



FLEET

ARC CENTRE OF EXCELLENCE  
FUTURE LOW-ENERGY  
ELECTRONICS TECHNOLOGY

# Novel Approaches to Low Energy Electronics

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Physics in Industry Day

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Australian Government  
Australian Research Council



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ARC CENTRE OF EXCELLENCE IN  
FUTURE LOW-ENERGY  
ELECTRONICS TECHNOLOGIES



# THE CHALLENGE



growing demand for computing power



Computing is using 8% of world's electricity & doubling every decade

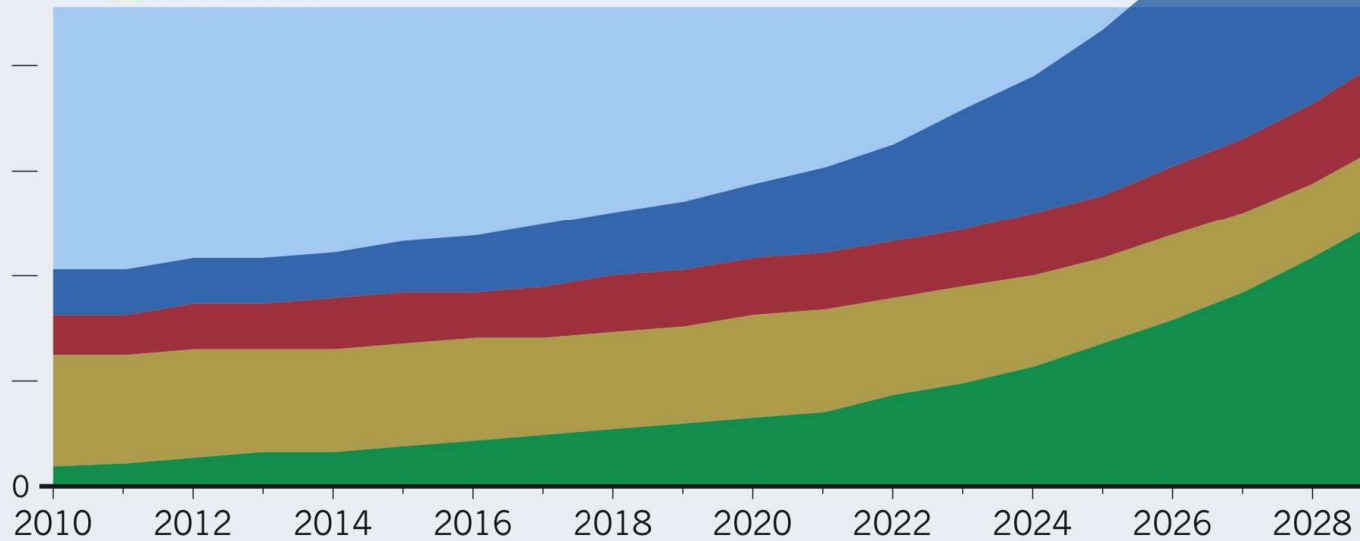
9,000 terawatt hours (TWh)

## ENERGY FORECAST

Widely cited forecasts suggest that the total electricity demand of information and communications technology (ICT) will accelerate in the 2020s, and that data centres will take a larger slice.

20.9% of projected electricity demand

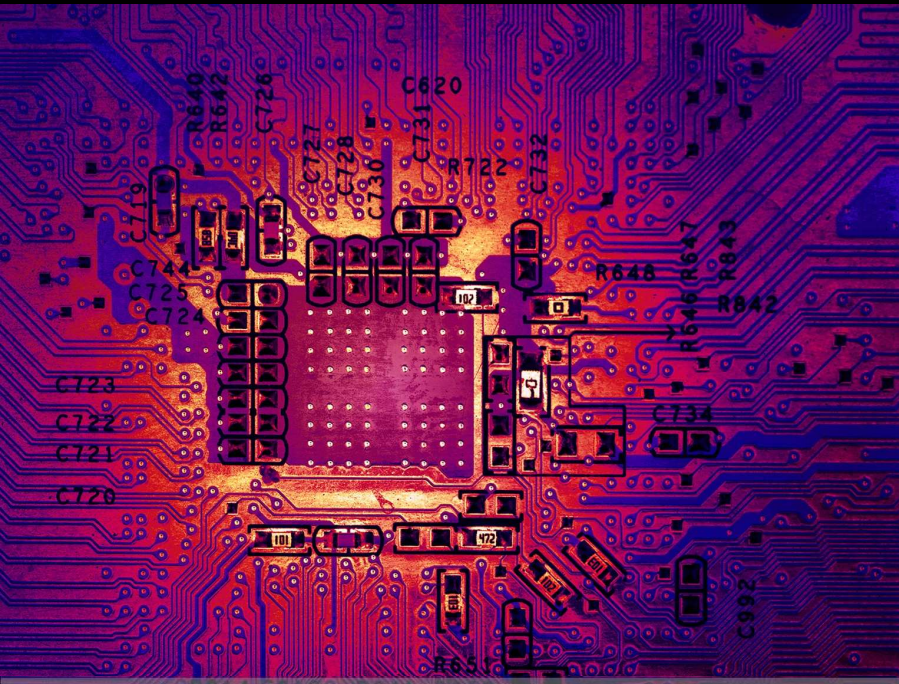
- Networks (wireless and wired)
- Production of ICT
- Consumer devices (televisions, computers, mobile phones)
- Data centres



N.Jones, Nature 561, 163 (2018)  
A. Andrae & T. Edler, Challenges 6, 117–1



# THE CHALLENGE



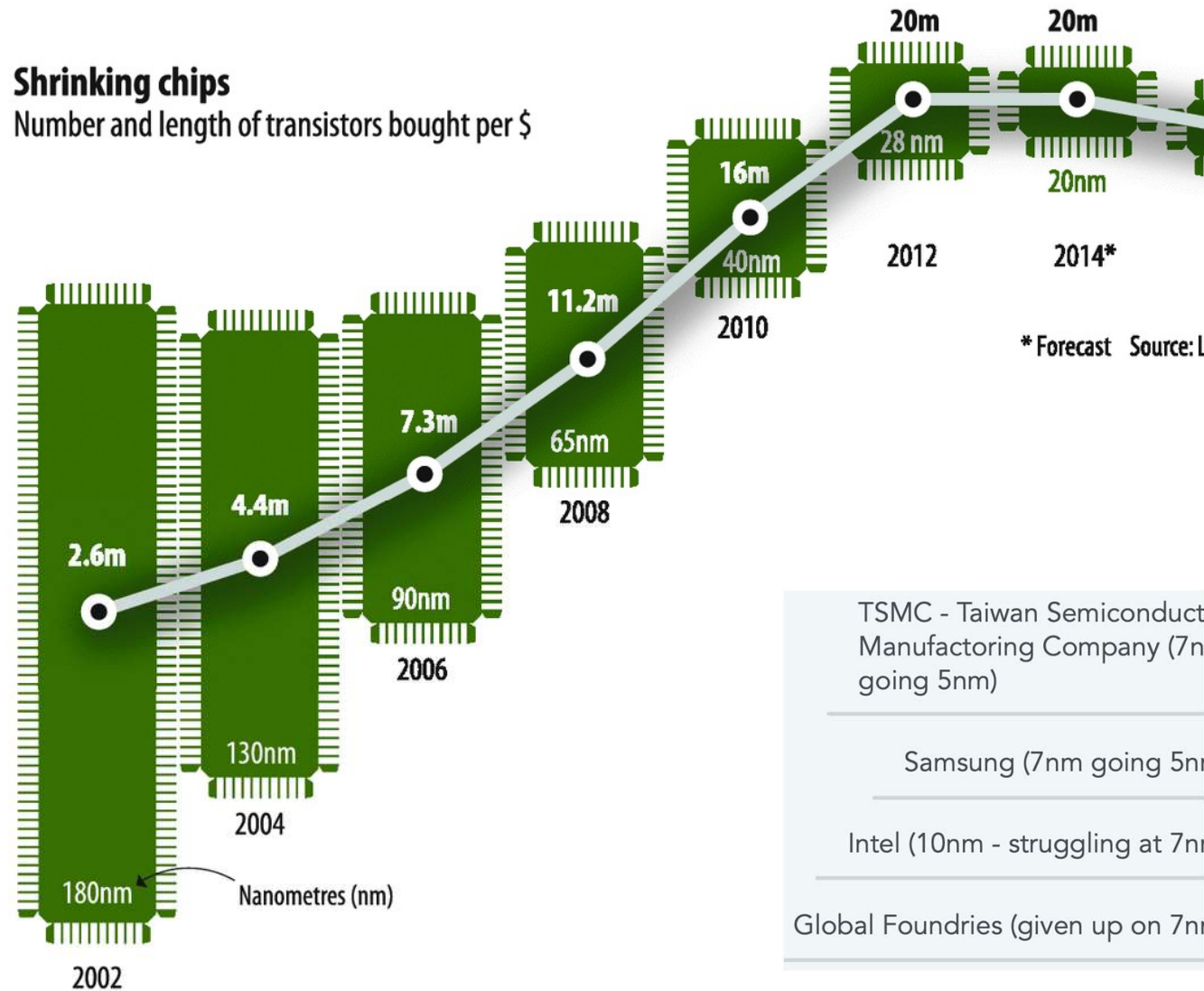
Computing energy loss through heat

10% more computations each year

~40% less energy consumed per computation each year

## Shrinking chips

Number and length of transistors bought per \$



TSMC - Taiwan Semiconductor Manufacturing Company (7nm going 5nm)

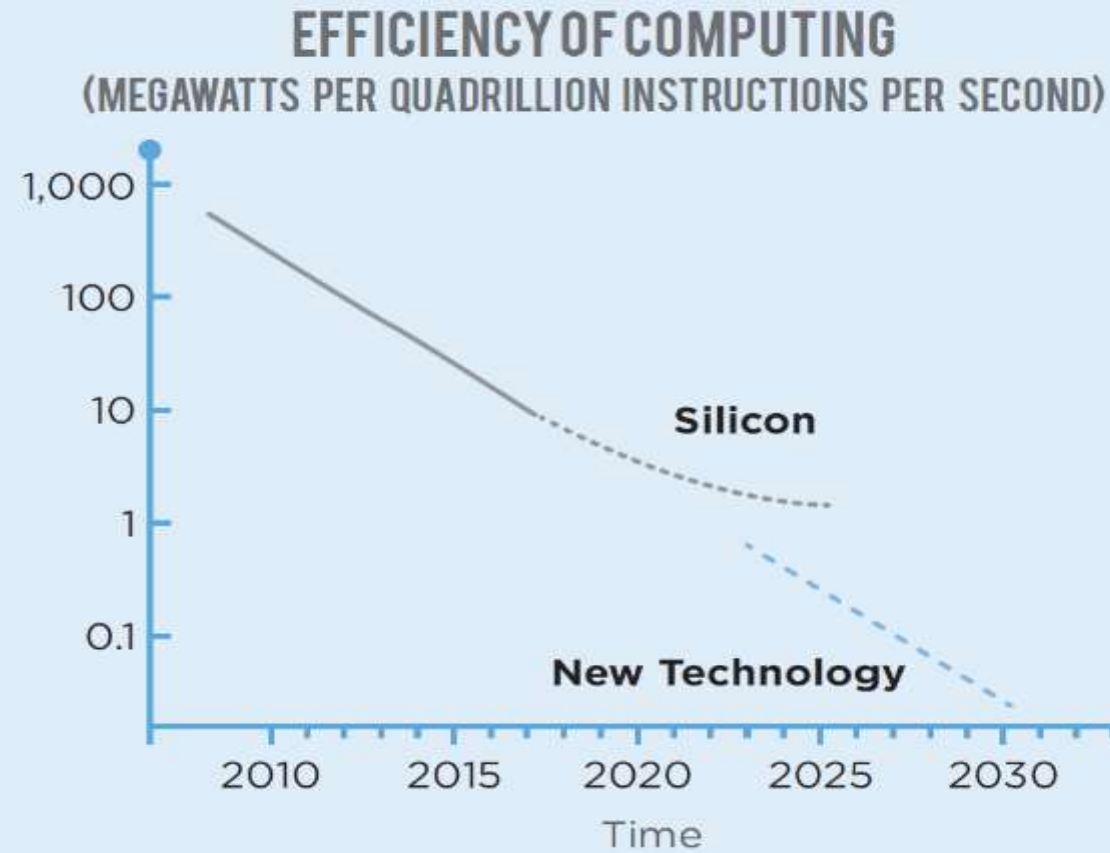
Samsung (7nm going 5nm)

Intel (10nm - struggling at 7nm)

Global Foundries (given up on 7nm)

"No Moore?" The Economist (2013)

# THE OPPORTUNITY



The current, silicon-based technology will stop becoming more efficient in the as Moore's law comes to an end

Reduce the energy used in IT – new electronic devices with vastly lower energy per computation

# ONE GOAL – THREE APPROACHES



Approach 1: **Topological insulators** – electricity only conducts along their edges and strictly in one direction without the back scattering that causes energy to be wasted



Approach 2: **Exciton superfluid** – scattering is prohibited by quantum statistics, so charge carriers can flow without resistance



Approach 3: **Light-transformed materials** – zero-resistance paths for electrical current can be created by forcing matter to adopt a new distinct topological state using light



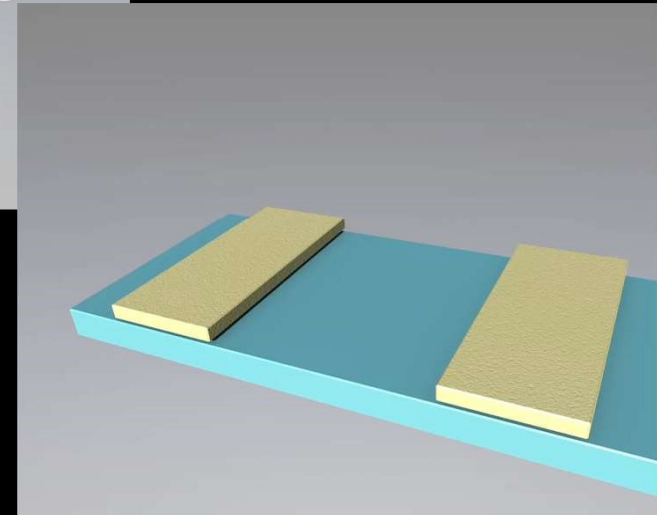
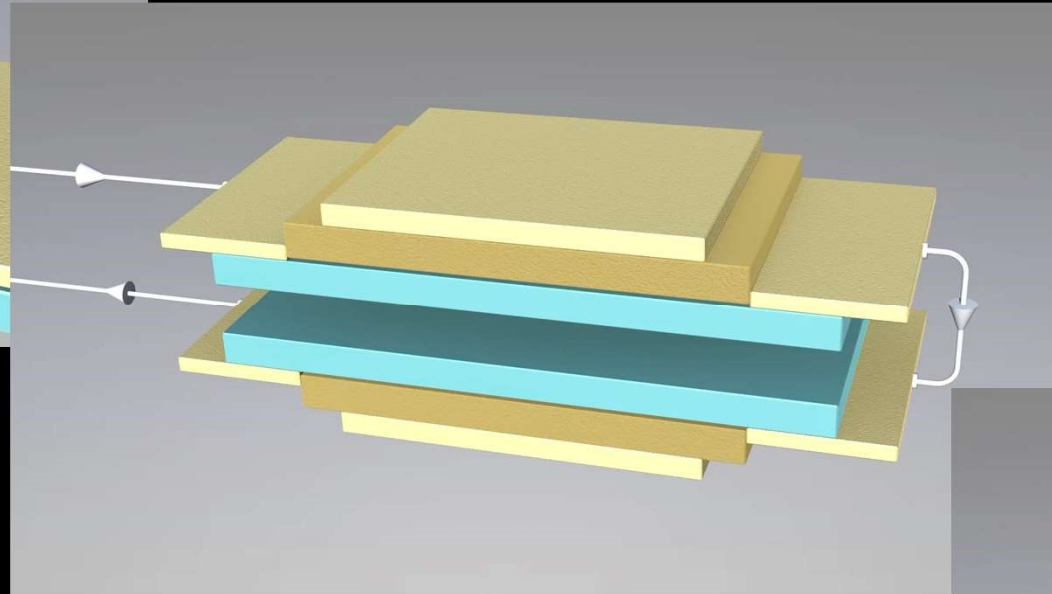
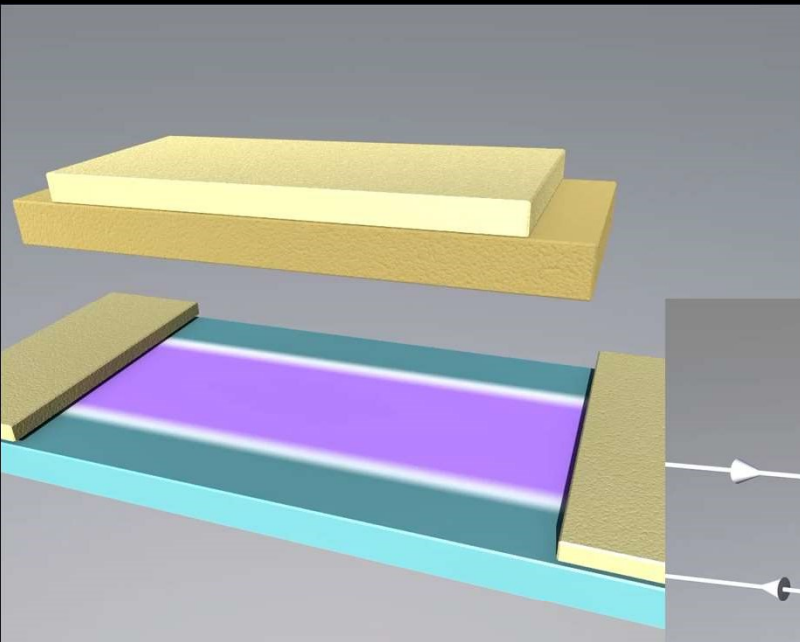
These pathways are enabled by the new science of two-dimensional, **atomically thin materials**

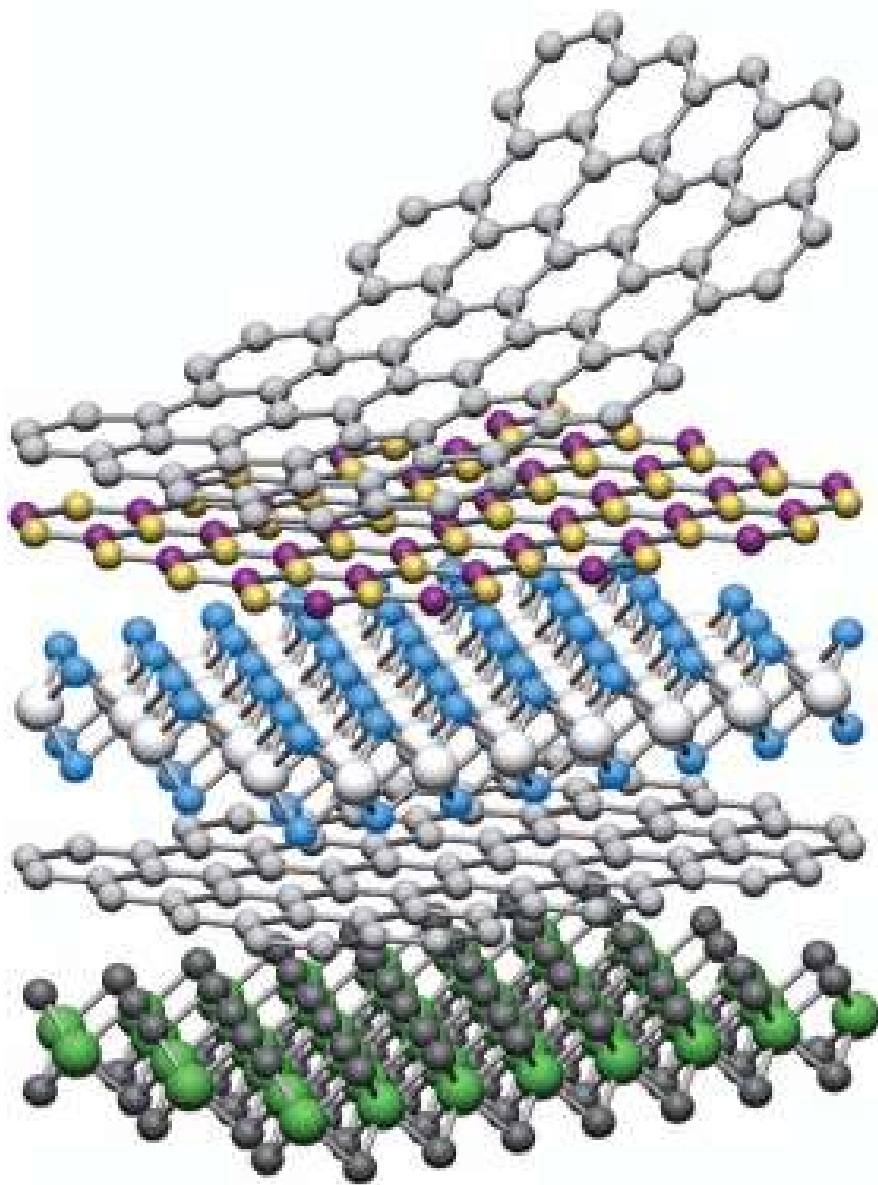












And the global expertise in **nano-fabrication** of functional devices.

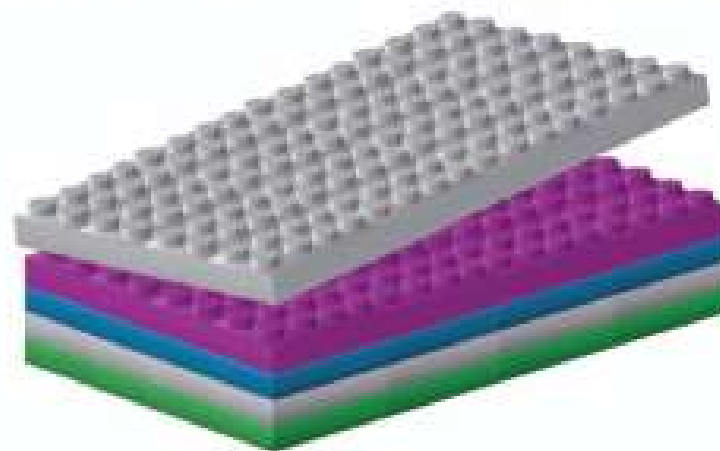


# ONE GOAL – THREE APPROACHES





	Graphene	
	hBN	
	MoS <sub>2</sub>	
	WSe <sub>2</sub>	
	Fluorographene	



Geim, *Nature* (2013)

New science of atomically thin materials





Electricity can flow with near-zero resistance in new materials

New types of electronic conduction without resistance (at room temperature)

# FLEET Leadership and Achievements

World leader in topological field-effect transistors

Demonstration of electric-field tuning of topology

Proved topological transistors can overcome conventional limit to switch at low energy

Filed foundational patents applied for this technology

Topological Insulator Electronics Devices recognized in the 2020 edition of the **IEEE International Roadmap for Devices and Systems**

World leader in devices for room-temperature exciton-polariton dissipationless transport

First observation of room-temperature dissipationless flow of exciton-polaritons over 10s of microns in 2D semiconductors

First viable path to large-area devices:

- Liquid metal synthesis of 2D  $\text{Ga}_2\text{O}_3$  on liquid Ga. First large-area passivation layer for 2D semiconductors

- **Spin-off company (LM Plus)** to develop liquid-metal synthesis techniques

World leading interdisciplinary collaboration in non-equilibrium condensed matter

Built unique collaborative network with expertise in atomic condensates, exciton-polaritons, and topological electronic systems

Key to understand prospects for ultrafast (>THz) switching – science is almost completely unexplored

New capacity in Australia for study of electron, exciton, and atomic systems from equilibrium at ultrafast time scales

Probed collective "negative temperature" nonequilibrium states of atomic condensates

- Energy consumption by electronics is a pressing problem
- Low energy electronics require novel materials and devices



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# et involved...

an industry challenge partner, mentor or sponsor

Collaborate with some of Australia's top researchers working on cutting-edge technologies

Have your industry challenge tackled by multiple teams of innovative researchers over a

two-day, in-person hackathon event

Gain fresh, scientific perspectives on challenges and emerging technologies

Build networks with innovative researchers from five ARC Centres of Excellence

on open

2-day in person  
Hackathon event

Shortlisted teams develop  
their ideas

23  
OV

2024  
FEB

2024  
MARCH

2024  
APR-MAY

2024  
MAY

Challenges announced  
Teams formed

1 team per  
Challenge Partner  
shortlisted

Final showcase and  
awards event

## BETTER FUTURES INNOVATION CHALLENGE

*A Science Meets Industry Hackathon*

Supported by the Australian Research Council Centres of Excellence

Australian Government  
Australian Research Council

exciton  
science

OzGrav  
ARC Centre of Excellence for Gravitational Wave Discovery

TMOS

FLEET  
ARC Centre of Excellence for Future Low-Emission and Efficient Transport

EQUS  
ARC Centre of Excellence for Equine and Human Performance

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