# Quantum Light, Information, Matter and Electronics

## School of Physics and Astronomy

MONASH University

The QLIME group involves both theoretical and experimental research across a range of topics in the quantum sciences.

## 2D Materials & Devices Lab

### Michael Fuhrer

Michael Fuhrer's group works on novel materials just one or a few atoms thick. His lab uses micro- and nano-fabrication techniques to assemble these materials into devices, and studies them with scanning tunneling microscopy (STM) and electronic measurements at low temperatures and high magnetic fields.

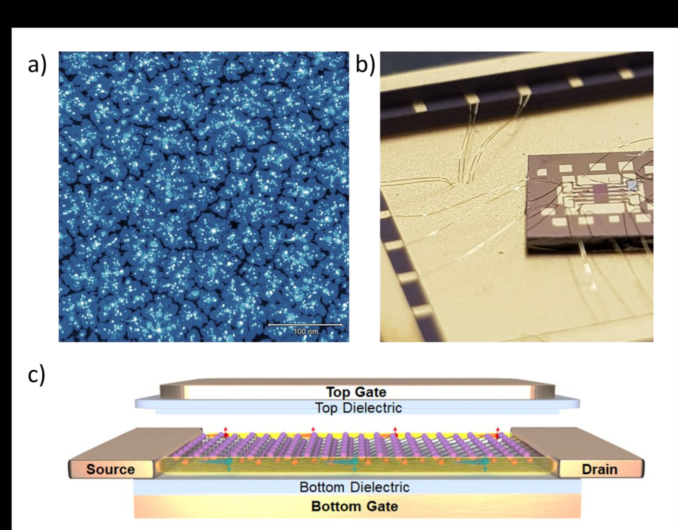



**Figure**: **(a)** STM image of a 2D topological insulator; **(b)** a typical electronic device; and **(c)** schematic of a new topological transistor, which could reduce the energy used by computers.

## Electronic Structure Lab

### Mark Edmonds

Our goal is to synthesize and characterise the electronic properties of new quantum materials that possess exciting properties that can be used in next generation electronics. One of our key experimental techniques is to use Angle-Resolved Photoelectron Spectroscopy (**ARPES**) at various Synchrotrons around the world to directly measure the electronic bandstructure

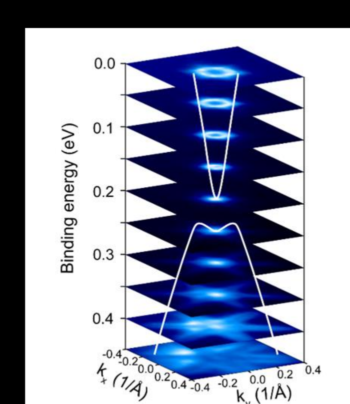
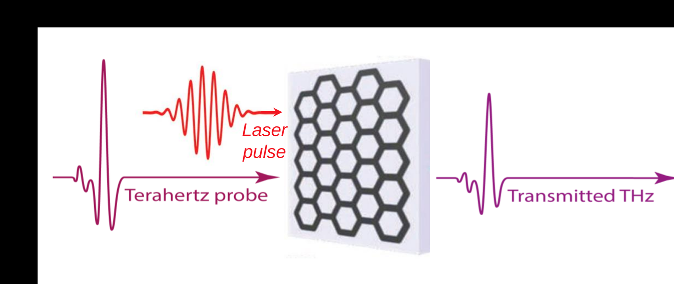



**Figure**: ARPES allows the direct measurement of electronic bandstructure, including the band gap as well as a visualization of the hexagonal warping (snowflake-like cross sections) that occurs in topological materials.

## Solid-state & Surface Nanophysics Lab

### Agustin Schiffrin

Our goal is to engineer functional low-dimensional materials with atomic-scale precision, and to probe and control them with methods such as time-resolved optical spectroscopies.



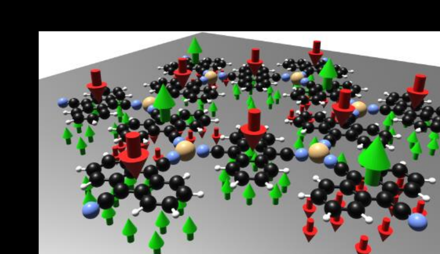



**Figure**: Ultrafast optical control of electrons in 2D materials (top); and an example of a 2D Kagome geometry in metal-organic nanostructures (bottom)

## Nanophotonics Lab

### Haoran Ren & Stefan Maier

Our nanophotonics research aims to develop advanced optical materials and nanotechnology to unlock the full potential of light for optical and quantum information processing, imaging, communications, displays, sensing, and energy conversion.

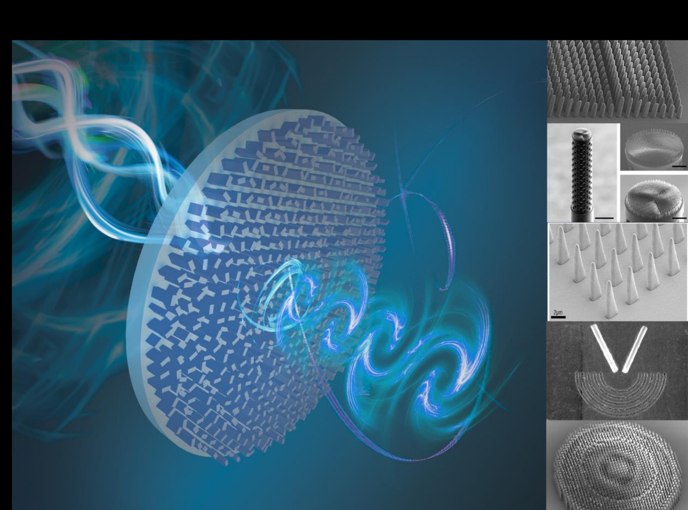
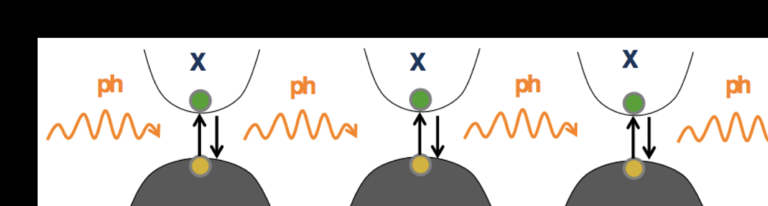


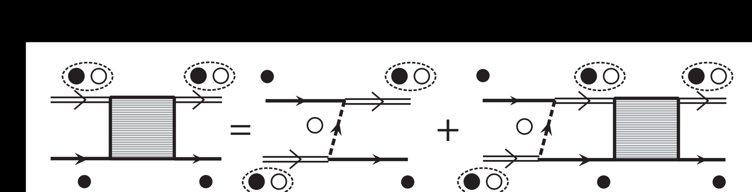
**Figure**: An ultrathin metasurface that deals with structured light modes, which is one of our key foci in nanophotonics research

## Theory of Quantum Matter

### Meera Parish (Head of QLIME)

Parish's research aims to provide a deeper understanding of quantum many-body systems across a range of different platforms, including electronic devices, atomic gases, and hybrid light-matter systems (pictured right).



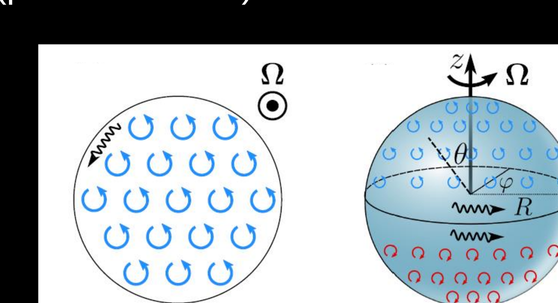



### Jesper Levinsen

Levinsen's research lies at the interface between quantum gases and condensed matter physics. His key focus is the interplay between few- and many-body physics in strongly interacting quantum systems, and this requires a range of techniques such as Feynman diagrams (pictured above).

### Dmitry Efimkin

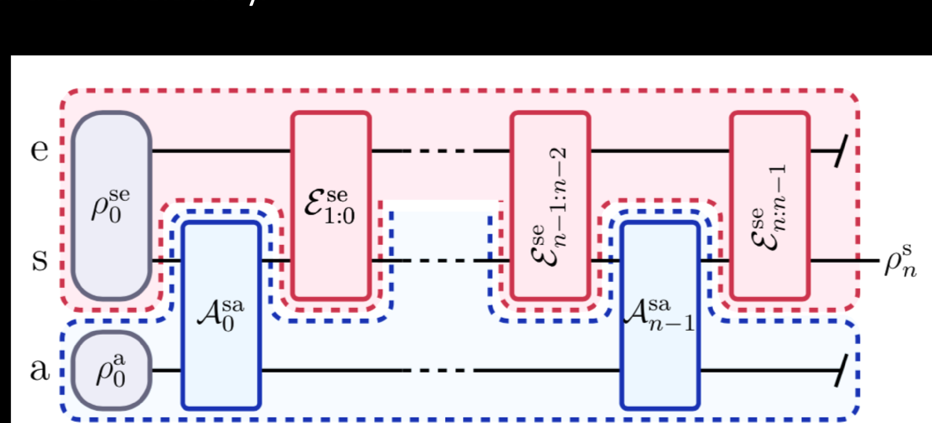
Efimkin's theory group works on novel and exotic materials in condensed matter physics and ultracold atomic gases, with a focus on unconventional superfluids, unconventional magnetism, and "topological matter" beyond electronic systems (pictured below)




## Quantum Information

### Kavan Modi

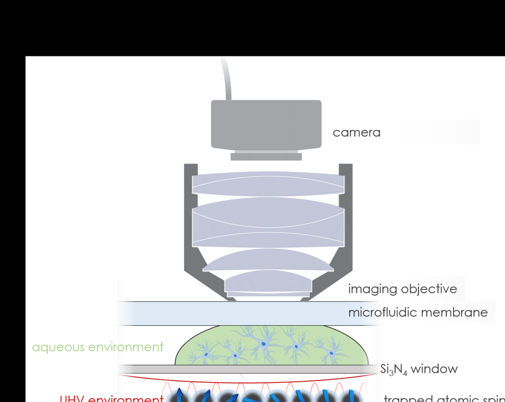
Modi's research focuses on several related areas of quantum physics. The group uses the tools of **quantum information theory** to understand and characterise quantum dynamics, metrology, computation, thermodynamics (quantum batteries and engines), and even relativity.

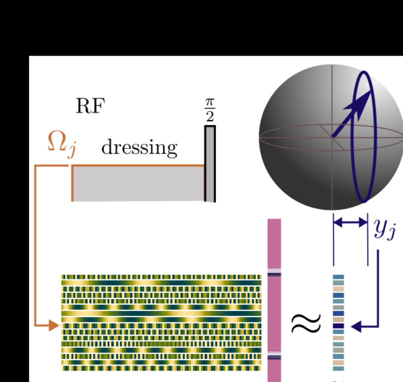



## Spinor BEC Lab

### Lincoln Turner

Turner's research group creates quantum sensors optimised for sensing real-world signals. We focus on biological and biochemical applications, where weak magnetic fields emanating from cellular-scale sources require microscopic quantum sensors to detect them. We are developing quantum signal processors based on ultracold atoms, programmed to detect biomagnetic signals under real-world conditions.




## Quantum Engineering Lab

### Kris Helmerson & Michael Barson

The quantum engineering lab is engaged in both fundamental and applied research in exploiting the quantum aspect of both ultracold atomic gases and the electron spin of defects in diamond to realise floquet topological behaviour and wide-bandwidth AC magnetometry, respectively, for future applications and devices.