SYMPOSIUM
PEACE AND
SECURITY IN
A QUANTUM AGE

Panelist Presentations

Quantum Moment

Michael Biercuk
Quantum Control Lab, University of Sydney

Title
The new quantum revolution

Abstract
My talk will introduce the basic premises of quantum mechanics as well as modern research seeking to apply systems obeying the laws of quantum physics to tasks in sensing, communications, and computation. I'll describe my own research using individual trapped atoms and describe how we are learning to exploit the most exotic quantum phenomena as resources powering new quantum technologies. With impacts of these technologies ranging from defence to finance I'll highlight key questions:

What is so unique about the opportunities provided by current research in quantum physics? Why are governments and private sector organizations ramping up investments? What are the ramifications of winning – or losing – this global technological race?

Shohini Ghose
Wilfrid Laurier University, Canada

Title
Quantum Diversity

Abstract
From atomic structure, to the composition of stars, to teleportation, quantum physics has led to amazing discoveries and modern technologies, and is transforming the way we think and act. This presentation will discuss my explorations of the invisible quantum world and the surprising lessons I have learned about physics and about being a physicist.

How does quantum physics relate to diversity? Why should we care?
What will social equality mean in the quantum age?

Bentley B. Allan
Johns Hopkins University

Title
Quantum Cosmologies and the Future of International Order

Abstract
This paper will place the possibility of a quantum moment in international politics in historical perspective. The last five hundred years of international history

demonstrate that scientific ideas shape international orders by reconfiguring the foundational, cosmological concepts that underlie political discourses. While quantum ideas had limited effects on political discourse in the 20th century, the second quantum revolution raises the prospect of a cosmological shift in 21st international order because it challenges understandings of humanity's place in the universe and reconfigures elements of state power. However, the proliferation of quantum cosmologies and technologies means that the political implications of the quantum depend on which quantum ideas and practices are diffused and institutionalized on a global scale.

What are implications of leading quantum interpretations and technologies for the cosmological basis of political discourses? How do quantum ideas shape beliefs about the origins and character of the universe, the nature of humanity, and humanity's role in the universe?

Why did quantum ideas have limited effects on the discourses underlying international order in the 20th century?

How do quantum technologies introduce practices that reconstitute state power?

Will new quantum technologies or macrophysical phenomena help choose between available quantum interpretations?

Who are the central actors (state agencies, businesses, universities, and civil society organizations) funding quantum research? What kind of quantum science do these actors promote?

What are the links and entanglements between quantum ideas and other dynamic scientific research programs such as the biological and ecological sciences? Are there possibilities for forging discursive connections between quantum and ecological cosmologies that would alter the classical basis of political discourses?

Quantum Matter

Andrew Dzurak
Centre for Quantum Computer Technology,
University of New South Wales

Title
Silicon-based Quantum Computing:
Converting the ubiquitous MOSFET to a quantum bit

Abstract
Quantum information technologies promise to revolutionize the way information is transmitted and processed. These transformational technologies require devices that enable the sensing and manipulation of individual electrons and photons. Spin-based quantum bits (or qubits) in silicon are excellent candidates for scalable quantum information processing due to the very long spin coherence times that are accessible in silicon and because of the enormous investment to date in silicon MOS technology [1].

While our Australian effort in Si QC has largely focused on spin qubits based upon phosphorus dopant atoms implanted in Si [2], we are also exploring spin qubits based on single electrons confined in SiMOS quantum dots [3]. In isotopically enriched Si-28 these SiMOS qubits have a control fidelity of 99.6% [3], consistent with that required

for fault-tolerant QC. Most recently we have coupled two SiMOS qubits to realize the world's first two-qubit logic gate in silicon [4]. I will conclude by discussing the prospects for scalability of this technology using traditional CMOS manufacturing.

[1] D.D. Awschalom et al., *Science* 339, 1174 (2013).
[2] J.J. Pla et al., *Nature* 489, 541 (2012).
[3] M. Veldhorst et al., *Nature Nanotechnology* 9, 981 (2014).
[4] M. Veldhorst et al., *Nature* 526, 410 (2015).

Chao-yang Lu
University of Science and Technology of China

Title
Creating perfect single photons for multi-photon experiments

Abstract
Self-assembled quantum dots (QD) are promising single-photon emitters with high quantum efficiency and fast decay rate. In the past decades, extensive efforts have been devoted to producing single photons with high purity, near-unity indistinguishability [1], and high extraction efficiency. These key properties have been compatibly combined simultaneously on the same QD-micropillar very recently [2,3]. An important next challenge is to extend the single-photon sources to multiple photonic qubits [4], as required by various quantum information protocols such as boson sampling, quantum teleportation [5], and quantum computation. To this end, by pulsed s-shell resonant excitation of a single QD-micropillar, we generate long streams of thousands of single photons with high mutual indistinguishability [6]. Interference of two photons are measured as a function of their emission time separation varying from 13 ns to 14.7 us, where the visibility slightly drops from 95.9% to a plateau of 91.8% through a slow dephasing process occurring at time scale of sub-microsecond. Such an efficient and highly indistinguishable single-photon source allowed scalable multi-photon Boson sampling experiments with a performance beating the best parametric down-conversion sources. [1] Y.-M. He et al. Nature Nanotechnology 8, 213 (2013). [2] X. Ding et al. Phys. Rev. Lett. 116, 020401 (2016). [3] N. Somaschi et al., arXiv:1510.06499 [4] J.-W. Pan et al. Rev. Mod. Phys 84, 777 (2012). [5] X.-L. Wang et al. Nature 518, 516 (2015). [6] H. Wang et al. in preparation (2016).

Stephen Barlett
University of Sydney

Title
Physics and information in quantum matter: Letting the cat out of the box

Abstract
Scientists and engineers developing quantum technologies aim to expand the quantum world into our everyday lives, and to exploit quantum theory's strange rules to our advantage. Experiments that recreate the central message of Schoedinger's cat - existing in an uncertain combination of alive and dead - are now routine. But what can we do with a capability that seems to defy common sense? In pushing quantum rules into the macroscopic realm, we are again forced to confront the central conceptual issues in quantum mechanics: what observable quantum effects are real, and what are simply a manifestation of our limited knowledge? I'll describe how new approaches to understanding "spooky action-at-a-distance" with hidden variables can shed light on this dichotomy, and give new approaches to using quantum physics in the macroscopic world.

Quantum Matter

Anirban Bandyopadhyay
National Institute for Materials Science,
Tsukuba Japan

Title
Threat is not where you think, but where you are certain, feel secured

Abstract
I will give a brief summary of three research glimpses carried out in our lab, one on the molecular robot, that is programmable, and how it kills cancer cells and beta plaques of Alzheimers. Secondly, I will give a brief on the communication of live neuron cells in a 2D and 3D neuron culture plate to argue absurdity of existing AI, thirdly, I would suggest a new human brain model that we are building for a futuristic human like robots, and why I think "weakness is embedded part of any AI supremacy". These three fundamentals have caused lots of hue and cry among the scientific community on the destruction of human civilization, I think those who are spreading the fear are like astrologers who market fear for their personal business. I will outline my three concerns that look very innocent but can wipe out the human race, I would point out one by one how innocent looking things around us are the reasons to fear, not which we humans have predefined as threats to civilization. In summary, all threats marketed in the world of science originates from Si-Fi fiction movies created by some who does not have any clue how science would reshape human civilization in the coming years. Those who are intelligent more than humans will not come with big guns and big machines, they will change the environment around you to let you think the way they want, that's where the threat is.

Are we humans intelligent enough to perceive threats that a superintelligent being would dawn on us? Do you think an intelligent system will ever bring primitive guns & nukes to make us slave as shown in Si-Fi movies?

Andrew Duggins
Sydney Medical School, University of Sydney

Title
The One-mind, Many-brain Paradox

Abstract
If we regard neuronal membrane polarisation and depolarisation as local manifestations of different brain states, yet associate a mixture of these neuronal states with the same mental state (for example, if we take the instantaneous firing rate to be the neural correlate of consciousness), then we are obliged to regard consciousness as a property of a statistical ensemble of brain states, only one of which exists at a moment in time. A similar quandary exists in statistical mechanics. We may take the classical view that a gas exists in a definite state at a moment in time, reflecting definite trajectories of all the gas particles. Yet it is the entropy of the system, usually regarded as a measure of our uncertainty about which one of these macroscopically indistinguishable states actually exists, that captures the thermodynamical properties of the gas. Recent work shows that the probability-weighted mixture of states that characterises a thermalised system can equally well be regarded as the local reduction of a pure state of the universe. I will argue that one might just as well derive neuronal firing probabilities from a mixed neural state that is the local reduction of a definite pure mental state, as regard these probabilities as a manifestation of lack of knowledge about of the actual state of the brain.

The brain is such a multipartite and anatomically distributed system, in which the stream of unified consciousness is driven by transition events in neuronal components. Could a single spike, and the chemical synaptic transmission that results, be modeled as a continuous interaction between an efferent and afferent neuron?

At the click of a Geiger counter, an observer infers that a nearby Americium-74 nucleus has decayed to Neptunium-72, emitting an alpha particle.

1) Is it true that both before and after this nuclear transmutation, the universe is in a coherent superposition of states of parent and of daughter radionuclide?

2) Does the state vector of the universe move smoothly and continuously through Hilbert space over the lifetime of the radionuclide from the parent to daughter eigenspace, a decay that had appeared spontaneous and random actually generated by the time-independent interaction between nucleus and its immediate environment?

3) Could other apparently discrete spontaneous events arising in the natural world be generated similarly? (This would be particularly plausible where transition events in subsystems were known to correlate with the state and smooth trajectory of a spatially distributed system of which subsystems were all part).

Johnjoe McFadden
University of Surrey

Title
Life on the Edge: the new science of quantum biology

Abstract
Life is the most extraordinary phenomenon in the known universe; but how does it work? It is remarkable that in this age of cloning and even synthetic biology, nobody has ever made anything living entirely out of dead material. Life remains the only way to make life. Are we missing a vital ingredient in its creation? In this talk I will shift the focus of understanding life from cells or biomolecules to the fundamental particles that drive life's dynamics. From this new perspective, life makes more sense as its missing ingredient is revealed to be quantum mechanics and the strange phenomena that lie at the heart of this most mysterious of sciences. Ground-breaking experiments show that photosynthesis relies on particles existing in many places at once; whilst other research demonstrates that inside enzymes, those workhorses of life that make every molecule within our cells, particles vanish from one point in space and instantly materialize in another. Birds appear to navigate around the globe by harnessing spooky quantum connections; and the scent of a rose may waft up from the quantum realm. Even our genes are quantum-coded. I will conclude that life, uniquely, navigates a narrow strait between the world we know and the strange and counterintuitive realm of quantum mechanics.

Life lives on the quantum edge.

Quantum Metaphysics

Alexa Meade
Artist

Title
Between Reality and Representation

Abstract
My style of living paintings creates the illusion that a three-dimensional form is but a two-dimensional representation thereof. By painting over surfaces of people and places in a mapping of colors that correspond to what lies directly below each brushstroke, I veil reality in a mask of itself.

The living paintings present contradictory pictures of space and reality, existing in multiple realms at the same time. They are neither completely two-dimensional nor three-dimensional; neither completely real nor representation. They reside in a third category: a quantum-like state of superimposition, seemingly co-habiting multiple dimensions of space and planes of reality.

John Phillip Santos
University of Texas San Antonio

Title
Intimations of Entanglement: Minding Prophetic Memory & Cultural Narrative in Search of Quantum Metaphysics

Abstract
As groundbreaking as the century-old discoveries in quantum science were, as transforming as their new visions of our universe proved to be for physics and cosmology, their impact in the fields of culture, arts and philosophy have been more muted. A host of prophetic writers, artists and thinkers have long pre-figured aspects of a self marked by contradictory features of contingency and exactitude, randomness and serendipity, specific origins and non-locality. Might a proposed metaphysics of the quantum self emerge out of a philosophical immanence that augurs a shape-shifting human agency, shirking boundaries of borders and national cultural identities, boundlessly immediate, unpredictably located, infinitely searchable in a virtual instantaneity and ubiquity, migrating across the planet and beyond, ever deploying to expand the circle of humanity's consciousness?

Christopher A. Fuchs
University of Massachusetts Boston

Title
On Participatory Realism

Abstract
In the *Philosophical Investigations*, Ludwig Wittgenstein wrote, "'I' is not the name of a person, nor 'here' of a place, … But they are connected with names. … [And] it is characteristic of physics not to use these words." One might say this statement expresses the dominant way of thinking in our field: Physics is about the impersonal laws of nature; the "I" never makes an appearance in it. Since the advent of quantum theory, however, there has always been a nagging tug to insert a first-person perspective into the very heart of physics. In incarnations of lesser or greater strength, one may consider the "Copenhagen'" views of Bohr, Heisenberg, and Pauli, the observer-participator view of John Wheeler, the informational interpretation of

Anton Zeilinger and Caslav Brukner, the relational interpretation of Carlo Rovelli, and, most radically, the QBism of David Mermin, Ruediger Schack, and the author. These views have lately been termed “participatory realism” to emphasize that rather than relinquishing the idea of reality (as they are often accused of), they are saying that reality is *more* than any third-person perspective can capture. In this talk, I will expand on this notion from the point of view of QBism.