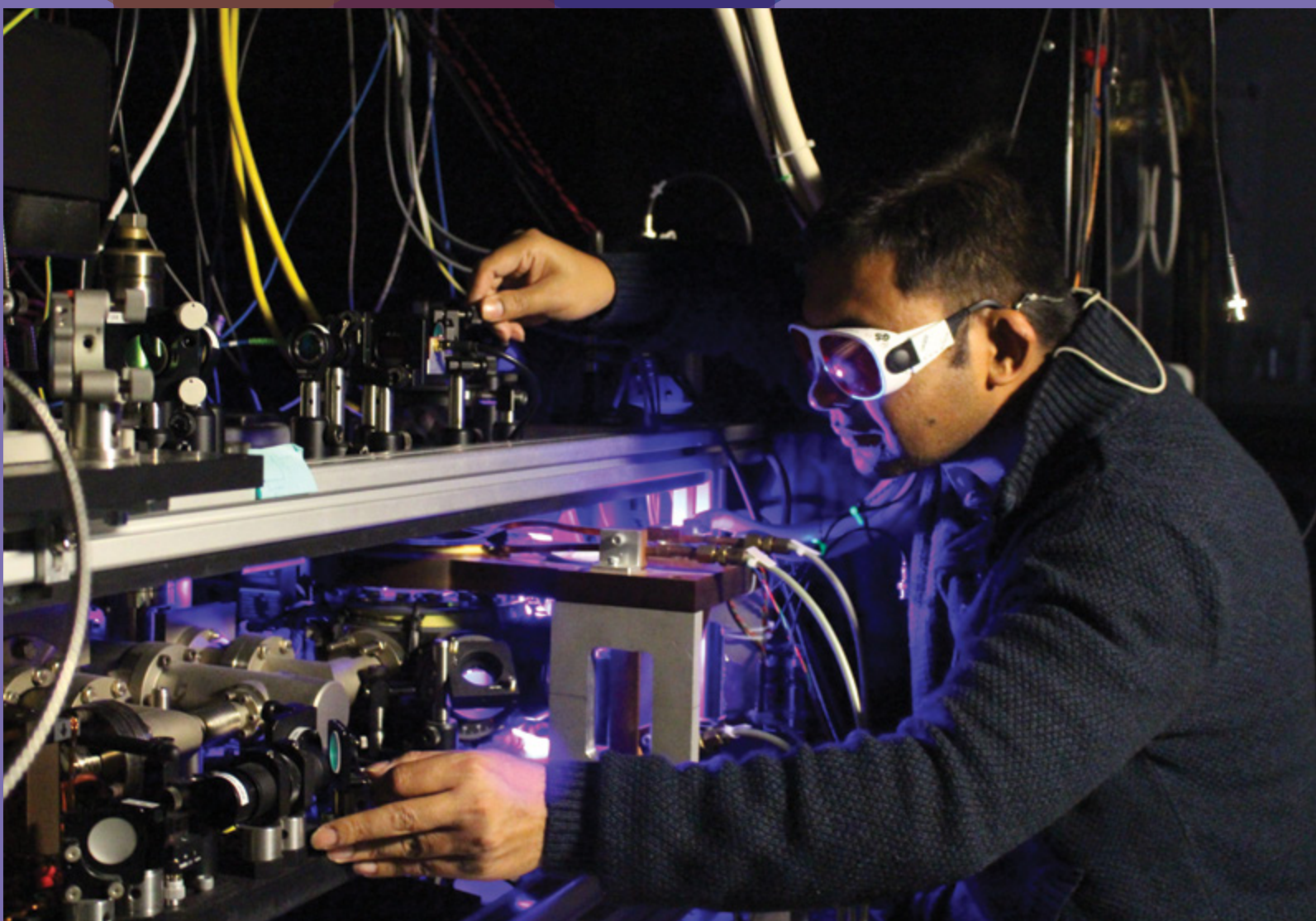


DODD-WALLS CENTRE
FOR PHOTONIC AND QUANTUM TECHNOLOGIES

2020
ANNUAL REPORT





DODD-WALLS CENTRE
for Photonic and Quantum Technologies

Cover image: This photo shows Dr Amita Deb, one of our Senior Research Fellows making adjustments to his experiment.

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GIFTING OF A MĀORI NAME

The Dodd-Walls Centre has been gifted the Māori name, Te Whai Ao. This represents the first beams of phosphorescent light that break through the darkness of the night and herald the coming of a new day. This saying is part of the Māori creation story, “Mai te Kore, ki te Pō, ki te Whai Ao, ki te Ao Mārama”, “From the nothingness to the dark night, to the glimmer of light, to the bright light of day”. Among other things, the phrase is used to talk about learning; with someone being in a state of te Kore when they have absolutely no knowledge of a particular subject, right through the stages of learning, te Pō, to the initial early grasp of the concept, te Whai Ao, to enlightenment, te Ao Mārama.

The name Te Whai Ao encapsulates our research, which is all about light and what we can learn and do with light. It also encapsulates what is most important about our Centre, the growth of our people. The primary outcome of our Centre is in the ability to guide our students and all our staff, young or old, along the path to enlightenment. As you will read in our report, the Centre has 135 postgraduate students in 2019 with 34 graduating during the year. Our graduates are amongst the most highly skilled, numerate, computer (programming) literate, articulate people in the country and are actively sought by NZ’s thriving knowledge-based companies.

In this report you can read about some of our alumni and the role of the Dodd-Walls Centre in their journey to date. You can also read contributions from some of our current students.



DODD-WALLS CENTRE
for Photonic and Quantum Technologies
Te Whai Ao

INTRODUCTION

New Zealand's Dodd-Walls Centre is a national Centre of Research Excellence involving six universities and is administratively hosted by the University of Otago. Our research focuses on New Zealand's acknowledged strength in the fields of precision atomic and quantum optical physics, and sensing applications ranging from the size of single atoms to crustal-scale geologic features such as the Alpine Fault.

Our research explores the limits of control and measurement at the atomic scale through the use of laser light, the generation and manipulation of light at its most fundamental, quantum level and the processing and physical nature of information in this quantum realm.

Our name honours two New Zealand pioneers in these fields: Jack Dodd (1922–2005), known for the first experiments of the quantum beat phenomenon and the theoretical explanation, and Dan Walls (1942–1999) who was accomplished across quantum optics, biophotonics, optical bistability, and was active in the field of Bose-Einstein condensation.

Our Mission

- to create a research centre that is recognised as one of the world's leading organisations in the field of photonic and quantum technologies;
- to build upon the acknowledged strength of New Zealand in the areas of non-linear and quantum optics and precision atomic physics;
- to train and develop skilled staff and students to the highest international standards;
- to help develop the high-tech industry sector, thus ensuring economic growth and continued career pathways in New Zealand.

Collaborating Partners

Tertiary Partners

University of Otago (Host Institution), The University of Auckland, Massey University, University of Canterbury, Victoria University of Wellington, and The University of Waikato.

Non-Tertiary Partners

Callaghan Innovation, Southern Photonics, Otago Museum, Auckland UniServices Limited, and Otago Innovation Limited.

International Partners

Centre for Quantum Technologies, Singapore; Fraunhofer Centre for Applied Photonics and the University of Strathclyde, U.K., the Joint Quantum Institute, USA, and the University of Science and Technology, Anhui, China.

Host University



UNIVERSITY OF NEW ZEALAND



REPORT FROM THE CHAIR

The year under review has been a major watershed year for the Dodd-Walls Centre. For seven years since it was first recognised by the Tertiary Education Commission as a Centre of Research Excellence (CoRE), the Dodd-Walls Centre has progressively consolidated its position as a globally significant contributor to human knowledge of light, of its quantum mechanical nature, and of its interaction at the atomic scale with matter. This is “big science” and it is linked to increasingly large applied investments in the world’s major economies as they vie for the lead in the next wave of quantum computing and communications technologies. Having some of the world’s “go to” experts in research on these topics based in New Zealand at the Dodd-Walls Centre is providing New Zealand with the ability to create niche opportunities to contribute devices to these revolutions in advanced technology, and early opportunities to find applications of these emerging enablers in our major existing industries and health services.

The announcement by the Tertiary Education Commission that the Dodd-Walls Centre will be one of ten such Centres to be funded until December 2028 has been both an endorsement of what has been achieved since 2014, but even more importantly a vote of confidence that continued support of the Centre will deliver on the obvious promise of our current positioning. I congratulate David Hutchinson and his team for achieving this recognition. The Dodd-Walls Centre has already contributed over 100 highly trained PhD graduates to New Zealand’s fast growing high technology sector. The knowledge and skills they have acquired are at the frontier of modern physics and travel with them in their heads into this sector.

For example, we aim to lead the world in the building of new and improved lasers. Lasers are quite small devices, and within the scale of technology where a New Zealand company can be a credible global supplier. The group at Auckland University lead by Stephen Coen and Neil Broderick have contributed the fundamental theories and models of how lasers work which are used by groups all over the world.

Companies such as Southern Photonics Ltd created by Dodd-Walls’ Commercialisation Director, John Harvey, export this technology in the form of devices worth thousands of dollars per kilogram. We aim to licence NZ based companies to produce the worlds next generation of lasers for cutting, sorting, and sensing.

At the same time as our partner companies build the world’s best lasers, we are equally intent on finding ways to use these lasers to advance our major industries. An Associate Investigator of the Dodd Walls Centre, Cather Simpson, and creator of the Photon Factory at Auckland University, is for example the founder Director of Orbis Diagnostics, a start-up company using lasers to analyse milk.

Although building the world’s best quantum computer may be a task outside of the reach and resources of any New Zealand based organisation, contributing niche technology to some of the huge global enterprises tackling this task certainly is not. An example here is Harald Schwefel’s recent contribution at Otago University which enables quantum computers to communicate using optical photons which can be transported over large distances via optical fibres.

Despite the COVID crisis, this last year was a highly productive one for research with commercial potential. In 2020 staff from the Centre reported at least 9 invention disclosures, 3 patents granted and 2 new patent applications. This is more than in any preceding year. And these inventions can be disarmingly simple in application. In this regard one of our research highlights this year was from Nate Davis – solar paint. A real DWC success, Nate was supported initially by a New Ideas Fund grant from the DWC and was assisted by DWC Business Development Manager, Shannon Scown, to develop a case to pitch to Return on Science. That led to industry engagement, an MBIE contract and now a Rutherford Discovery Fellowship. Nate’s colourful science can be seen gracing the report’s back cover. Hopefully Nate’s solar paint will be gracing a roof near you soon. Read more in the research highlights.

So, we approach a new phase in the life of the Dodd-Walls Centre with deep research capability, a growing deal flow emerging from which commercial applications are envisaged, and secured funding which will give the Centre the confidence to carry out its mission on behalf of the country and the international community. I wish David and his team every success as they prepare themselves for the task ahead.



A handwritten signature in black ink that reads "G.A. Carnaby". The signature is written in a cursive style.

G.A. CARNABY | 10 MAY 2021



REPORT FROM THE DIRECTOR

There's no denying that 2020 was a unique year for us all. The global COVID pandemic has touched all of our lives and our work. This annual report is therefore delivered within that framework. It is therefore appropriate that we lead with a Research Highlight from one of our spin-out companies, Orbis Diagnostics. DWC Investigator and one of the Directors of Orbis, Cather Simpson, speaks about how they could utilize their technology that they had developed for analysis of milk to test for COVID antibodies. I refuse to use the word "pivot", but this shows the agility of photonics-based companies and our smart people to respond to need. A very clear example of the value in investing in the development of our staff and students and enabling them utilise and create wealth through new technology or, as in this case, to respond to the nation's (and the world's) needs.

To continue the theme of investing in people, this has really been the most important aspect of the year. Many of our students have had their studies and research interrupted – as have our postdocs and early career researchers. They also have nowhere to go afterwards as job opportunities and travel overseas have dried up. A key focus of the Centre's resources has therefore been in supporting these individuals to be able to continue, and indeed thrive, through this past year. We graduated a total of 34 students in 2020, including 20 PhD students. This brings our totals to over 200 graduate degree completions with 100 PhD completions since the start of the DWC as a Centre of Research Excellence in 2015.

Our research remains excellent by any measure. According to *Nature Index* we produce over a quarter of all New Zealand's research impact in the Physical Sciences and are consistently ranked as eighth out of all institutions for research impact in New Zealand across all disciplines. Furthermore, our researchers are recognised regularly for their outstanding contributions. For example, DWC Investigator Michel Nieuwoudt was awarded a prestigious HRC Hercus Fellowship this year and Miro Erkintalo was awarded the Prime Minister's MacDiarmid Emerging Scientist Prize.

A key element of our initiatives around industry engagement this year came through our support of the Australia New Zealand Optical Society's commission of an industry review, *Photonics in Australia & New Zealand* which was released in August. This is detailed further in this report, but it highlighted that photonics is already a \$1.2bn industry in New Zealand, and rapidly growing. Coming back to our people, it is essential that we train a strong cohort of individuals that are able to fill the needs of this industry and also create further expansion in this sphere. Most of our graduates (every year, not just this COVID year) remain and enter the workforce in New Zealand. Investment in a DWC graduate student is ultimately an investment in New Zealand's high-tech industry.



We also need to ensure that these opportunities are open to as wide a breadth of our population as possible. This is why we place so much emphasis on our education outreach programmes. Obviously this year has been harder than most, but again our flexibility and the vibrancy of our education team has meant that we could adapt quickly to provide online delivery whilst in Lockdown, through to support for the first episode of Michelle Dickinson's TVNZ *Breaking it Down* science programme aimed at years 7-9 for the Home Learning Channel, featuring DWC science and scientists. A mere glimpse of the outreach activities undertaken by the Centre is provided in this report.

The one final item from 2020 I have to highlight is that we were successful in securing the next round of CoRE funding. This ensures the continued work of the Centre through to the end of 2028 at least. As Director, I thank the staff and students of the Dodd-Walls Centre for all their work to make it the success it is and to enable us to secure this support. I also acknowledge the Tertiary Education Commission for their support. We believe we provide an excellent return for New Zealand upon the investment you make in us. Thank you.



DAVID HUTCHINSON | 6 MAY 2021

RESEARCH THEMES

THEME 1a: Photonic Sensors and Imaging

Leader

Jon-Paul Wells, University of Canterbury

Lasers are amongst the most powerful tools of modern science. In this theme we use their extraordinary properties to see, hear, smell and feel far beyond the reach of basic human senses. When you fire a laser at an object there is a tremendous amount of information in the light that bounces back – but lasers can also see, without touching. We use different colours, pulses and powers of laser light to learn about the dynamics of the Earth itself, the structure and function of biological tissue and even test Einstein's theory of relativity.

Our expertise in interpreting the way that light interacts with matter has led to many unexpected yet fruitful collaborations across New Zealand and abroad. For example, we are developing sensors to sort bull sperm for the dairy industry, detect bacteria on carcasses, grade the quality of meat, and locate blossoms on kiwifruit plants. We are working with engineers and medical researchers to develop techniques for detecting eye disease, new methods for measuring the intensity of skin burns, force sensors for keyhole surgery and high resolution optical sensors to work in parallel with state-of-the-art X-ray scanners. We are working with geophysicists to measure earthquake vibrations and temperature deep within New Zealand's Alpine Fault and make measurements of Earth rotation that can contribute to the international time keeping service.

Our sensing and imaging projects are underpinned by a strong focus on theory and numerical modelling. Our researchers are world renowned for their understanding of laser physics, spectroscopy and nonlinear optics – when light stops behaving according to the normal rules. We are able to exploit such nonlinear effects to create novel sensing and imaging technologies.

THEME 1b: Photonic Sources and Components

Leader

Stéphane Coen, The University of Auckland

They say workers are only as good as their tools. This theme is about developing new and improved lasers, new optical materials, and other optical tools that will open new frontiers for research and medical or industrial applications. We work in collaboration with the other three themes to provide tools that enhance their research and probe further into the quantum world. The fundamental theories and numerical models that we develop are also used by top research groups across the world. We are world-renowned for our expertise in fibre lasers that are versatile, lightweight and cheap to produce. We develop these to be used as cutters, sorters and sensors for a wide variety of industrial and science applications. We are also well-known for our fundamental research in nonlinear optics and in nonlinear (micro) resonators. Here, we experimentally explore key new fundamental dynamics, devices, and materials that could in time revolutionise the internet and many other fields, such as optical frequency combs or photosensitive molecules.

THEME 2a: Quantum Fluids and Gases

Leader

Maarten Hoogerland, University of Auckland

The quantum realm is one of the most advanced and untamed frontiers of modern science. Although we know some of the basic rules, the vast majority of quantum interactions remain uncharted. In this theme we explore cold atom physics, which is like a portal to directly observe and interact with quantum phenomena. By cooling atoms to just above absolute zero and precisely controlling their state, we have the ability to create and observe almost any quantum effect that we can think of. We run experiments and develop theory to investigate quantum phenomena such as quantum vortices, superconductivity, and conditions just after the Big Bang. We are exploiting newly won understandings of these processes and interactions to develop quantum technologies such as extremely precise gravimeters and clocks. We are world-renowned for our legacy in quantum theory and have developed excellent experimental facilities that are enabling world-class results.

THEME 2b: Quantum Manipulation and Information

Leader

Harald Schwefel, University of Otago

It is one thing to understand how the quantum world works yet it requires another level of precision and control to build reliable devices and systems that exploit quantum phenomena. This kind of ‘quantum engineering’ is the focus of this theme. Through precise observation and control of the interactions between single photons of light and single atoms we are contributing to the development of a new generation of quantum technologies. Our aim is to exploit the apparently weird aspects of the quantum world such as quantum superposition—the ability of a quantum particle to exist in more than one state at once—and quantum entanglement, when several particles behave as if they were a single entity. Our researchers lead the world in isolating and controlling the motion of single atoms. We can move atoms around with laser light and put them together to create completely new molecules, and conduct ultra-precise experiments.

Our research is contributing to the development of quantum computers capable of rapidly solving extremely complex problems. We are looking at novel ways of creating qubits, the fundamental processing units for quantum computers, and developing solutions for quantum memory and quantum debugging. Quantum communication is the focus of several projects: we are working on a technique to enable communication between quantum computers over large distances. This involves translating single microwave photons, which quantum computers operate on, to optical photons, which are easily transported down optical fibres. We are also contributing to the fundamental theory behind quantum communication networks and quantum measurement.

2020 RESEARCH HIGHLIGHTS

LEADING THE WORLD IN COVID IMMUNITY TESTING

“Every scientist wants to do something important and relevant,” says DWC Associate Investigator Cather Simpson. “When something like COVID comes along, the chances you’ll be in the right space to contribute are very small so it was very very exciting to realise that our technology could help.”

Cather Simpson is one of the founder directors on the board of Orbis Diagnostics, a start-up company, based in the Photon Factory at The University of Auckland. Until March 2020, Orbis was working on a laser-based technology for analysing the composition of milk in the cowshed with the aim of helping farmers to improve milk quality and cow health. Just six months later they are on the brink of releasing a COVID-immunity test that has the potential to open up borders, save lives, revive the economy and enable safe quarantine-free travel – all using the same laser-based technology.

Orbis calls their technology a “lab-on-a-disc”. It’s a transparent disc the shape of a CD with hundreds of tiny channels and wells etched inside. Samples of blood (or milk) react with other chemicals inside the channels, causing changes that are measured by lasers. The magic lies in microscopic beads, which bounce around inside the channels, mixing the liquids and speeding up the reactions as the disc is spun. For the user it’s as easy as playing a CD. Each disc can process hundreds of samples at a time and produce results in a matter of minutes.

The plan is to incorporate this lab-on-a-disc technology into airport security checks to screen travellers coming into the country. It measures the level of COVID antibodies in the blood and if the concentration is above a certain threshold, they are immune and are safe to travel quarantine-free. It

could also be used to screen visitors to aged-care facilities, where the residents are most vulnerable to COVID.

It was just before the first national lockdown that the idea struck to pivot from cows to COVID. The team was filing a patent for a progesterone test on milk to inform farmers when cows are pregnant. The test is a lab-on-a-disc version of a standard medical diagnosis technique known as an ELISA (enzyme-linked immunosorbent assay) used to detect and quantify hormones, antibodies and other biological compounds. Normally it takes days to get results from a lab, but the lab-on-a-disc gives results in less than fifteen minutes and can process hundreds of samples at a time. They realised the same technique would work for the COVID virus and antibodies.

One of Orbis technology’s advantages is that it is quantitative – it doesn’t just detect the presence of antibodies, it tells you how many there are. This is essential for COVID-19 Immunity, as the concentration of antibodies needs to be above the necessary threshold in order to confer protection. The technology is also robust. It was designed to be kicked and pooped on by cows, so it can handle the knocks of airport security.

Within a week the team shifted its entire focus. Lockdown provided a crucible for the transformation. With nothing else to do and a sense of life-and-death urgency they learnt all they could about the virus, researched the landscape of existing technologies and identified the gaps. By the end of lockdown they had a comprehensive plan, had applied for funding, obtained essential business status and were in the lab starting research. Since then they have doubled their staff and are aiming to deploy the technology in May 2021.

“This project is moving so fast,” says Cather. “We’re leaping from strength to strength. The fact that people are dying today and that we know our technology could help makes the Orbis team stay that extra hour or two at night. Science isn’t just a job at the moment. It’s a mission.”

When Cather founded the Photon Factory in 2010, her vision was to create a thriving innovation hub that draws on fundamental laser and photonics research to serve the needs of New Zealand as a whole. Orbis Diagnostics is one of the fruits of this vision and Cather’s second spin-off company.

Cather co-founded Orbis in 2016 in response to needs articulated by the dairy industry and investors. Her co-founder, Professor David Williams, also at The University of Auckland, is a leading authority in chemical sensors. His accolades include developing the first digital home pregnancy test. Cather herself is an award-winning expert in using laser light to reveal the intricacies of biological molecules and processes. Orbis combines their strengths. The company’s Chief Scientific Officer is Brazilian-born Mattheus Vargis, who has just finished his PhD in the Photon Factory, developing the concept behind Orbis technology. Now, he sits at the helm.

The company received seed funding from Auckland UniServices and has partnered with local venture capital company Pacific Channel to take the technology to market.

With no one else in the world producing cheap, fast, high-throughput COVID immunity tests, Orbis are in to win and racing the clock.

“We know it will work,” says Cather. “The question is whether we will get there fast enough to have an impact.”

Orbis has attracted a team of international heavy weights to support their mission. World-leading virologist Allan Goldberg has joined the board and helped broker relationships in the US.

“The US National Cancer Institute (NCI) will run all our baseline testing on their blood samples, at their own expense,” says Cather. “If it’s successful they’ll accelerate through all the FDA (Food and Drug Administration) processes so that we can deploy the test faster. That’s a huge win!”

To create a prototype device, they are working with a US-based engineering and product development company, D&K Engineering, who are experts at designing products and manufacturing. They recently signed a deal with a world-leading airport biometric company who will help deploy the technology.

"THE FACT THAT PEOPLE ARE DYING TODAY AND THAT WE KNOW OUR TECHNOLOGY COULD HELP MAKES THE ORBIS TEAM STAY THAT EXTRA HOUR OR TWO AT NIGHT. SCIENCE ISN'T JUST A JOB AT THE MOMENT. IT'S A MISSION."

“They are a multinational company who developed the first e-gates for automated passport control and deployed them to Australia and New Zealand,” says Emerald Scofield, Orbis’s Operations Manager. “Now, they are developing whole systems for contactless check-in and immigration and our technology would become a key component of this larger solution.”

“One of the most exciting areas is the human-machine interface,” says Cather. “If you’re going to take blood samples at airports, the last thing you want is parents holding kids down as they scream in pain. We’re working with people who can take blood samples you can hardly feel, from a tiny finger prick.”

New Zealand has an incredible advantage, in being largely COVID-free, to see beyond the immediate crisis to the challenges and opportunities ahead.

“Globally, everyone is focused on the urgent problem of detecting who has COVID so they can stay home,” says Emerald. “But we’re thinking about what will happen in six to twelve months’ time when borders start to open. Everyone thought a vaccine would turn up and magically solve the problem overnight. But vaccines are going to take forever to roll out and they don’t always work. We will need a way to determine, not just who has had the vaccine but who it has worked on.”

Here in New Zealand, the Orbis technology could enable our tourism industry to get back on its feet and open up international trade. It could help to reunite estranged families and save lives.

“This is all about returning us to economic and social health,” says Cather, “opening borders and allowing people to travel and move around without putting anyone else in danger.”

The team is on fire, sprinting towards the finish line.

“It’s almost getting scary because we’re so close,” says Emerald. “It’s all very well to have an idea but when it starts becoming real you’ve got a greater responsibility to see it through to the end.”

Investment in fundamental science has made all this possible.

“It’s not today’s CoRE funding that enabled us to do this,” says Cather. “It’s the funding from eight years ago that built our capability to do this today. You have to have the fundamental science funding in order to realise the real impact technology of ten years later.”

Just as a tree bears fruit in time, the Photon Factory is beginning to deliver commercial outcomes. Cather’s message to the government is to keep watering the tree. There is plenty more fruit to come.

Written by Elizabeth Connor

"IT'S THE FUNDING FROM EIGHT YEARS AGO THAT BUILT OUR CAPABILITY TO DO THIS TODAY. YOU HAVE TO HAVE THE FUNDAMENTAL SCIENCE FUNDING IN ORDER TO REALISE THE REAL IMPACT TECHNOLOGY OF TEN YEARS LATER."

MAKING SOLAR POWER ACCESSIBLE TO ALL

In October 2020, the International Energy Agency announced that the cost per megawatt to build solar plants has dropped below the cost of fossil fuels, making solar power officially the cheapest energy source in the world. However, the high cost of installation makes it inaccessible to most households and businesses, particularly in developing countries. Dodd-Walls Centre Associate Investigator Nathaniel Davis and his team at Victoria University of Wellington are on the verge of commercialising a solar paint that works with existing solar technologies and could make solar power accessible to all.

“You paint it directly onto your roof and then install solar panels in the guttering,” Nathaniel explains. “The paint contains luminescent molecules that absorb and emit sunlight, guiding it into the gutters where the solar panels are.”

A single coat of solar paint will gather enough sunlight from a roof to power a home, using a narrow strip of solar panels, approximately the width of a finger. The average cost of installing a solar panel system in New Zealand is currently around \$9,000. The solar paint would reduce this to a fraction of the cost.

Nathaniel and his team are collaborating with New Zealand paint company Resene to test how long the paint lasts and to do prototyping and upscaling. He plans to partner with a solar company to enter the international market. Unlike solar panels, the paint requires little infrastructure and is easy and cheap to produce, making it an ideal fit for New Zealand.

Originally from Australia, Nathaniel came across solar concentrators in his Honours research at the University of Sydney.

“I was interested in solar energy because it’s the only energy source that doesn’t involve moving parts,” Nathaniel explains. “Wind, hydro, coal and nuclear energy all spin turbines. That seemed silly when we could make energy directly.”

During his PhD and Research Fellowship at the University of Cambridge, he built up a research programme to explore solar concentrators further, filing several patents. In 2018 he came to New Zealand.

“When I first got here I had no money,” Nathaniel says. “I was writing grants and not getting them but slowly learning.”

**A SINGLE COAT OF
SOLAR PAINT WILL
GATHER ENOUGH
SUNLIGHT FROM A ROOF
TO POWER A HOME...**

DWC Business Development Manager Shannon Scown played a pivotal role in getting the project off the ground. She organised for Nathaniel to pitch his research to Auckland's Return on Science investment panel. On their suggestion, he gathered an advisory board, including Resene, a glass company, a solar company, an angel investor and an architect. Due to their letters of support and Nathaniel's proactivity in seeking early advice from industry, he was awarded an MBIE grant in 2019.

In the same year he secured funding from the Marsden Fund and New Zealand's Science Challenges. Nathaniel now has eight PhD students and a team of fifteen. He sees the people as the most important aspect of the project.

"I think the biggest impact I could make is to train eight leaders in renewable technology that can contribute to New Zealand's economy," Nathaniel says.

Solar concentrators have been around since the 1970s but there have been significant challenges to their development. Firstly the process was inefficient. The molecules lost up to 80% of the light every time they absorbed and reemitted it. Nathaniel has solved this problem by using luminescent quantum dots - tiny chunks of semiconductor materials that absorb blue and green light and send out red. Attached to these are organic molecules which act as antennae grabbing onto light and passing it in to the quantum dots. The beauty of the system is that the red light emitted by the quantum dots can travel through the material, reaching the solar panels without being reabsorbed.



Photo credit: Vanessa Young, MacDiarmid Institute.

Nathaniel's expertise in both Physics and Chemistry gives him the ability to understand the existing problems with solar concentrators and design clever ways to make them more efficient. He is currently designing a T-shaped molecule that helps to direct the light towards the solar panels and molecules that make the most of all the light available, by splitting large photons in half to create two photons, and adding small ones together to produce one photon of usable energy. Within two years he has gone from being a new lecturer straight out of his PhD to running a group of fifteen with three research grants. He was recently promoted to Senior Lecturer and awarded a prestigious five year Royal Society Rutherford Discovery Fellowship.

"It is exciting and scary," he says, "to be on the verge of starting a company, but also to have the freedom to keep exploring. I'm lucky that my research aligns with the government's interests. In Australia they have seventeen categories for coal research and only one for renewable energy. In New Zealand there are around fifteen renewable energy categories to choose from."

Written by Elizabeth Connor



NATHANIEL DAVIS

Born in 1989 in Sydney, Australia, Nathaniel dreamt of being a scientist as a child. He won the University medal for top graduating student in Chemistry at the University of Sydney, then the Australian Bragg Scholarship to attend Cambridge University, England. He completed his PhD in the Optoelectronics Group at the Cavendish Laboratory and was awarded the Oppenheimer Research Fellowship to continue his research there. In 2018 he accepted a lecturer position in the School of Chemical and Physical Sciences at Victoria University Wellington.

SCIENTIST MUM TACKLES COELIAC DISEASE

University of Otago Research Fellow Sara Miller was just about to go on maternity leave to have her second baby when she found out that her MBIE Smart Ideas research proposal had got through to the final round. Weeks into her maternity leave she discovered she was into the final round for her Marsden proposal as well. She is working on spectroscopy techniques to diagnose Coeliac disease and other gastrointestinal illnesses. The fact that she was in to win two grants was extremely exciting and relieving. Her livelihood and research for the next three years depended on it and she is on the brink of a breakthrough. But the task of writing two full proposals while having a baby was daunting to say the least.

"I found out that we got through to the next round for the MBIE grant on my last day of work," says Sara. "I finally had this wee burst of energy so I sat down to write and then fifteen minutes later I went into labour. Then I had a newborn to look after as well as my four-year old daughter."

Sara describes the next few months as some of the most challenging of her life.

"I was right on the edge," she said, "almost wanting to give up. I just wanted to cuddle my baby but the proposals needed to be finished. It was only the support of my partner, my family and fellow female scientists in the Dodd-Walls Centre that kept me going."

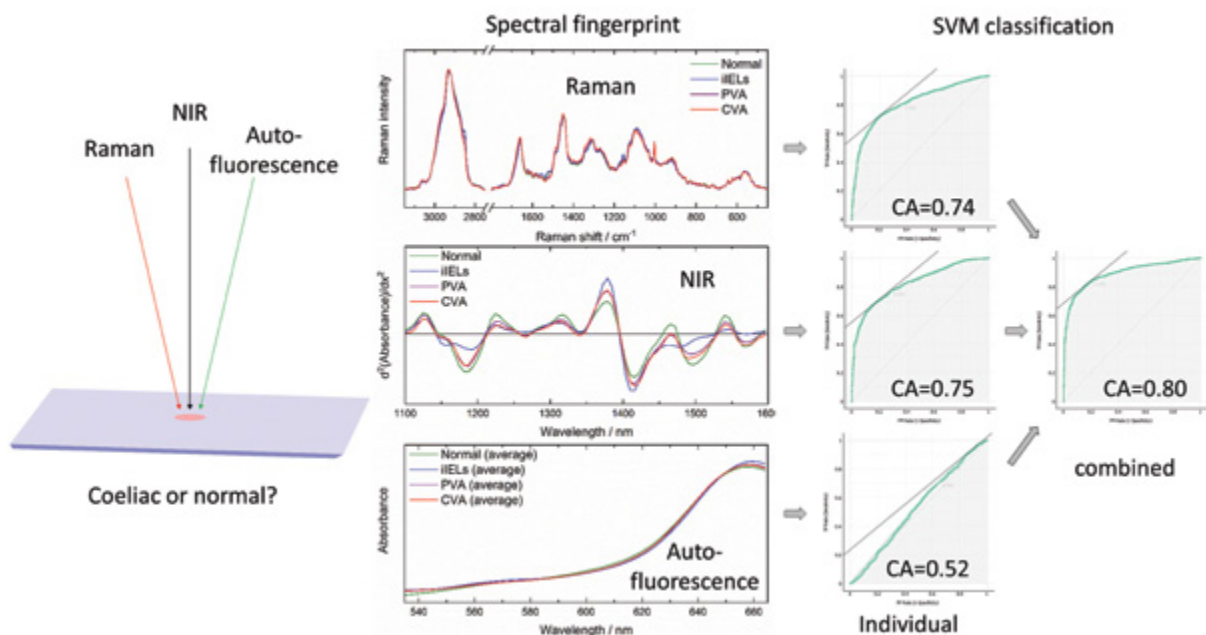
DWC Principal Investigator Frederique Vanholsbeeck and Associate Investigator Cushla McGoverin at The University of Auckland, who are collaborators on Sara's MBIE project, stepped in to write parts of the proposal and gave Sara the little pushes she needed to get it done. DWC business development manager, Shannon Scown, helped shape the industry side of the proposal. Her husband, Mum and mother-in-law took turns having time off work to help look after the baby while Sara wrote.

"Cushla and Fred were absolute stars," says Sara. "I couldn't have done it without them."

After all that Sara won both grants!

**"IT WAS ONLY THE
SUPPORT OF MY
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AND FELLOW FEMALE
SCIENTISTS IN THE DODD-
WALLS CENTRE THAT
KEPT ME GOING."**

COELIAC DISEASE IS JUST THE BEGINNING. THE SAME TECHNIQUE COULD BE ADAPTED TO DETECT OTHER GASTROINTESTINAL DISEASES SUCH AS CANCER.



This diagram shows how Raman, near infrared (NIR) and autofluorescence spectral signatures from biopsies used in conjunction with support vector machine classification (SVM) yield classification accuracies (CA) between 52 and 75% for diagnosing coeliac disease. The final graph on the right shows that the accuracy is improved to 80% when the data from the three techniques is fused together.

This triumph sets out an exciting challenge for the next three years. The focus of the MBIE Smart Ideas research is to create a fibre-optic probe to be incorporated into standard medical endoscopes. Currently endoscopes have tiny cameras that scan the gastrointestinal tract for signs of disease. But it is very difficult to make a diagnosis just by looking. Doctors usually have to collect biopsies, small samples of tissue that are sent to a lab for confirmation. This is a costly and time-consuming process. Sara's probe uses laser spectroscopy to pick up subtle abnormalities in the chemistry and physical structure of the digestive tract. The aim is to make accurate diagnoses possible in a single visit and to identify the right spots to collect a biopsy if needed. The principle of the technique is simple. You fire a laser at the tissue and collect the light that bounces back. The art is in interpreting the signal.

"We use a type of machine-learning," Sara explains. "You feed all your spectroscopic data into a computer along with all the known data on healthy and diseased tissue. The computer compares them and tries to find patterns associated with disease or healthy tissue."

Coeliac disease is just the beginning. The same technique could be adapted to detect other gastrointestinal diseases such as cancer.

The Marsden Grant research will push the limits of spectroscopy. For this project Sara is using a range of different techniques to see below the surface of biological tissue, to reveal the texture and composition of the layers beneath.

"This is a more challenging problem," she says. "The further you go into the sample, the wider the area signals come from, so you have to be careful with the analysis to pull out the useful information."

If successful, this ability to see below the surface of tissue will give endoscopes superpowers for detecting disease.

None of this important research would be possible if Sara had not pushed through to complete her proposals. It is challenging for emerging scientists to bridge the gap from postgraduate study to a secure job in science research with few permanent positions available. For women and caregivers, the hurdles are especially high. The Dodd-Walls Centre has helped in big and small ways, funding Sara's postdoc for the past three years and connecting her with collaborators like Cushla and Fred. They also provide a caregiver fund that pays for researchers to bring an additional person to conferences to look after the children as they attend.

When asked what it is like balancing the responsibilities of family and science she says:

"The fact that I get to do science is a huge pay-off. And I have a wonderfully supportive supervisor which makes a big difference. But it can be a real struggle to balance the two. On one hand I want to say 'women can do it all!' and push through. But at the same time I don't want to give the impression that it is easy. I would hate for someone else to find it hard and wonder what they are doing wrong. In reality I think everyone is struggling to some degree."

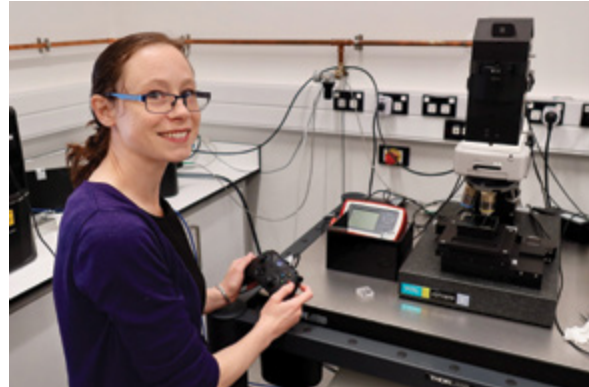
It makes you ask, what can we do to make it easier for emerging women scientists to succeed? New Zealand and the world have a lot to gain if they do.

One of the motivations for Sara to continue is to be a role model for her daughter who is now four.

"She loves numbers and we try to do experiments on the weekend," says Sara. "The other day I asked her what she wants to do when she grows up. 'I want to be a mum scientist', she replied, 'A science Mum!'"

That makes it worth all the effort!

Written by Elizabeth Connor



SARA MILLER

Born in Christchurch and raised in Timaru, Sara's science explorations began when she was a toddler. She remembers hunting for fossils, exploring rock pools and making electrical circuits with her Grandad who was a physicist. Her mum was a great female role-model working in the male-dominated field of engineering. She encouraged Sara to do the subjects she enjoyed rather than following the crowd. Sara first came to Otago to do a BSc majoring in Chemistry. She then won a University of Otago scholarship to do her PhD in analytical spectroscopy. Her first postdoctoral position was in Helsinki, in the field of pharmaceuticals. She then returned to Otago for a postdoctoral role where she explored how spectroscopy can be used to determine characteristics of primary produce such as fruit and meat. Her research has focused on the use of various vibrational spectroscopic techniques in combination with chemometric methods to analyse materials. She has used these techniques to analyse a wide range of materials including pharmaceutical drugs, biominerals like teeth, gallstones and bone, geological minerals, traditional textiles and primary products. Most recently she has been developing medical diagnostic applications.

PROBING THE MYSTERIES OF THE EARTH

DWC Principal Investigator Jon-Paul Wells is playing a central role in the development of what Science magazine dubbed “the most sophisticated ring laser in the world”. German built, with key elements contributed by New Zealand, this five-story high, pyramid-shaped laser, buried under a field near Munich, is the first instrument in the world capable of measuring the earth’s rotation in three dimensions. It is called ROMY, which stands for Rotational Motions in Seismology. Just as ordinary gyroscopes measure the tilt of submarines and airplanes to keep them on track, this massive device monitors the rotational motion of the entire earth as it hurtles through space, spinning on its axis.

Jon-Paul has spent the past fifteen years at the forefront of research in this field. Large Ring Laser Gyroscopes, like ROMY, are among the most sensitive instruments known to science. They pick up on all the forces acting on the earth – the gravitational pull of the sun and the moon, ocean currents, seasonal weather patterns and seismic activity. They are so sensitive, they even measure the wind in the trees as it tugs on the roots in the ground.

ROMY’s quest is to uncover secrets beneath the earth’s crust, which remain more of a mystery than outer space. “Ring lasers measure the rotational component produced by seismic activity,” Jon-Paul explains, “which is difficult to measure in any other way. With ROMY we can watch seismic waves travelling around the globe multiple times.”

This new source of data will help seismologists model and understand earthquakes. Engineers will be able to design more resilient structures and geophysicists answer age-old questions about the composition of the Earth’s layers and the fluid dynamics of its liquid core.

Jon-Paul’s big aspiration is to measure tiny variations in the length of day. Although we are taught at school that each day is 24 hours long and corresponds to one full rotation of the Earth on its axis, this is not precisely true. The length of a day changes as the Earth is bumped and jostled by earthquakes, oceans, weather and cosmic forces. Knowing this variation is important as the accuracy

**“RING LASERS
MEASURE THE
ROTATIONAL
COMPONENT
PRODUCED BY
SEISMIC ACTIVITY.”**



Photo credit: Heiner Igel.

of our Global Position Systems (GPS) depends on it. Today's GPS systems work well for driving cars but for faster moving objects like rockets, greater accuracy is required. Large Ring Laser Gyroscopes, like ROMY, are getting close to reaching the required precision.

They also have the potential to solve some of the most elusive fundamental questions of physics. Einstein's theory of relativity, for example, predicts that planets drag the fabric of space and time around them as they rotate, like a spoon turned in honey. Large ring laser gyroscopes are getting close to measuring this effect.

Until thirty years ago nobody thought it would be possible to make a gyroscope large enough to measure the earth's rotation. It was Jon-Paul's predecessor Geoff Stedman who proved them wrong. In the late 1980s, Geoff and his US collaborators demonstrated the first direct measurements of the earth's rotation in an old World War 2 bunker, forty metres under the Cashmere Hills. New Zealand has played a lead role in the development of this technology ever since, in close collaboration with German partner Ulrich Schreiber from the Technical University of Munich.

A ring laser gyroscope is constructed out of pipes, forming a closed loop in the shape of a square or triangle. These pipes are filled with highly compressed gas that generates light. Mirrors at each corner reflect the light as it travels around. The basic principle is that you send two identical laser beams around the loop in opposite directions. When the Earth rotates, the instrument rotates with it. This means that one laser beam has further to travel than the other, causing one beam to stretch and the other to compress. When they meet they generate a beat (known as the Sagnac frequency) which gives the rate of rotation.

The larger the instrument, the more sensitive it becomes. But size also brings serious engineering challenges. "The trick in this field is making small increments build up to a big piece of progress," Jon-Paul says. "That requires patience and perseverance which are our superpowers."

Jon-Paul joined the programme in 2006. In 2010 he was awarded almost a million dollars in Marsden funding to build a gyroscope to measure microsecond variations in the length of day.

"We got this money in February and in September the Christchurch earthquakes hit," Jon-Paul explains. "That completely shut the Cashmere caverns down."

ROMY'S QUEST IS TO UNCOVER SECRETS BENEATH THE EARTH'S CRUST, WHICH REMAIN MORE OF A MYSTERY THAN OUTER SPACE.

THE REFUNDING OF THE CENTRE BRINGS INTO SIGHT ONE OF JON-PAUL'S BIGGEST DREAMS – TO CREATE A MICHELSON CENTENARY RING – A RING LASER GYROSCOPE, HALF A KILOMETER ON EACH SIDE AND OVER THREE ORDERS OF MAGNITUDE MORE SENSITIVE THAN THE CURRENT WORLD BEST.

There is an irony that their efforts to understand the earth were thwarted by seismic activity. It was the biggest challenge of Jon-Paul's career. Without a local site, he was forced to shift focus to experiments in Germany where he travels frequently to work with his German collaborators.

The designs and components for these large experiments are still made at Canterbury University. In 2020, Jon-Paul and his team launched an experiment to discover the optimal colour of laser light for large ring lasers. Most use red light. But shorter wavelengths, like blue or green, would increase the precision of measurements without increasing the size of the overall structure. This research will help to improve the performance of ROMY and other instruments like it.

The Dodd-Walls Centre has been a huge support over this shaky period, providing certainty of funding and PhD studentships. The refunding of the Centre brings into sight one of Jon-Paul's biggest dreams – to create a Michelson Centenary Ring – a ring laser gyroscope, half a kilometer on each side and over three orders of magnitude more sensitive than the current world best. Jon-Paul's team will design this extraordinary instrument under the umbrella of the DWC. It will involve high profile international collaborations and be nothing short of a landmark experiment in physics.

Written by Elizabeth Connor



JON-PAUL WELLS

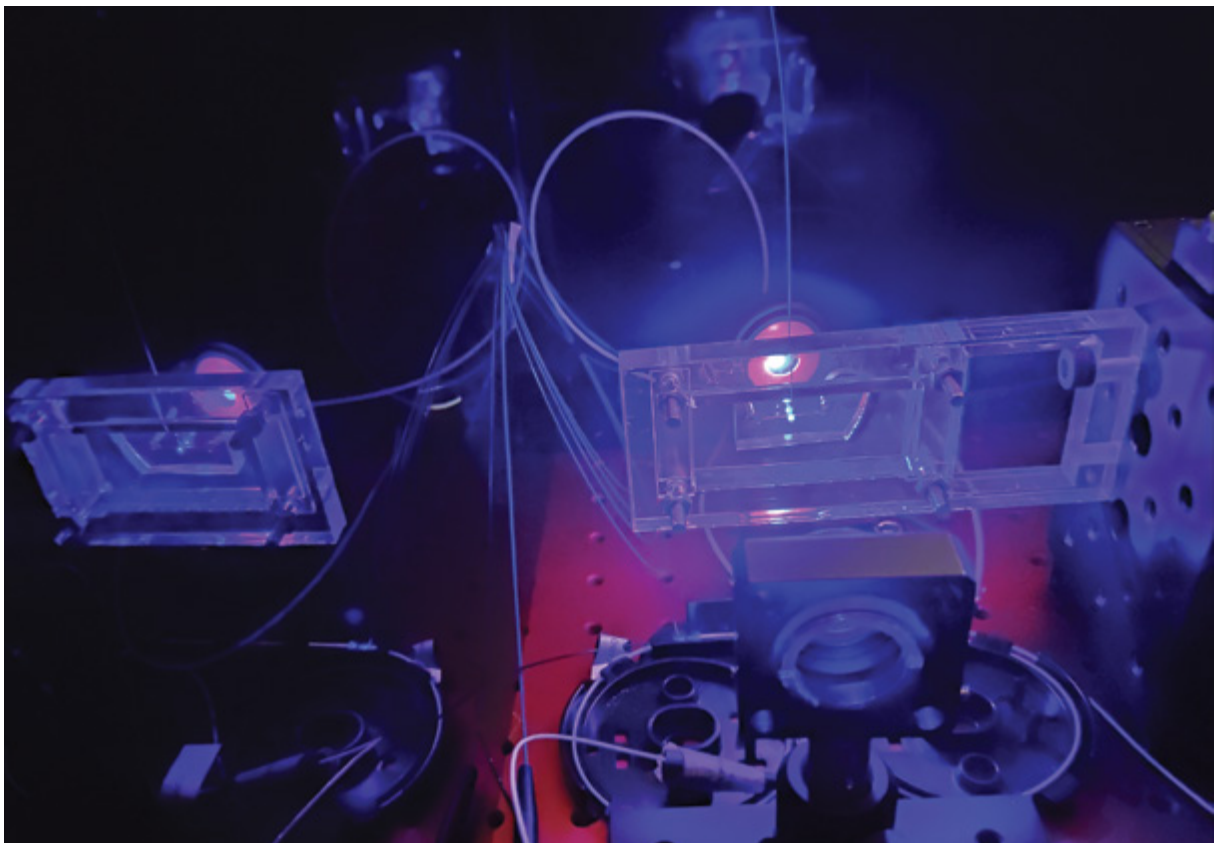
Jon-Paul Wells was born in Auckland and grew up in the seaside town of Papamoa in the Bay of Plenty. At age 15 he decided he wanted to be a scientist. He did his undergraduate and PhD studies in Physics at the University of Canterbury before heading to Europe for a Postdoctoral Fellowship in ultrafast laser spectroscopy at the University of Strathclyde in Glasgow. He then spent four years as the UK facility scientist at the Dutch Free Electron Laser and several more as a lecturer in the Department of Physics at the University of Sheffield, specialising in short pulsed lasers and semiconductor physics. In 2006 he accepted a permanent position at the University of Canterbury where he is now a professor in the Department of Physics.

TACKLING THE THREAT OF SUPERBUGS

These days, many of humanity's greatest threats are invisible like the coronavirus and deadly superbugs that outwit the strongest antibiotics and disinfectants. COVID is not the last battle on the microscopic front. The World Health Organisation has identified superbugs as one of the top ten global public health threats facing humanity. These resistant strains of bacteria, viruses, fungi and parasites make infections harder to treat and increase the risk of disease, severe illness, and death.

"I am mindful of the range of illnesses that antibiotics are seemingly prescribed for, and of how few companies are developing these medicines," says DWC Associate Investigator Dr Cushla McGoverin. "It doesn't take long for bacteria to develop resistance to antibiotics when they are misused or overused."

**THIS NEW TECHNIQUE
COULD BE USED TO
INFORM DOCTORS
WHETHER ANTIBIOTICS
WILL BE EFFECTIVE
BEFORE THEY PRESCRIBE
THEM TO PATIENTS.**



Here, we see microfluidics and fluorescence being used in concert to count bacteria in suspension.

The World Health Organisation has called for urgent action to address this issue and Cushla's research is part of the solution. She is working in the lab of DWC Principal Investigator Associate Professor Frederique Vanholsbeeck at The University of Auckland, using lasers to bring the invisible world of bacteria into view. If we can see the problem, we have a greater chance of solving it.

They are developing a technique to detect very small concentrations of bacteria, identify their type, and tell you whether they are alive or dead. This new technique could be used to inform doctors whether antibiotics will be effective before they prescribe them to patients. It could also save us from food poisoning and open up the vast and fascinating world of these villainised little critters. Bacteria are not all bad!

The new technique is a form of laser spectroscopy. You shine a specific colour of laser light at the sample then collect the spectrum of light that comes back. Each different type of bacteria leaves a fingerprint on the spectrum. It takes an expert spectroscopist like Cushla to decode it.

"I love the puzzle aspect of it," she says, "looking at a spectrum and trying to figure out what was happening with the bacteria."

For this project, Cushla and her team are using fluorescent dye molecules that latch onto bacteria, causing them to glow when illuminated by laser light. They are working with microbiologists, Associate Professor Simon Swift and DWC-funded Postdoctoral Fellow, Dr Julia Robertson at the Auckland Medical School, to understand and fine-tune the dyes so they give more information about the bacteria.

"You need to understand the chemistry of the dyes, the physics of lasers, and the microbiology of the bacteria," says Cushla. "Over the years we've started to talk the same language."

For the past three years Cushla has been working with DWC-funded PhD student Rachel Fang Ou to devise a way of measuring whether bacteria are alive or dead.

"It's surprisingly hard to tell," says Cushla. "There are no obvious signs over a short period of observation."

Some methods of killing bacteria, penicillin for example, blow its cell wall into pieces. Rachel Fang Ou used a dye that could only latch onto bacteria once their cell wall had broken. It only glows when bacteria are dead. But other methods of killing bacteria, including some antibiotics, leave the cell wall intact.

**THE DODD-WALLS
CENTRE PROVIDED
FUNDING FOR
ADDITIONAL PHD
STUDENTS TO EXPAND
THE SCOPE AND EXPLORE
OTHER APPLICATIONS.
THIS WAS THE ORIGIN
OF THE VALUABLE WORK
BEING DONE TODAY.**

Cushla is working with a new PhD student, Craig Steed, to find a dye that will work in these cases. He is working with computer scientists, using bioinformatics to scan the existing databases for other signs (or biomarkers) of death.

Another challenge in the project is that the concentrations are often very low; just a few bacteria floating in a large volume of liquid. Cushla is supervising DWC-funded PhD student Ayomikun (Samuel) Esan, who is developing microfluidic devices that guide bacteria into a narrow channel where they can be easily detected.

Over the past fifteen years, Cushla has worked all around the world, applying spectroscopy to the fields of chemistry, food science, mechanical engineering, bioengineering, physics and device development. In the bacteria project, as in several others, she forms a vital bridge, supporting students and drawing together the various perspectives into a cohesive whole.

This bacteria research was initially funded by MBIE with the aim of developing a probe to detect bacteria on meat for food safety. The Dodd-Walls Centre provided funding for additional PhD students to expand the scope and explore other applications. This was the origin of the valuable work being done today.

Written by Elizabeth Connor



CUSHLA MCGOVERIN

Cushla grew up in Te Kauwhata in rural Waikato. Like many science enthusiasts she was encouraged to do health sciences at university, but soon swapped to chemistry. She wanted to do microbiology too but the timetables didn't fit – so she is delighted to now be working with bacteria. She discovered spectroscopy in her second-year summer scholarship at the University of Otago working in DWC Principal Investigator Keith Gordon's group where she stayed for her third-year project and her PhD.

Cushla's spectroscopy skills have taken her all around the world. In her PhD she helped Fonterra identify additives to milk and analyse the texture and spreadability of cheese. She also helped pharmacists study the solid forms of drugs. In her first postdoctoral position at Stellenbosch University in South Africa she studied grains to find out which ones made the best cornflakes. In her second postdoctoral role, at Temple University Philadelphia in the United States, she grew cartilage from cells in the lab, helping to develop a probe to tell doctors when bioengineered tissue is ready to implant. Since returning home to New Zealand she has worked as a research fellow and now senior research fellow at The University of Auckland. Alongside the bacteria project, she is also helping DWC Associate Investigator Dr Sara Miller develop a tool to diagnose coeliac disease; you can read more about Dr Miller's project on page 16 of this report.

BUILDING WITH ATOMS

In a world-first experiment, DWC Principal Investigator Mikkel F. Andersen and his team at the University of Otago used tweezers made of laser light to pick up three individual atoms, bring them together and watch them collide and form molecules. Their observations revealed surprising gaps in our understanding of fundamental processes in chemistry. To help make sense of their results, the team worked with DWC Principal Investigator and quantum theorist Joachim Brand and his team at Massey University's Albany Campus. Their co-authored paper, published in *Physical Review Letters*, caught the world's attention. Articles were published in *Physics* magazine, *Physics World* and several other popular science media, and the paper received an attention score in the top 1% of papers at the time.

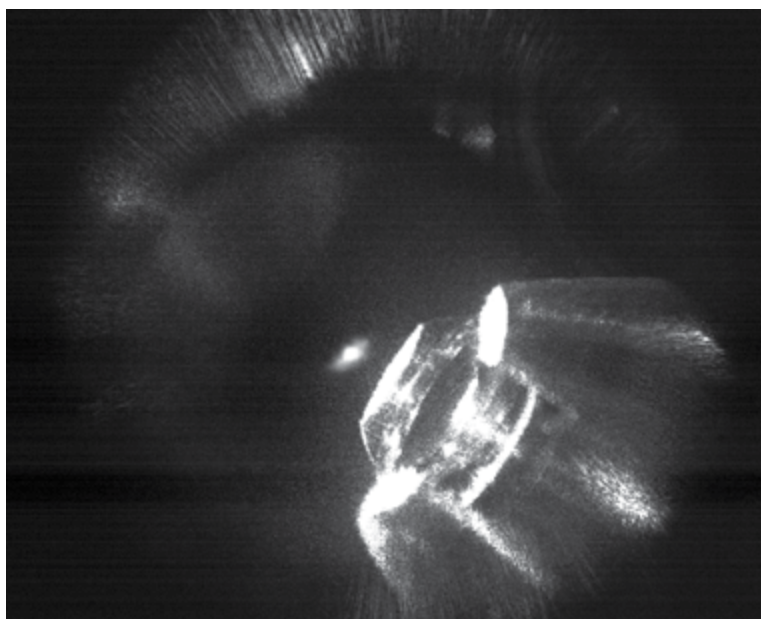
The reason for the big splash was that this was the first time scientists have observed three individual atoms colliding. Every object around us results from atoms combining to form molecules. This is the basic process by which matter forms. Mikkel describes this experiment as "the simplest example of conventional chemistry" – two atoms forming a molecule in the presence of a third.

A burst of energy is released whenever a molecule is formed. The third atom is needed to absorb this energy. It's like a little explosion. The molecule shoots off in one direction and the leftover atom in the other.

The experiment required extreme precision and control to isolate and control the atoms. This was made possible by a myriad of lasers, mirrors, microscopes and a vacuum chamber, fine tuned by Mikkel's team over many years.

"We use highly focused laser beams to trap and cool the atoms to a temperature about a millionth of a degree above absolute zero in a vacuum chamber around the size of a toaster," says Mikkel.

**"THE SIMPLEST EXAMPLE
OF CONVENTIONAL
CHEMISTRY' – TWO ATOMS
FORMING A MOLECULE IN
THE PRESENCE OF A THIRD."**



This photo shows a laser cooled atom cloud viewed through a microscope. Photo credit: University of Otago

The experiments were spearheaded by MSc student Luke Reynolds. Lasers were used for just about everything – cooling the atoms down, isolating and capturing them and bringing them together so they can interact and collide. When all three atoms bump into each other, a molecule can form. The tiny explosion propels them out of the trap, leaving it empty. By observing how many atoms were left in the laser trap after a certain time and repeating the experiment, they measured the probability of a molecule forming. Much to their surprise, it happened about a thousand times less often than expected. They thought they must have made a mistake so asked someone else to repeat the measurements. They got the same results.

What was going on? Were the atoms avoiding each other? Were they colliding but not forming molecules? Mikkel initially got chatting to Joachim about the experiment at a DWC Symposium and he was intrigued.

“It seemed like a simple problem at first,” Joachim said. “But when I sat down, with my postdoctoral fellow Ulrich Ebling, we discovered it was much more complex. It turned out that the common assumptions that we initially made when analysing the data were not valid.”

Until now, collisions between three atoms have only been studied in bulk gas experiments with crowds of atoms. The theoretical models used to explain these experiments assume that the atoms move independently of each other before they collide. Initially, Joachim and Mikkel had used these bulk gas models to predict their experimental results. On further investigation, they suspect that the atoms avoid each other within the tight confines of the laser trap. This effect, technically known as an “anti-correlation”, would explain why molecules formed far less often than expected.

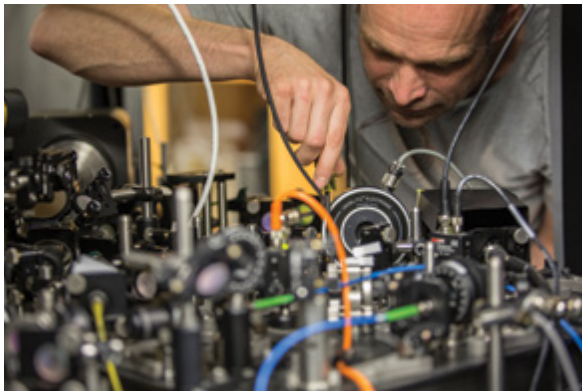
More research is needed to test this theory and fill in the details. Joachim has been awarded a Marsden Grant to investigate further with Mikkel who is an Associate Investigator on the project. Joachim will use a powerful technique he has developed to make sense of impossibly complex quantum problems - a flavour of what is known as “quantum Monte Carlo”. Mikkel will test Joachim’s predictions in further experiments. Together they will shed light on the fundamental processes that build our universe.

The ultimate goal of this research is to learn to control atoms so we can construct molecules, materials and technologies from scratch. It is the ground-work for the next revolution of quantum technologies that will transform our communications, medicine, energy, information technology and materials. But first we need to understand the intricate behaviour of atoms.

Without the Dodd-Walls Centre none of this research would be possible. It has provided the consistency of funding to develop a world-class experimental set-up, students and postdoctoral researchers to do the work, and opportunities to form collaborations and connect both nationally and internationally.

Written by Elizabeth Connor

IT IS THE GROUND-WORK FOR THE NEXT REVOLUTION OF QUANTUM TECHNOLOGIES THAT WILL TRANSFORM OUR COMMUNICATIONS, MEDICINE, ENERGY, INFORMATION TECHNOLOGY AND MATERIALS.



MIKKEL ANDERSEN

Born in 1971, Mikkel Andersen grew up in Denmark where he studied physics and mathematics. After graduating with an MSc, he moved to the Weizmann Institute of Science in Rehovot, Israel for his PhD studying laser cooling - firing lasers at atoms to slow them to a stand-still and reveal their quantum properties. Next, he went to the National Institute of Standards and Technology (NIST) in America, for postdoctoral study with Nobel Laureate William D. Phillips who won the Nobel prize for inventing laser cooling. After a year at New York University, Mikkel moved to Dunedin in 2007 and joined the University of Otago Physics Department where he is now an Associate Professor.



JOACHIM BRAND

Born in 1969, Joachim Brand grew up in Germany. He fell in love with New Zealand as an undergraduate backpacker in 1993. He did his undergraduate studies at the University of Erlangen and his PhD in quantum chemistry at Heidelberg University. After that he discovered the emerging field of cold atoms and switched direction. He was already captivated by quantum theory and saw the field as a playground to create and observe almost any quantum effect. Joachim was a postdoctoral fellow at the University of Washington studying cold atoms, then returned to Germany for four years at the Max Planck Institute working with world-leading theorists as an advanced postdoctoral fellow. In 2006 he moved to Massey University's Albany Campus in Auckland where he spends his time developing techniques to chart the wild untamed realms of the quantum world.

PRIME MINISTER'S SCIENCE PRIZE

Dodd-Walls Laser Scientist Wins Top Prize

In June 2020, Dodd-Walls Centre Principal Investigator Miro Erkintalo was awarded the 2019 Prime Minister's MacDiarmid Emerging Scientist Prize. The \$200,000 award recognises the extraordinary achievements of his team at The University of Auckland and gives a shot of funding and recognition to push their research to the next level.

For the past eight years Miro has been working in close collaboration with Dodd-Walls Principal Investigators Stuart Murdoch, Stéphane Coen, and Harald Schwefel on new types of laser technologies based on so-called microresonators – tiny dielectric discs that can trap laser light and transform it into thousands of different colours. These ingenious little devices are a hot topic internationally because of their enormous potential. Just as transistors are integral to electronic technologies, microresonators could become integral components of cutting-edge photonic technologies, which are based on laser light. Behind the scenes, it is lasers that run the modern world. They are the basis of the internet, used to encode and send every email and Zoom call. They are used to sense diseases, chemicals, gases, pressure, vibration and force, to perform surgery and for precision engineering. Microresonators could be used to improve the efficiency of the internet, diagnose diseases like cancer and detect methane and carbon dioxide in the air. Miro and his team are leading the world in these developments.

Back in 2012, Miro and Stéphane were the first to develop theoretical models to describe how microresonators generate so-called optical frequency combs, which transform a single colour of light into hundreds or even thousands of different coloured laser beams. Their work kicked off a flurry of international research. Since then they have worked closely with Stuart and Harald, both exceptional experimentalists, to further develop the technology. Miro was awarded a Rutherford Discovery Fellowship in 2015 and three Marsden grants as Principal Investigator to pursue related research. In 2016 he won the Hamilton Award, the Royal Society Te Apārangi's Early Career Research Excellence Award for Science.

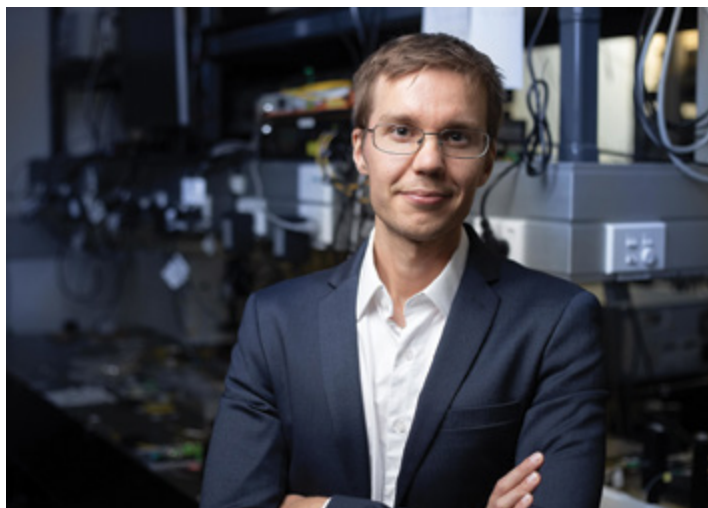


Photo credit: By Royal Society Te Apārangi – own work, CC BY-SA 4.0.

"NEW ZEALAND HAS A FANTASTIC CROP OF PEOPLE WITH WORLD-CLASS EXPERTISE IN PHOTONICS. GIVEN THE RIGHT TOOLS, WE COULD ACHIEVE SO MUCH MORE."

As to the source of his success, Miro credits teamwork as the most important ingredient.

"It's quite rare to have so many senior academics working closely with each other in the same place as a single team," he says. "But it works really well. We complement each other's skills, bounce ideas off each other and share the administration. And we've been super lucky to have so many talented students and postdocs to work on our research."

It was the people who first attracted Miro to New Zealand. Born in a city called Pori on the West Coast of Finland, Miro did his undergraduate studies and PhD at Tampere University of Technology. There he met Goëry Genty who impressed him with his pioneering work and high profile. Miro swapped groups to do his PhD with Goëry, finishing it in two years when it usually takes five or six. During his PhD, Miro became familiar with Goëry's close collaborator, John Dudley, a world-renowned New Zealand-born optics researcher. John brought New Zealand under Miro's radar, and made the University of Auckland sound like an interesting possibility for postdoctoral research.

"I wanted to go to a place where I could make a name for myself rather than being one of fifty postdocs in a huge group. Auckland seemed like an excellent opportunity because the people here are great! Together with John and Goëry, Stéphane had co-authored a research paper that I referred to as "the bible" during my PhD. Neil Broderick, Stuart Murdoch, Rainer Leonhardt, and Frédérique Vanholsbeeck are likewise all famous in my field and I had read papers written by each of them during my PhD."

Miro met these researchers at CLEO Europe, an international conference on laser science and photonic applications. There was a postdoctoral position open and Miro was hired immediately. When he first came to New Zealand Miro planned to stay for two years. That was nine years ago.

"New Zealand really grew on me," Miro said. "The people are amazing and the climate just right. I like laser physics and the great outdoors and New Zealand strangely has both. The physics department at The University of Auckland is a really fun place to work at, and the Dodd-Walls Centre provides an additional layer of support and a sense of community. In hindsight I think it was a really good idea to come here and also a good idea to stay."

One of the main challenges of working in New Zealand has been the lack of established photonics-related industries. Most of the microresonators used by Miro and his team are made from discs of crystal. But internationally the focus is shifting to devices that can be integrated onto silicon chips, similar to the ones used in computers. These integrated devices require expensive infrastructure which is not yet developed in New Zealand.

Miro's big dream would be to set up a national facility for fabricating integrated photonic devices. Such a facility would foster an ecosystem of new research and industries that would provide jobs and export niche photonic devices to the international market.

"I would be happy to help lead that kind of initiative," Miro says. "It would be a huge thing - a government facility bringing together numerous researchers and Centres of Research Excellence. It's an ambitious long-term dream, but it is possible. New Zealand has a fantastic crop of people with world-class expertise in photonics. Given the right tools, we could achieve so much more."

Written by Elizabeth Connor

PROFILING OUR ROYAL SOCIETY TE APARANGI MEDAL WINNERS

DODD-WALLS CENTRE MEMBERS AND STUDENTS HAVE WON AN IMPRESSIVE ARRAY OF AWARDS SINCE THE CENTRE WAS FOUNDED IN 2015. HERE WE PROFILE FOUR WINNERS OF PRESTIGIOUS ROYAL SOCIETY TE APARANGI AWARDS AND MEDALS.

Professor Cather Simpson FRSNZ

Winner of the 2019 Pickering Medal for Technology Excellence



.....
**HER VISION WAS TO
CREATE AN INNOVATION
HUB, USING HIGH-TECH
LASERS TO SERVE THE NEEDS
OF ALL NEW ZEALANDERS.**
.....

Cather was awarded the Pickering Medal for 'her pioneering research and commercialisation of innovative photonic technologies, addressing challenges with a New Zealand focus and global impact.'

Cather is a Professor of Physics and Chemistry at the University of Auckland, a DWC Associate Investigator and academic entrepreneur. Originally from America, Cather has had an enormous impact on New Zealand's photonics industry since 2007 when she came to New Zealand. In her early career she did fundamental research in laser spectroscopy. She used ultra-short pulses of light to study important biological molecules like haemoglobin in blood. When she arrived in New Zealand she had to find a way of raising money to pay for the expensive lasers needed for her research. This was her initial motivation for getting involved with applied industrial research. But she soon became inspired by its wider value to society. In 2010 Cather founded the Photon Factory, a laser laboratory at The University of Auckland. Her vision was to create an innovation hub, using high-tech lasers to serve the needs of all New Zealanders. Her interdisciplinary team of physicists, chemists, engineers and biologists has

attracted millions of dollars of commercial contracts and government funding.

Cather is the founder of two spinout companies: Engender Technologies, which uses lasers to sort sperm for artificial insemination of cows, and Orbis Diagnostics, which is developing an immunity test for COVID-19 (you can read more about this on page 10 of this report). She has won national and international awards for her research and companies, including being the first woman named Supreme Winner at the Kiwinet Research Commercialisation Awards in 2016. She was elected Fellow of the Royal Society of New Zealand in 2018 and Fellow of the New Zealand Institute of Chemistry in 2016 and is a past President of the New Zealand Institute of Physics. She is also an award-winning lecturer, a passionate advocate and dedicated science communicator. As a co-chair of the New Zealand Committee for the UNESCO 2015 International Year of Light, she led the 'Illuminating New Zealand' initiative, which brought hands-on light-based experiments to tens of thousands of New Zealand children and youth.

Professor Keith Gordon FRSNZ

Winner of the 2019 MacDiarmid Medal for scientific research that demonstrates the potential for application for human benefit



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KEITH HAS USED HIS SPECTROSCOPIC EXPERTISE TO IMPROVE THE PERFORMANCE OF SOLAR CELLS, TO MEASURE MICROPLASTICS ON NEW ZEALAND'S COASTS, TO ANALYSE WHALE MUSEUM ARTEFACTS AND TO IDENTIFY DIFFERENT FORMS OF PHARMACEUTICAL COMPOUNDS.

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Keith was awarded the MacDiarmid Medal 'for his innovative use of light to understand molecular structure across a range of areas that impinge on technology, health and the environment.'

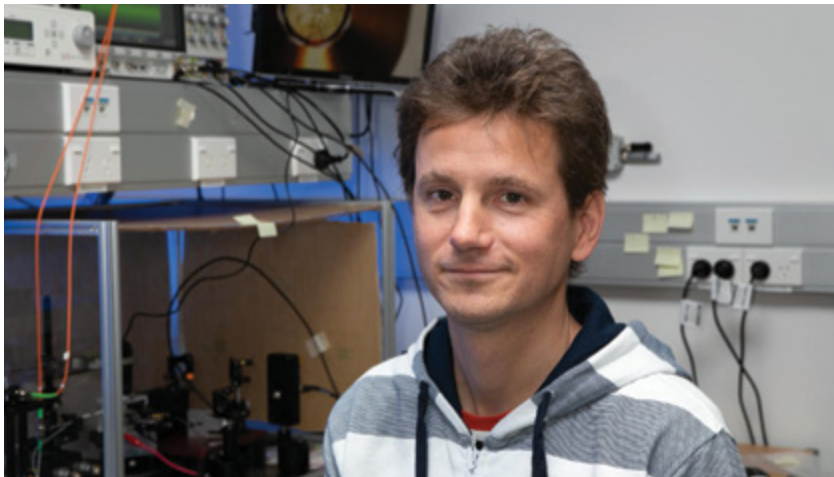
Keith is a Professor of Chemistry at the University of Otago, a DWC Principal Investigator and an expert at spectroscopy: getting lasers to reveal information about the molecular structure and composition of materials. The beauty of spectroscopy is that you can do it on almost anything. Keith has used his spectroscopic expertise to improve the performance of solar cells, to measure microplastics on New Zealand's coasts, to analyse whale museum artefacts and to identify different forms of pharmaceutical compounds. He has worked with New Zealand industry groups to assess the quality and composition of various foodstuffs, including dairy, fish, meat and horticultural products.

Initially Keith specialised in excited states of molecules, the different forms they take for microseconds after they absorb light. He has adapted these techniques and combined them with computational chemistry to develop innovative methods of analysis. He uses mathematical models to remove noise and obtain clear spectral signatures.

His research has had a profound impact on industry, health and the environment and he is a dedicated supporter of his team of students and postdoctoral fellows. He was elected a Fellow of the New Zealand Institute of Chemistry in 2004, a Fellow of the Royal Society of Chemistry in 2011 and a Fellow of Royal Society Te Apārangi in 2012. In 2010 he was awarded the Maurice Wilkins Centre Prize for Chemical Science by the New Zealand Institute of Chemistry.

Associate Professor Stéphane Coen

Winner of the 2016 Hector Medal for work which has made an outstanding contribution to the advancement of physical sciences



Stéphane was awarded the Hector Medal for ‘his fundamental physics research into optical phenomena in optical fibres and microresonators.’

Stéphane is an Associate Professor at The University of Auckland and a DWC Principal Investigator. He works in close collaboration with DWC Principal Investigators Miro Erkintalo and Stuart Murdoch. He won the Hector Medal for his groundbreaking research into optical cavity solitons - tiny packets of light that travel around loops of optical fibre. In 2010 his group were the first to observe optical solitons experimentally, thirty years after they were predicted. They have since demonstrated that they can move the solitons as they travel around the loop. This discovery offers a potential method for storing and editing optical data on the fly, which would avoid the power-consuming process of converting between optical and electrical signals. This could radically improve the efficiency of the internet.

Stéphane has also played a key role in the development of microresonator optical frequency combs, tiny dielectric discs which transform a single colour of light into hundreds or even thousands

of different coloured laser beams. A hot topic internationally, these devices could be used in telecommunications, ultra-accurate clocks and precision sensing and measurement applications. Stéphane and his colleague Miro were the first to develop theoretical models to describe how optical frequency combs are generated. Their models were quickly taken up by research groups around the world and now underpin many microresonator technologies.

“In the future, temporal cavity solitons might allow your cell phone to keep time accurately enough that it could be used as a precise scientific measuring device,” Stéphane said. “You could then use your cell phone as a spectroscope to identify chemicals in the environment.”

Stéphane was elected a Fellow of the Optical Society of America in 2015 and was awarded the Research Medal of the New Zealand Association of Scientists in 2015. The University of Auckland awarded him a Research Excellence Award in 2014 and he has received a number of prestigious Marsden Fund grants from the Royal Society of New Zealand.

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“ IN THE FUTURE, TEMPORAL CAVITY SOLITONS MIGHT ALLOW YOUR CELL PHONE TO KEEP TIME ACCURATELY ENOUGH THAT IT COULD BE USED AS A PRECISE SCIENTIFIC MEASURING DEVICE,” STÉPHANE SAID. “YOU COULD THEN USE YOUR CELL PHONE AS A SPECTROSCOPE TO IDENTIFY CHEMICALS IN THE ENVIRONMENT.”

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Ryan Thomas

Winner of the 2017 Hatherton Award for demonstrating the no side-stepping rule of quantum mechanics

Ryan received the Hatherton Award for ‘the best scientific paper by a PhD student at any New Zealand university in chemical sciences, physical sciences, mathematical and information sciences.’

At the time Ryan was a PhD student in the lab of DWC Principal Investigator Niels Kjærgaard at the University of Otago using laser beams to trap clusters of atoms, cool them down to temperatures a millionth of a degree above absolute zero and gently nudge them into each other. At these low speeds, the electrons around the outside of the atoms interact in a beautiful quantum dance.

Ryan used this technique to demonstrate and extend our understanding of the so-called Pauli exclusion principle, a fundamental rule of quantum physics. He observed collisions between potassium atoms, which are in a class of particles called fermions. The Pauli exclusion principle states that fermions cannot scatter at a 90 degree angle to the collision axis. Even though this phenomenon, known as the ‘no-side-stepping’ rule, has been known about for almost a century this was the very first time it has been directly observed. Ryan also observed atoms passing right through each other instead of scattering, demonstrating a mind-boggling quantum principle, known as the Wigner threshold law.

The award selection committee noted that Ryan had demonstrated both technological and theoretical excellence in producing this paper, which was published in Nature Communications.

Ryan completed his Bachelor of Science (Honours) at Simon Fraser University in British Columbia where he received the Governor General’s Silver Academic Medal, awarded for the highest-grade average at the university. Following that he completed a Master’s degree at the University of Calgary before winning a scholarship to do his PhD at the University of Otago. In 2010 he received the Ralph Steinhauer Award of Distinction and the Bill Bridger Award. He was awarded Best Postgraduate Paper in the Division of Sciences at the University of Otago in 2016. He is now working at the Australian National University as a postdoctoral researcher.

Written by Elizabeth Connor



.....
RYAN ALSO OBSERVED ATOMS PASSING RIGHT THROUGH EACH OTHER INSTEAD OF SCATTERING, DEMONSTRATING A MIND-BOGGLING QUANTUM PRINCIPLE.
.....

DWC RESEARCH EXCELLENCE

Dodd-Walls Centre researchers and their collaborative teams were again very successful at winning funding that adds to TEC CoRE funding and aligns with the Centre's strategic goals. External funding was won to support fundamental science and pre-commercial R&D in the agriculture, medical, and high-tech manufacturing industries. Our investigators and research students won prizes and awards, evidence of highly effective mentoring and capability-building in the next generation of New Zealand's workforce.

Investigators

Research Funding Awards



JOACHIM BRAND AND MIKKEL ANDERSEN

DWC Principal Investigators
University of Otago

Marsden Fund Standard Grant, \$919,000
Three atoms in a tight spot (3 years)

Grant PI (Brand)
Grant AI (Andersen)



NATHANIEL DAVIS

DWC Associate Investigator
Victoria University of Wellington

Rutherford Discovery Fellowship, \$800,000
Pushing the limits on renewable energy technology through hybrid organic/inorganic nanomaterials (5 years)

Grant PI



JULIETTE CHEYNE

DWC Associate Investigator
The University of Auckland

Auckland Medical Research Foundation (AMRF) Grant, \$158,373

Exploring hippocampal deficits in a mouse model of Autism Spectrum Disorder using miniscopes (2 years)

Grant PI

Maurice & Phyllis Paykel Trust (MPPT) Grant, \$16,000

Linking behavioural and cellular deficits in a mouse model of Alzheimer's disease using miniscopes (2 years)

Grant PI

OVER
\$4
MILLION

NEW COMPETITIVE,
EXTERNAL RESEARCH
FUNDING AWARDED IN
2020 IN RECOGNITION
OF EXISTING RESEARCH
EXCELLENCE

HARALD SCHWEFEL

DWC Principal Investigator
University of Otago

MBIE Catalyst Funding, \$150,000

Miniature sources of quantum light (2 years)
\$80,000 (seeding grant)
Space ready radiometers: detecting microwaves with light
(3 years)

Grant PI

Marsden Fund Standard Grant, \$899,000

Dual-comb spectroscopy - resolving optical precision electronically
(3 years)

Grant PI



MICHEL NIEUWOUDT

DWC Associate Investigator
The University of Auckland

Health Research Council (HRC) Hercus Fellowship, \$482,706

Photonic device for real-time measurement of ischaemic tissue
margins in surgery (3 years)

Grant PI

MBIE Funding Extension, \$166,700

Point-of-care device for skin cancer diagnosis (6 months)

Grant PI



Prizes and Peer Recognition

MIRO ERKINTALO

Awarded Prime Minister's MacDiarmid Emerging Scientist Prize

JOACHIM BRAND

Awarded the American Physical Society (APS) Outstanding Referee award in 2020

FREDERIQUE VANHOLSBECK

Elected Senior Member of the OSA

KAI CHEN

2020 New Zealand Institute of Chemistry (NZIC) Applied and Industrial Chemistry Prize

Students

EMA MARETIC

PhD candidate, Auckland University of Technology

Supervisor: Nicola Brasch

New Zealand Institute of Chemistry (NZIC) Prize, top Chemistry major graduating in 2020

CALUM GORDAN

PhD candidate, Victoria University of Wellington

Supervisor: Nathaniel Davis

Best Poster Prize, Christchurch Materials

DEANNA AYUPOVA

PhD candidate, Victoria University of Wellington

Supervisor: Nathaniel Davis

Victoria University of Wellington Landers Award

ROBERT CHIMA

PhD candidate, University of Otago

Supervisor: Sara Miller

Presentation Prize, 2020 Pharmaceutical Solid State Research Cluster (PSSRC) online meeting

EDUCATIONAL AND PUBLIC OUTREACH

Despite the global pandemic, the Dodd-Walls Centre managed to maintain momentum across its Education and Public Outreach activities in 2020. Although some events, including a significant presence planned at Auckland's ASB Polyfest and the final leg of a Pasifika outreach tour to Samoa, were curtailed by the onset of COVID-19, the team quickly pivoted to virtual delivery over lockdown, and then rapidly geared up to start in-person delivery when it was safe to do so again. As a result, 2020's silver lining was that our forced foray into virtual delivery enabled us to add yet another outreach platform by which the Dodd-Walls Centre can engage non-traditional audiences.

We begin with a story about one of our students whose engagement with Māori has altered the course of his PhD and provided him with both employment and learning opportunities as a consequence of his interest in outreach and education, particularly being able to inspire and share learning with others.

A Blossoming Relationship with Rangitahi Māori

It was 2017 when DWC outreach coordinator Andy Wang first met with Te Pu-a-nga Maara, a collective of rangatahi (youth) from three marae in South Auckland. This was the beginning of a rich reciprocal relationship.

"Their school had no science lab but they wanted to do all these cool science activities," Andy says.

Andy supported the students to develop water testing kits using cheap LEDs, light detectors and a chemical from a pet shop, used in fish tanks. These kits measure the nitrogen content in waterways and streams, giving a measure of pollution. With the help of \$30,000 from MBIE's Unlocking Curious Minds Fund, they have now produced and distributed over 200 kits and run events and workshops to train people how to use them. The four students who started the project are now reaching the end of high school and have been asked by Auckland Council to deliver workshops to local communities. Their experience has made them local authorities in water testing.

As Andy taught the students about science, they taught him about mātauranga Māori.

"As we worked they shared their insights into a Māori world view of the environment," says Andy. "All their research questions and hypotheses were informed by maramataka, the traditional lunar calendar, which tells you when to do certain things like planting, fishing, resting and taking stock."

Andy joined with Rereata Makiha, an expert in the Maramataka (Māori lunar calendar), on his talks around the country, introducing communities to the water testing kits.

"I've started learning Te Reo Māori so I can talk to people and understand what's going on," he says. "You can't do that if you don't speak the language."



ANDY WANG

Born in China, Andy Wang first came to New Zealand when he was six years old. He studied undergraduate Physics and Maths at The University of Auckland and started his PhD in laser physics at the Photon Factory before putting his studies aside to take the role of Outreach Coordinator for the Dodd-Walls Centre. He recently began a new PhD researching the impacts of science outreach initiatives in New Zealand.

“I WAS FASCINATED BY THE IDEA THAT YOU COULD EXPLORE RELATIVELY SIMPLE STUFF AT HOME THAT SHOWS REALLY COOL AND DEEP SCIENCE LIKE LASER FIBRE OPTICS OR FLUORESCENCE.”

Five years ago, Andy had no idea he would be working with young Māori. He was a PhD student studying lasers and molecules in the Photon Factory at The University of Auckland when he got involved in science outreach. His PhD supervisor, DWC Associate Investigator Cather Simpson, had taken the lead on organising celebrations for UNESCO’s 2015 International Year of Light in Aotearoa.

“She had a big vision,” Andy says. “We partnered up with the Otago Museum and ran events all over New Zealand. Our whole group got involved.”

Andy got hooked on making “Light Matters Kits”, cardboard boxes containing simple experiments that children could do at home. His team made and distributed thousands of these. This was a turning point in Andy’s career.

“I was fascinated by the idea that you could explore relatively simple stuff at home that shows really cool and deep science like laser fibre optics or fluorescence,” Andy says. “Like the glow-in-the-dark stars kids have on their ceilings. They glow because they have phosphorescent molecules that absorb light and release it hours later. Or tonic water, which glows blue under UV light because the quinine molecules are fluorescent. You need quantum physics to explain all this.”

Andy saw these simple demonstrations as doorways to invite people of all ages into the wonders of science.

In 2017 the Dodd-Walls Centre was looking for someone to coordinate outreach activities in Auckland. Andy put his PhD aside and accepted the role. One of his first initiatives was a science fair at the University of Auckland.

“We rented costumes and got students to dress up as famous physicists,” he said. “We borrowed a chunk of Uranium and had Marie Curie demonstrate radioactivity with a geiger counter. Michael Faraday demonstrated electricity and Rosalind Franklin did diffraction. We hired a bus and brought kids in from South Auckland. They had a great time!”

The Dodd-Walls Centre introduced Andy to another Māori science programme called Science Wānanga, run by the University of Otago’s Division of Sciences. Here, the community chooses science topics they are interested in, and university scientists and students develop a programme in response. They gather with young people and elders on the marae for three days to learn, eat, sleep and work together. Andy was invited to take part because so many of the communities were interested in water quality. He has now been involved in seven Wānanga bringing several DWC researchers and students to join him.

After three years in the role, Andy has visited Tonga, organised three outreach tours of Northland and two science fairs, and developed a travelling exhibition with Auckland’s Museum of Transport and Technology (MOTAT). His approach is always to listen, learn and share what he can.

“I’m not a fan of programmes that parachute in, dictate what’s going on and then leave,” he says. “When I know something, I go ahead and share. When I don’t, I stay quiet and learn something. There’s a lot you don’t learn at school in New Zealand, mātauranga is one of those things, which is a shame. I find it very interesting learning more about Aotearoa, especially its cultural heritage.”

Written by Elizabeth Connor

ANDY SUPPORTED THE STUDENTS TO DEVELOP WATER TESTING KITS USING CHEAP LEDS, LIGHT DETECTORS AND A CHEMICAL FROM A PET SHOP, USED IN FISH TANKS.

SELECTED HIGHLIGHTS FROM 2020

Going Virtual

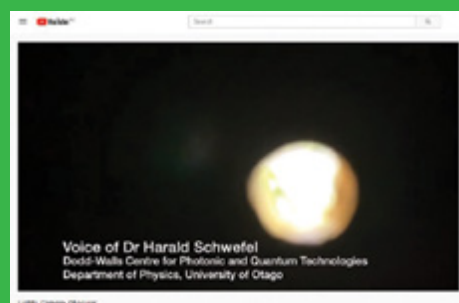
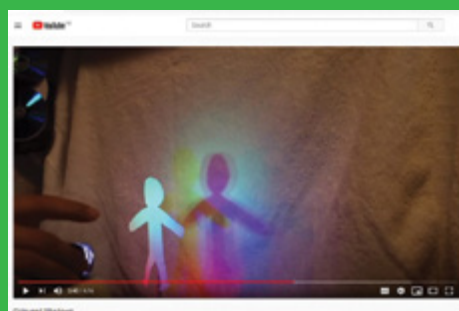
With the announcement of the move to Covid Alert Level 4 at the end of March, and no way of knowing how long NZ would be under those restrictions, a series of short videos of a selection of our photonics-based demonstrations were developed in collaboration with Otago Museum. The demonstrations used materials that viewers were likely to have around their homes. As no special equipment was required, these videos were not only accessible to all audiences, but showcased physics as engaging, fun and not restricted to laboratories.

Of the videos planned, three were produced before the country shifted to Alert Level 2 and in-person delivery was possible again. Those three films – Making Rainbows, Coloured Shadows, and Lights, Camera, Obscura! – were made publicly available via Otago Museum’s YouTube channel and embedded on the Otago Museum website (<https://otagomuseum.nz/athome>).

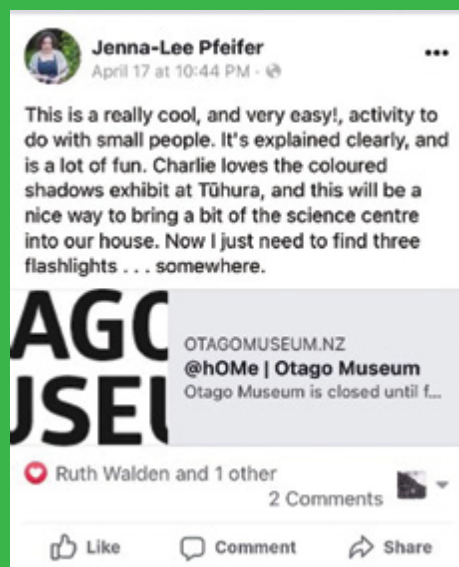
Google Analytics reports that all three videos have had an average watch time of four minutes, which is double the average holding time for videos on YouTube. Overall, these three short films engaged over 250 individuals during the 52 day lockdown.

Additionally, a virtual celebration for the International Day of Light (on 16 May 2020) was coordinated across Otago Museum’s social media and the Otago Optics Chapter at University of Otago, and has received over 600 engagements to date.

The engagement with the virtual content indicates it was a successful pivot that can continue to be expanded in order to reach future audiences that are unable to access Centres for Illumination or participate in our wider science outreach initiatives.



Stills from “Coloured Shadows” and “Lights, Camera, Obscura!”



Online feedback on the videos.

Shine Bright With Us – UNESCO International Day of Light Celebration

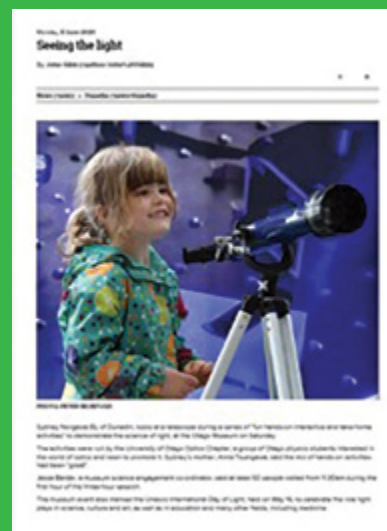
As it was unclear what delivery would be possible on the actual UNESCO International Day of Light, a post-lockdown celebration was planned. This was successfully launched within two weeks of the Alert Level change allowing for in-person delivery, over which time the team worked to ensure all additional health and safety procedures required were in place.

On the 6th of June, the Otago Optics Chapter set up in Otago Museum’s Atrium to deliver demonstrations exploring the visible light spectrum, how refraction works, and how we can see it. A demonstration on ultraviolet light, and its ability to both help and harm us, was particularly well-received given the well-publicised studies into UV light as a means of destroying the novel coronavirus.

This was the first open-to-the-general-public outreach event since the Covid Alert levels were introduced, and it was enormously well-received, with over 200 people directly engaged over the course of three hours, and attracting the attention of news media.

Matariki

Although a rāhui (restriction) due to the pandemic prevented the annual Puanga-Matariki Festival from occurring in Dunedin in mid-July, permission was granted from the local Rūnanga to host a small celebration in Lab-in-a-Box outside Otago Museum over two evenings, focusing on photonics and optics as they relate to starlight and Puanga and Matariki in particular. The development of this content and theme included offering a daytime preview to a group of tamariki from Te Rūnanga o Ōtākou to pilot a new outreach programme that featured more mātauranga Māori in the content.



Tamariki from Te Rūnanga o Ōtākou experience diffraction glasses.

Te Pua Nga Maara

In 2020 we have continued to build on our relationship working with Māori communities in Auckland through Te Pua Nga Maara: a rangatahi Māori collective focused on indigenous innovation for sustainability. In particular, Andy Wang has been working with students from Manurewa to develop a portable and affordable water testing kit for measuring dissolved nitrogen called Te Kete Waiora. The rangatahi have been delivering activations for Māori community groups, Auckland Council and local boards. With the Dodd-Walls Centre's support, the group have been able to travel all over the North Island as well as to Dunedin to present their work. In the last year we participated in over a dozen different noho marae (marae visits) and noho taiao (outdoor camps) from Te Hapua all the way down to Tauranga Moana.

The visit to Dunedin was of particular note this year, as it afforded the rangatahi the opportunity to attend a water quality community monitoring workshop at Otago Museum, where they presented their water quality testing kit, Te Kete Waiora, to the coordinators of Participatory Science Platform projects from around Otago.

Additionally, the trip south was significant because it was coordinated to overlap with a full-day school holiday programme delivered at Ōtākou marae for tamariki and rangatahi of that Rūnanga. This programme was developed out of the preview of the Matariki programme, as a way of supporting local tamariki and building content with a mātauranga Māori focus. The October visit was particularly focused on how optics and photonics can facilitate kaitiakitanga, and the rangatahi from Te Pua Nga Maara supported the programme by facilitating tuakana/teina. Both manuhiri and tāngata whenua came away inspired and motivated.



Te Pua Nga Maara present their work to the public at Te Mahurehure Marae in Pt Chevalier, Auckland.



Presenting at the Otago Museum workshop; the team outside the Museum.

Feedback from manuhiri:

"I love that Rani and Aunty Ngapz came up with that game in 1-2 hours... Daph and Kahu were awesome at presenting TKW and Akaroa was great at explaining the connections between Matauranga Maori and TKW and standing up on behalf of TPNM and saying thanks to everyone that was there..."

Feedback from tāngata whenua:

"I just want to thank you and your team again for making our first holiday programme a massive success! The feedback from the holiday programme was all really positive and the parents liked the fact that it not only exposed their tamariki to their Ōtākoutaka and Kāi Tahuaka but also had an element of education that linked with the school curriculum, possible pathways for mahi and science curriculum."

As a result of the success of this programme, Ōtākou marae have expressed interest in full-day programmes for all of the 2021 school holidays.

As a result of the confidence and empowerment that has been fostered in the rangatahi from Te Pua Nga Maara throughout their work with the Dodd-Walls Centre, they have requested assistance in registering a business that would enable them to sell Te Kete Waiora to the public.



A game that teaches the whakapapa of water.



Learning how to use Te Kete Waiora to test water from around the marae.

Northland Roadshow

The return from Whangarei in the latter half of 2020 marked the final school visit and the conclusion of the Northland Roadshow. In total, approximately 1,400 kms was travelled to reach over 300 students across four different schools in Northland. The team of eleven was made up of a diverse team of physicists and chemists: one postdoctoral fellow, seven PhD candidates, two honours students and one undergraduate student. Together, they ran 45 workshops showing the students how to do water testing, make their own rockets, and what it feels like to have your hands set just a little bit on fire (safely, of course). A massive thanks to Andy, Sneh, Praveen, Max, Shalvin, Frank, Ashly, Caitlin, Liam, Aljo, and Jacob for the amazing work.

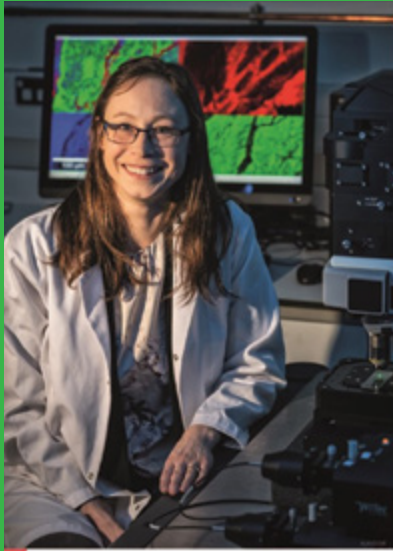
Full STE(a)M Ahead

This project was the result of a successful proposal to MBIE's Unlocking Curious Minds fund to engage more young women in science, technology, engineering, and maths, and help resolve the gender gap that persists in those fields.

To kick off the project, a Women in Science Expo was piloted in Otago Museum's Beautiful Science gallery on February 11th for International Day of Women and Girls in Science. The expo featured tables set up by local women in STEM, showcasing their respective fields through hands-on demonstrations. Feedback from the presenters, students and teachers was unanimously enthusiastic, and this has informed our workshop design for 2021.

Later that same evening, Sara Miller joined a panel of other local women in STEM, giving a short talk on her journey and experience pursuing a career in STEM prior to a live video call with a team of women working at Amundsen-Scott South Pole Station, including a winner of the 2020 Breakthrough Prize in Fundamental Physics.





SARA MILLER

It has been exciting to discover the variety of different samples that can be investigated by light beams. I have had the opportunity to explore and solve questions for a range of samples, from glacioclasts to traditional basalt, geological and fine research to diamond tissue, and even a 100-year-old bird from Antarctica. The wide range of samples and applications has made every day interesting. It has also allowed me to meet many people with diverse backgrounds and expertise which I have found to be a particularly valuable experience. A supportive network has been an integral part of my STEM journey – my thanks goes to all those involved.



CATHERINE SMITH

The biggest surprise in my STEM career is that it happened at all - I was told at school I was not good at science. As my interest in plants grew, I realised how important science was to sustaining and preserving the planet, and that there was no clear division between science and the humanities. My work bridges that divide, and solving problems and working collaboratively with communities to reveal information about the human history is really dynamic and always exciting. It's just didn't occur to me that people who had to find the possibilities for me. When you want to learn something, there is always a way forward.



MADHURI KUMARI

One afternoon my physics teacher contacted me to fill his toolbox my test scores. He said, "Your score is good, but I can tell that you haven't been paying attention in the class or reading much from the textbook. The way you have approached the problems is very original and impressive. You have a gift, one day you will achieve big things, but remember to ignore the noise from society".

Many years down the line, I often find strength in those words when someone challenges my ideas and approach for being different.



SONIA MOBASSEEM

When I was a little girl, I was ambitious and determined. I grew up in a very small town in Iran. I was fascinated by science. By 10 I knew I wanted to be a scientist. However, while growing up everything changed for me. My world was shut down by the Iranian regime, and then religious rules. Female scientists were not taken seriously in Iran and women's rights were compromised. I changed to some extent becoming a physicist in a free country. It took me 10 years to achieve. Every step was a big challenge. Two years ago, I finally fulfilled my dream. Now I am working on one of the hottest topics in the world quantum optics.

The major highlight of the *Full Ste(a)m Ahead* project in 2020, however, was the development and delivery of *100 women, 100 words... infinite possibilities*, a digital portrait exhibition featuring 100 women and girls from Otago and Southland nominated by their communities as role models for the inspiring way they have engaged with the science, technology, engineering, and maths all around them.

Nominations opened during lockdown on 1 May and ran for the entire month. Over 300 nominations were received and these were processed down to the final 100 subjects by a selection committee. Photographers then began capturing images of the subjects, while the subjects themselves worked on 100-word captions that described what has been most surprising or unexpected about their specific experiences in their field. The final digital files were then installed in the Otago Museum's Beautiful Science gallery, where the images appear over 3m high, demonstrating that these women and girls are truly "larger than life" when it comes to engagement in their fields.

The exhibition opened to the public on 5 December with approximately 200 individuals in attendance, including most of the women and girls involved in the exhibition. Feedback has been overwhelmingly positive and indicates the exhibition has already been successful at raising awareness of the diversity of career opportunities – and pathways to them – in STEM.

Planning and coordination for the 2021 phase of the project was also completed. This will include in-person workshops with GirlBossNZ and other role models from the exhibition, a larger version of the Women in Science expo, and a tour of the exhibition to Gore, Invercargill, Oamaru, and Alexandra, with accompanying panel discussions.

Dodd-Walls Centre women represented in the exhibition.

INDUSTRY ACTIVITIES

As we come to the end of the first six years of TEC funding, we thought we would take the opportunity to look at both the quantum technology sector and the photonics sector, and the contributions made by New Zealand researchers and the opportunities for us to continue to pioneer world-leading research. Having secured funding from TEC for a further eight years, we are looking forward to continuing the multi-disciplinary approach to research that has become a feature of the Centre and which enables us to train and mentor our students, positioning them to become the leaders of the future in these industries.

The Kiwi contribution to the quantum revolution

For a small country, New Zealand has played a surprisingly significant role in the global development of quantum technology. Now, as the Dodd-Walls Centre enters a new phase with eight more years of funding, we step back to view how the global frontiers of quantum science and technology have shifted, how New Zealand has contributed and what opportunities and challenges lie before us.

A century ago, the quantum world was just being discovered by the great pioneering physicists Niels Bohr, Albert Einstein, Erwin Schrödinger and others. They invented quantum theory to explain some experiments that broke the rules of classical physics. The new theories turned our view of reality on its head. They describe a world that operates at the miniscule scale of atoms where things can be in many places at once; where light is made of tiny chunks and particles spread out to form fuzzy clouds that collapse to a single point whenever a measurement is made. It is mind-boggling.

“Quantum mechanics completely overthrows all the common-sense ways of understanding the world,” says DWC Principal Investigator and theoretical physicist Howard Carmichael. “You need a completely different paradigm even to talk about it. Quantum physics really is the untold intellectual revolution.”

The quantum realm became a promised land. When physicists thought they had solved all the major problems and just had details to fill in, it threw open a new frontier for exploration. But being so tiny and inaccessible, it took many decades to develop the technological ability to test these theories and to explore and manipulate the quantum world. Now we are on the verge of a quantum revolution, with billions of dollars of public and private funding being poured into the quantum technology research in the US, UK, Europe and China. Extremely powerful quantum computers, secure communication systems and ultra precise sensing and measurement devices are being developed that harness the strange properties of the quantum world.

**NEW ZEALAND'S
ROLE IN QUANTUM
AND ATOMIC SCIENCE
DATES BACK TO ERNEST
RUTHERFORD WHO, IN
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OF OPEN SPACE.**

NEW ZEALAND HAS GROWN AS A CENTRE FOR QUANTUM OPTICS ATTRACTING TOP INTERNATIONAL AND LOCAL RESEARCHERS WHO HAVE ACHIEVED WORLD FIRST RESULTS.

Dodd-Walls Centre researchers are contributing in all these fields. New Zealand's role in quantum and atomic science dates back to Ernest Rutherford who, in 1911, discovered that atoms consist mainly of open space. Then, in the 1950s and 60s, Jack Dodd made pioneering discoveries about the interactions between atoms and light.

But it was Dan Walls, another Kiwi physicist, who really put New Zealand on the map in recent times. He returned home, after studying with the pioneers of laser physics at Harvard and Stuttgart Universities and set up a research centre at Waikato University. It was the development of the laser in the 1960s that threw open the gates to the quantum world. The extremely precise colours of laser light could be used as probes to interact directly with atoms and reveal their quantum properties. Dan Walls gathered a star team including Crispin Gardiner and Howard Carmichael who was his PhD student. Together they laid theoretical foundations for the field of quantum optics - using lasers to explore the world of atoms. Dan and Howard were the first to successfully propose a way to coax the little chunks of light, called photons, to show themselves. Their suggested experiment soon led to conclusive measurements. Dan Walls and John Harvey (now the Dodd-Walls Centre's Industry Manager), organised conferences and summer schools that attracted Nobel prize winners and leaders in the field from all around the world.

"When you live in a small country like New Zealand," Howard says, "it is extremely important to stay connected with the broader international community. Dan Walls achieved that and we have continued to stay connected at the very highest level. I see that as one of our most significant achievements."

After focusing mainly on theory, New Zealand made its first big splash in the experimental realm in 1998. A team of scientists led by Andrew Wilson at the University of Otago were the first in the Southern Hemisphere to create a so-called Bose-Einstein Condensate or BEC. This new phase of matter was created by firing lasers at a cloud of atoms to cool them down – an extremely difficult technological feat. Below a certain temperature, the atoms

condense into an "exotic quantum phase", where they collaborate with each other and behave more like a single wave than a collection of particles.

The emergence of Bose Einstein Condensates gave physicists an unparalleled new system to explore the quantum world of matter. Perhaps the biggest advance since the invention of the laser – and New Zealand was at the forefront. The Dodd-Walls Centre continues to excel in BEC research today.

Since the nineties, New Zealand has grown as a centre for quantum optics attracting top international and local researchers who have achieved world first results – quite an accomplishment when competing against countries with billions of dollars of funding. In the past five years, the Dodd-Walls Centre has given research in this field critical mass by pooling resources, coordinating efforts, funding research projects, providing scholarships and supporting people to stay connected internationally.

Quantum manipulation is one of our specialities. For example, DWC Principal Investigator Mikkel Andersen and his group at the University of Otago are world leaders in catching and controlling individual atoms. They use highly focused laser beams to move them around, control their state and bring them together to form molecules with absolute precision.

Precision measurement and sensing is another speciality. The more accurately we can measure the world, the more precise and powerful we can make our technologies. Quantum systems are extremely fragile and sensitive to their environment. DWC researchers are harnessing this sensitivity to make precision measurements of properties like force, magnetic field, distance, gravity and time. In 2018 they developed a compact gravimeter, so sensitive it could detect the gravitational pull of water deep underground. This could be used, for example, to locate the water table on farms.

One of the landmark events of the past decade was the redefinition of the kilogram. Ever since the 19th century, scientists have based their definition of mass on a chunk of metal stored in an underground vault in France.

NEW ZEALAND HAS THE POTENTIAL TO BUILD ON OUR LEGACY TO DEVELOP LOCAL INDUSTRIES BASED ON QUANTUM TECHNOLOGIES THAT WOULD INTEGRATE WITH THE DODD-WALLS CENTRE'S EXPERTISE IN PHOTONIC DEVICES.

In 2018, representatives from more than 60 nations gathered to approve a new definition for the kilogram, one based on a quantum measurement. Dodd-Walls Centre researchers at New Zealand's Measurement Standards Laboratory are currently devising a new experiment that will become the local reference for all measurements of mass.

The quantum technology that has most captured the world's attention is quantum computing. There is a global multi-billion dollar race to develop this enormously powerful new computing infrastructure, with companies like Google and IBM leading the charge. If quantum computers can be developed at a large enough scale they could revolutionise the fields of artificial intelligence, energy, climate solutions, banking, cybersecurity, medicine and many more. They would also throw the quantum realm open for further fundamental discoveries.

The technological challenge of creating a quantum computer is enormous. The global effort has produced some of the most significant advances of any field over the past decades. For example, artificial atoms have been engineered that behave just like atoms but are much larger and easier to work. They can be integrated into networks on chips, similar to normal computer chips.

Although New Zealand doesn't have the resources to build a full quantum computer, we are leading the world in several enabling technologies. Quantum communication is our greatest strength. One of the problems with today's leading quantum computers, is that they operate using microwave signals, which can't be transported long distances. In order to connect quantum computers together and to share quantum information, you need to convert microwave signals into optical signals that can be sent down optical fibres like the internet. Several DWC researchers have developed world-leading methods for efficient microwave to optical conversion. DWC Principal Investigator Jevon Longdell has also developed the world's most efficient quantum memory device – like a hard-drive for a quantum computer. DWC researchers are currently investigating the possibility of combining these technologies and installing them on satellites and

space stations to enable long distance quantum communication that would be 100% secure.

Perhaps New Zealand's most significant contribution to the global quantum story has been fundamental theory, in particular Howard Carmichael's quantum trajectory theory (QTT). Developed in the late eighties, QTT has been used for decades and forms the basis of computer simulation packages used by thousands of people around the world. But it is in the last decade that it has made its biggest impact. As experimentalists have begun to work with individual atoms and quantum systems, QTT has provided a way to predict and simulate their experiments. The problem with traditional quantum theory, given by the Schrödinger equation, is that it only provides probabilities rather than specific outcomes. QTT provides a more specific and detailed view of the quantum world. It has been an essential guide for the development of quantum computers and other technologies.

QTT is also helping to untangle one of the biggest, longest-standing mysteries of quantum physics – what happens when a measurement is made and the fuzzy cloud of possibilities collapses into a single state. Ever since quantum physics was conceived, physicists have argued fiercely about this. Unlike classical physics, quantum theory does not suggest an objective picture of physical reality. It is like a person pointing in two directions and saying "this way". In 2019, Howard worked with an experimental group at Yale University who were able to observe the process of quantum measurement in detail. They showed that the process was not instantaneous but happened gradually over time. The experiment, inspired by QTT, offers clarity to the century-old mystery of quantum measurement.

As the Dodd-Walls Centre embarks on the next phase of its journey, the country needs to decide where to go next. New Zealand has the potential to build on our legacy to develop local industries based on quantum technologies that would integrate with the Dodd-Walls Centre's expertise in photonic devices. It would require significant investment and long-term commitment, but it would put New Zealand in a position to contribute in significant and niche ways to the approaching global quantum revolution.

Written by Elizabeth Connor

Hidden industry to light New Zealand's future

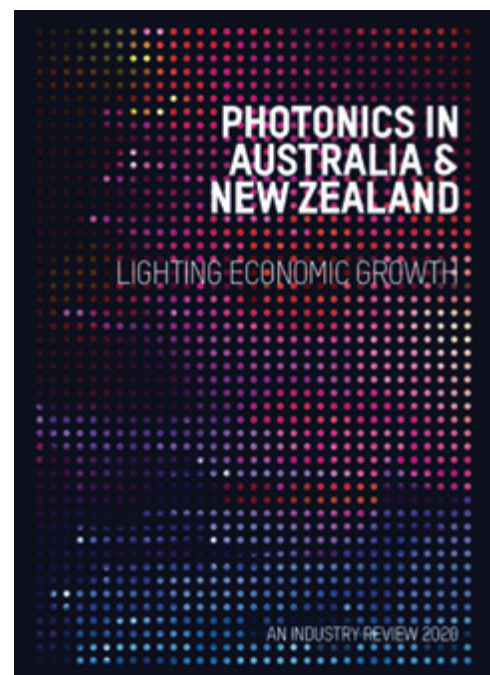
New Zealand is sitting on a hidden pot of gold. It is a local industry that contributes over a billion dollars a year to the nation's economy, pays well, is non-polluting, high-margin and has enormous potential for growth. Its value is comparable to the wine industry and yet most New Zealanders have never heard of it. It is the photonics industry, made up of all the companies that use or produce lasers and light-based technologies. Photonics has been described as a 'hidden economy'. Behind the scenes lasers are everywhere. They form the backbone of the internet, they are in our phones, homes, hospitals and cars. They are used for farming, diagnosing diseases, precision manufacturing, surgery and environmental monitoring. New Zealand is one of the pioneers of laser research and has world-leading expertise in this area. With a little encouragement, the photonics industry could transform the economy, attract world-class talent and help tackle some of our biggest problems like climate change, water pollution and COVID-19.

To uncover the extent and impact of the photonics industry in New Zealand, the Dodd-Walls Centre commissioned a report in partnership with the Australian and New Zealand Optical Society and with support from SPIE, the international society for optics and photonics. They contracted an independent consultant to assess the photonics industries in New Zealand and Australia using an internationally recognised methodology.

The report, released in July 2020, revealed that New Zealand has 121 companies, employing 2,530 people and making an annual income of NZ\$1.2 billion. Analysis of the data shows that companies in this sector have high productivity with a high added value per employee. On average these companies add NZ\$153,000 per employee each year, which suggests they are highly productive. Most of the companies are small or medium sized. Just a few specialise in photonics and the rest use photonic technologies as tools. The companies are dispersed through a wide range of sectors including telecommunications, agriculture, medicine, medical technology, environmental monitoring and construction.

"We were really surprised how many small companies there are," says John Harvey, DWC Industry Manager and co-author of the report. "I was only expecting to find thirty to forty. Even though some of them only employ a few people they have tremendous growth potential."

WITH A LITTLE ENCOURAGEMENT, THE PHOTONICS INDUSTRY COULD TRANSFORM THE ECONOMY, ATTRACT WORLD-CLASS TALENT AND HELP TACKLE SOME OF OUR BIGGEST PROBLEMS LIKE CLIMATE CHANGE, WATER POLLUTION AND COVID-19.





“YOU HAVE TO START WITH THE PUREST RESEARCH TO GET TO THE FINAL NEW PRODUCTS.”

The low profile of photonics in New Zealand has made it challenging for the Dodd-Walls Centre to capture the attention of industry. DWC Associate Investigator Cather Simpson took the initiative to meet with a dairy industry representative and ask about their problems. Her team has now developed two spin-off companies. Engender Technologies uses lasers to sort sperm for artificial insemination in cows to avoid the problem of unwanted bobby calves. In November 2018 Engender was bought by multinational genetics company CRV-Ambreed but the research and development team remains in NZ. The other company, Orbis Diagnostics, started out developing a photonic device to measure the composition of milk in the cowshed with the aim of improving milk quality and cow health. But in 2020 they rapidly adapted their device to undertake COVID-19 immunity tests, which could be installed in airport security checks within a year. These examples demonstrate the value that fundamental laser research can bring to New Zealand. The Photon Factory laboratory, which Cather set up in 2010, has attracted millions of dollars of commercial contracts for local and international companies.

Auckland-based company Quantifi Photonics, which makes testing and measurement equipment, has grown steadily from about fifteen to fifty people since it was founded in 2012.

“It shows how you can start with a small photonics company and end up with a decent sized one,” says John Harvey.

Other DWC researchers are using lasers to develop diagnostic tools for eye disease, coeliac disease and skin cancer, to detect bacteria on food, test the effectiveness of antibiotics, and measure the ripeness of fruit, the quality of timber and the structure of bones. The scale of these tools ranges from a tiny photonic device to make the internet more efficient and a massive one to measure the rotational motion of the Earth.

The Dodd-Walls Centre’s vision is to grow New Zealand’s photonics industry into a thriving ecosystem of startup companies and services that complement New Zealand’s agricultural industries. Nobel Prize-winning physicist, Donna Strickland, a

supporter and collaborator of the Dodd-Walls Centre, emphasises the vital role of fundamental research in achieving this vision.

“You have to start with the purest research to get to the final new products,” she says. “If we don’t keep feeding from the bottom we can’t keep coming up with new products.”

Another of the Dodd-Walls Centre’s international collaborators, Thomas Baer, is the Executive Director of the Stanford Photonics Research Center in Silicon Valley. He points out the need for government support.

“In Silicon Valley there are literally hundreds if not thousands of companies being generated each year within a fifty mile radius,” he says. “One of the challenges facing New Zealand is that you don’t have that critical mass. It’s important that the government recognises the risk that is involved in starting a new enterprise and provides incentives, security and a network to allow risk-taking.”

The Dodd-Walls Centre is training young people with the skills needed to grow new start-up companies.

“The thing I’m most passionate about,” says DWC Director David Hutchinson, “is developing pathways for our graduate students to have fulfilling careers in New Zealand so they don’t have to go overseas. I think it is absolutely essential for New Zealand’s economy.”

The authors of the report identified a number of opportunities to stimulate the growth, vitality and recognition of the photonics industry. They suggested giving photonics its own industry category and code, creating networks to link companies, industry organisations and researchers, and establishing more internships and opportunities for researchers to engage with business. To track the development of the sector over time they plan to repeat the survey every two years.

It is clear that New Zealand’s photonics sector has huge potential. But fostering successful industry will take time, commitment and support. It is a question of choosing our identity as a country. Are we going to remain a largely agricultural nation? Or will we build on those foundations to become a high-tech innovation hub?

“WE ARE DELIGHTED TO HAVE NEW ZEALAND JOIN THE GEMM NETWORK,” SAID **DONNA STRICKLAND. “NOT ONLY DOES THIS INCREASE THE TECHNICAL RANGE OF THE NETWORK, BUT ALSO BRINGS THE OPPORTUNITY FOR CANADA AND NEW ZEALAND TO WORK TOGETHER TO STUDY THE IMPACTS OF CHANGING POLAR CLIMATES.”**

Tackling climate change with photonics

The Dodd-Walls Centre is proud to have formed a node of the Global Environmental Measurement and Monitoring (GEMM) Network, an initiative of the Optical Society of America and the American Geophysical Union. The purpose of this initiative is to get better local data on greenhouse gases and other environmental pollutants so that governments and policymakers are better equipped to mitigate and adapt to climate change.

Along with Canada, Scotland and the US, New Zealand is one of the first members of the GEMM Network. They are working in collaboration with environmental scientists, climate modellers, policymakers, local authorities and industry worldwide to develop better sensing technologies and to establish dense networks of sensors to collect measurements.

The Dodd-Walls Centre is leading this initiative in New Zealand and held the inaugural meeting of the NZ GEMM node at the Royal Society Te Apārangi in November 2019. One of our regional focuses will be helping to improve water quality by developing sensors to measure nitrate pollution in waterways. The Dodd-Walls Centre has also set up a pilot scheme for testing particulate pollution across the city of Dunedin.

Through the GEMM Network, the Dodd-Walls Centre is developing its international reputation. In November 2020, Nobel Laureate Donna Strickland who leads the Canadian node of the network and Thomas Baer, Executive Director of the Stanford Photonics Research Center and one of the network’s founders, joined DWC Director David Hutchinson for a panel discussion with Radio New Zealand presenter Kim Hill.

“We are delighted to have New Zealand join the GEMM Network,” said Donna Strickland. “Not only does this increase the technical range of the Network, but also brings the opportunity for Canada and New Zealand to work together to study the impacts of changing polar climates.”

“New Zealand was a target country for us because of your leadership,” says Thomas Baer. “The leaders recognise that we need to work globally to solve these issues.”

Taking this leadership role also brings economic opportunities. One of the aims is to develop new technology companies for monitoring the environment.

“We got such a wide range of people from different backgrounds attending our first GEMM meeting,” says John Harvey, “We had people talking to each other who we never normally meet. That’s incredibly valuable.”

While 2020 precluded much of the planned industry activity, despite lockdown we were able to continue with the internships in the Office of the Prime Minister’s Chief Science Advisor funded by the Dodd-Walls Centre. Here, our “lockdown intern”, Dr Madhuri Kumari, and Abi Thampi share their internship experiences.

Written by Elizabeth Connor

Building Bridges between Business, Science and Policy

During her postdoctoral study at the University of Otago, experimental physicist Madhuri Kumari spent two months doing an internship with the Office of the Prime Minister's Chief Science Advisor. Her project was to investigate interactions between New Zealand businesses, university scientists and government funding agencies working in the photonics sector, which includes anything involving lasers or light. She reports on her experience:

I have wanted to be a policy intern since my undergraduate days in India. I was training to become a science teacher in the college where all of India's education policy and curricula were designed. My lecturers were the policymakers. At primary and secondary school I had a horrible time. The teachers were terrible so I had to teach myself. Teacher's college was the first time I felt inspired by education. I learnt how you are supposed to teach and I was amazed by the disconnect between policy and practice in the classroom. This experience taught me how important it is for policy to connect with people in the field. After working as a teacher I gave in to my love of physics and shifted to a career in research, eventually moving to New Zealand. I wanted to do this internship to help bridge the worlds of research science, business and policy.

In my research, I conducted over thirty interviews with scientists and business people, identifying opportunities, challenges and gaps that need bridging. I worked closely with Dodd-Walls Centre Industry Manager John Harvey who was reviewing the photonics industries in New Zealand and Australia.

One of the first things I learnt was that the word "photonics" is poorly understood. Often when I wrote to people requesting an interview they would say, 'I don't think I do any photonics.' They didn't realise that using lasers and light was photonics.

These responses showed that photonics has not matured as an economic sector in its own right in New Zealand. And yet it is already playing a key role in the economy. Lasers and light are being used to advance agritech, healthcare, telecommunications and manufacturing. There are eight universities, two centres of research excellence and 71 businesses actively engaging in photonics research. In 2019, their combined sales were estimated over 147 million. On top of this, there are 79 businesses who don't do

much research and development but have significant economic impact. These include big telecommunication companies that provide optical fibre-based internet and small enterprises that use lasers to manufacture their products.

One of the major obstacles that my interviewees spoke about was a gap in funding and expertise for converting lab-based research into market-ready prototypes. Researchers were frustrated by university funding models that make it difficult to acquire the equipment needed for photonics research. There is also a lack of suitable jobs to retain highly skilled scientists and engineers.

One of the entrepreneurs I interviewed spoke about the need for more start-up culture in New Zealand universities. She said that if you go to New York or San Francisco postdocs and PhDs are enthusiastic and savvy about what start-ups have to offer. But here, there is much less interaction between academic researchers, graduates and businesses.

One of the things that drew me to this research topic was attending the 2019 Conference on Lasers and Electro-Optics (CLEO) in Munich. This amazingly vibrant event brought together top researchers in the field of photonics and featured over a thousand exhibits from businesses. I was impressed by the way European governments help to harness the outcomes of academic research through industries. They provide shared facilities that give both researchers and business people access to equipment. The European Commission recognises photonics as "one of Europe's key enabling technologies of the 21st Century."



In New Zealand the photonics industry is predicted to grow and I think we could learn from Europe's approach. It would give businesses and researchers a shared sense of pride to have a common identity under the umbrella of photonics. I hope that my research can play a small part in providing the argument for that.

Unfortunately, the national COVID-19 lockdown was announced just as I began my internship. This made it harder to engage business people and meant I had to do all my interviews and meetings online. But still the team at the Prime Minister's Chief Science Advisor's Office was amazingly helpful in guiding me. As a physicist I know how to set up experiments to make inanimate objects give me information. But getting information from people is harder.

In some ways the internship was a humbling experience. As physicists we often think we are the ones changing the world and should get all the funding. I realised how many different and important issues there are and came to recognise our place in a bigger picture. It helps you understand and respect the challenges faced by policymakers.

Written by Madhuri Kumari

"IT WOULD GIVE BUSINESSES AND RESEARCHERS A SHARED SENSE OF PRIDE TO HAVE A COMMON IDENTITY UNDER THE UMBRELLA OF PHOTONICS. I HOPE THAT MY RESEARCH CAN PLAY A SMALL PART IN PROVIDING THE ARGUMENT FOR THAT."

Unleashing Potential in Citizen Science

Here, our PhD Student, Abi Thampi from The University of Auckland, reports on his internship with the Office of the Prime Minister's Chief Science Adviser:

A piece of research is never complete until it becomes useful to society. This is the idea I want to take back to the world of science from my internship in the Office of the Prime Minister's Chief Science Adviser (PMCSA). I spent one day a week for six months of 2020 researching global citizen science initiatives and how different policies strengthen and increase public participation. I was challenged to consider how different policies would affect every single person in the country, from policymakers to organisations and communities. I think this kind of deep consideration of how research impacts the broader society would be extremely valuable in science where it is often too easy to focus on technical details.

I was surprised and delighted to discover how valuable the skills that I have developed during my PhD were in a policy context and that the process was much the same - discussing and deciding on a methodology then collecting and analysing data. Since every scientist's basic instinct is to solve problems, I think we can contribute a lot to policy-making by bringing this constructive approach to data collection and analysis.



Abi Thampi with Professor Juliet Gerrard, the Prime Minister's Chief Science Adviser.

Citizen science is a global movement that creates opportunities for the general public to get involved with science research. It brings professional scientists together with volunteers to do all kinds of projects such as environmental data collection, bird watching and astronomy.

When I visited the office before my internship there was a huge wall, listing the issues they were concerned about – all interesting and relevant. I chose citizen science because I am inspired by its potential to unleash the curiosity and scientific capacity in the general public. I believe every human has a natural instinct to question and explore the world around them. We just need the resources and opportunities to develop these instincts. Citizen Science creates opportunities for people with no exposure to science, including school kids, remote communities and other under-represented groups.

In my research I looked at the policies of different countries including Australia, Germany, Austria, USA and France and different organisations like the European Union and the Australian Citizen Science Association. I was amazed to discover the power of citizen science to expand the reach and scale of scientific knowledge. One study of 388 citizen science projects in the USA, for example, estimated that 1.36 to 2.28 million volunteers participate annually which gives an estimate of in-kind contribution between US\$667 million and US\$2.5 billion every year! Another study by the European Commission analysed more than forty citizen science projects and found that over 70% of them effectively influenced environmental policies. Isn't this remarkable?!

My research showed how useful it is to have a central platform and vision that supports and connects the diversity of projects. In a similar way to how the Dodd-Walls Centre integrates and connects researchers from around the country, these centralised approaches expand the impact of citizen science. All the successful policies actively identified and engaged participants, assessed the capacity and need for citizen science, developed visions, missions and action plans, created resources like websites and guidance, implemented citizen science programmes and evaluated them. I hope my research will help to establish such a support system for citizen science in New Zealand.

At times, during the COVID lockdown, I wasn't sure if I would make it through the internship. The condition and uncertainties back home in India and the pressures of my final year of PhD sometimes felt too much to handle. But the team at the office of the PMCSA were incredibly supportive – a special thanks to Susie and Rachel for their guidance, support and weekly meetings. Along with the constant support of my supervisor, the wonderful people at the Dodd-Walls Centre and my parents, I was able to pull off the research successfully. Even though I missed the fun of working in the PMCSA office, sharing jokes and ideas, I had an amazing experience and gained so much confidence. I feel prouder to be a scientist now, realising how transferable my skill sets are, even in a field I knew little about before.

My hope is to enter a career in industry and the internship was a perfect opportunity to experience a completely different working environment outside academia. During my studies with the Dodd-Walls Centre I have taken every opportunity to get involved in outreach and industry activities – I've travelled around the country getting kids excited about science and was recently invited onto the Auckland Momentum Investment Committee. All these experiences have given me confidence to forge my new career. I would recommend the internship experience to any student who has the opportunity.

Written by Abi Thampi

"MY HOPE IS TO ENTER A CAREER IN INDUSTRY AND THE INTERNSHIP WAS A PERFECT OPPORTUNITY TO EXPERIENCE A COMPLETELY DIFFERENT WORKING ENVIRONMENT OUTSIDE ACADEMIA."

STRATEGIC OUTCOMES

The research plan of the Dodd-Walls Centre and our strategic initiatives will deliver results in six key outcome areas as follows:

Increased Scientific Impact

- Foster cutting-edge translational research by collaboration across different areas of research
- Establish a pipeline of new research to scientific and industrial communities
- Establish New Zealand as a hub of international conferences and events
- Raise the international profile of the Dodd-Walls Centre as a world-class research centre

Enhanced Economic Output

- New start-up businesses with support from external capital
- Foster initiatives with established New Zealand enterprises
- Attract investment from overseas multi-national corporations

A Stronger Workforce

- Build expertise in research translation to commercialisation
- Build a pool of highly trained individuals with interest in high-tech and other skilled jobs
- Link the pool of highly trained individuals to companies in need of these skills

Better Careers

- Foster skills that enable a variety of career options for students and staff
- Enhance career development through opportunities for leadership within the Dodd-Walls Centre
- Address barriers to participation or advancement related to gender and diversity

Improved Decision-Making

- Offer advice on matters of scientific or technological importance to government
- Use and share best practice governance and management for research centres
- Engage with government agencies about performance and impact
- Use performance reports to demonstrate how outcomes will be achieved

Improved Scientific Literacy

- Educational outreach programmes established or augmented through museums and in rural areas
- Programmes enhance the experience of learning about science, encouraging further participation by students, teachers, whānau and the general public
- Scientific educational materials generated as part of the programmes is available to teachers

WE CONTINUE TO BE RANKED IN THE TOP TEN INSTITUTIONS FROM NEW ZEALAND IN THE NATURE INDEX (IN 8TH POSITION).

WE WORK WITH SOME OF NEW ZEALAND'S LARGEST COMPANIES AND WE HAVE FOSTERED START-UP BUSINESSES SUCH AS ENGENDER TECHNOLOGIES.

OUR RESEARCH EXTENDS FROM FUNDAMENTAL TO THE COMMERCIALY FOCUSSED AND WE HAVE HAD SPIN-OUT COMPANIES FORMED. THIS BREADTH OF RESEARCH PROVIDES EXPOSURE FOR OUR STUDENTS ACROSS THE RESEARCH SPECTRUM AND WE WORK CLOSELY WITH OUR STUDENTS TO PROVIDE THEM OPPORTUNITIES THAT BENEFIT BOTH THEM AND THE COMPANIES THEY JOIN.

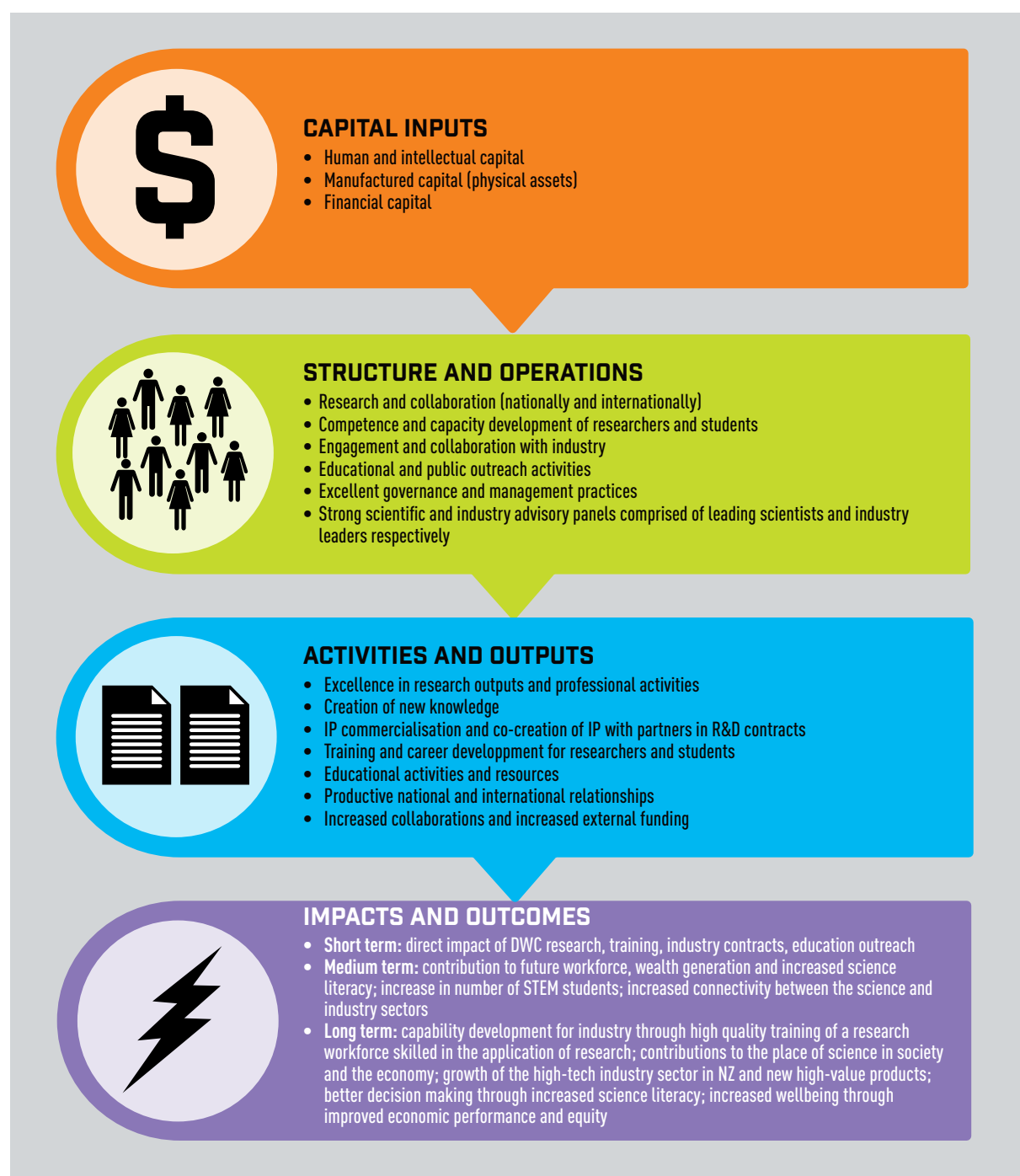
THE OPPORTUNITIES OFFERED TO OUR STUDENTS MAKE OUR GRADUATES SOUGHT AFTER IN THE MARKETPLACE, THEY ARE PROVIDED OPPORTUNITIES FROM START-UP WORKSHOPS TO LEARNING TIKANGA MĀORI THROUGH PARTICIPATION IN WANANGA.

OUR RESEARCHERS SERVE IN ROLES ON NUMEROUS PUBLIC SECTOR PANELS AND BOARDS. THROUGH THESE THEY ARE ABLE TO ENGAGE WITH GOVERNMENT AGENCIES TO ADD EXPERTISE TO DECISION MAKING OR DATA ANALYSIS; WE ALSO PROVIDE EXPERT ADVICE. SOME EXAMPLES OF THE (NATIONAL) PUBLIC SECTOR STAKEHOLDERS OUR RESEARCHERS HAVE SERVED ARE THE DEFENCE TECHNOLOGY AGENCY (DTA), NEW ZEALAND DEFENCE FORCE (NZDF), MINISTRY FOR PRIMARY INDUSTRIES (MPI) AND CALLAGHAN INNOVATION. AS WELL AS DIRECT SCIENTIFIC ADVICE, WE HAVE BEEN ENGAGED BY THE MINISTRY OF FOREIGN AFFAIRS & TRADE (MFAT) TO DELIVER SCIENCE OUTREACH TO PACIFIC ISLANDS AND HAVE PROVIDED COMMUNITY ENGAGEMENT/ SCIENCE OUTREACH ADVICE TO THE BIOHERITAGE NATIONAL SCIENCE CHALLENGE.

THROUGH OUR EDUCATIONAL OUTREACH PROGRAMMES WE CONTINUE TO MAKE A SIGNIFICANT CONTRIBUTION TO IMPROVING THE SCIENTIFIC LITERACY OF ALL NEW ZEALANDERS AND OUR PACIFIC NEIGHBOURS. WORKING WITH MUSEUMS AND OTHER PARTNERS, WE CREATE PROGRAMMES AND RESOURCES TO PROVIDE OPPORTUNITIES FOR ONGOING LEARNING AND DISCOVERY.

VALUE CREATION IN THE DODD-WALLS CENTRE

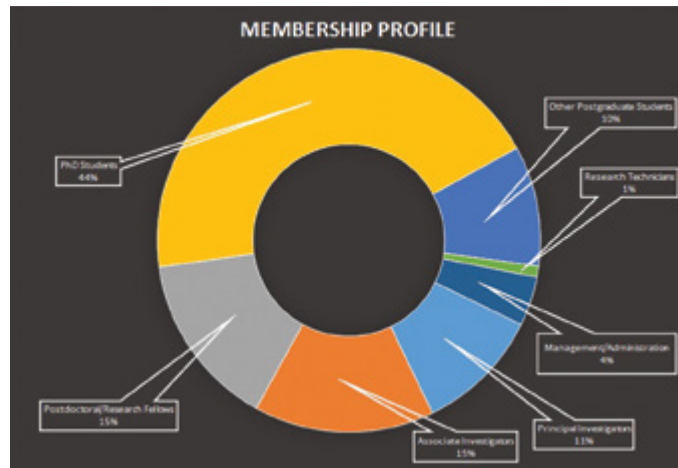
The Dodd-Walls Centre's research themes and management teams are linked and resourced such that the capital resources effectively support activities and produce outputs that over time are delivering impact and achieving strategic outcomes. The Dodd-Walls Centre's value chain is illustrated here:



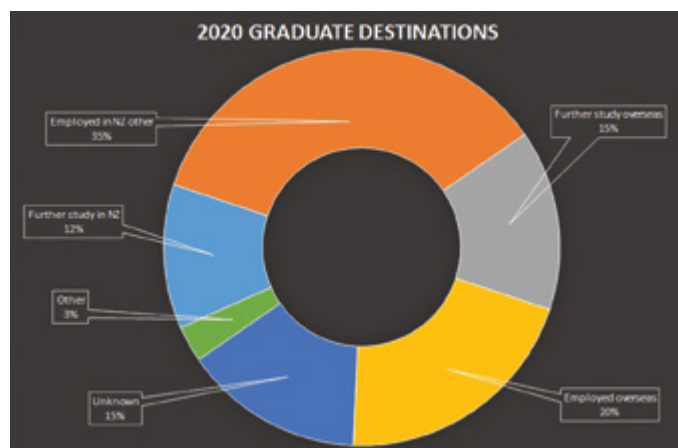
FACTS AND FIGURES

Broad category	Detailed category	Y6 (2020)
Value of CoRE funding from TEC (\$M)		5.04
FTEs by category	Principal Investigators	0.85
	Associate Investigators	3.73
	Postdoctoral Fellows	11.40
	Research Technicians	1.30
	Administrative/Support	3.28
	Research Students	86.54
	Total	106.30
Headcounts by category	Principal Investigators	23
	Associate Investigators	33
	Postdoctoral Fellows	32
	Research Technicians	5
	Administrative/Support/ Management	9
	Research Students	120
	Total	222
Peer reviewed research outputs by type	Journal articles	135
	Books	0
	Book chapters	1
	Conference papers	34
	Other	3
	Total	173
Value of external research contracts awarded by source (\$M NZD)	Vote Science and Innovation contestable funds	9.21
	Other NZ Government	0
	Domestic - private sector funding	0.12
	Overseas	0
	Host/Partner Support	0.47
	Total	9.80
Commercial activities	Patent applications	2
	Patents granted	3
	Invention disclosures	9
	Total number of spinouts (2015-2020)	2
Students studying at CoRE by level	Doctoral degree	96
	Other	22
	Total	118
Number of students completing qualifications by level	Doctoral degree	20
	Other	14
	Total	34
Immediate post-study graduate destinations	Further study in NZ	4
	Further study overseas	12
	Employed in NZ	5
	Employed overseas	7
	Other	1
	Unknown	5
	Total	34

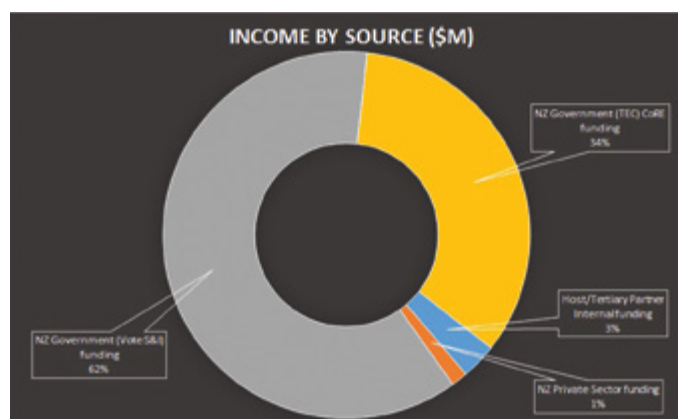
The DWC has a total of 56 Investigators (including the Director and Deputy Director) and 32 other research staff. Doctoral students comprise 44% of the total membership of the DWC and in addition to research training, many of our strategic activities involve students including educational outreach activities, Ka Hikitia, and industry interface and R&D. DWC strategic and central activities are led and supported by 4 managers and 5 administrative/support staff.



All DWC students undertake research and most of them at the highest level in PhD programmes. Those categorised as 'Other' in the Table (students studying at CoRE by level) include masters, honours, and postgraduate diploma students. Some of these students will go on to PhD programmes while others go on to employment in New Zealand or overseas. Graduate destinations include all PhD and other degree students.



The Dodd-Walls Centre receives funding from sources other than the TEC's CoREs Fund, and the additional funding contributes directly to research projects in the four Research Themes. Some DWC staff and student members are supported by these external research funds, whereas others are supported by CoRE funding. The membership profile includes all DWC members, while the financial report indicates only those directly supported by CoRE funds.



FINANCES

Report by Programme 2020

The Tertiary Education Commission granted a six month extension to all Centres of Research Excellence in late 2020. The reporting period is now 1 January 2020 to 30 June 2021.

The 2020 finance report will be audited following the end of this period and will be reported in the 2021 Annual Report.

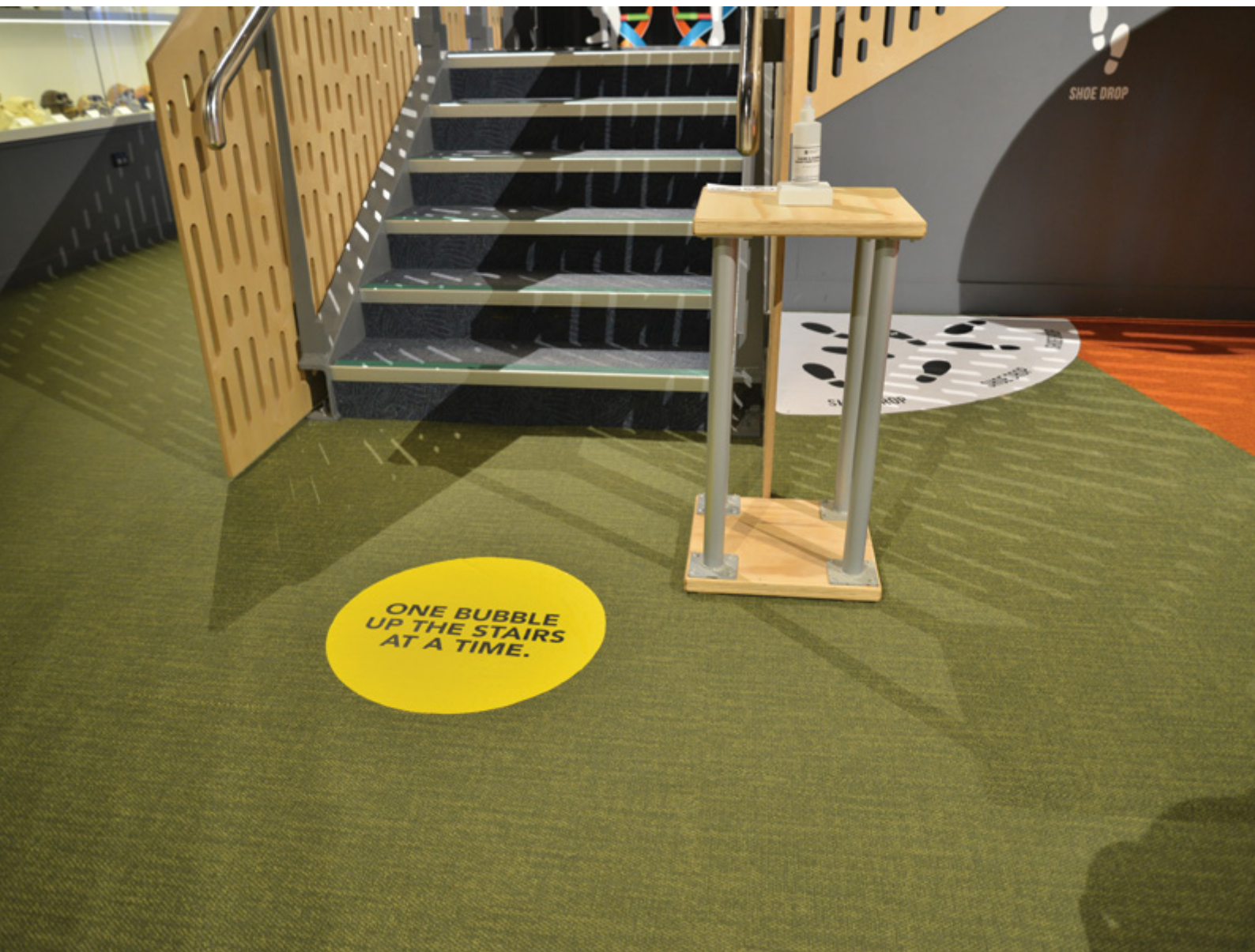


Photo credit, Otago Museum. From: Grant, C., et al., "Re-opening after COVID-19 in New Zealand", *Journal of Conservation and Museum Studies*, 18 (2020)

MEMBERS, GOVERNANCE AND MANAGEMENT

DWC Board members



DR GARTH CARNABY, CHAIR

FRSNZ, MNZM, CNZM

Dr Garth Carnaby spent the first part of his career applying mathematics and physics to the industrial utilisation of wool. Today he runs his own company providing research, governance, and consultancy in the science, agriculture, manufacturing, food, and wool fields. He is a past President of the Royal Society of New Zealand and past chair of the Marsden Fund. He currently chairs the NZ Synchrotron Group Ltd and Wool Industry Research Ltd. He was made a Member of NZ Order of Merit (MNZM) in 2006 for services to the wool industry and a Companion (CNZM) in 2018 for services to Science and Governance.



DR DIANNE MCCARTHY

CRSNZ, ONZM, CNZM

Dianne has extensive experience in a number of senior management and governance roles in the tertiary education, science and health sectors. She is Deputy Chair of the New Zealand Institute of Economic Research, a member of the Healthier Lives National Science Challenge Governance Group, and Chair of the Ageing Well National Science Challenge Governance Group. She is a Trustee of the Malaghan Institute of Medical Research and the Hearing Research Foundation (NZ) and a member of the Council of Victoria University of Wellington. She was made an Officer of the New Zealand Order of Merit for her services to Education in 2008, a Companion of the Royal Society of New Zealand for her services to Science in 2015, and a Companion of the New Zealand Order of Merit for her services to science, business and women in 2016.



MS CHARLOTTE WALSH

Charlotte Walshe is the Chief Executive Officer of Christchurch based Jade Software Corporation. Charlotte, with degrees from the University of Canterbury in mathematics and physics as well as in Entrepreneurial Development from the MIT Sloan School of Management, has a background in the technology and export sectors. Charlotte is current a director on the Board of New Zealand Trade and Enterprise, and was CEO of Dynamic Controls for more than a decade prior to joining Jade Software.



SIR IAN TAYLOR

KNZM NZM

Sir Ian Taylor is an innovator and business leader whose companies include Taylormade Media and Animation Research Limited, the latter renowned for its sports graphics and decision review systems. Sir Ian is of Ngāti Kahungunu and Nga Puhī descent, has a law degree from the University of Otago and a background in broadcasting. He was named the 2019 *New Zealand Innovator of the Year*, the 2013 *Outstanding Māori Business Leader of the Year* and the 2010 *New Zealander of the Year*. In 2012, Ian was appointed a Companion of the New Zealand Order of Merit for services to television and business. Sir Ian was recognised as a Knight Companion of the New Zealand Order of Merit in the New Year's Honours of 2021.



PROFESSOR RICHARD BLAIKIE

FRSNZ

Professor Richard Blaikie is Deputy Vice-Chancellor (Research and Enterprise) at the University of Otago and Professor in Physics. He is a former Director of the MacDiarmid Institute (2008-11), former member of the Marsden Fund Council and served for one year on the New Zealand Science Board (2011). He was awarded the Hector Medal in 2013 for his fundamental and wide-ranging contributions to the field of nano-optics and a Thomson Medal in 2015 in recognition of his science leadership.



PROFESSOR JIM METSON

Professor Metson is the Deputy Vice-Chancellor (Research) at The University of Auckland. He is a physical chemist, co-founder of the University's Research Centre for Surface and Materials Science and of the Light Metals Research Centre, a founding member of the MacDiarmid Institute, and he has worked extensively with international industry. He was Chief Science Advisor to NZ's MBIE and the NZ Government's representative on the science group that developed the Australian Synchrotron. He currently serves as a Director of Auckland UniServices Limited, REANNZ and the New Zealand Synchrotron Group.



PROFESSOR RICHARD BARKER

Professor Barker was appointed Pro-Vice-Chancellor of the Division of Sciences at the University of Otago in 2017 and is proud to head the Division at New Zealand's most science intensive university. Richard joined the Department of Mathematics and Statistics at the University of Otago in 1998, was appointed Professor of Statistics in 2007, and was Head of the Department of Mathematics and Statistics from 2008 to 2016. His research speciality is Bayesian hierarchical modelling and statistical ecology. Richard is a current director on the Boards of Oritain Global Ltd, Brain Research New Zealand, Dinsdale Ltd and the Riddet Institute.

Investigators, Management and Administration

Last Name	First Name	Title	Institution	Role in the DWC
Hutchinson	David	Professor	University of Otago	Director
Broderick	Neil	Professor	The University of Auckland	Deputy Director
Aguergaray	Claude	Dr	The University of Auckland	Associate Investigator
Albert	Michael	Professor	University of Otago	Principal Investigator
Andersen	Mikkel	A/Professor	University of Otago	Principal Investigator
Auguié	Baptiste	Dr	Victoria Uni. of Wellington	Associate Investigator
Baillie	Danny	Dr	University of Otago	Associate Investigator
Ballagh	Rob	Professor	University of Otago	Principal Investigator
Barder	Jessa	Ms	Otago Museum	Outreach Coordinator
Blaikie	Richard	Professor	University of Otago	Associate Investigator
Blakie	Blair	Professor	University of Otago	Principal Investigator
Borbely	Joseph	Dr	Callaghan Innovation, MSL	Associate Investigator
Bradley	Ashton	A/Professor	University of Otago	Principal Investigator
Brand	Joachim	Professor	Massey University	Principal Investigator
Brasch	Nicola	Professor	Auckland Uni. Of Technology	Associate Investigator
Bubanja	Vladimir	Dr	Callaghan Innovation	Associate Investigator
Carmichael	Howard	Professor	The University of Auckland	Principal Investigator
Chen	Kai	Dr	Victoria Uni. Of Wellington	Associate Investigator
Cheyne	Juliette	Dr	The University of Auckland	Associate Investigator
Coen	Stéphane	A/Professor	The University of Auckland	Principal Investigator
Craigie	Cameron	Dr	AgResearch NZ Ltd	Associate Investigator
Croft	James	Dr	University of Otago	Associate Investigator
Davis	Nathaniel	Dr	Victoria Uni. Of Wellington	Associate Investigator
Deb	Amita	Dr	University of Otago	Associate Investigator
Erkintalo	Miro	A/Professor	The University of Auckland	Principal Investigator
Golovko	Vladimir	A/Professor	University of Canterbury	Associate Investigator
Gordon	Keith	Professor	University of Otago	Principal Investigator
Grant	Craig	Dr	Otago Museum	Ed. Outreach Manager
Griffin	Ian	Dr	Otago Museum	Honorary Fellow
Harvey	John	Professor	The University of Auckland	Industry Team Leader
Hoogerland	Maarten	Dr	The University of Auckland	Principal Investigator
Jin	Jianyong	Dr	The University of Auckland	Associate Investigator
Jones	Marcus	Dr	Auckland Uni. Of Technology	Associate Investigator
Kjærgaard	Niels	Professor	University of Otago	Principal Investigator
Krauskopf	Bernd	Professor	The University of Auckland	Principal Investigator
Künnemeyer	Rainer	Dr	University of Otago	Associate Investigator
Leonhardt	Rainer	A/Professor	The University of Auckland	Associate Investigator
Longdell	Jevon	A/Professor	University of Otago	Principal Investigator
McCane	Brendan	Professor	University of Otago	Associate Investigator
McGoverin	Cushla	Dr	The University of Auckland	Associate Investigator
Miller	Sara	Dr	University of Otago	Associate Investigator
Murdoch	Stuart	Dr	The University of Auckland	Principal Investigator
Nieuwoudt	Michel	Dr	The University of Auckland	Associate Investigator
Parkins	Scott	A/Professor	The University of Auckland	Principal Investigator
Reeves	Roger	Professor	University of Canterbury	Associate Investigator
Reid	Michael	Professor	University of Canterbury	Associate Investigator
Reis	Marlon	Dr	AgResearch NZ Ltd	Associate Investigator
Schwefel	Harald	A/Professor	University of Otago	Principal Investigator
Shepherd	Jami	Dr	The University of Auckland	Associate Investigator
Simpson	Cather	Professor	The University of Auckland	Associate Investigator

Last Name	First Name	Title	Institution	Role in the DWC
Smith	Catherine	Dr	University of Otago	Associate Investigator
Taylor	Luke	Dr	University of Otago	Prototype Manager
Van Wijk	Kasper	A/Professor	The University of Auckland	Principal Investigator
Vanholsbeeck	Frédérique	A/Professor	The University of Auckland	Principal Investigator
Vogt	Dominik	Dr	The University of Auckland	Associate Investigator
Wang	Andy	Mr	The University of Auckland	Outreach Coordinator
Waterhouse	Geoff	A/Professor	The University of Auckland	Associate Investigator
Wells	Jon Paul	Professor	University of Canterbury	Principal Investigator
Xu	Peter	Professor	The University of Auckland	Associate Investigator
Zülicke	Ulrich	Professor	Victoria Uni. of Wellington	Associate Investigator
Woodhouse	AJ	Mrs	University of Otago	Programme Manager
Scown	Shannon	Ms	Scown Strategic Limited	BD Manager
de Jager	Liesl	Ms	University of Otago	Administrator
Baikie	Susan	Ms	University of Otago	Administrator
Yeo	Alice	Ms	University of Otago	Administrator
Menezes	Jillian	Ms	The University of Auckland	Administrator
Dailey	Brett	Mr	University of Otago	Accountant
Lata	Avinesh	Ms	The University of Auckland	Accountant

Postdoctoral and Research Fellows

Last Name	First Name	Title	Institution	Position
Balabhadra	Sangeetha	Dr	University of Canterbury	Postdoctoral Fellow
Calderon	Miguel Martinez	Dr	The University of Auckland	Postdoctoral Fellow
Cobus	Laura	Dr	The University of Auckland	Postdoctoral Fellow
Ding	Boyang	Dr	University of Otago	Research Fellow
Giraldo	Andrus	Dr	The University of Auckland	Postdoctoral Fellow
Haneef	Shahna	Dr	The University of Auckland	Postdoctoral Fellow
Isarov	Maya	Dr	University of Otago	Postdoctoral Fellow
Jezszenski	Peter	Dr	Massey University	Postdoctoral Fellow
Kammermeier	Michael	Dr	Victoria University of Wellington	Postdoctoral Fellow
Kolenderska	Sylwia	Dr	The University of Auckland	Postdoctoral Fellow
Kumari	Madhuri	Dr	University of Otago	Postdoctoral Fellow
Lambert	Nicholas	Dr	University of Otago	Postdoctoral Fellow
Liu	Junchen	Dr	University of Otago	Postdoctoral Fellow
Low	Jeffery	Dr	The University of Auckland	Postdoctoral Fellow
Ma	Li	Dr	University of Otago	Postdoctoral Fellow
Major	Jan	Dr	Massey University	Postdoctoral Fellow
Maria	Michael	Dr	The University of Auckland	Postdoctoral Fellow
Monahan	Nick	Dr	Victoria University of Wellington	Postdoctoral Fellow
Ng	Vincent	Dr	The University of Auckland	Postdoctoral Fellow
Novikova	Nina	Dr	The University of Auckland	Postdoctoral Fellow
Pal	Sukla	Dr	University of Otago	Postdoctoral Fellow
Ramavararamaja	Kishor Kumar	Dr	University of Otago	Postdoctoral Fellow
Reza	Armani	Dr	The University of Auckland	Postdoctoral Fellow
Robertson	Julia	Dr	The University of Auckland	Postdoctoral Fellow
Ruschel	Stefan	Dr	The University of Auckland	Postdoctoral Fellow
Schumayer	Daniel	Dr	University of Otago	Postdoctoral Fellow
Shamailov	Sophie	Dr	University of Otago	Postdoctoral Fellow

Last Name	First Name	Title	Institution	Position
Terrien	Soizic	Dr	The University of Auckland	Postdoctoral Fellow
Thomas	Ryan	Dr	University of Otago	Postdoctoral Fellow
Weyland	Marvin	Dr	University of Otago	Postdoctoral Fellow
Xu	Gang	Dr	The University of Auckland	Postdoctoral Fellow
Xu	Yiqing	Dr	The University of Auckland	Postdoctoral Fellow

PhD Students

Last Name	First Name	Institution	Completed (C) DWC Scholarship (S)
Abbas	Navid	The University of Auckland	
Ahmed	Fatima	University of Otago	
Alizadeh	Yashar	University of Canterbury	S
Arabamadi	Eshan	University of Otago	S
Arshad	Faiza	University of Otago	
Ashforth	Simon	The University of Auckland	C
Azeem	Farhan	University of Otago	S
Baber	Logan	The University of Auckland	S, C
Bandara	Ravindra	The University of Auckland	S
Bangalore Shashidhar	Vinay Bharadwaj	Auckland University of Technology	S
Berzins	Karlis	University of Otago	
Bitha	Rodrigues	The University of Auckland	S
Brett	Matthew	Victoria University of Wellington	
Chan	Andrew	The University of Auckland	
Chilcott	Matthew	University of Otago	
Chima	Robert	University of Otago	
Choudhury	Sarthak	Massey University	S
Clarke	James	The University of Auckland	S, C
Cormack	Maddy	University of Otago	S
Dong	Yusong	The University of Auckland	
Dosado	Aubery Gabasa	The University of Auckland	S, C
Emeny	Chrissy	University of Canterbury	
Esan	Ayomikun Samuel	The University of Auckland	S
Fernando	Lakshini	The University of Auckland	C
Garagoda	Samanali	University of Otago	S
George	Anand	The University of Auckland	
Giglio	Cannon	The University of Auckland	
Goodwin (prev. Brown)	Matthew	The University of Auckland	
Gordon	Callum	Victoria University of Wellington	
Groiseau	Caspar	The University of Auckland	S
Hardy	Jake	Victoria University of Wellington	
Hendry	Ian	The University of Auckland	C
Hennin	Geraud	The University of Auckland	S
Hirashi	Masyay	University of Otago	
Hope	James	The University of Auckland	C
Hosking	Peter	The University of Auckland	C
Ismael	Fouad	Auckland University of Technology	S
Jamil	Mahamood	The University of Auckland	
Jobbitt	Nicholas	University of Canterbury	S
Jones	Tobin	The University of Auckland	
Jose	Ashly	The University of Auckland	S

Last Name	First Name	Institution	Completed (C) DWC Scholarship (S)
Kaur	Harpreet	University of Waikato	C
Kazemzadeh	Mohammadrahim	The University of Auckland	S
King	Gavin	University of Otago	
Laouby	Zahra	The University of Auckland	
Lee	Au Chen	University of Otago	
Li	Zongda	The University of Auckland	C
Loveday	James	The University of Auckland	S
Mapley	Joseph	University of Otago	
Martin	Jamin	University of Canterbury	S
Mautner	Ira	The University of Auckland	
McPhail	Vivian	The University of Auckland	S
Mobassem	Sonia	University of Otago	S
Misiuk	Kirill	University of Otago	
Mooney	Rosie	Auckland University of Technology	
Mothkuri	Sagar	University of Canterbury	
Neiman	Alex	University of Canterbury	
Nesbitt	Sam	University of Canterbury	
Ngaha	Jacob	The University of Auckland	
Nielsen	Alexander	The University of Auckland	S
Onyema	Chikezie	University of Canterbury	C
Otto	Suzanne	University of Canterbury	
Otupiri	Robert	The University of Auckland	S, C
Qureshi	Pierce	The University of Auckland	
Rajkumar	Damenraj	University of Otago	
Rooney	Jeremy	University of Otago	
Ruksasakchai	Poramaporn (Up)	University of Otago	
Rwizinkindi	Dominique	Auckland University of Technology	S
Sadeghi	Mohammad	The University of Auckland	S
Sales	Ruth	University of Otago	S
Savoie	Maxime	University of Canterbury	C
Sawyer	Bianca	University of Otago	
Sayson	Noel	The University of Auckland	S, C
Scott	Jonty	University of Canterbury	C
Shikhali Najafabadi	Mojdeh	University of Otago	S
Shillito	Georgina	University of Otago	C
Simpson	Jonathan	The University of Auckland	
Smith	Joseph	University of Otago	
Solanki	Pratik	University of Canterbury	S
Solis	Daniel	University of Otago	C
Steed	Craig	The University of Auckland	
Stitely	Kevin	The University of Auckland	
Sutton	Joshua	University of Otago	C
Tang	Stanley	The University of Auckland	
Tesana	Siriluck	University of Canterbury	C
Thampi	Abi	The University of Auckland	S
Thorn	Karen	Victoria Uni. of Wellington	
Trainor	Luke	University of Otago	
Urbanska	Magdalena	The University of Auckland	S
Vargas	Matheus	The University of Auckland	C
Wang	Mark	The University of Waikato	S

PhD Students continued

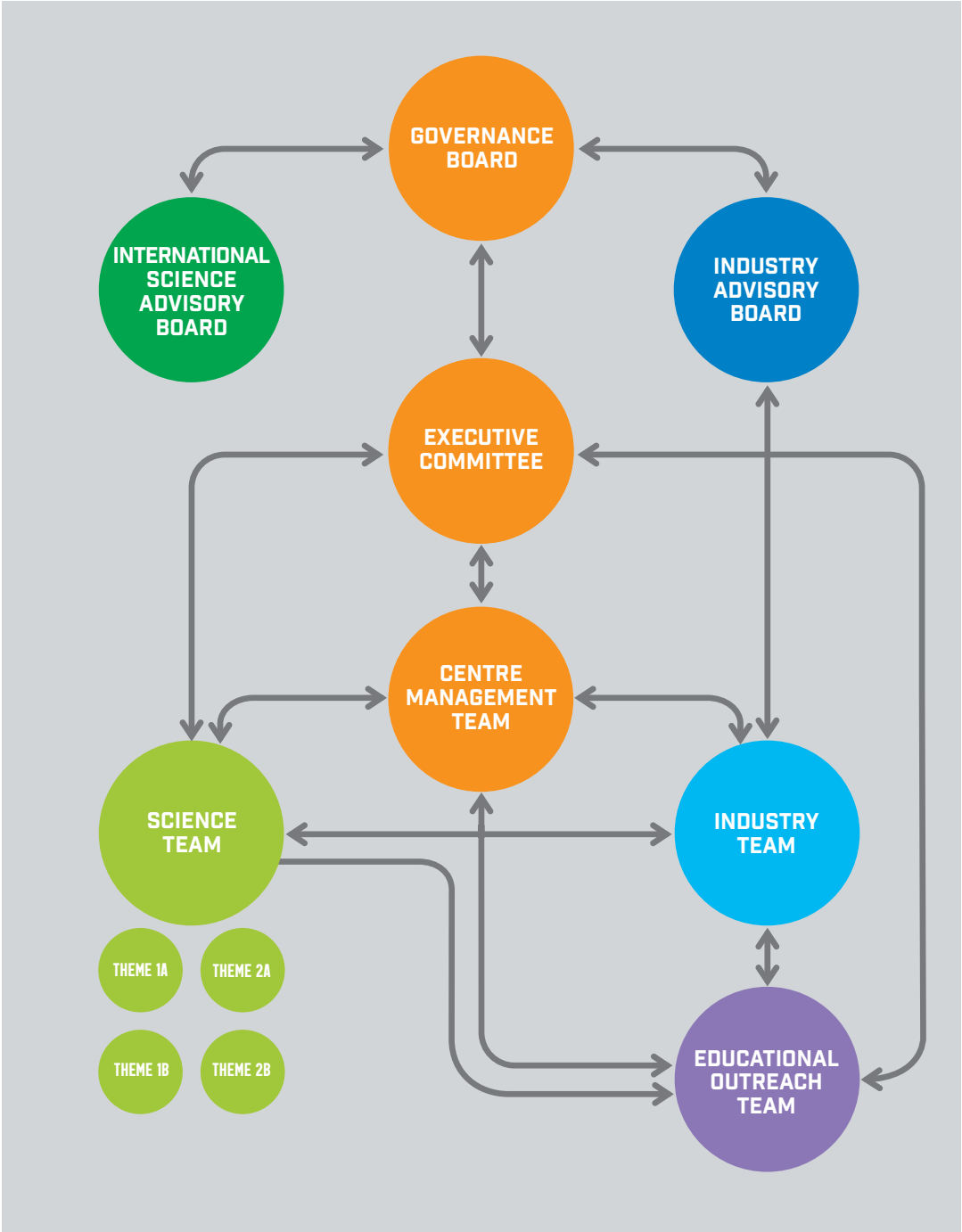
Last Name	First Name	Institution	Completed (C) DWC Scholarship (S)
Wang	Qing	The University of Auckland	
Wang	Xindi (Andy)	The University of Auckland	
White	Joni	The University of Auckland	
Wu	Yimei	The University of Auckland	
Yang	Mingrui (Ray)	Massey University	
Ye	Piao (Tracy)	The University of Auckland	C
Zhou	Huihua	The University of Auckland	S, C
Zlygostiev	Mykola	The University of Auckland	S
Zou	Dian	University of Canterbury	S

Other Research Degree Students

Last Name	First Name	Institution	Completed (C) DWC Scholarship (S)
Arul	Rakesh	The University of Auckland	C
Beckwith	Adam	University of Otago	
Chan	Sanutep	Victoria University of Wellington	
Chiang	Jessica	The University of Auckland	C
Chung	Yeon Wook (John)	University of Otago	C
Clarke	Jordan	University of Otago	
De Clercq	Damon	Victoria University of Wellington	C
Everts	Jono	University of Otago	C
Harrison	Jacob	University of Otago	
Hayton	Chris	University of Otago	
Jones	Angus	The University of Auckland	C
Kristofferson	Andreas	The University of Auckland	C
Li	Zongda	The University of Auckland	C
Matthews	Hannah	The University of Auckland	C
Ostrowski	Lucas	The University of Auckland	S, C
Said	Sultan	Auckland University of Technology	
Semke-Smith	Chase	Victoria University of Wellington	C
Su	Andrew	The University of Auckland	C
Tay	Elliot	University of Otago	C
Underwood	Andrew	University of Otago	C

ORGANISATIONAL AND COMMITTEE STRUCTURE OF THE DODD-WALLS CENTRE

The DWC is organised into four research themes, two engagement teams (Educational and Industry) and a Centre management team. Three boards (governance, science advisory and industry advisory) support the DWC in achieving its strategic goals.



COMMITTEE AND THEME MEMBERSHIP

Governance Board

Independent Chair	Garth Carnaby	G.A. Carnaby Associates Ltd
DVC Research Host Institution	Richard Blaikie	University of Otago
DVC Research Partner Institution	Jim Metson	The University of Auckland
PVC Sciences (Director's line manager)	Richard Barker	University of Otago
Independent Director	Di McCarthy	DCM Solutions Ltd
Independent Director	Charlotte Walshe	Jade Software Ltd
Independent Director	Ian Taylor	Animation Research Ltd
Director (ex officio)	David Hutchinson	University of Otago
Deputy Director (ex officio)	Neil Broderick	The University of Auckland
Programme Manager (ex officio)	AJ Woodhouse	University of Otago
Secretary	Liesl de Jager	University of Otago

Executive Committee

Director	David Hutchinson (Chair)	University of Otago
Deputy-Director	Neil Broderick	The University of Auckland
Principal Investigator	Michael Albert	University of Otago
Principal Investigator	Blair Blaikie	University of Otago
Principal Investigator	Maarten Hoogerland	The University of Auckland
Principal Investigator	Harald Schwefel	University of Otago
Principal Investigator	Frédérique Vanholsbeeck	The University of Auckland
Principal Investigator	Cather Simpson	The University of Auckland
Principal Investigator	Stéphane Coen	The University of Auckland
Principal Investigator	Jon-Paul Wells	University of Canterbury
Industry Team Leader (ex officio)	John Harvey	Southern Photonics Limited
Programme Manager (ex officio)	AJ Woodhouse	University of Otago
Secretary	Liesl de Jager	University of Otago

Industry Advisory Board

Dr Simon Poole (Chair)	Finisar Australia Pty Ltd
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Education Outreach Team

Principal Investigator	Bernd Krauskopf	The University of Auckland
Principal Investigator	Kasper van Wijk	The University of Auckland
Director	David Hutchinson	University of Otago
Education Manager	Craig Grant (Chair)	Otago Museum
Director of Otago Museum	Ian Griffin	Otago Museum
Outreach Co-ordinator	Andy Wang	The University of Auckland
Agnes Blaikie Research Fellow	Jami Shepherd	The University of Auckland
Secretary	Liesl de Jager	University of Otago

Dodd-Walls Centre Management Team

Programme Manager	AJ Woodhouse	University of Otago
Director	David Hutchinson	University of Otago
Deputy Director	Neil Broderick	The University of Auckland
Administrator and PA to Director	Susan Baikie	University of Otago
Administrator	Liesl de Jager	University of Otago
Finance Accountant	Avinesh Lata	The University of Auckland
Finance Accountant	Brett Dailey	University of Otago

Science Advisory Board

Professor Bill Phillips	Joint Quantum Institute, U.S.A.
Professor Artur Ekert	Centre for Quantum Technologies, Singapore & University of Oxford, UK
Professor Nergis Mavalvala	Massachusetts Institute of Technology, USA
Professor Ian Walmsley	Imperial College, UK
Professor John Dudley	University Bourgogne Franche-Comté, France

Industry Strategy Group

Chairperson (Governance Board Member)	Charlotte Walshe	Independent Director
Industry Team Leader	John Harvey	Southern Photonics Limited
Director	David Hutchinson	University of Otago
Deputy Director	Neil Broderick	The University of Auckland
Principal Investigator	Keith Gordon	University of Otago
Principal Investigator	Jevon Longdell	University of Otago
Associate Investigator/ECR	Cushla McGoverin	The University of Auckland
Incoming Associate Dean Māori	Katharina Ruckstuhl	University of Otago
Business Development Manager	Shannon Scown	The University of Auckland
Programme Manager	AJ Woodhouse	University of Otago
Secretary	Liesl de Jager	University of Otago

Science Team

Deputy Director	Neil Broderick	The University of Auckland
Director (to May 2020)	Nominee: Blair Blakie	University of Otago
Director (from May 2020)	Nominee: Jevon Longdell	University of Otago
Theme Leader (1a)	Jon-Paul Wells	University of Canterbury
Theme Leader (1b)	Stéphane Coen	The University of Auckland
Theme Leader (2a)	Maarten Hoogerland	The University of Auckland
Theme Leader (2b)	Jevon Longdell	University of Otago
Industry Team Leader (ex-officio)	John Harvey	Southern Photonics Limited
Programme Manager (ex-officio)	AJ Woodhouse	University of Otago
Secretary	Susan Baikie	University of Otago

Theme 1a – Photonic Sensors and Imaging (PSI)

Professor Jon-Paul Wells	THEME LEADER, University of Canterbury, Physics and Astronomy
Dr Baptiste Auguie	Victoria University of Wellington, Physics
Professor Richard Blaikie	University of Otago, Physics
Dr Cameron Craigie	AgResearch Ltd
Dr Marlon dos Reis	AgResearch Ltd
Dr Vladimir Golovko	University of Canterbury, Chemistry
Professor Keith Gordon	University of Otago, Chemistry
Dr Cushla McGoverin	The University of Auckland, Physics
Professor John Harvey	Southern Photonics Limited
Professor Jari Kaipio	The University of Auckland, Maths
Associate Professor Rainer Leonhardt	The University of Auckland, Physics
Associate Professor Jevon Longdell	University of Otago, Physics
Associate Professor Rainer Künemeyer	University of Waikato, Engineering
Associate Professor Brendan McCane	University of Otago, Computer Science
Professor Roger Reeves	University of Canterbury, Physics & Astronomy
Professor Mike Reid	University of Canterbury, Physics & Astronomy
Associate Professor Harald Schwefel	University of Otago, Physics
Associate Professor Kasper Van Wijk	The University of Auckland, Physics
Associate Professor Frédérique Vanholsbeeck	The University of Auckland, Physics
Professor Peter Xu	The University of Auckland, Mechanical Engineering
Dr Claude Agueraray	The University of Auckland, Physics
Dr Juliette Cheyne	The University of Auckland, Physiology
Dr Nathaniel Davis	Victoria University of Wellington, Chemical and Physical Sciences
Dr Michel Nieuwoudt	The University of Auckland, Physics
Professor Cather Simpson	The University of Auckland, Physics
Dr Catherine Smith	University of Otago, Dodd-Walls Centre
Dr Marcus Jones	Auckland University of Technology, Chemistry
Professor Nicola Brasch	Auckland University of Technology, Chemistry
Dr Jami Shepherd	The University of Auckland, Physics
Dr Sara Miller	University of Otago, Chemistry

Theme 1b – Photonic Sources and Components (PSC)

Associate Professor Stéphane Coen	THEME LEADER, The University of Auckland, Physics
Professor Neil Broderick	The University of Auckland, Physics
Associate Professor Miro Erkintalo	The University of Auckland, Physics
Dr Jianyong Jin	The University of Auckland, Chemistry
Professor Bernd Krauskopf	The University of Auckland, Mathematics
Associate Professor Rainer Leonhardt	The University of Auckland, Physics
Associate Professor Stuart Murdoch	The University of Auckland, Physics
Associate Professor Harald Schwefel	University of Otago, Physics
Associate Professor Geoff Waterhouse	The University of Auckland, Chemistry
Dr Claude Agueraray	The University of Auckland, Physics
Professor Cather Simpson	The University of Auckland, Physics
Dr Dominik Vogt	The University of Auckland, Physics
Dr Kai Chen	Victoria University of Wellington, Chemical and Physical Sciences

Theme 2a – Quantum Fluids and Gases (QFG)

Dr Maarten Hoogerland	THEME LEADER, The University of Auckland, Physics
Professor Niels Kjærgaard	University of Otago, Physics
Dr Danny Baillie	University of Otago, Physics
Emeritus Professor Rob Ballagh	University of Otago, Physics
Professor Blair Blakie	University of Otago, Physics
Associate Professor Ashton Bradley	University of Otago, Physics
Professor Joachim Brand	Massey University, NZ Institute for Advanced Study
Professor Howard Carmichael	The University of Auckland, Physics
Dr Amita Deb	University of Otago, Physics
Professor David Hutchinson	University of Otago, Physics
Associate Professor Scott Parkins	The University of Auckland, Physics
Professor Ulrich Zülicke	Victoria University of Wellington, Chemical and Physical Sciences
Dr James Croft	University of Otago, Physics

Theme 2b – Quantum Manipulation and Information (QMI)

Associate Professor Harald Schwefel	THEME LEADER, University of Otago, Physics
Professor Michael Albert	University of Otago, Computer Science
Associate Professor Mikkel Andersen	University of Otago, Physics
Professor Joachim Brand	Massey University, NZ Institute for Advanced Study
Dr Vladimir Bubanja	Callaghan Innovation
Professor Howard Carmichael	The University of Auckland, Physics
Dr Maarten Hoogerland	The University of Auckland, Physics
Professor David Hutchinson	University of Otago, Physics
Associate Professor Jevon Longdell	University of Otago, Physics
Associate Professor Scott Parkins	The University of Auckland, Physics
Professor Mike Reid	University of Canterbury, Physics and Astronomy
Professor Jon-Paul Wells	University of Canterbury, Physics and Astronomy
Dr Joseph Borbely	Callaghan Innovation, MSL

2020 PEER-REVIEWED JOURNAL PUBLICATIONS

AUTHORS	TITLE	JOURNAL
Adhikari, Bishal Raj; Bērziņš, Kārlis; Fraser-Miller, Sara J.; Gordon, Keith C.; Das, Shyamal C.	Co-Amorphization of Kanamycin with Amino Acids Improves Aerosolization	Pharmaceutics 715 , 12 (2020)
Al-Sarayreh, Mahmoud; Reis, Marlon M.; Yan, Wei Qi; Klette, Reinhard	Potential of deep learning and snapshot hyperspectral imaging for classification of species in meat	Food Control 107332 , 117 (2020)
Ashforth, Simon A.; Oosterbeek, Reece N.; Bodley, Owen L. C.; Mohr, Catherine; Agueraray, Claude; Simpson, M. Cather	Femtosecond lasers for high-precision orthopedic surgery	Lasers in Medical Science 1263-1270 , 35 (2020)
Bagheri, Ali; Bainbridge, Chris William Anderson; Engel, Kyle Edward; Qiao, Greg G.; Xu, Jiangtao; Boyer, Cyrille; Jin, Jianyong	Oxygen Tolerant PET-RAFT Facilitated 3D Printing of Polymeric Materials under Visible LEDs	ACS Applied Polymer Materials 782-790 , 2 (2020)
Bagheri, Ali; Engel, Kyle Edward; Bainbridge, Chris William Anderson; Xu, Jiangtao; Boyer, Cyrille; Jin, Jianyong	3D printing of polymeric materials based on photo-RAFT polymerization	Polym. Chem. 641-647 , 11 (2020)
Baillie, D.; Blakie, P. B.	Rotational tuning of the dipole-dipole interaction in a Bose gas of magnetic atoms	Phys. Rev. A 43606 , 101 (2020)
Bainbridge, Chris William Anderson; Engel, Kyle Edward; Jin, Jianyong	3D printing and growth induced bending based on PET-RAFT polymerization	Polym. Chem. 4084-4093 , 11 (2020)
Balabhadra, Sangeetha; Reid, Michael F.; Golovko, Vladimir; Wells, Jon-Paul R.	Absorption spectra, defect site distribution and upconversion excitation spectra of CaF ₂ /SrF ₂ /BaF ₂ :Yb ³⁺ :Er ³⁺ nanoparticles	Journal of Alloys and Compounds 155165 , 834 (2020)
Balabhadra, Sangeetha; Reid, Michael F.; Golovko, Vladimir; Wells, Jon-Paul R.	A comparison of the Yb ³⁺ absorption and upconversion excitation spectra for both the cubic and hexagonal phases of NaYF ₄ :Yb ³⁺ /Er ³⁺ nanoparticles	Optical Materials 110050 , 107 (2020)
Balabhadra, Sangeetha; Reid, Michael F.; Golovko, Vladimir; Wells, Jon-Paul R.	Influence of the synthesis method on preferential clustering of Yb ³⁺ in CaF ₂ :Yb ³⁺ /Er ³⁺ upconverting nanoparticles	Optical Materials 110736 , 112 (2020)
Barnett, Peter S.; Longdell, Jevon J.	Theory of microwave-optical conversion using rare-earth-ion dopants	Phys. Rev. A 63718 , 102 (2020)
Bērziņš, Kārlis; Fraser-Miller, Sara J.; Gordon, Keith C.	Recent advances in low-frequency Raman spectroscopy for pharmaceutical applications	International Journal of Pharmaceutics 120034 , 592 (2020)
Bērziņš, Kārlis; Harrison, Samuel D. L.; Leong, Claudia; Fraser-Miller, Sara J.; Harper, Michelle J.; Diana, Aly; Gibson, Rosalind S.; Houghton, Lisa A.; Gordon, Keith C.	Qualitative and quantitative vibrational spectroscopic analysis of macronutrients in breast milk	Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy 118982 , 246 (2020)
Bērziņš, Kārlis; Sales, Ruth E.; Barnsley, Jonathan E.; Walker, Greg; Fraser-Miller, Sara J.; Gordon, Keith C.	Low-wavenumber Raman spectral database of pharmaceutical excipients	Vibrational Spectroscopy 103021 , 107 (2020)
Bērziņš, Kārlis; Sutton, Joshua J.; Fraser-Miller, Sara J.; Rades, Thomas; Korter, Timothy M.; Gordon, Keith C.	Solving the Computational Puzzle: Toward a Pragmatic Pathway for Modeling Low-Energy Vibrational Modes of Pharmaceutical Crystals	Crystal Growth & Design 6947-6955 , 20 (2020)

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Blakie, P. B.; Baillie, D.; Chomaz, L.; Ferlaino, F.	Supersolidity in an elongated dipolar condensate	Phys. Rev. Research 43318 , 2 (2020)
Blakie, P. Blair; Baillie, D.; Pal, Sukla	Variational theory for the ground state and collective excitations of an elongated dipolar condensate	Communications in Theoretical Physics 85501 , 72 (2020)
Boehme, Simon C.; Brinck, Stephanie ten; Maes, Jorick; Yazdani, Nuri; Zapata, Felipe; Chen, Kai; Wood, Vanessa; Hodgkiss, Justin M.; Hens, Zeger; Geiregat, Pieter; Infante, Ivan	Phonon-Mediated and Weakly Size-Dependent Electron and Hole Cooling in CsPbBr ₃ Nanocrystals Revealed by Atomistic Simulations and Ultrafast Spectroscopy	Nano Letters 1819-1829 , 20 (2020)
Canela, V. S. C.; Carmichael, H. J.	Bright Sub-Poissonian Light through Intrinsic Feedback and External Control	Phys. Rev. Lett. 63604 , 124 (2020)
Carmelet, Alexander; Nemet, Nikolett; Canela, Victor; Parkins, Scott	Pronounced non-Markovian features in multiply excited, multiple emitter waveguide QED: Retardation induced anomalous population trapping	Phys. Rev. Research 13238 , 2 (2020)
Carmelet, Alexander; Parkins, Scott; Knorr, Andreas	Quantum-optical realization of an Ornstein-Uhlenbeck-type process via simultaneous action of white noise and feedback	Phys. Rev. A 33712 , 102 (2020)
Chakraborti, T.; McCane, B.; Mills, S.; and Pal, U.	Distance Metric Learned Collaborative Representation Classifier (DML-CRC)	IEEE Letters of the Computer Society 34-37 , 2 (2020)
Chen, Hao; Li, Xin; Broderick, Neil G.R.; Xu, Weiliang	Low-resolution fiber-optic Raman spectroscopy for bladder cancer diagnosis: A comparison study of varying laser power, integration time, and classification methods	Journal of Raman Spectroscopy 323-334 , 51 (2020)
Chen, Wan-Ting; Dong, Yusong; Yadav, Pooja; Aughterson, Robert D.; Sun-Waterhouse, Dongxiao; Waterhouse, Geoffrey I.N.	Effect of alcohol sacrificial agent on the performance of Cu/TiO ₂ photocatalysts for UV-driven hydrogen production	Applied Catalysis A: General 117703 , 602 (2020)
Chilcott, Matthew; Kjærgaard, Niels	Low-cost wireless condition monitoring system for an ultracold atom machine	Internet of Things 100345 , 13 (2020)
Cônsolo, Nara R. B.; Olivecrona, Natalia; Samuelsson, Linda M.; Reis, Mariza G.; Edwards, Patrick J. B.; Reis, Marlon M.	Investigation of metabolites associated with confinement odour in chilled vacuum-packed lamb by proton nuclear magnetic resonance (1H NMR) spectroscopy	Meat Science 108207 , 169 (2020)
Cônsolo, Nara R. B.; Samuelsson, Linda M.; Barbosa, Luís C. G. S.; Monaretto, Tatiana; Moraes, Tiago B.; Buarque, Vicente L. M.; Higuera-Padilla, Angel R.; Colnago, Luiz A.; Silva, Saulo L.; Reis, Marlon M.; Fonseca, André C.; Araújo, Cristiane S. da S.; Leite, Bruna G. de S.; Roque, Fabricia A.; Araújo, Lúcio F.	Characterization of chicken muscle disorders through metabolomics, pathway analysis, and water relaxometry: a pilot study	Poultry Science 6247 - 6257 , 99 (2020)
Croft, James F. E.; Bohn, John L.; Quémener, Goulven	Unified model of ultracold molecular collisions	Phys. Rev. A 33306 , 102 (2020)
Crowder, Gavin; Carmichael, Howard; Hughes, Stephen	Quantum trajectory theory of few-photon cavity-QED systems with a time-delayed coherent feedback	Phys. Rev. A 23807 , 101 (2020)
Dai, Shuixing; Zhou, Jiadong; Chandrabose, Sreelakshmi; Shi, Yanjun; Han, Guangchao; Chen, Kai; Xin, Jingming; Liu, Kuan; Chen, Zhenyu; Xie, Zengqi; Ma, Wei; Yi, Yuanping; Jiang, Lang; Hodgkiss, Justin M.; Zhan, Xiaowei	High-Performance Fluorinated Fused-Ring Electron Acceptor with 3D Stacking and Exciton/Charge Transport	Advanced Materials 2000645 , 32 (2020)

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Deas, Robert; Pearce, Sean; Goss, Katherine; Wang, Qing ; Chen, Wan-Ting; Waterhouse, Geoffrey I.N.	Hierarchical Au/TiO ₂ nanoflower photocatalysts with outstanding performance for alcohol photoreforming under UV irradiation	Applied Catalysis A: General 117706 , 602 (2020)
Deb, A. B. ; Chung, J. ; Kjærgaard, N.	Dispersive detection of atomic ensembles in the presence of strong lensing	New Journal of Physics 73017 , 22 (2020)
Dixit, Y.; Al-Sarayeh, M.; Craigie, C. R. ; Reis, M. M.	A global calibration model for prediction of intramuscular fat and pH in red meat using hyperspectral imaging	Meat Science 108405 , (2020)
Dixit, Y.; Pham, H. Q.; Realini, C. E.; Agnew, M. P.; Craigie, C. R. ; Reis, M. M.	Evaluating the performance of a miniaturized NIR spectrophotometer for predicting intramuscular fat in lamb: A comparison with benchtop and hand-held Vis-NIR spectrophotometers	Meat Science 108026 , 162 (2020)
Dixit, Y.; Hitchman, S.; Hicks, T.M.; Lim, P.; Wong, C.K.; Holibar, L.; Gordon, K.C.; Loeffen, M.; Farouk, M.M.; Craigie, C.R. ; Reis, M.M.	Non-invasive spectroscopic and imaging systems for prediction of beef quality in a meat processing pilot plant	Meat science 108410 , (2020)
Everts, Jonathan R.; King, Gavin G. G.; Lambert, Nicholas J. ; Kocsis, Sacha; Rogge, Sven; Longdell, Jevon J.	Ultrastrong coupling between a microwave resonator and antiferromagnetic resonances of rare-earth ion spins	Phys. Rev. B 214414 , 101 (2020)
Fatome, Julien; Kibler, Bertrand; Leo, François; Bendahmane, Abdelkrim; Oppo, Gian-Luca; Garbin, Bruno ; Murdoch, Stuart G. ; Erkintalo, Miro ; Coen, Stéphane	Polarization modulation instability in a nonlinear fiber Kerr resonator	Opt. Lett. 5069–5072 , 45 (2020)
Fersterer, Petra ; Ballagh, R. J.	Analytic solutions for the spatial character and coherence properties of light scattered from two dipole-coupled atoms	Physical Review A 13431 , 101 (2020)
Garbin, Bruno ; Fatome, Julien; Oppo, Gian-Luca; Erkintalo, Miro ; Murdoch, Stuart G. ; Coen, Stéphane	Asymmetric balance in symmetry breaking	Phys. Rev. Research 23244 , 2 (2020)
Garhwal, Abhimanyu Singh; Pullanagari, Reddy R.; Li, Mo; Reis, Marlon M. ; Archer, Richard	Hyperspectral imaging for identification of Zebra Chip disease in potatoes	Biosystems Engineering 306 - 317 , 197 (2020)
Ge, Yaqing; Li, Cuiping; Waterhouse, Geoffrey I.N. ; Zhang, Zhiming; Yu, Liangmin	ZnFe ₂ O ₄ @SiO ₂ @Polypyrrole nanocomposites with efficient electromagnetic wave absorption properties in the K and Ka band regions	Ceramics International 1728-1739 , 47 (2020)
Gebauer, André; Tercjak, Monika; Schreiber, Karl Ulrich; Igel, Heiner; Kodet, Jan; Hugentobler, Urs; Wassermann, Joachim; Bernauer, Felix; Lin, Chin-Jen; Donner, Stefanie; Egdorf, Sven; Simonelli, Andrea; Wells, Jon-Paul R.	Reconstruction of the Instantaneous Earth Rotation Vector with Sub-Arcsecond Resolution Using a Large Scale Ring Laser Array	Phys. Rev. Lett. 33605 , 125 (2020)
Giraldo, Andrus ; Krauskopf, Bernd ; Broderick, Neil G. R. ; Levenson, Juan A.; Yacomotti, Alejandro M.	The driven-dissipative Bose–Hubbard dimer: phase diagram and chaos	New Journal of Physics 43009 , 22 (2020)
Giraldo, Andrus ; Krauskopf, Bernd ; Osinga, Hinke	Computing connecting orbits to infinity associated with a homoclinic flip bifurcation	Journal of Computational Dynamics 489-510 , 7 (2020)
Gong, Ruizhi; Yang, Liuliu; Qiu, Shuo; Chen, Wan-Ting; Wang, Qing ; Xie, Jiazhuo; Waterhouse, Geoffrey I. N. ; Xu, Jing	A Nitrogen-Rich Covalent Triazine Framework as a Photocatalyst for Hydrogen Production	Advances in Polymer Technology 7819049 , 2020 (2020)
Grant, Craig ; Griffin, Ian ; McConnell, Michelle; Quiñones-Mateu Miguel; Schumayer, Daniel; Hutchinson, David	Re-Opening after COVID-19 in New Zealand	Journal of Conservation and Museum Studies, 1-5 , 18 (2020)

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Guo, Manli; Chi, Jingtian; Li, Yijing; Waterhouse, Geoffrey I. N. ; Ai, Shiyun; Hou, Juying; Li, Xiangyang	Fluorometric determination of mercury(II) based on dual-emission metal-organic frameworks incorporating carbon dots and gold nanoclusters	Microchimica Acta 534 , 187 (2020)
Guther, Kai; Anderson, Robert J.; Blunt, Nick S.; Bogdanov, Nikolay A.; Cleland, Deidre; Dattani, Nike; Dobrautz, Werner; Ghanem, Khaldoon; Jeszenszki, Peter ; Liebermann , Niklas; Manni, Giovanni Li; Lozovoi, Alexander Y.; Luo, Hongjun; Ma, Dongxia; Merz, Florian; Overy, Catherine; Rampp, Markus; Samanta, Pradipta Kumar; Schwarz, Laretta R.; Shepherd, James J.; Smart, Simon D.; Vitale, Eugenio; Weser, Oskar; Booth, George H.; Alavi, Ali	NECI: N-Electron Configuration Interaction with an emphasis on state-of-the-art stochastic methods	The Journal of Chemical Physics 34107 , 153 (2020)
Harris, Jonathan; Silk, Ryan; Smith, Mark; Dong, Yusong ; Chen, Wan-Ting; Waterhouse, Geoffrey I. N.	Hierarchical TiO ₂ Nanoflower Photocatalysts with Remarkable Activity for Aqueous Methylene Blue Photo-Oxidation	ACS Omega 18919-18934 , 5 (2020)
Harwell, J. R.; Glackin, J. M. E.; Davis, N. J. L. K. ; Gillanders, R. N.; Credgington, D.; Turnbull, G. A.; Samuel, I. D. W.	Sensing of explosive vapor by hybrid perovskites: Effect of dimensionality	APL Materials 71106 , 8 (2020)
Hease, William; Rueda, Alfredo ; Sahu, Rishabh; Wulf, Matthias; Arnold, Georg; Schwefel, Harald G.L. ; Fink, Johannes M.	Bidirectional Electro-Optic Wavelength Conversion in the Quantum Ground State	PRX Quantum 20315 , 1 (2020)
Hendry, Ian ; Trainor, Luke S. ; Xu, Yiqing ; Coen, Stéphane ; Murdoch, Stuart G. ; Schwefel, Harald G. L. ; Erkintalo, Miro	Experimental observation of internally pumped parametric oscillation and quadratic comb generation in a $\chi(2)$ whispering-gallery-mode microresonator	Opt. Lett. 1204-1207 , 45 (2020)
Hope, James ; RaviChandran, Narrendar; Vanholsbeeck, Frederique ; McDaid, Andrew	Augmentation of neural activity in peripheral nerve of sheep using 6 kHz subthreshold currents	Physiological measurement 10NT01 , 41 (2020)
Hughes-Currie, Rosa B.; Ivanovskikh, Konstantin V.; Wells, Jon-Paul R. ; Reid, Michael F. ; Meijerink, Andries	Intrinsic electronic excitations and impurity luminescent centres in NaMgF ₃ and MgF ₂ doped with Yb ²⁺	Optical Materials 109553 , 99 (2020)
Jeszenszki, Péter ; Ebling, Ulrich ; Luo, Hongjun; Alavi, Ali; Brand, Joachim	Eliminating the wave-function singularity for ultracold atoms by a similarity transformation	Phys. Rev. Research 43270 , 2 (2020)
Jobbitt, N. L. ; Wells, J.-P. R. ; M. F.	Energy transfer between Sm ³⁺ ions in Y ₂ SiO ₅ crystals	Journal of Luminescence 117302 , 224 (2020)
Kaur, Harpreet ; Künne Meyer, Rainer ; McGlone, Andrew	Investigating aquaphotomics for temperature-independent prediction of soluble solids content of pure apple juice	Journal of Near Infrared Spectroscopy 103-112 , 28 (2020)
Kazemzadeh, M. R. ; Broderick, N. G. R. ; Xu, W.	Novel Time-Domain Electromagnetic Simulation Using Triangular Meshes by Applying Space Curvature	IEEE Open Journal of Antennas and Propagation 387-395 , 1 (2020)
Kazemzadeh, Mohammad ; Xu, Weiliang ; Broderick, Neil	Faster and More Accurate Time Domain Electromagnetic Simulation Using Space Transformation	IEEE Photonics Journal 44197 , 12 (2020)
Killeen, Daniel Patrick; Card, Asli; Gordon, Keith Christopher ; Perry, Nigel Brian	First Use of Handheld Raman Spectroscopy to Analyze Omega-3 Fatty Acids in Intact Fish Oil Capsules	Applied Spectroscopy 365-371 , 74 (2020)
Kolenderska, Sylwia M. ; Vanholsbeeck, Frédérique ; Kolenderski, Piotr	Quantum-inspired detection for spectral domain optical coherence tomography	Opt. Lett. 3443-3446 , 45 (2020)

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Kolenderska, Sylwia M.; Vanholsbeeck, Frédérique; Kolenderski, Piotr	Fourier domain quantum optical coherence tomography	Opt. Express 29576–29589 , 28 (2020)
Lambert, N. J.; Esmail, A. A.; Edwards, M.; Ferguson, A. J.; Schwefel, H. G. L.	Random telegraph signal analysis with a recurrent neural network	Phys. Rev. E 12312 , 102 (2020)
Lambert, Nicholas J.; Rueda, Alfredo; Sedlmeir, Florian; Schwefel, Harald G. L.	Coherent Conversion Between Microwave and Optical Photons – An Overview of Physical Implementations (Adv. Quantum Technol. 1/2020)	Advanced Quantum Technologies 2070011 , 3 (2020)
Lee, Seunghoon; Hwang, Heeyeon; Lee, Wonseok; Schebarchov, Dmitri; Wy, Younghyun; Grand, Johan; Auguié, Baptiste; Wi, Dae Han; Cortés, Emiliano; Han, Sang Woo	Core–Shell Bimetallic Nanoparticle Trimers for Efficient Light-to-Chemical Energy Conversion	ACS Energy Letters 3881–3890 , 5 (2020)
Li, Cuiping; Zhang, Ziqiu; Sui, Jing; Jiang, Xiaohui; Waterhouse, Geoffrey I.N.; Zhang, Zhiming; Yu, Liangmin	Microwave-based synthesis of (NiCo) _x /(MnO) _y /C composites and their tunable wave absorption properties in the K band	Ceramics International 9353–9362 , 46 (2020)
Li, Zongda; Xu, Yiqing; Coen, Stéphane; Murdoch, Stuart G.; Erkintalo, Miro	Experimental observations of bright dissipative cavity solitons and their collapsed snaking in a Kerr resonator with normal dispersion driving	Optica 1195–1203 , 7 (2020)
Ling, Honglei; Qazvini, Omid T.; Telfer, Shane G.; Jin, Jianyong	Effective enhancement of selectivities and capacities for CO ₂ over CH ₄ and N ₂ of polymers of intrinsic microporosity via postsynthesis metalation	Journal of Polymer Science 2619–2624 , 58 (2020)
Liu, Chang; Zhang, Xiangchun; Han, Xu; Fang, Yide; Liu, Xuemei; Wang, Xiaolin; Waterhouse, Geoffrey I. N.; Xu, Chao; Yin, Hongzong; Gao, Xueyun	Polypeptide-Templated Au Nanoclusters with Red and Blue Fluorescence Emissions for Multimodal Imaging of Cell Nuclei	ACS Applied Bio Materials 1934–1943 , 3 (2020)
Liu, Fubin; Li, Cuiping; Xiaohui, Jiang; Waterhouse, Geoffrey; Xing, Cuijuan; Zhang, Zhiming; Yu, Liangmin	Novel three-dimensional TiO ₂ -Fe ₃ O ₄ @polypyrrole composites with tunable microwave absorption in the 2–40 GHz frequency range	Journal of Materials Science 15493–15509 , 55 (2020)
Liu, Shibei; Wen, Bo; Xiaohui, Jiang; Waterhouse, Geoffrey; Zhang, Zhi-Ming; Yu, Liang-min	Enhanced photocathodic antifouling/antibacterial properties of polyaniline–Ag–N-doped TiO ₂ coatings	Journal of Materials Science 16255–16272 , 55 (2020)
Lowe, Gemma; McCane, Brendan; Sutherland, Mhairi; Waas, Joe; Schaefer, Allan; Cox, Neil; Stewart, Mairi	Automated Collection and Analysis of Infrared Thermograms for Measuring Eye and Cheek Temperatures in Calves	Animals: an open access journal from MDPI, 10 (2020)
McGoverin, Cushla; Robertson, Julia; Jonmohamadi, Yaqub; Swift, Simon; Vanholsbeeck, Frédérique	Species Dependence of SYTO 9 Staining of Bacteria	Frontiers in Microbiology 2149 , 11 (2020)
McIntyre, Samantha M.; Ma, Qianli; Burritt, David J.; Oey, Indrawati; Gordon, Keith C.; Fraser-Miller, Sara J.	Vibrational spectroscopy and chemometrics for quantifying key bioactive components of various plum cultivars grown in New Zealand	Journal of Raman Spectroscopy 1138–1152 , 51 (2020)
Mombassen, S.; Lambert, N.J.; Rueda, A.; Fink, J.M.; Leuchs, G.; Schwefel H. G. L.;	Thermal Noise in Electro-Optic Devices at Cryogenic Temperatures	arXiv:2008 8764 , (2020)
Német, Nikolett; White, Donald; Kato, Shinya; Parkins, Scott; Aoki, Takao	Transfer-Matrix Approach to Determining the Linear Response of All-Fiber Networks of Cavity-QED Systems	Phys. Rev. Applied 64010 , 13 (2020)
Nieuwoudt, Michel K.; Shahlori, Rayomand; Naot, Dorit; Patel, Rhea; Holtkamp, Hannah; Agueraray, Claude; Watson, Maureen; Musson, David; Brown, Cameron; Dalbeth, Nicola; Cornish, Jillian; Simpson, M. Cather	Raman spectroscopy reveals age- and sex-related differences in cortical bone from people with osteoarthritis	Scientific Reports 19443 , 10 (2020)

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Novakovic, Dunja; Peltonen, Leena; Isomäki, Antti; Fraser-Miller, Sara J. ; Nielsen, Line Hagner; Laaksonen, Timo; Strachan, Clare J.	Surface Stabilization and Dissolution Rate Improvement of Amorphous Compacts with Thin Polymer Coatings: Can We Have It All?	Molecular Pharmaceutics 1248-1260 , 17 (2020)
Novis, Phil M.; Sales, Ruth E. ; Gordon, Keith ; Manning, Nathan; Duleba, Mónica; Ács, Éva; Dressler, Mirko; Schallenberg, Marc	Lindavia intermedia (Bacillariophyceae) and Nuisance lake Snow in New Zealand: Chitin Content and Quantitative PCR Methods to Estimate Cell Concentrations and Expression of Chitin Synthase1	Journal of Phycology 1232-1244 , 56 (2020)
Oh, Sue Ann ; Coker, David F. ; Hutchinson, David A. W.	Variety, the spice of life and essential for robustness in excitation energy transfer in light-harvesting complexes	Faraday Discussions, 59-76 , 221 (2020)
Otto, J. Susanne ; Kjærgaard, Niels ; Deb, Amita B.	Strong zero-field Förster resonances in K-Rb Rydberg systems	Phys. Rev. Research 33474 , 2 (2020)
Otupiri, R. ; Krauskopf, B. ; Broderick, N.G.R.	The Yamada model for a self-pulsing laser: bifurcation structure for non-identical decay times of gain and absorber	Int. J. Bifurcation and Chaos 2030039 , 30(14) (2020)
Pal, Sukla ; Baillie, D. ; Blakie, P. B.	Excitations and number fluctuations in an elongated dipolar Bose-Einstein condensate	Phys. Rev. A 43306 , 102 (2020)
Price, Michael B.; Lewellen, Keiran; Hardy, Jake; Lockwood, Stephanie M.; Zemke-Smith, Chase; Wagner, Isabella; Gao, Meiqi; Grand, Johan; Chen, Kai ; Hodgkiss, Justin M. ; Le Ru, Eric ; Davis, Nathaniel J. L. K.	Whispering-Gallery Mode Lasing in Perovskite Nanocrystals Chemically Bound to Silicon Dioxide Microspheres	The Journal of Physical Chemistry Letters 7009-7014 , 11 (2020)
Qin, Jian; Chen, Yu-Hui; Zhang, Zhepeng; Zhang, Yanfeng; Blaikie, Richard J. ; Ding, Boyang ; Qiu, Min	Revealing Strong Plasmon-Exciton Coupling between Nanogap Resonators and Two-Dimensional Semiconductors at Ambient Conditions	Phys. Rev. Lett. 63902 , 124 (2020)
Rakonjac, Jelena V.; Chen, Yu-Hui; Horvath, Sebastian P.; Longdell, Jevon J.	Long spin coherence times in the ground state and in an optically excited state of 167Er ³⁺ :Y2SiO5 at zero magnetic field	Phys. Rev. B 184430 , 101 (2020)
Reynolds, L. A.; Schwartz, E. ; Ebling, U. ; Weyland, M. ; Brand, J. ; Andersen, M. F.	Direct Measurements of Collisional Dynamics in Cold Atom Triads	Phys. Rev. Lett. 73401 , 124 (2020)
Ricciardi, Iolanda; Mosca, Simona; Parisi, Maria; Leo, François; Hansson, Tobias; Erkintalo, Miro ; Maddaloni, Pasquale; De Natale, Paolo; Wabnitz, Stefan; De Rosa, Maurizio	Optical Frequency Combs in Quadratically Nonlinear Resonators	Micromachines, 11 (2020)
Rob G. McDonald, Peter S. Barnett, Fradom Atayee, Ashton S. Bradley	Dynamics of hot Bose-Einstein condensates: stochastic Ehrenfest relations for number and energy damping	SciPost Physics 29 , 8 (2020)
Robert, Chima ; Fraser-Miller, Sara J. ; Bērziņš, Kārlis; Okeyo, Peter O.; Rantanen, Jukka; Rades, Thomas; Gordon, Keith C.	Monitoring the Isothermal Dehydration of Crystalline Hydrates Using Low-Frequency Raman Spectroscopy	Molecular Pharmaceutics (2020)
Robert, Chima ; Fraser-Miller, Sara J. ; Jessep, William T.; Bain, Wendy E.; Hicks, Talia M.; Ward, James F.; Craigie, Cameron R. ; Loeffen, Mark; Gordon, Keith C.	Rapid discrimination of intact beef, venison and lamb meat using Raman spectroscopy	Food Chemistry 128441 , 343 (2020)
Rossi, Aurélien; Price, Michael B.; Hardy, Jake; Gorman, Jeffrey; Schmidt, Timothy W.; Davis, Nathaniel J. L. K.	Energy Transfer between Perylene Diimide Based Ligands and Cesium Lead Bromide Perovskite Nanocrystals	The Journal of Physical Chemistry C 3306-3313 , 124 (2020)
Ruschel, S. ; Krauskopf, B. ; Broderick, N.G.R.	The limits of sustained self-excitation and stable periodic pulse trains in the Yamada model with delayed optical feedback	Chaos 93101 , 30(9) (2020)

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Sabet, Saman; Rashidinejad, Ali; Melton, Laurence D.; Zujovic, Zoran; Akbarinejad, Alireza; Nieuwoudt, Michel ; Seal, Chris K.; McGillivray, Duncan J.	The interactions between the two negatively charged polysaccharides: Gum Arabic and alginate	Food Hydrocolloids 106343 , 112 (2020)
Salim, Malinda; Fraser-Miller, Sara J. ; Bērziņš, Kārlis; Sutton, Joshua J.; Ramirez, Gisela; Clulow, Andrew J.; Hawley, Adrian; Beilles, Stéphane; Gordon, Keith C. ; Boyd, Ben J.	Low-Frequency Raman Scattering Spectroscopy as an Accessible Approach to Understand Drug Solubilization in Milk-Based Formulations during Digestion	Molecular Pharmaceutics 885-899 , 17 (2020)
Salkeld, Alexander J.; Reid, Michael F. ; Wells, Jon-Paul R.	Interpreting ab initio energy level calculations for the trivalent praseodymium ion using a parametrized crystal-field Hamiltonian	Optical Materials 109998 , 106 (2020)
Samanali, G. A. P. ; Paasi, I.; Lowe, B. J.; Smith, C. A. ; Fraser-Miller, S. J. ; Gordon, K. C.	Understanding consolidants on harakeke fibres using Raman microscopy: Implications for conservation	Journal of Cultural Heritage 41 - 47 , 45 (2020)
Shafiee, Golnoush; Strelakov, Dimitry; Otterpohl, Alexander; Sedlmeir, Florian; Schunk, Gerhard; Vogl, Ulrich; Schwefel, Harald ; Leuchs, Gerd; Marquardt, Christoph	Nonlinear power dependence of the spectral properties of an optical parametric oscillator below threshold in the quantum regime	New Journal of Physics, 22 (2020)
Shepherd, J. ; Renaud, G.; Clouzet, P.; van Wijk, K.	Photoacoustic imaging through a cortical bone replica with anisotropic elasticity	Applied Physics Letters 243704 , 116 (2020)
Simpson, Jonathan ; Adam, Ludmila; van Wijk, Kasper ; Charoensawan, Jirapat	Constraining Microfractures in Foliated Alpine Fault Rocks With Laser Ultrasonics	Geophysical Research Letters e2020GL087378 , 47 (2020)
Song, Jiali; Ye, Linglong; Li, Chao; Xu, Jinqiu; Chandrabose, Sreelakshmi; Weng, Kangkang; Cai, Yunhao; Xie, Yuanpeng; O'Reilly, Padraic; Chen, Kai ; Zhou, Jiajia; Zhou, Yi; Hodgkiss, Justin M.; Liu, Feng; Sun, Yanming	An Optimized Fibril Network Morphology Enables High-Efficiency and Ambient-Stable Polymer Solar Cells	Advanced Science 2001986 , 7 (2020)
Soni, Aswathi; Al-Sarayreh, Mahmoud; Reis, Marlon M. ; Smith, Jeremy; Tong, Kris; Brightwell, Gale	Identification of Cold Spots Using Non-Destructive Hyperspectral Imaging Technology in Model Food Processed by Coaxially Induced Microwave Pasteurization and Sterilization	Foods, 9 (2020)
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* Dodd-Walls Centre investigators and students are indicated by boldface type

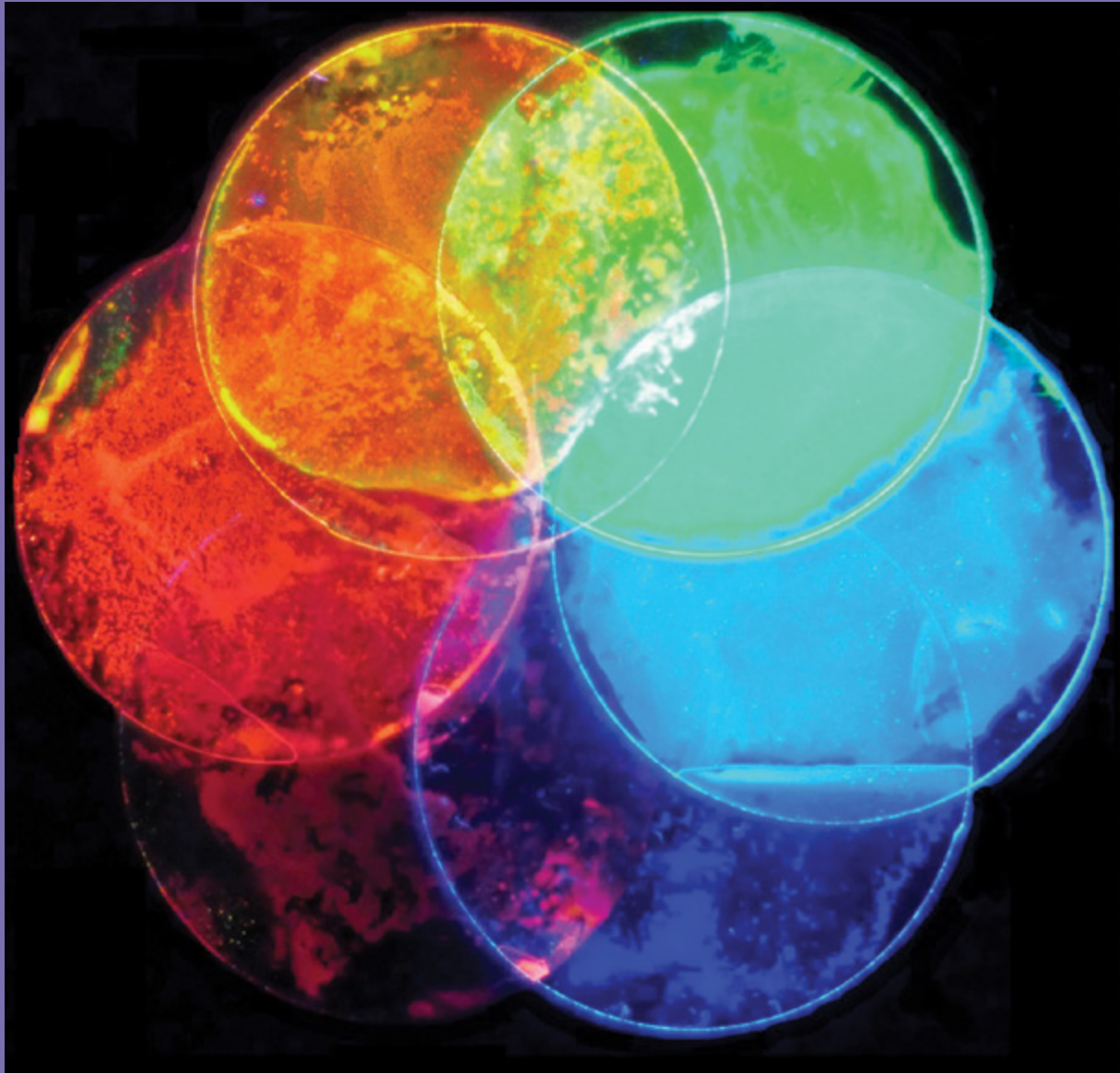


Photo credit: Nathaniel Davis

Colloidal quantum dots are revolutionising the material industry through their tuneable light emissions.

The image shows caesium lead halide nanocrystals, CsPbX_3 (where $X = \text{Cl}, \text{Br}, \text{I}$). The image was made by mixing different ratios of CsPbCl_3 , CsPbBr_3 , CsPbI_3 , together to achieve the desired emission colour under UV excitation (365 nm). These nanocrystals exhibit photoluminescence quantum efficiencies approaching 100% without the core-shell structures usually used in conventional semiconductor nanocrystals. These high photoluminescence efficiencies make these crystals ideal candidates for light-emitting diodes.

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