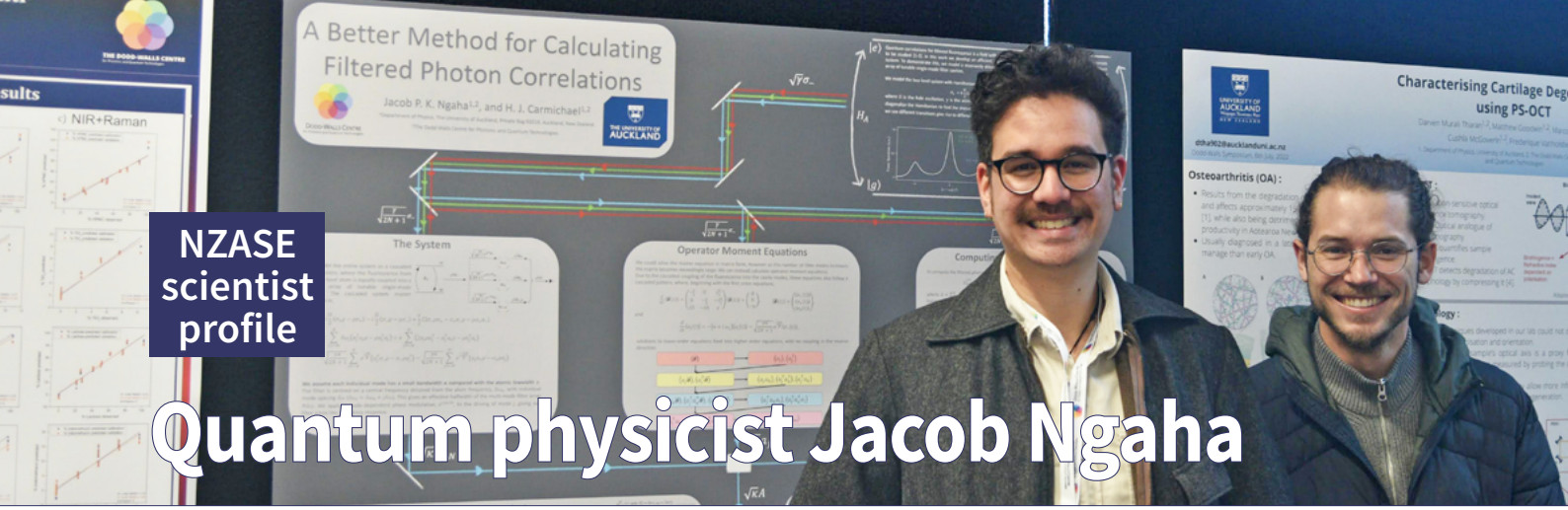



NZASE scientist profile

# Quantum physicist Jacob Ngaha

*Jacob, left, with fellow PhD student Geraud Arencibia in front of their research posters at a 2022 Dodd-Walls Symposium. Photo: Yourong Wang.*

## Born

Tāmaki Makaurau/Auckland, 1985.

## Affiliations

Ngāti Maniapoto, Ngāti Kahu, and Waikato Tainui.

## School and subjects

Rosmini College: "I did Science, Physics, Maths – I wasn't particularly great at Maths. I did Te Reo only in Year 9".

## How he got into science

"I watched the *Cosmos* series by Carl Sagan in Year 12, got really into astronomy, cosmology and the universe, and shot off in another direction.

"I had originally planned to study history at uni; I combined a degree in Ancient Greek History and Physics, but ended up finishing a science degree in Physics and Maths."

## Training and jobs

**BSc**, 2016; **BSc Hons**, 2017; **Master's of Science** in Physics, 2019, all at the University of Auckland (UoA). Jacob's PhD oral exam will be held in September and he already has a UoA post-doctoral fellowship. Jacob also studies te reo Māori at Te Wānanga o Aotearoa, gaining **Certificates** in Levels 1-4 in 2021, and a **Diploma** in Level 5 in 2022.

In his studies he has learnt several computer languates: LaTeX for writing maths and physics; Fortran, "a very fast, older language usually used in simulations; Python, a popular programming language for data processing simulations and images; and data analysis tools, like uncertainty calculations of trend lines."

## Field of science

Quantum optics, a branch of physics that studies how light interacts with matter at the tiny scale of individual photons of light and atoms. In quantum physics, photons have properties of both energy particles and waves.

## Research topic

For his Master's, Jacob studied what happens when two photons of light are aimed at an atom. "We were studying the atom at three energy levels; the ground state, an intermediate state, and an excited state.

*Jacob with his dog Attie on a Waiheke Island ride.*

"We aim light at the atom at a resonant frequency, that is, the same frequency as the energy difference between the three states. Two-photon resonance means that the laser frequency is half of the difference between the three states, so the atom needs to absorb two photons at once to reach the next state.

"When we did this, the atom was excited into its highest state, followed by a cascaded decay. We calculated the fluorescence spectrum that it emitted as it decayed and found there were up to seven different peaks, or frequencies of light.

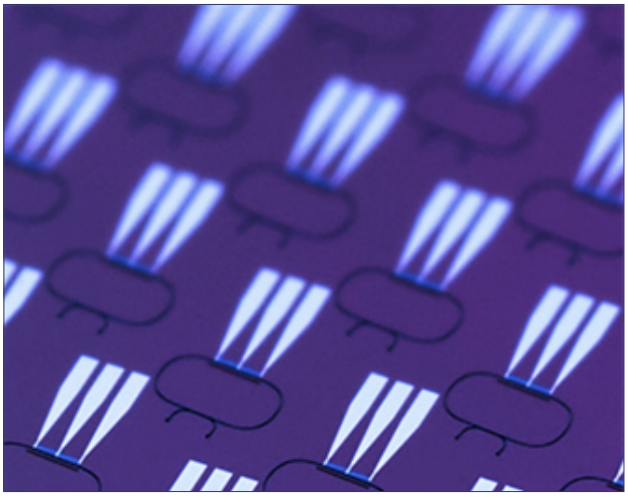
The frequencies are not colours we can see; we can only infer what's happening because we can't examine it in a quantum system."

For his PhD, Jacob developed a computational model that allows researchers to better filter those frequency signals in quantum optics simulations. This is easy to do experimentally, but he wanted to provide a theoretical tool that could do better.

"We've looked at only two simple systems, to prove that it works well. We hope that other scientists will use the filter to explore different systems and other types of atoms."

Isolating how quantum atoms produce beams of single photons in particular frequencies can be applied to build quantum computers, like China's Quantum Science Satellite, and to encode information in computing in a more secure way than conventional methods.

*Optical isolators for two different nanometre wave-lengths, made of lithium niobate at the University of Illinois Urbana-Champaign. Image: Ogulcan Orsel.*



*Jacob with his instructor, Sensei Len Monk, after a practice at Seishin Ryu Karate in Foxton.*

## How he finds things out

"We model quantum systems in maths and computational languages, and use different techniques to understand the dynamics as the system changes. "I find it hard to conceptualise things in maths, but in physics I can imagine and anticipate what we expect to see.

"There are two pathways – analytical and numerical. With analytic methods, the ideal is to derive an equation for your result. But if you can't or don't want to assign a number to any parameter, then it can be too complicated to derive simple equations. We spent three months on maths to derive a nice equation, and the final result took up half a page.

"When systems are that complicated, we use numerical calculations." Jacob and his supervisor booked time on Mahuika, a supercomputer run by the New Zealand eScience Infrastructure (NeSI), where they ran almost 100 calculations of photon trajectories with different parameters at the same time.

## Mātauranga Māori

"Some fields, like environmental science, geology, biology and astronomy, have a good grounding in mātauranga," Jacob says.

"Other fields are quite new for the world in general – quantum mechanics only solidified in the 1930s or so, and quantum optics is still very new. We could only start exploring it when lasers were developed.

"There's not a lot of development of mātauranga Maori about the quantum world. I heard of an interview with a kaumātua in the 1950s after the atomic bomb was dropped, asking about atomic physics. He was able to conceptualise it as atoms splitting into smaller parts, but I haven't been able to find that."

"Mātauranga evolves, and there's still a lot to explore in the interface of quantum physics and mātauranga."

## What he likes about science

"I love exploring things that no one has really looked at before, it's really exciting. Quantum physics is fun – maths plus thinking."

Jacob has often visited schools to talk with students about science. "It's less about teaching and more about showing them cool stuff you can do in physics and chemistry, the applications of science.

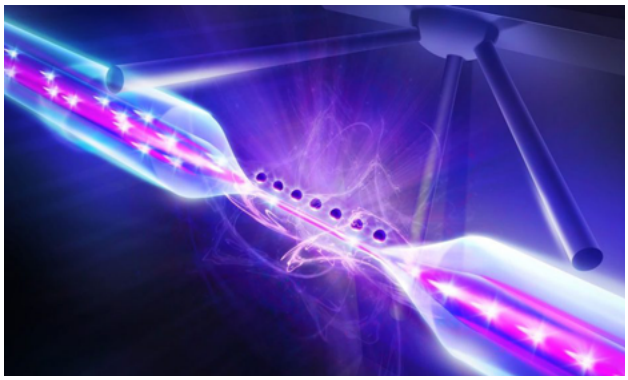
"I used to think that physicists were people who wrote on chalkboards or worked in a lab, but there's lots of different types of work in physics.

"The further you go, the more the science subjects blend together, not like in school where they're separate. Physics is blended with medical applications, or with chemistry – there's lots of merging and overlap. It's exciting."

## Other interests

Jacob plays "old-school Hawai'ian music" on the double bass with a friend on lapsteel guitar. "A lot of prominent players were Māori in the 40s and 50s. We used to play cafes, but not so much this year; we still practise regularly."

He has also practiced karate "since I was six. I'm still doing it every week, and teaching little kids." He has a first level black belt.



*Photons interacting with atoms while they pass through a glass fibre. Image: Humboldt University.*

*Jacob DJs at a friend's wedding.*

## Links


Mārena Mane, July 25, 2023, Aotearoa's first Māori quantum physicist Jacob Ngaha is up and at 'em, *NZ Herald*.

Aroha Awarau, July 15, 2023, Rising star: Quantum physicist Dr Jacob Ngaha, *Radio NZ*.

University of Auckland, 2023, Jacob Ngaha.

Chris Scott, 2019, Understanding the behaviours of light, *NZeScience Infrastructure*.


## Ngā Kupu

**Aho** – Light (radiant); to shine
**Hihi taiaho** – Laser beam
**Matai ahupuna** – Physics (study of)
**Matai ahupuna tataunga** – Quantum physics (study of)
**Matūriki** – Sub-atomic particle
**Ngota** – Atom, particle
**Pūaho** - Photon
**Reo rorohiko** – Computer language
**Taiaho** – Laser
**Tātari raraunga** – Data analysis
**Tīaho** – To emit rays of light, to shine
**Waehere** – Computer code.

*From Paekupu and Te Aka Maori Dictionary*

*All scientist profiles by Science Communicator Jenny Rankine.*