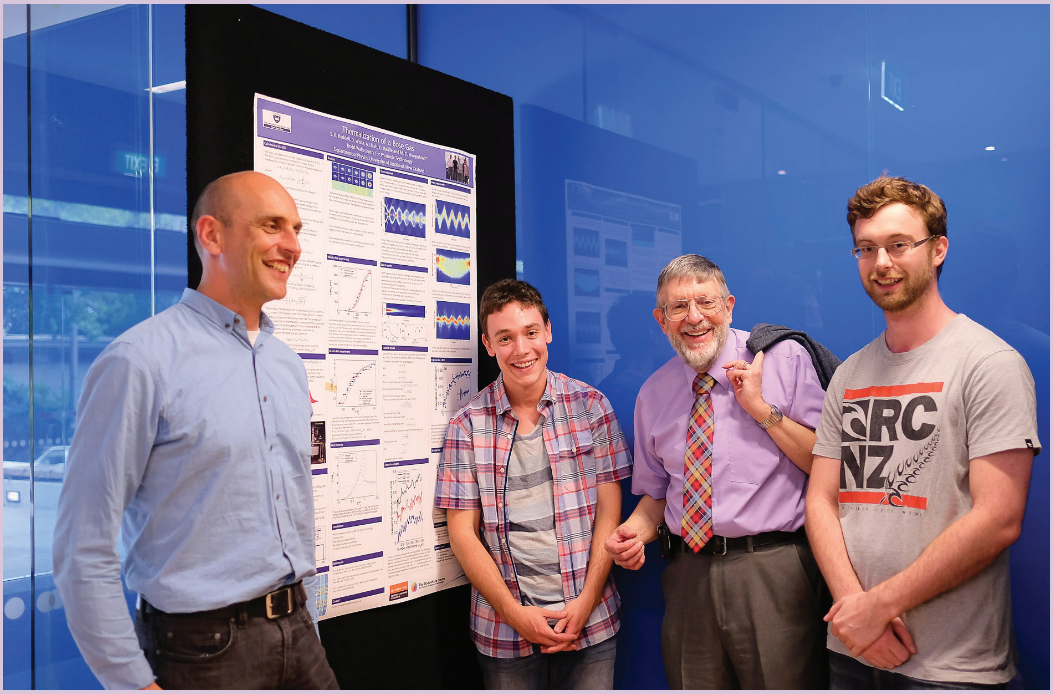
A World-Leading Quantum Collaboration

At The University of Auckland, a team of Dodd-Walls Centre researchers are developing a unique way solve one of the major barriers facing the global quantum computing effort: how to transport quantum information from one place to another.

One of the major limitations of today's most advanced quantum computers is that they only operate at exceedingly low temperatures (colder than deep space) and in complete isolation from background interactions. As soon as the quantum information leaves this pristine environment it is destroyed, which makes communication virtually impossible. Around the world, researchers have long been searching for a way to convert stored quantum information into light. In this form it could be transported through fibre optic cables, just like ordinary data are today sent through the internet.

The University of Auckland team has succeeded in doing this. Their approach is based on the same fibre optic cables used in the internet. Normally these fibres are about the width of a human hair. But the team stretches them until they are thinner than the wavelength of light. Then, when laser light is sent through them, some of it leaks out the side. In the area surrounding the fibre, ultra-cold atoms are suspended in a vacuum. As light pass by, the atoms on the outside respond, singing in tune. In this way the team have managed to communicate information between individual atoms and individual photons of light.



Discussing quantum information and computing with 1997 Nobel Prize winner Bill Phillips *(centre right)*. Professor Phillips is on the Dodd-Walls Centre's International Science Advisory Board. Also photographed are Principal Investigator Maarten Hoogerland *(far left)* and Dodd-Walls Centre Ph.D. students Sam Ruddell *(centre left)* and Donald White *(far right)*.

Their success is a stepping stone towards a new type of quantum computing network where the individual components (qubits) would be atoms that communicate using light through fibre-optic cables.

Last year the team published their results in *Optica*, a prominent optics publication. Since then Principal Investigator Maarten Hoogerland, has given talks in Austria, Japan, Italy and The Netherlands with enthusiastic responses.

The project is a collaboration between three Principal Investigators within the Dodd-Walls Centre: Maarten Hoogerland, Stuart Murdoch and Scott Parkins. Their unique combination of expertise epitomizes the kind of collaborations made possible by the CoRE. Maarten's speciality is cold atoms. Stuart is an expert in fibre-optics and has the skills to make the tapered fibres. Scott is a quantum theoretical whizz with an interest in how photons and cold atoms interact. Together they are a formidable team.

"None of this would have happened without the Dodd-Walls Centre being there," said Maarten. "They had funding for my Ph.D. student to work on the project and they purchased some of the equipment that was used. In New Zealand it is sometimes difficult to find money to fund a good idea. But because there is funding within the Dodd-Walls Centre it means that when someone has a good idea we can actually make it happen."

New Zealand is a long way from most other countries so it makes sense to specialise in better, faster more secure modes of connecting and communicating. At the University of Otago, Dodd-Walls Centre Principal Investigators are developing two world-leading solutions to the problem of communicating between microwave circuit-based quantum computers.

Harald Schwefel is a world-leading expert in converting light and other electromagnetic radiation from one frequency to another using high quality resonators made of thin discs of crystal. He has developed a way to mix single microwave photons together with photons of visible light to produce visible photons that contain the same quantum information and can be communicated via optical telecommunication fibre. This method has demonstrated greater efficiency than any other fast conversion process.

Jevon Longdell is fine-tuning a method for converting single microwave photons into photons of visible light by using a different type of crystal that has rare earth ions embedded within it. These tiny ions have electronic properties that enable them to absorb photons of microwave energy and emit photons of visible light. Jevon's method, once perfected, will be of high efficiency and be very fast. The technology also has the possibility to act as quantum memory.

DODD-WALLS CENTRE
for Photonic and Quantum Technologies

www.doddwalls.ac.nz
dwc@otago.ac.nz
+64 (0)3 479 7973

May 2018