, though, is that you've probably never been told where these crazy ideas come from. Dark matter is widely known but not widely understood. That may be why you're reading this article. The natural assumption is that anything which can stump the best physicists of our generation must be so advanced that it will be beyond the reach of anyone without a PhD. In reality, though, dark matter can be understood by anyone who's spun something in a circle and has experienced gravity. I'm guessing that's most of us.

By the end of this article, you will understand why scientists treat an idea as ridiculous as dark matter seriously. To get there, though, we need to make sure you know enough about swinging things in circles and experiencing gravity.

## Swinging Things in Circles

In 1686, Isaac Newton revolutionised physics when he laid out his three laws of motion (although we only need the first one). Newton realised that objects move in a constant direction at a constant speed unless there is a force acting on them. This can be unintuitive because you've never set something in motion that has kept going forever, but that's only because forces like friction and air resistance slowly sap a moving object's energy. If you threw a ball out in deep space, far from any gravitational pull or atmosphere, it would keep moving in the direction you threw it and at the same speed. That's Newton's first law in action. Conversely, if you threw the ball here on earth, its path would curve because gravity acts on it as a force. So the first law tells us that to curve an object's path, we need a force acting on it.

But we can go further: it is possible to work out precisely what force is required. Suppose you were to tie a weight to



the end of a string and try to spin it around. After a bit of experimentation, you would figure out that three factors influence how hard you have to hold onto the string to keep the mass from flying off in a straight line. These are: how heavy it is, how fast you're swinging it, and how long the string is. Without going into the details, there is an exact relationship between the force on the object, the mass of the object, its speed, and the radius of the circle in which it moves. If you know the speed, mass, and radius involved in any circular motion you observe, then you know exactly what the force is without needing to measure it.

That's everything you need to know about circular motion to understand dark matter. It's a very straightforward idea: knowing the speed, mass, and radius of things going in a circle tells you the force acting on them. The other puzzle piece we need is gravity, which is the topic of the next section.

### Gravity

As with circular motion (and, in fact, virtually all of physics), the story of gravity starts in earnest with Isaac Newton. He was the first person to formulate a universal theory of gravity, and it was a game-changer. Astronomy was arguably the biggest field of research at that time, and Newton showed that his theory of gravity could predict the planets' behaviours perfectly.

A few generations before Newton, Johannes Kepler had observed that the planets all moved in ways that obeyed three laws of planetary motion. Kepler's laws described the properties of celestial motion, but gave no justification for why they were so. They were observations lacking explanation. When Newton published his theory of gravity, he proved its validity by showing that Kepler's three laws arise as natural consequences of the theory. Newtonian gravity solved arguably the most significant outstanding problem in physics at the time, so, naturally, the scientific community accepted it as correct. But the story doesn't end there.

Over time, as we made more refined measurements and Newton's theory of gravity was put to the test, people started noticing discrepancies. Newton's predictions did not match perfectly with what we observed out in the universe. Most famously, in 1859, the precession of Mercury's orbit was observed to be too large to be purely Newtonian. Ad hoc justifications were proposed, but they all ultimately failed to be satisfying solutions. On the one hand, Newton's theory of gravity had been so successful in so many areas that it was difficult to discount it. On the other hand, it had serious gaps that couldn't be ignored. A new theory was needed.

Enter Einstein.

In 1905, Einstein had his *annus mirabilis*, or 'year of miracles'. Within the space of a few months, he published four papers that would revolutionise physics. One which decisively proved the existence of atoms, one on the

quantum theory of light, one proposing the most famous equation ever ( $E = mc^2$ ), and one on his special theory of relativity, which redefined how we understood space and time. All in one year. It then took him ten more years to derive his general theory of relativity.

In essence, Einstein's general theory of relativity was his theory of gravity. It describes the force of gravity as the experience of curvature in the spacetime continuum. When a moving object's path is bent by gravity, it's because it is moving in a straight line through curved space, not because it's moving in a curved line through flat space. If that doesn't make sense, then don't worry because it really shouldn't. The critical point is that the general theory of relativity is a theory of gravity, and – as you may have guessed – it does not suffer the shortcomings of Newtonian gravity. The precession of Mercury's orbit aligns perfectly with general relativity's (GR's) predictions. Every test thrown at GR has validated its veracity. In fact, some of the most well-known and widely-discussed areas of modern physics are direct consequences of Einstein's theory. The observation of gravitational waves, for instance, was among the final predictions of GR to be experimentally observed. Black holes, too, arise as solutions to Einstein's equations. In short, it can't be beaten.

Now you know much more than you need to know about gravity to grapple with dark matter. The gist is that we have a robust theory of gravity standing up to every prediction we can throw at it. Well, almost every prediction.

### The Problem

Now we finally get to tie our two concepts together. We know that objects can move in circles given the proper force, and the size of that force is entirely determined by the speed and mass of the object and the circle's radius. We also know that general relativity is a well-established theory of gravity that can predict the gravitational forces on objects accurately. You may see where this is going.

Galaxies are made up of hundreds of billions of stars orbiting around their mutual centre. They effectively undergo circular motion, with gravity acting as the force keeping them bound. Astrophysicists can measure stars' masses, speeds, and distance from the centre of the galaxy. They can also derive the gravitational force acting on all these stars by working out the galaxy's total mass and where that mass is distributed. So, we can calculate the force required to make the stars move in a circle, compare that to the force Einstein predicts the stars to be experiencing, and find that they are equal.

As it turns out, they aren't equal.

In several different measurements over a number of years, physicists noticed that the stars orbiting in galaxies were moving too quickly. In other words, the gravitational force we know must exist significantly exceeds our expectations.

Einstein's gravitational theory failed to predict the galactic forces acting on stars correctly. There are only two possibilities: either general relativity is wrong, or galaxies contain a lot more mass than we can see.

### Dark Matter

General relativity's success makes it difficult to dismiss, which forces us to consider the second option. The proposal is this: there is a new type of matter that does not interact with light. Its only measured influence on 'normal' matter is through gravity. This would explain why galactic gravitational forces are greater than what we would expect; they are subsidised by unseen matter that is covertly increasing the mass in galaxies. Physicists are very original, so they named the substance which doesn't interact with light 'dark matter'.

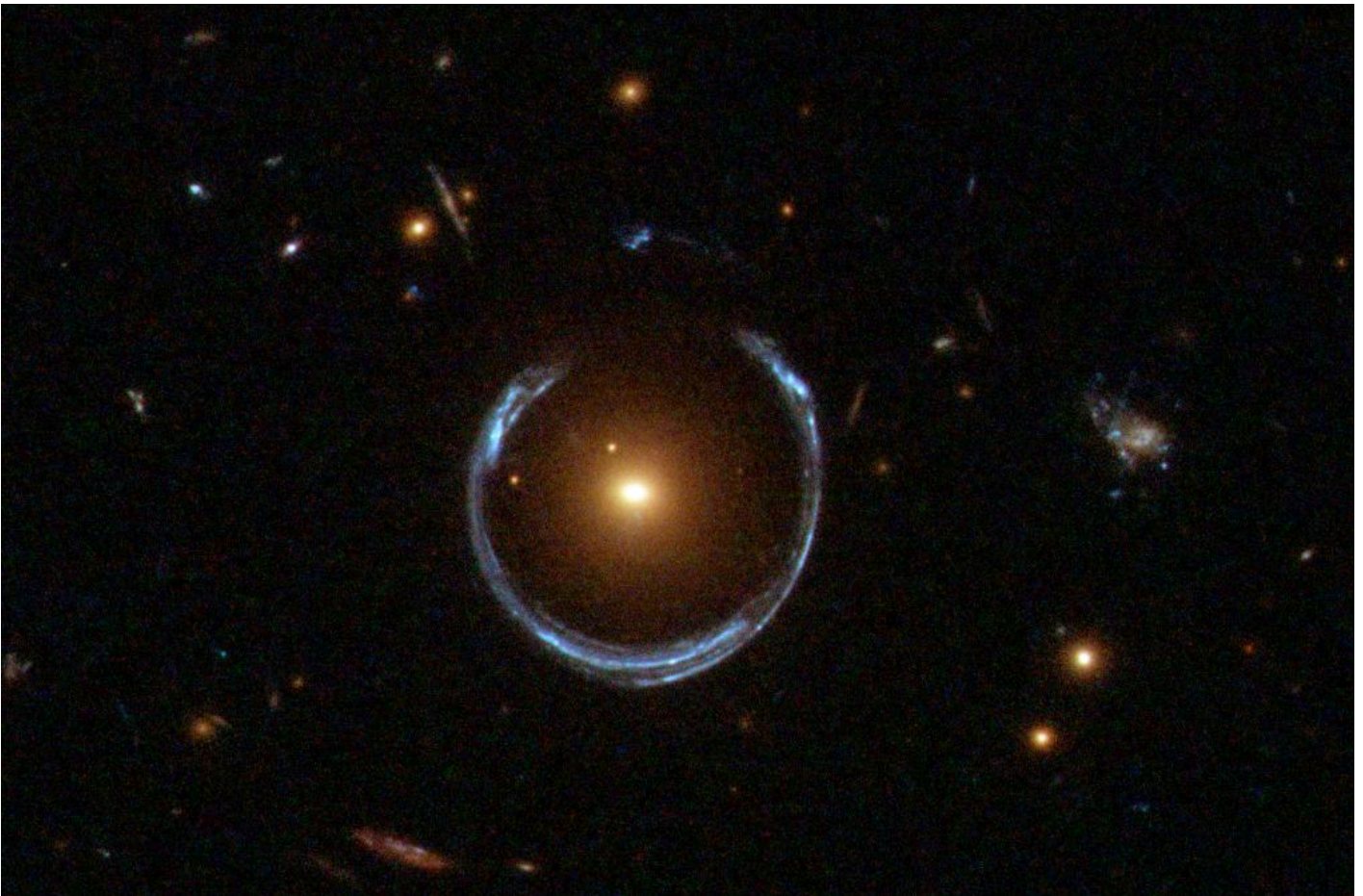
The conceptual route we've taken here to motivate their existence is only one of many. Mass of cosmological structures can be measured in many different ways, and they all point to the presence of missing matter. For example, gravitational lensing is a process where large masses (like galaxies) with strong gravitational fields bend light around them. We regularly observe gravitational lensing around clusters of galaxies, and the geometry of

the lensing allows us to estimate the mass involved. Again, we find that there is more mass in galaxies than we can see. A host of different observations all support this same thesis.

However, that is not the end of the story. As elusive as dark matter may be, it does have (feeble) effects on other matter. We should, in principle, be able to detect it directly. Indeed, many researchers are trying to do precisely that. As of yet, though, none have been successful. On the one hand, this is not unexpected. Any direct interaction between a dark matter particle and normal matter will be so slight that incredible experimental precision is needed. Furthermore, there is considerable ambiguity over exactly what properties dark matter would have and where we should look, meaning detection efforts have to be aimed at a broad range of candidate properties. Nonetheless, a lack of direct evidence for these particles is a valid objection to their veracity. That takes us back to the other possibility: general relativity could be wrong.

### A New Theory of Gravity

Let's come back to Newtonian gravity. We said that it was a revolutionary theory that was taken on board because of its startling ability to predict otherwise unexplained



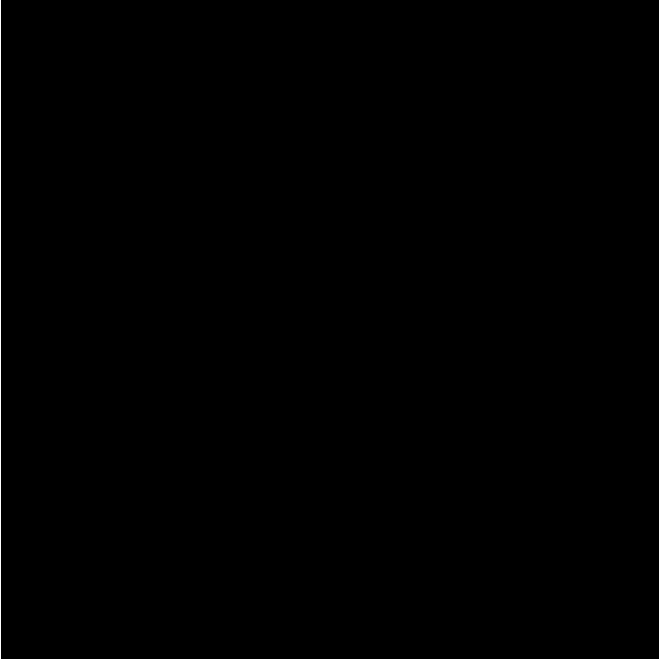
*An observation of gravitational lensing by the Hubble space telescope. The orange light in the centre is a large galaxy. Behind it is a blue galaxy whose light is bent around the red galaxy in all directions because of gravity, causing the illusory ring effect. The precise position and shape which the lensed image takes on depends on the gravitational field strength, which, in turn, depends on the mass of the red galaxy and where the mass is distributed. Such observations have provided evidence for the existence of dark matter.*

phenomena. But, over time, discrepancies arose between observations and expectations that forced us to look elsewhere for our theory of gravity. Now let us consider general relativity. GR was a revolutionary theory that was taken on board because of its startling ability to predict otherwise unexplained phenomena. But, over time, discrepancies have arisen between observations and expectations. Sound familiar?

Admittedly, dark matter is a more satisfying solution to general relativity's problems than anything proposed for Newtonian gravity's. However, there is a second strike against GR's name which redoubles the doubts over it: we already know it's wrong. This may seem surprising after I spent so much time talking about how it has passed every test thrown at it, but at the time, I was omitting an important detail: general relativity has only really been tested on particular scales. We know it works incredibly well for objects the size of planets or stars, but it may no longer apply at larger scales. Newtonian gravity worked incredibly well for objects the size of you and me, but it began to fail when considering things the size of our solar system. Testing a theory in one regime offers no guarantees of its validity in another regime.

The problems for general relativity get worse, though. GR is one of two theories central to modern physics; it describes things on large scales, while quantum field theory describes things on small scales. Both theories have been highly robust within their own domains, but they cannot be reconciled with each other. There is no definitive quantum theory of gravity that would unify physics under a single conceptual framework. General relativity simply cannot be reconciled with quantum field theory at small scales. Quantum field theory is the best supported theory in science - its predictions have been proven to a level of accuracy beyond any others' - so we know that GR cannot be entirely correct.

Having said that, GR being an imperfect theory does not imply that dark matter does not exist. To dismiss dark matter, we would first have to find a theory of gravity that



*A computer-generated image which approximates what some scientists believe dark matter would look like. This is only a theoretical conjecture, though, as we are yet to directly detect any dark matter.*

explains the phenomena that made us consider dark matter in the first place. Many attempts have been made at correcting GR. Some of these attempts have successfully explained some of the phenomena, but none have explained all of them. The single proposal of dark matter can explain a huge variety of observations, and Occam's razor suggests that a single, simple proposition that is consistent with many observations is more likely to be correct than a large number of complex solutions which partially explain some observations.

For this reason, dark matter is the more widely accepted solution to the problems which astrophysicists face. Still, until it is directly observed, the question mark over dark matter remains, and physicists will continue to debate its veracity. You can judge which side of the debate you sit on.



# Commercialisation of Research

## Interview with Assoc. Professor Geoff Willmott

By Alex Chapple

**F**or many young students, commercialisation of research, and industrial research is not something we come across very often. And yet, this field of research is incredibly important and brings about a huge amount of innovation and entrepreneurship. If you haven't been exposed to industrial research much, it can be difficult to see how it works, who funds it, and how to get involved. The following is a conversation I had with Associate Professor Geoff Willmott from the University of Auckland. Geoff is a Principle Investigator, as well as the Deputy Director (Commercialization and Industry Engagement) at the MacDiarmid Institute, and has a joint appointment with the Department of Physics and the School of Chemical Sciences. We talked about how industrial research works, and how you can get involved as well.

**How does industry research work? And how's it different to research that is funded, for example, through the Marsden fund?**

The industry refers to companies that are making things, selling things, producing items, or selling services. In the course of doing that, they come across challenges or opportunities in their business that require research to figure out how to address them.

So Apple wants to create an iPhone, everyone wants to buy an iPhone, that's going to make them and the shareholders a lot of money. But in order to do that, they need to get some research done to figure out how to make a good phone. So that's kind of how industry research works, it creates value in companies. In a very important way, it's not different from any other research. So if you're a scientist working on an industrial project, you will quite often have a very similar process to what you would have if it were a more fundamental project. You have a research question that you're trying to find something out about. History is littered with these discoveries, where fundamental advances come as a result of industrial problems.

A really good example would be one of the recent Nobel Prizes awarded for the blue LED. It was a fundamental material science problem of how do you get a blue LED material? In doing so it meant you could have a white light LED, so it's an extremely valuable problem. So in general there can be a bit of an arbitrary line between industrial research and fundamental research.

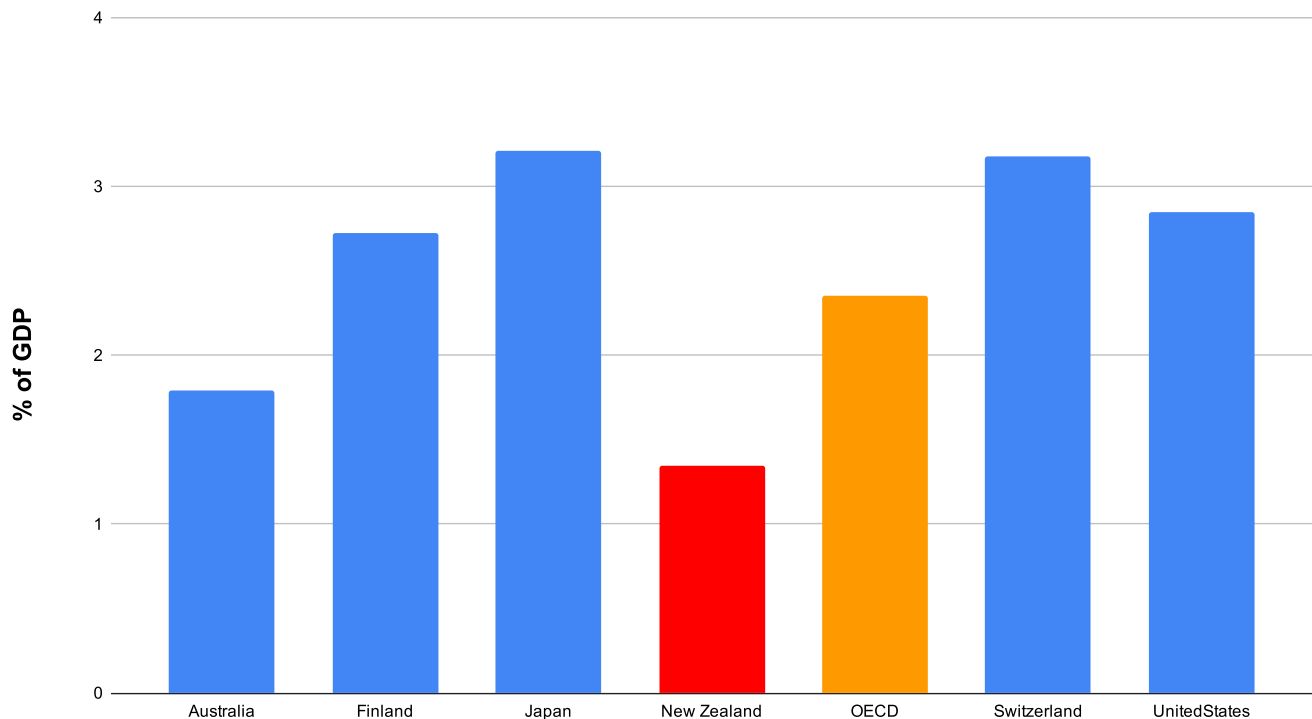
Now, having said that, there's obviously some kind of difference because otherwise we wouldn't be talking about it. So in terms of funding, a company can directly fund research themselves. So they might pay say, myself or the university, to carry out research that's of interest to them. But there's also quite a large amount of government funding and quite a large number of schemes that support industrial research. So the companies are not really paying for it. Callaghan innovation is one of the agencies in New Zealand and they can fund PhD projects. So the money will come from the government and it's seen as a public good that supports the company, but it's also a public good in the sense that it supports the broader economy as well.

Whereas when you apply for the Marsden fund, people will not judge you on how applicable your science is, it's all about is this a world leading, game changing, academic idea? In industrial funding applications, it's about what is it gonna do, who are you working with, and who's interested? I should also mention that lots of, and some of the best innovative companies employ their own R&D (research and development) staff. So many people with undergraduate/postgraduate science degrees can go on to become researchers at companies that conduct internal research.

**So if a business has a problem, and it requires research to solve the problem, are the research problems more physics/chemistry based problems rather than an engineering problem?**

Often these lines we draw between departments are pretty arbitrary. Engineering schools, and the profession of

## Gross Domestic Spending on R&D (2017)



The figure shows the gross domestic spending on research and development as a percentage of the countries GDP in 2017. Gross domestic spending on R&D is defined as the total expenditure on R&D carried out by all resident companies, research institutes, university and government laboratories, etc. New Zealand's R&D expenditure falls short of the OECD average. Source: [data.oecd.org/rd](http://data.oecd.org/rd)

engineering may be more set up to do directly applicable things.

Perhaps the chemists and physicists are more set up to think outside the box, and do things that are entirely new but that's a generalisation. But perhaps that's how it can be classified. There are plenty of commercial projects that go through physics and chemistry departments as well as engineering.

***So I think you had a project that you were looking to commercialise. So how does that work? It sounds like it's the opposite direction of what you said before.***

So commercialisation is where you take the research that you're doing within the university and say, hey, we think this could be useful outside the university. It's a very interesting area, because it's where the two different worlds meet. So people who are researchers who have done research, all of a sudden, come in contact with the idea of a market. You need people to want to buy your product before you've got the products. There's a lot of stuff that happens at the interface there, and that's kind of interesting. So one thing is to educate our scientists and engineers about how the commercial world works. We have an organisation called Uniservices. They're attached to the University of Auckland in what's called a technology transfer office.

So if you are trying to commercialise your research as a University of Auckland researcher, then typically you go to

Uniservices and talk with some of their specialists. They may say this isn't really for commercialisation come back in a year when you figured out this or that, or they might say, this is great, lets go patent it. Or they might say, this is great, this company we know could really use that technology so you should go talk to them.

The idea of protecting intellectual property, and to be able to capture some of the knowledge for your own private benefit is really important in societies. Otherwise, if you couldn't protect your intellectual property, then somebody can steal your idea and so there's no point in doing the research in the first place.

In terms of dealing with intellectual property, there are different ways to go about it. People are most familiar with patents. So that's kind of like a paper except you write down what your idea is, and it goes to a patent office and gets judged whether it's a good patent. Once you've got your patent, then competing companies overseas that come up with the same idea cannot commercialise it in the same domain that you've got your patent in. The other thing you can do with your patent is licensing. You can go to another company and say, we've got this cool idea and you can use it for X dollars a month or something along those lines.

That's quite a good model in many cases because it means you don't have to go and set up a business yourself which can often be hard and costly. This way you can still make money from your inventions.

So the other way is to set up your own company and that's what startups or spin off companies are. More and more are emerging from universities in New Zealand. A lot of young physics, engineering, chemistry graduates get involved in startups.

***I went to the bio engineering building over the summer and there were tons of spin off companies that were based in that building.***

Yeah, and that's a healthy ecosystem of companies. So in order to grow your company, you need capital investment, which are people who want to give you their money for a stake in the company.

Then when the company grows, they can sell that stake and make money. So you need to find those people that believe in you to grow the company, and it's easier to find those people if you're all based in the same place/building. A good example is Silicon Valley, where a lot of the IT and electronic companies sprang out of one particular geographical location in California. And the idea was that because all these companies were rubbing shoulders with one another, and because they shared people (people moving from one company to one another and cross pollinating ways of doing things) the investors would go to Silicon Valley to find cool things to invest in.

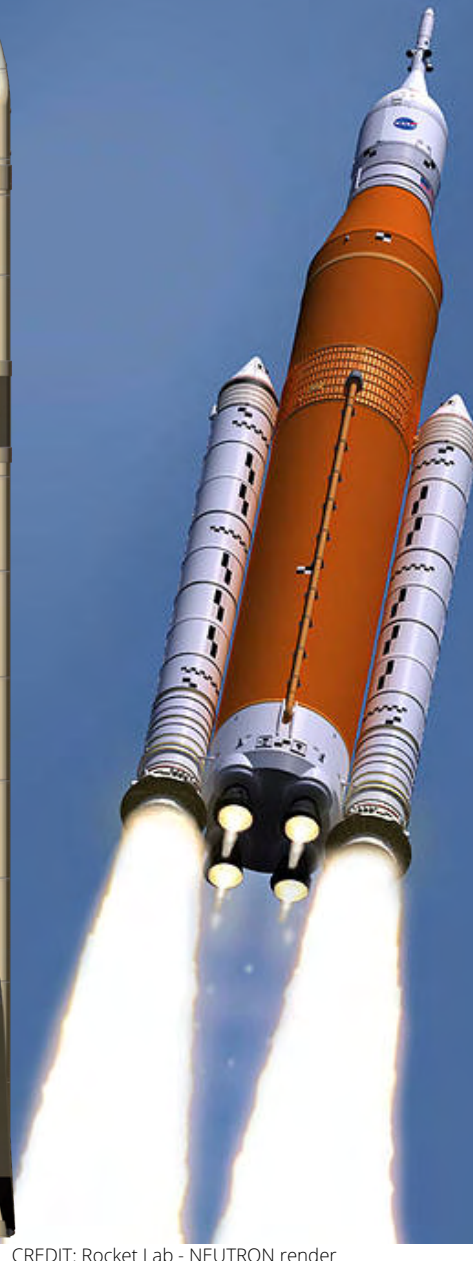
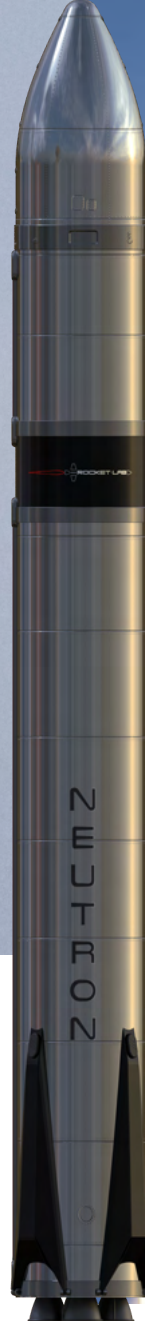
***What do you find most exciting about industry research?***

I think it's exciting because you can see some kind of tangible effect of what you're doing. You can see a product go from A to B. I worked on one product, where the

research we did provided the sales material. So when the company was going to customers, they would show the research and the customers would say, wow that's cool, let's buy it. So you can see that type of impact. It's also a little more dynamic. There'll be kind of harder deadlines that are out of your control. In the academic environment you might set yourself a deadline and then halfway to getting there realise there's some other thing that's more interesting and change plans and so on. In industrial research it can be a little bit more prescribed in terms of what you're doing but it's also more energetic sometimes, and that makes it exciting.

***How can you get involved in industry research?***

One thing is go look for jobs in these startup companies because they might be employing people. There are also a number of R&D heavy large companies in New Zealand that will recruit scientists. If you're looking at research projects within the university, then they might have an industrial partner too. Taking advantage of skills development is the other thing. Uniservices put on workshops, and they're things like the Velocity challenge, which is a challenge where people can take their ideas and pitch them for investment as young students. Lots of science undergraduate students will go into fourth year honours and do a research project as part of that. So talk to your supervisor about whether there is intellectual property associated with it and whether you should be publishing it or keeping it a secret. The supervisor should have a bit of an idea about that. So it's not too early to ask around and get involved in commercial projects.



CREDIT: Rocket Lab - NEUTRON render

# The Next Generation of Rockets

By Struan Caughey

**A**s we conclude the first quarter of 2021, the rocket industry has shown vital signs of moving from strength to strength. The past few years have been defined by small to medium-sized rockets with a strong focus on reusability. This legacy started in 1977 with the launch of the Enterprise space shuttle. The turn around for the space shuttle cost approximately \$450 million USD, and the shortest time to turn around and reuse it was 54 days. This is a far cry from SpaceX's 27 day current record at USD 15 million with the Falcon 9 B1060 on February 4th this year. We also now have players in the reusable market other than SpaceX, such as Rocket Lab, which also has fully operational rockets as well as projects at the developmental stage from Blue Origin, European Space Agency, I-space in China and Roscosmos, amongst others.

This year, however, three rockets have frequented the news, all from drastically different businesses. They have all been in the news for various reasons, what they share however is they're all the flagship rocket for each company.

## SpaceX

First, we have the Starship from SpaceX. Their current line up of operational rockets are the Falcon rocket and the Falcon heavy rocket; however, neither of these have been making the news this year. Instead, Starship, the company's current rocket in development, has been hitting the headlines. There have been two successful 'hop' flights in 2020, reaching 150m. However, the main news is the four subsequent flights, all reaching at least 10km, three being this year, and all of which resulted in "rapid unscheduled disassembly". These rockets have excited space enthusiasts for two reasons; first, they will be the first operational fully reusable rocket with existing models having some single-use components. The second reason is that these are the rockets envisioned to take humans to Mars. They can take over 100 tonnes to low earth orbit, which would put it in a class of its own, there only ever being one other rocket, the Saturn V, with the same capacity.



### Rocket Lab

Next, we look to the other end of the spectrum, New Zealand. Rocket Lab is a small reusable rocket firm operated out of Auckland but registered in the United States. This was not the company's original intention, with the original plan to be small, cost-effective single-use rockets; however, the electron has now been iterated upon to become reusable like the Falcon and in dramatic fashion. A mid-air helicopter interception is used to catch the electron rocket on its descent. The CEO Peter Beck had intended that they would not venture towards the more populated part of the market of medium-sized rockets, instead sticking with their 300kg capacity booster; this now is in question. On March 2nd, again playing into Rocket Lab's flair for the dramatic, a Hollywood trailer-like announcement was released on Youtube where Peter Beck literally ate his hat as he announced their new Neutron Rocket, which would have 8000kg payload capacity launching the company directly into the upper end of small payload rockets and in a new direction. This will be similar to the company's Electron rocket, having only the first stage be reusable.

### NASA

Lastly, there is NASA. The most famous space agency which still has the record for the rocket with the largest payload capacity (the Saturn V which took astronauts to the moon)



This rocket was able to handle sending 140,000 kg into low-earth orbit but was retired in 1973. With the current focus on renewed missions to both the Moon and Mars, there is a new need for a similar rocket. Instead of resurrecting a 50-year-old booster, NASA took steps to design the SLS, also known as the Space Launch System. This new rocket has been hitting the headlines for its recent static fire test, which showed the sheer amount of power this next-generation, interplanetary rocket has. When the SLS does go to launch, it will overtake the previously stated record. This rocket represents one of the few newsworthy rockets which is still only designed to be launched once. This is to increase the ship's maximum payload size. While the Rocket Lab Neutron rocket is substantially different from the SLS, SpaceX's Starship will compete with it. The trade-off at this moment would seem to be payload size on the SLS side with reusability and cost in favour of the Starship.

This is a recap of the three most reported rockets of 2021, which are all in different stages of development; however, there are many more that will also be going up against these boosters and further iterations on existing ones to make them more advanced. There are interesting arguments on both sides of reusability, with there being a great many benefits both in cost and speed of turn around; however, NASA shows that there is still a very real place for the more traditional rocket with high yield requirements. Wherever the industry goes, one thing is certain. Rocket science is only going up.





Image from IBM Research

# The State of Quantum Computing Today

## Interview with Professor Cristian Calude

By Alex Chapple

**Q**uantum computers are a new class of computers that have been receiving a lot of media attention in the last decade. These computers' underlying structures are entirely different from the modern computers we're all familiar with, which are known as "classical computers". The underlying architecture of classical computers is based on "classical physics," which is the macroscopic physics we experience in our daily lives.

In contrast, quantum computers, like the name suggests, manipulate quantum behaviours to do computations. In classical computers, the information is stored as bits, which take on values of either 1 or 0. Quantum computers are built on qubits (quantum bits). Instead of taking on 1 or 0 as their value, they take on both simultaneously (Yes, freaky I know). So if you have ten quantum bits,  $2_{10}$  states are being represented at the same given time.

Because of this, quantum computers promise to be exponentially quicker at certain computing tasks and may revolutionise fields like computational biology, cryptography, quantum chemistry, quantum simulations, and more.

These computers have certainly been gaining traction from the media, most notably when two years ago Google claimed to be the first to achieve "quantum supremacy". Quantum supremacy, also known as quantum advantage, is a term coined by California Institute of Technology Professor John Preskill. It is the notion that a quantum computer can compute things that a modern classical computer cannot in a meaningful amount of time. Perhaps what drives the most media attention is the multi-billion dollar investments companies such as Google, IBM, and Microsoft and large governments like the United States, China, and the UK are putting into research and engineering.

In December 2018, the United States Congress passed the National Quantum Initiative Act, which aimed to advance quantum technologies in the next ten years by further supporting research and engineering. It seems as though governments and large tech companies around the world are betting heavily on a future filled with quantum technologies, but is the hype and media attention around quantum computing justified?

The following is a conversation I had with Professor Cristian Calude from the School of Computer Science. Professor Calude is the director of the Centre for Discrete Mathematics and Theoretical Computer Science, and a research consultant for the Quantum Computing Research Initiatives at Lockheed Martin, USA. We talked about the state of quantum computing today, where it may be heading, and why the media attention that quantum computing is getting is getting may not be for the right reasons.

**How does your research tie in with quantum computing?**

I'm a mathematician and a theoretical computer scientist with interests in quantum physics and computing. All my papers in quantum areas have been done jointly with physicists (Professor Karl Svozil from Vienna is my longest collaborator) to ensure that the physics is correct. Initially we used finite automata with outputs to model quantum phenomena. For example, we've described Bell's inequalities with finite automata.

*(Finite automata are simple idealised machines used to recognise patterns)*

In the last ten years, I was involved in two quantum projects. One was to study quantum annealing, because we've got support to use the D-Wave machines. It makes a huge difference when you work in quantum computing if you have access or not to a real quantum computer.

*(D-Wave is a Canadian quantum computing company based in Burnaby, British Columbia, Canada. They use a particular technique called quantum annealing to solve problems. The technique finds the global minimum of a particular function by manipulating a quantum system).*

So you look at the machine and say, what can you do with it? Is there something useful one can do with it? How far can one push the limits of the machine?

The other project is connected with my work for many years in algorithmic information theory, a very beautiful and powerful mathematical theory of randomness. So at some stage, I said 'quantum randomness is believed to be the best form of real life randomness, so is algorithmic information theory relevant to understand it?' I have been also interested in quantum randomness because physicists believe that quantum randomness is perfect randomness,

while mathematically there is no perfect randomness, so one should only look at degrees of randomness.

We also proposed protocols for quantum random generators and proved theoretically that they are better than any pseudo-random generators. We were fortunate that a lab at University of Queensland led by Professor Arakady Fedorov did the experiments. We published the protocols, and the physicists published the experiments.

We were very interested in the experimental results because one is a theoretical protocol written on paper, and the other is an experiment that cannot be done under ideal conditions. We developed tests for assessing the quality of the quantum random bits generated in the lab and analysed to what extent theoretical results are reflected in the experimental results.

**Why does and doesn't quantum computing deserve the media attention it gets?**

Well, I am not a media expert, but I have some guesses. There are many promises about quantum computing, which, assuming that the dreams come true (which I don't believe they will) will change many technologies that are used today. Encryption and security are examples. So, if you are a government or a big IT company with lots of money, you cannot afford to leave the competition to develop a technology which can be used against you, even if there are very few solid arguments that it will. Google cannot accept that Microsoft can do it, and Americans cannot accept that the Chinese can do it, and vice versa. So in a word, it's driven by fear. It has escalated into a huge race, and none of the big actors are bold enough to stop. But this race cannot continue forever if critical results are not delivered.

For the time being, the media is a very strong supporter of the field because writing about this race will bring readers and, like most businesses, the media is channelled on making a profit.

**Yes, I agree with that. When I read stuff about quantum computing, especially if it's from less reputable news websites, it's so clear that they're sending false hope because quantum computing is not very close to being what they think it is.**

They don't know what it is in the first instance.

**Can quantum computers really solve the problems that the media is saying it will solve?**

I should probably say, first of all, that even in an ideal scenario, quantum computers can compute much less than classical computers. This is because quantum computers can compute only total functions. If you have a function that divides two integers, X divided by Y, you have to exclude the possibility to divide by zero. So you can't return an answer for X divided by zero. That is undefined and illegal. This kind of test, which is trivial for classical

# Some popular models of quantum computing

And who makes them

## Superconducting Quantum Computers

Uses superconductors to create qubits



## Trapped Ion Quantum Computers

Uses ions confined in electromagnetic fields



## Linear Optical Quantum Computers

Uses light and optical instruments to process quantum information.



## Superconducting Quantum Annealer

Uses superconducting circuits and quantum fluctuation to find global minimum of functions



computers, cannot be performed by any quantum computer.

Let me give you a picture. Let's imagine the Pacific Ocean is a set of all mathematical problems. How many of them can be solved by classical computers? A small drop. Most of them cannot be solved with any classical computer. From this drop, only a smaller part can be solved by quantum computing.

So what's the point of quantum computing? The only justification is in this small area where quantum computers can solve problems of practical interest. If these problems could be solved with quantum computing tremendously faster than with classical computers, then the effort would be justified.

In the early 80s the American physicist Richard Feynman and the Russian mathematician Yuri Manin came with the idea of quantum computing. Both of them were talking about simulations and Feynman said 'look, I have this kind of quantum system I want to simulate and I know that I can simulate it with a classical computer, but it will take an exponential time. Can I do it faster?' And Manin said that it's possible if the machine is quantum itself.

But Manin noticed something even deeper. He said that to simulate a quantum system, a classical machine needs to understand a lot of quantum theory and incorporate it into the program, and this takes time to develop and run. But a quantum computer will not need this because it is already based on the same quantum principles, so that it will be faster. It's a shortcut.

Quantum computing is intrinsically interdisciplinary. You have people from engineering with their cultures, businesses with their cultures, mathematicians with their own, programmers with their own, etc. It's a very young field, and it doesn't have its own sound culture.

*Yes, it's an interesting field like you said because it's so young. There are many engineering problems, physics problems, and mathematical problems.*

Yeah, lots of problems, I'm not saying that this field is not interesting or exciting. And there will be benefits, possibly not those discussed so much in the media. For example the idea of "de-quantisation", where you take a fast quantum algorithm, find a way to rewrite it for classical computers and obtain a much faster classical algorithm than the current algorithms.

The hype for quantum computing is damaging because if you claim things you cannot prove or deliver, at some stage people will say, oh, that's not serious. This will be detrimental for the field.

*To change the topic: there are many ways, many different architectures for building quantum computers. Google uses superconducting qubits, others like ion Q use ion traps, and there are many other ways. I know Microsoft recently thought of giving up on their topological qubit because its engineering was too complicated.*

That one is from a mathematical point of view the most interesting... If the engineers feel that this is beyond the capability of the current technology, maybe it's best to shelve it, maybe for 20 years, and then look at it again.

*Which type do you believe is most promising or will be the most fruitful.*

Well, I don't know, you cannot predict even the past, and you're asking me to predict the future. I think that quantum annealing, which is the form D-Wave machines use, will survive many years and be fruitful just because they take a more pragmatic attitude.

*So their architecture is to use thousands of weaker (less*

*connected) qubits, as opposed to using 50 well connected (strong) qubits like Google's qubits.*

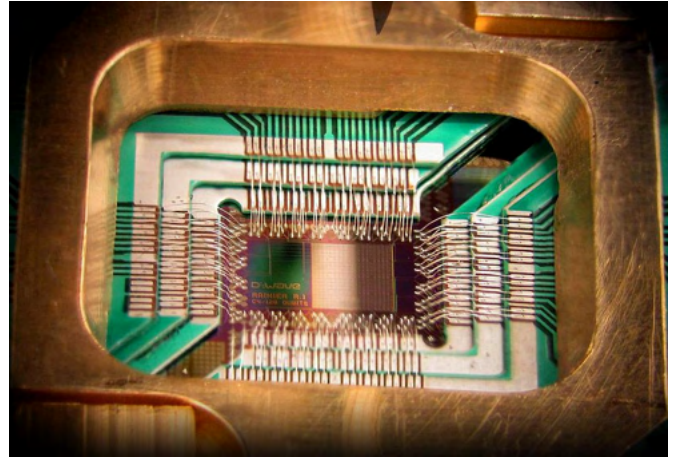
So you say they have weaker qubits: true, but this is an advantage. They use qubits that are weaker (meaning fewer problems, in particular with error correction), but strong enough to solve problems.

I was amazed by the engineering decisions made by D-Wave even before we started working with them. One was to solve one single problem. It's a discrete optimisation problem, but this problem is generic, so many practical problems can be reformulated as instances of this problem and solved by D-Wave. This makes a controversial decision a smart choice.

*My next question is: what are you most sceptical about the field of quantum computing in general?*

Well, I am sadly sceptical about the hype. I fear that it will attract people for the wrong reasons, mostly because of fashion and money. I have seen this trend in the late 90s when there was a strong interest in a field called structural complexity. It attracted lots of young people, producing papers and PhDs. Many results are correct, but without meaning. And then after 15 years, nobody reads those papers, they had to switch fields.

*My last question is sort of on the more optimistic side.*



*A 128 qubit D-Wave processor. This is one of their earlier models, currently they have systems with up to 5000 qubits.*

*Suppose we're in the future, and there is a perfect quantum machine that you can use. What kind of computation would you like to do on it?*

Well, I would like to test the Riemann hypothesis.

*I read somewhere that with 2000 perfect qubits you can prove the Riemann hypothesis.*

Oh, if you find that article, please send it to me: I'm interested.

# OPINION: AUSTRALIA VS TECHNOLOGY

By Struan Caughey

Google would be in the right to pull out of the Australian market. This is due to their Governments' poorly thought through legislation and lack of understanding around digital technology.

Throughout this piece, I will be looking into the Australian Government's approach in its attempt to regulate the internet through two separate pieces of legislation. The first will be looking at the impact of *The Assistance and Access Act 2018*, specifically its effect on encrypted messaging. The second will be reviewing the impact of the *Treasury Laws Amendment (News Media and Digital Platforms Mandatory Bargaining Code) Bill 2021* and looking at Facebook and Google's responses to these.

## *The Assistance and Access Act 2018*

On 6 December 2018, the Australian Government required companies to provide access to encrypted data on request. This specifically affected end-to-end encrypted messaging applications such as WhatsApp and Signal as this, in essence, banned their technology. The reason cited was for "national security" in response to the increasing threats of terrorist attacks across Europe and domestically. There are three major flaws with this. The first being a privacy issue, the second is the technical and security issues of implementing a system that would be compliant, and third is the ability to circumnavigate the legislation, rendering it ineffective.

**Privacy:** First are the ethical issues of this approach. If two people have a private conversation in a private location, the vast majority of people would agree that both parties would feel violated if a third person was listening in, irrespective of whether it is a friend eavesdropping or a government planted bug. There is an expectation within society that private conversations are kept private. Why should this not be true when you are having the same conversation via a digital platform? This also ignores the impact this could have on people who require such protections, such as government whistleblowers.

**Technical Limitations:** The second, and arguably the more compelling point, is the technical limitations of such an approach. To understand this, one needs to understand how end-to-end encryption works. We will look at a situation where person A is sending a message to person B through WhatsApp.

The system works through two keys, a 'public' and a 'private' key; both keys are generated on person B's device. The 'public key' is then broadcasted by person B's device and is available to everyone. This can be used by person A to

encrypt the message on their device before sending. This message can now only be decrypted by the 'private key', which should only exist on person B's device. This makes it nearly impossible for anyone to see the message's content, including WhatsApp, the messaging provider. This is a robust system as it is highly secure, being virtually unhackable except through brute computational force. Brute force would in itself take thousands of years on current technology to work. Even if an individual's private key did get revealed, you could never construct a large scale attack on an app using the technology, provided that the encryption is properly implemented.

For the Australian Government to have access to the messages, they would have to hold a copy of the private keys. This could be done in several ways, but all of them leave the individual's security open to malicious actors. The simplest interception approach would be to have either the Government or individuals phone generate the private key, and then send it to the other. However, this immediately opens a vulnerability to potential bad actors who could intercept this. The other alternative is that all messages get sent to a second account, the governments' account, but this is large-scale data collection that the public would be unlikely to support.

Suppose you could get messages to the government securely. In that case, this relies on their storage being both secure and unable to be accessed by malicious actors. While you would hope that a government would be capable of doing this, recent news show this is not necessarily the case. In November 2018, Brazil's high court launched an investigation into a hack that shut all proceedings down. This should be a warning to err on the side of caution. This situation has the possibility of happening with the Government of Australia.

**Ineffectiveness:** Any organisation that wanted to have encrypted communication for nefarious communication has options; they could code their own app, sideload an existing app or use a VPN to get an existing app from another country such as Signal. Programming your own app is not overly advanced, as Signal's code is open source.

Putting the three issues; privacy, security and ineffectiveness, together, we can see how this legislation demonstrates the Australian Government's ignorance in producing this legislation.

## *Treasury Laws Amendment (News Media and Digital Platforms Mandatory Bargaining Code) Bill 2021*

We now look at our second case study, the Treasury Laws Amendment (News Media and Digital Platforms Mandatory

Bargaining Code) Bill 2021. The internet has existed as a platform, since its founding, where publicly accessible information is done so freely. The legislation we are considering has attacked that existence and even brought out Tim Berners-Lee, the person credited with founding the world wide web, to speak on the issue. He stated that this bill “risks breaching a fundamental principle of the web by requiring payment for linking between certain content online”.

To explain how Australia has brought such heated debate to the forefront, we must look at the legislation and its implications. As both Google and Facebook have been in the news regarding this legislation, we will look at this bill from their perspectives. We will look at the current system, the issues with the legislation and if there are other solutions.

The legislation's key point is to require payment from content distributors, such as Google and Facebook, to news sources for the sharing of their articles, as they make income from ads on these searches. Without context, this doesn't appear to be too great an issue. At first glance, it appears to be a good way for news organisations, who in general have struggled with finances due to the shift to digital, to gain a new stream of income. That is until you look at who the primary beneficiaries of the current system are.

**Pre-existing system beneficiaries:** In the current system, Google and Facebook benefit from sharing these articles since it brings traffic through their particular services. This, in turn, allows them to run ads on these searches, which generate income. The other side of this is the benefits to the news publishers. By being made available through these services, traffic is directed to their site. Again, this allows them to run adverts on their site, allowing them to generate revenue. You could argue that the primary beneficiary in this system is the news sites, as Google and Facebook do not require news sites to operate, whereas, for the news sites, the ability to reach a global audience through these services is invaluable. Because of this arrangement, the idea of Google and Facebook having to pay for, in their eyes, facilitating a service to these news outlets makes little to no sense.

**Arbitrator issues:** The situation worsens with the method that the Australian Government is implementing as the payment system. The two interested parties have to agree on the price which they feel that the news organisation should be paid. This is then what is charged; however, an arbitrator decides the value if an agreement is not made. This is not able to be appealed. This gives a considerable amount of power to the news organisations, as even if they had previously been okay with the existing situation, there are no repercussions to them asking for as high a value as they wish as, at worst, this will just go to arbitration. This has already occurred with News Corp claiming that they should be paid between \$600 million and \$1 billion USD for their content by the likes of Google and Facebook. In contrast, Google has stated that they only earn around \$10 million USD in advertising revenue from searches related

to news-related services in Australia for 2019, while Facebook stated, in response to being asked a similar question at a Senate Committee hearing, they earned “virtually zero” revenue.

**Reaction and backlash:** You can see that in this situation, the tech companies may not be inclined to engage in the system that leaves them with so few options. For this reason, I am sympathetic to Facebook removing news sites from their Australian operations and not publishing any of their links abroad, as well as Google's consideration to remove themselves from the Australian market altogether. However, I feel that they did not go about this in a way that was likely to garner public support. They did not clearly explain their reasoning, which made it appear that these corporations were using their size to force and manipulate a government. In reality, it was their attempt to demonstrate that they may not be able to operate economically as usual under these new rules. Both acted overzealously, especially Google, which led to the public outcry against them.

These corporations deciding that they do not want to work under these situations is a perfectly legitimate response. I would understand if they withdrew, at least, the most affected services from the Australian market. If this had happened, the stakeholders worst affected would have been the news corporations. Facebook and Google ended up shooting themselves in the foot as they lost public support, taking away their perceived position of control.

**Revealing trade secrets:** The final issue with this legislation is that one of its requirements is that the tech companies must let news corporations know about any change in their algorithm, which could affect the standing of their news in the search results. How this will be conducted is still unknown. As an example, Google makes a multitude of changes to their algorithm daily, most of which don't even require human input and many times, even Google may not be aware of the effect of a specific change. On top of this, Google, as a business is essentially their algorithm; everything else is auxiliary. To give this information up is giving up trade secrets.

**Another way:** There is widespread acknowledgement that news sources are struggling, and to all the failings of this legislation, at least the Australian Government is attempting to remedy this issue. But what are some alternative solutions? There are a few ideas that have been floated. One is, interestingly, a project of Google's. A new service called Google News Showcase may be coming to New Zealand. This has Google pay and curate news corporations for articles that are made available for free to users. This can also include paywalled news sites, and brings the reader directly to their websites, resulting in increased traffic to the news corporations. These stories would later be made available freely on the web. While this does bring in the new stream of revenue required by their news corporations, it also does not entirely undermine Google's negotiating position. As a solution, this is a sort of halfway house. There have also been suggestions of

allowing taxpayers' funds to be made available to supplement news organisations. This can be argued, as some see it as a democratic right to have access to a wide array of news sources; however, this could be criticised for reducing the autonomy and impartiality of news sources. There may not be a clear way to resolve the issue.

**Conclusion:** As we continue to push into the digital age, more of these issues will become apparent, and we have to try for better systems of distribution that do not impact the freedom the web has been founded upon. Brute force such as the Australian methods are not the way forward; they

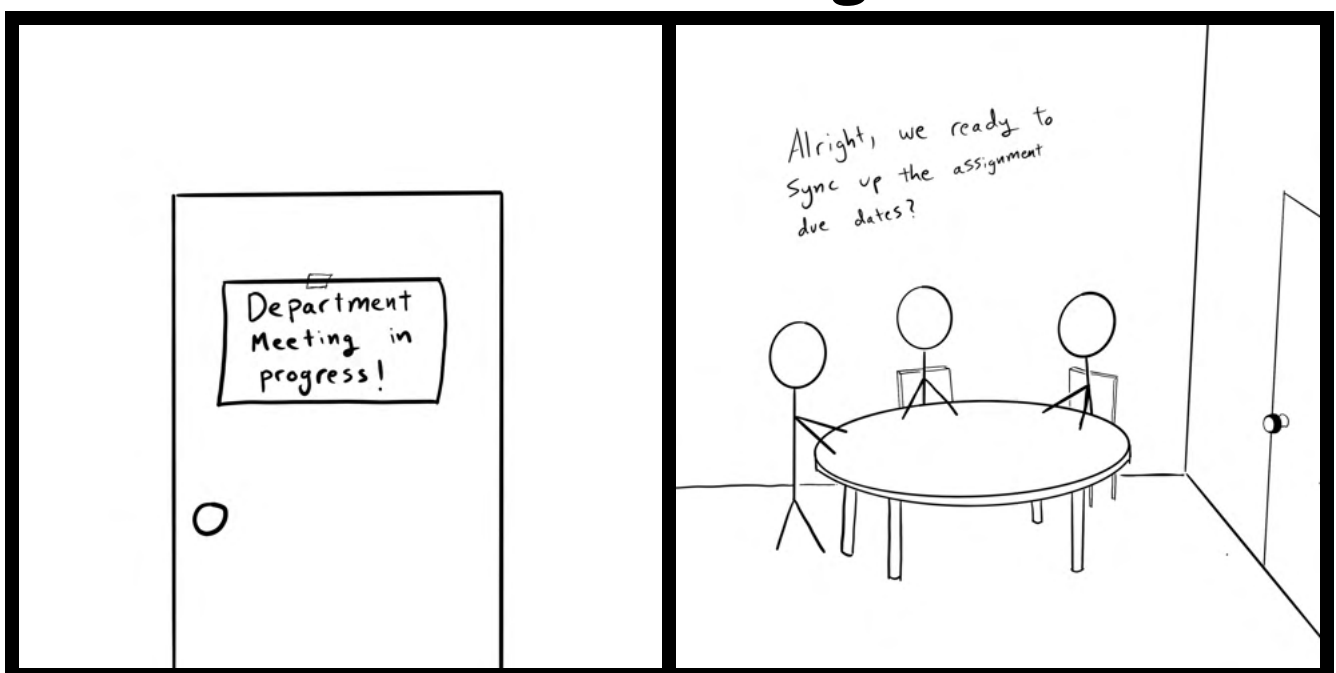
break existing systems and risk reducing freedoms of individuals and companies, while remaining ineffective at their objective. In the end it comes down to the individual, you the reader. If you value digital news from a particular source and are able, then subscribe or donate to them. As for the end-to-end encryption, keep pressure on your local representatives and educate them. While their intentions may be good, they are acting on areas where they lack knowledge. It is dangerous and impacts us all. Lastly, if you have the ability to influence changes like the ones mentioned, have just one take away: don't look to Australia.

# Comics

## Path to class



## The meeting



## **Fun Fact**

Sea otters are the furriest creatures on Earth, with 120,000 hairs per square centimetre

## **Closing Comments**

We hope you enjoyed this first edition of the University of Auckland Scientific. If you have any thoughts about or reactions to our articles, or would like to request an article topic, we'd love to hear from you. After all, engagement is our goal.

If you want to write for us (either as a one-off or regularly), let us know. We have an online application for just such a purpose, and we're always looking for new writers that can knock our socks off.

Otherwise, we'll see you in the next issue.

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