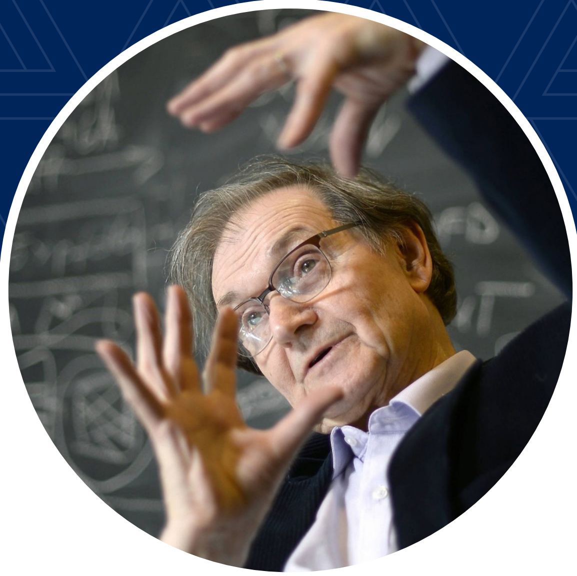


Science &
ROGER PENROSE

Live Webinar - hosted by the Center for Consciousness Studies

August 3 – 6, 2021

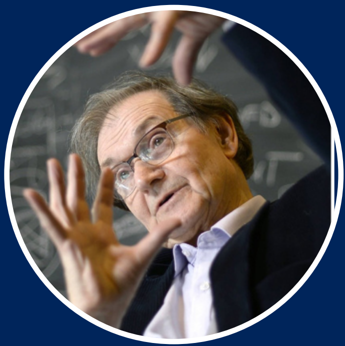
9:00 am – 12:30 pm (MST-Arizona) each day

4 Online Live Sessions

DAY 1
Tuesday August 3, 2021

9:00 am to 12:30 pm MST-Arizona

Overview / Black Holes



SIR ROGER PENROSE *(Nobel Laureate)*

Oxford University, UK

Tuesday August 3, 2021

9:00 am – 10:30 am MST-Arizona

Roger Penrose was born, August 8, 1931 in Colchester Essex UK. He earned a 1st class mathematics degree at University College London; a PhD at Cambridge UK, and became assistant lecturer, Bedford College London, Research Fellow St John's College, Cambridge (now Honorary Fellow), a post-doc at King's College London, NATO Fellow at Princeton, Syracuse, and Cornell Universities, USA. He also served a 1-year appointment at University of Texas, became a Reader then full Professor at Birkbeck College, London, and Rouse Ball Professor of Mathematics, Oxford University (during which he served several 1/2-year periods as Mathematics Professor at Rice University, Houston, Texas). He is now Emeritus Rouse Ball Professor, Fellow, Wadham College, Oxford (now Emeritus Fellow). He has received many awards and honorary degrees, including knighthood, Fellow of the Royal Society and of the US National Academy of Sciences, the De Morgan Medal of London Mathematical Society, the Copley Medal of the Royal Society, the Wolf Prize in mathematics (shared with Stephen Hawking), the Pomeranchuk Prize (Moscow), and one half of the 2020 Nobel Prize in Physics, the other half shared by Reinhard Genzel and Andrea Ghez. He has designed many non-periodic tiling patterns including a large paving at entrance of Andrew Wiles Mathematics Building, Oxford, and the Transbay Center, San Francisco, California.

Sir Roger is widely acclaimed for fundamental advances in understanding the universe. His 2020 Nobel Prize in Physics was bestowed for showing that black holes are robust predictions of Einstein's theory of general relativity. Roger has also proposed a solution to the measurement problem in quantum mechanics ('objective reduction', 'OR'), which he suggests is also the origin of consciousness, leading to a theory of brain function ('orchestrated objective reduction', 'Orch OR'). And Roger's concept of Conformal Cyclic Cosmology ('CCC') posits a serial, eternal universe, with the Big Bang preceded by a previous aeon which had its own Big Bang, that aeon preceded by another and so on. The webinar will cover these 4 major inter-related areas of Roger's work.

Consciousness, Quantum State Reduction, Black Holes, and Conformal Cyclic Cosmology

Roger Penrose

Three lecture courses, attended by me in the early 1950s (not part of my official PhD topic in algebraic geometry) had a profound influence on my later research: Steen, on mathematical logic, Bondi, on general relativity, and Dirac on quantum mechanics. Steen showed, in effect, via Gödel's theorem and Turing Machines, why conscious understanding could not be computational. Bondi conveyed the beauty and over-arching framework of general relativity. Dirac demonstrated the, power and elegance of quantum mechanics for small-scale activity, yet with its underlying conundrum of quantum measurement. Over many years of worrying—and eventually with the key input of microtubules from Hameroff—a plausible picture of how an explanation of a non-computational consciousness might perhaps emerge.

This required a better view of how general relativity would have to fit in with quantum mechanics. A basic question arises from the inevitability of space-time singularities in classical gravitational collapse into what we now call black holes. Yet the quantum measurement issue cannot be divorced from the nature of these singularities, particularly in view of a gross time-asymmetry in relation to the extraordinarily special nature of the big-bang singularity—deeply related to the origin of the 2nd law of thermodynamics. The picture of conformal cyclic cosmology arises as a natural outcome of this line of thinking—a scheme which appears now to be receiving increasing observational support.

REINHARD GENZEL *(Nobel Laureate)*

Max Planck Institute | UC Berkeley

Tuesday August 3, 2021

10:30 am – 11:15 am MST-Arizona

Reinhard Genzel, born 1952 in Bad Homburg v. d. H., Germany, is one of the Directors of Max Planck Institute for Extraterrestrial Physics, Professor in the Graduate School of the University of California, Berkeley and an Honorary Professor at the Ludwig Maximilian University, Munich.
He is a Scientific Member of the Max Planck Society and a member of the US National Academy of Sciences. His research interests include astrophysics of galactic nuclei, star formation, kinematics and cosmic evolution of galaxies, massive black holes and experimental infrared, submillimeter and millimeter astronomy. He has received numerous honours and awards, including the Shaw Prize of The Shaw Prize Foundation and the Crafoord Prize in Astronomy. In 2020, he received the Nobel Prize in Physics, jointly with Andrea Ghez, for the discovery of a supermassive compact object at the centre of our galaxy.

A 40-Year Journey

Reinhard Genzel

More than one hundred years ago, Albert Einstein published his Theory of General Relativity (GR). One year later, Karl Schwarzschild solved the GR equations for a non-rotating, spherical mass distribution; if this mass is sufficiently compact, even light cannot escape from within the so-called event horizon, and there is a mass singularity at the center. The theoretical concept of a 'black hole' was born, and was refined in the next decades by work of Penrose, Wheeler, Kerr, Hawking and many others. First indirect evidence for the existence of such black holes in our Universe came from observations of compact X-ray binaries and distant luminous quasars. I will discuss the forty- year journey, which my colleagues and I have been undertaking to study the mass distribution in the Center of our Milky Way from ever more precise, long term studies of the motions of gas and stars as test particles of the space time. These studies show the existence of a four million solar mass object, which must be a single massive black hole, beyond any reasonable doubt.

ROGER BLANDFORD

Stanford University

Tuesday August 3, 2021
11:15 am – 12:00 noon MST-Arizona

Roger Blandford took his BA, MA and PhD degrees at Cambridge University. Following postdoctoral research at Cambridge, Princeton and Berkeley he took up a faculty position at Caltech in 1976 where he was appointed as the Richard Chace Tolman Professor of Theoretical Astrophysics in 1989. In 2003, He moved to Stanford University to become the first Director of the Kavli Institute for Particle Astrophysics and Cosmology and the Luke Blossom Chair in the School of Humanities and Science. His research interests include black hole astrophysics, cosmology, gravitational lensing, cosmic ray physics and compact stars. He is a Fellow of the Royal Society, the American Academy of Arts and Sciences, the American Physical Society and a Member of the National Academy of Sciences. In 2008-2010, he chaired a two year National Academy of Sciences Decadal Survey of Astronomy and Astrophysics. He was awarded the 1998 Dannie Heineman Prize of the American Astronomical Society, the 2013 Gold Medal of the Royal Astronomical Society, the 2016 Crafoord Prize for Astronomy and the 2020 Shaw Prize for Astronomy. He co-authored with Kip Thorne the textbook Modern Classical Physics.

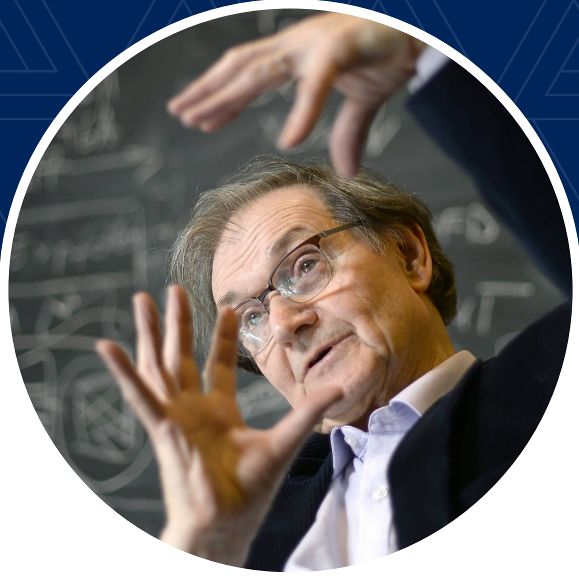
Black Holes - Nature or Nurture?: The Roles of Rotation and Accretion in Powering Cosmic Sources

Roger Blandford

In 1969, Roger Penrose argued that the existence of negative energy orbits of test particles within the ergosphere implies that it is possible to extract rotational energy from a spinning black hole. There is now substantial observational evidence that astrophysical black holes release rotational energy through a related process involving electromagnetic field and that this powers relativistic jets. Recent observations, including those from the Event Horizon Telescope, will be discussed in these terms and it will be argued that black hole spin has an even larger role than usually advertised in powering cosmic sources.

Discussion

12:00 noon – 12:30 pm



Science &
ROGER PENROSE

Live Webinar - hosted by the Center for Consciousness Studies

DAY 2
Wednesday August 4, 2021

9:00 am to 12:30 pm MST-Arizona

QUANTUM MEASUREMENT – OBJECTIVE REDUCTION (OR)

IVETTE FUENTES-GURIDI

University of Southampton, UK

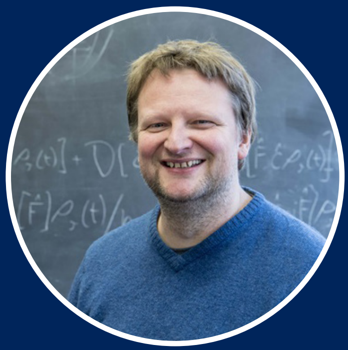
Wednesday August 4, 2021
9:00 am – 9:45 am MST-Arizona

Prof. Ivette Fuentes–Guridi is a theoretical physicist working at the University of Southampton, UK. She has led research in a number of topics, including quantum information, quantum optics, quantum metrology, quantum communications and, in particular, in the overlap of these topics with relativity. She pioneered Relativistic Quantum Information, a field that studies the effects of relativity on the processing of quantum information. Experimentalists have verified her earlier, often controversial, work on photon entanglement during detector free-fall, the generation of multipartite entanglement and quantum gates in superconducting circuits and the effects of the vacuum field on geometric phases. She obtained her PhD at Imperial College, London and has held several prestigious fellowships, including a Career Acceleration Fellowship (EPSRC), a Humboldt Fellowship at TU Berlin and Glasstone, and Junior Research Fellowships at Mansfield College, Oxford.

Exploring the unification of quantum theory and general relativity with a Bose-Einstein condensate

Ivette Fuentes-Guridi

The unification of quantum theory and general relativity remains one of the most important open issues in fundamental physics. A main problem is that we are missing experimental input at scales where quantum and relativistic effects coexist. Developing instruments sensitive at these scales might also help answer other big questions, such as the nature of dark energy and dark matter. In this talk I will show how Bose-Einstein condensates (BECs) could be used to search for clues. A single BEC in a superposition of two locations could test if gravity induces the collapse of the wavefunction. Current experiments involve solids such as mirrors and glass nanobeads. In BECs atoms are not bounded as in solids, producing a variety of quantum states that might present advantages. I will also present a proposal to use Bose-Einstein condensates to access new spacetime scales directly. Applications include detecting gravitational waves at high frequencies, miniaturize devices to measure gravitational fields and gradients and set further constrains on dark energy/matter models.



HENDRIK ULBRICHT

UNIVERSITY OF SOUTHAMPTON, UK

Wednesday August 4, 2021
9:45 am – 10:30 am MST-Arizona

Hendrik Ulbricht is Professor of Physics at University of Southampton. He obtained his undergraduate degree in physics (Dipl.-Phys.) from the Technical University at Berlin (Germany) and the Albert Einstein Institute (Max Planck Institute for Gravitational Physics, Golm) in 2000 with a theoretical work on Black Hole Thermodynamics. He graduated with a PhD (Dr. rer. nat.) from the Free University of Berlin and the Fritz Haber Institute of the Max Planck Society (Germany) in 2003 with a work on experimental surface science in the group of Nobel Laureate Gerhard Ertl (NP in Chemistry 2007). After a postdoc position at Vanderbilt University in Nashville, US on a Max Kade fellowship and as senior postdoc and Assistant Professor at the University of Vienna (Austria), he joined the Department of Physics & Astronomy in 2008 as a Reader and was promoted a personal chair in 2014. He leads the Quantum Nanophysics and Matterwave Interferometry research group. Hendrik is Deputy Head of School for Research & Enterprise at the School of Physics and Astronomy and has served as the head of the Quantum, Light and Matter (QLM) research division at the same school.

Probing new physics by levitated mechanical systems

Hendrik Ulbricht

I will report on our recent progress with experiments with trapped nano- and micro-particles, especially with Meissner-levitated ferromagnets above a type-1 superconductor. We find a system with ultralow mechanical damping showing great potential for sensing tiny forces [1] and, apparently, independent from the standard quantum limit - which holds promise to detect record low magnetic fields and we discuss ideas for a ferromagnetic gyroscope [2], where the precession motional degree of freedom is used to sense tiny magnetic fields. We also discuss how other rotational degrees of freedom can be used for inertial and force detection. We apply force noise measurements to bound collapse models to test the quantum superposition principle in the macroscopic domain of large mass systems [3, 4]. We illustrate ideas to used levitated mechanical systems to probe into gravity interactions leading toward the experimental exploration of the interplay between quantum mechanics and gravity [5]. We also mention ideas to probe into the physics of quantum field theory effects in non-inertial reference frames based on spinning micro-particles [6, 7].

1] Vinante, A., P. Falferi, G. Gasbarri, A. Setter, C. Timberlake, and H. Ulbricht, Ultrahigh mechanical quality factor with Meissner-levitated ferromagnetic microparticles, Phys. Rev. Appl. 13, 064027 (2020) with Editor's Suggestion, and arXiv:1912.12252.

[2] Fadeev, P., C. Timberlake, T. Wang, A. Vinante, Y. B. Band, D. Budker, A. O. Sushkov, H. Ulbricht, and D. F. J. Kimball Ferromagnetic Gyroscopes for Tests of Fundamental Physics, Quantum Sci. Technol. 6, 024006 (2021), and arXiv:2010.08731.

[3] Vinante, A., M. Carlesso, A. Bassi, A. Chiasera, S. Varas, P. Falferi, B. Margesin, R. Mezzena, and H. Ulbricht, Narrowing the parameter space of collapse models with ultracold layered force sensors, Phys. Rev. Lett. 125, 100404 (2020), and arXiv:2002.09782.

[4] Vinante, A., G. Gasbarri, C. Timberlake, M. Toroš, and H. Ulbricht, Testing Dissipative Collapse Models with a Levitated Micromagnet, Phys. Rev. Research 2, 043229 (2020) with Editor's suggestion, and arXiv:2008.06245.

[5] Carlesso, M., A. Bassi, M. Paternostro, and H. Ulbricht, Testing the gravitational field generated by a quantum superposition, New J. Phys. 21 093052 (2019), and arXiv:1906.04513.

6] Braidotti, M. C., A. Vinante, G. Gasbarri, D. Faccio, and H. Ulbricht, Zel'dovich amplification in a superconducting circuit, Phys. Rev. Lett. 125, 140801 (2020), and arXiv:2005.03705.

[7] Lochan, K., H. Ulbricht, A. Vinante, S. K. Goyal, Detecting acceleration-enhanced vacuum fluctuations with atoms inside a cavity, Phys. Rev. Lett. 125, 241301 (2020), and arXiv:1909.09396.

DIRK BOUWMEESTER

UC SANTA BARBARA | LEIDEN UNIVERSITY NL

Wednesday August 4, 2021
10:30 am – 11:15 am MST-Arizona

Dirk Bouwmeester obtained his PhD in 1995 for his experimental and theoretical research on analogue simulations of quantum-mechanical models using optics systems. In 1996 he held a postdoctoral researcher in the group of Prof. R. Penrose at the Mathematical Institute in Oxford where he studied "twisted" solutions of Maxwell's equations. From 1997 to 1999 he was a postdoctoral researcher in the group of Prof. A. Zeilinger at the University of Innsbruck where he performed the first demonstration experiments of quantum teleportation, entanglement swapping and three-particle (Greenberger-Horne-Zeilinger) entanglement. From 1999 to 2001 he established a research group at the University of Oxford at the Centre for Quantum Computation. There he performed first demonstrations of optimal quantum cloning of photon states and of stimulated emission of entangled photons. In this period he also re-established his collaboration with Prof. Penrose. Together they proposed an experiment for generating and testing macroscopic quantum superpositions. In the same period the PI was the main editor (with co-editors A. Ekert and A. Zeilinger) of the Springer book: "The Physics of Quantum Information". Since 2001 Bouwmeester holds a faculty position at the University of California at Santa Barbara (UCSB) where he initiated several new projects at the interface of physics, engineering, and biology. The topics are solid-state cavity quantum electrodynamics, knotted-states of light, gravitational waves and plasma, optical cooling and quantum states of micromechanical systems, and DNA-templated optical emitters. The research makes use of the excellent cleanroom facilities at UCSB. In order to perform ultra low-temperature and ultra-low vibration experiments on some of the samples, Dirk Bouwmeester has a second affiliation to the University of Leiden, specialised in such experiments. In 2014, Dirk Bouwmeester received a Spinoza award (the highest science award in the Netherlands).

An experimental investigation of the reduction of the quantum wavefunction.

Dirk Bouwmeester

An overview will be given of the ongoing experimental efforts towards detecting the reduction of the quantum wavefunction. In particular experiments with optomechanical systems will be presented because such systems are well suited to create quantum superpositions involving large masses. For such experiments it is essential to have a deep understanding of environment induced decoherence and to identify this dynamical process in the experiments. Only after this identification one can make claims about possible additional decoherence mechanisms, perhaps connected to gravitational effects, as proposed by Roger Penrose.

PHILIP C.E. STAMP

UNIVERSITY OF BRITISH COLUMBIA, CANADA

Wednesday August 4, 2021
11:15 am – 12:00 noon MST-Arizona

Philip Stamp has been a professor at the University of British Columbia (UBC), and director of the Pacific Institute for Theoretical Physics at UBC, since 2002; he also holds a visiting position in Theoretical Astrophysics at Caltech. Previously he was joint director (with G. 't Hooft) of the Spinoza Institute in Utrecht. His current research interests include (i) quantum magnetism, decoherence, and quantum information processing, and (ii) theoretical and experimental quantum gravity. In recent years his decoherence work has been applied to superconductors, to insulating, semiconducting, and hybrid quantum optical/solid-state systems, and to quantum Ising systems. The company "d-Wave Systems", the first company in the world to market and sell quantum computers, was founded in Stamp's research group. His recent quantum gravity work has focused on the "Correlated Worldline" theory, and experimental consequences of it; and on decoherence processes and asymptotic properties in conventional quantum gravity.

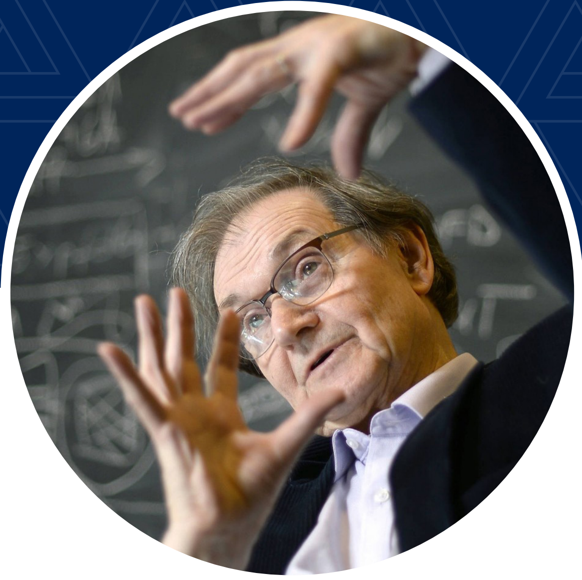
The Correlated Worldline (CWL) Theory of Quantum Gravity

Philip C.E. Stamp

In the Correlated Worldline (CWL) theory, superposition breaks down for sufficiently large rest masses, because of gravitational interactions between paths in a path integral formulation of quantum gravity. The form of these interactions is dictated by the equivalence principle. CWL theory satisfies all known consistency tests (Ward identities, well-defined classical limit, semiclassical and perturbative expansions, etc.); it has no adjustable parameters, and is renormalizable. Measurable departures from quantum mechanics are predicted already for masses ~ picograms, but they are currently obscured by decoherence effects. I will discuss both the theory and possible experiments.

Discussion

12:00 noon – 12:30 pm



Science &
ROGER PENROSE

Live Webinar - hosted by the Center for Consciousness Studies

DAY 3
Thursday August 5, 2021

9:00 am to 12:30 pm MST-Arizona

CONSCIOUSNESS – ORCH OR

9:00 am – 11:15 am

Consciousness – Orch OR

Chair, Justin Riddle, University of North Carolina, Chapel Hill

STUART HAMEROFF, MD

UNIVERSITY OF ARIZONA

Thursday, August 5, 2021

9:00 am – 9:45 am MST-Arizona

Stuart Hameroff MD is a clinical anesthesiologist and researcher on how the brain produces consciousness, and how anesthetics act to erase it. In medical school in the early 1970s, Hameroff became interested in consciousness, and in protein structures called microtubules inside brain neurons which he came to believe processed information supporting consciousness. In the mid- 1990s he teamed with Sir Roger Penrose to develop the controversial 'Orch OR' theory in which consciousness derives from "orchestrated" ("Orch") microtubule quantum vibrations linked to processes in spacetime geometry, the fine scale structure of the universe, leading to "Penrose objective reduction" ("OR", hence "Orch OR"). And he has further proposed the 'microtubule quantum vibration' theory of anesthetic action. Hameroff organizes the well-known conference series 'The Science of Consciousness', has written or edited 5 books and over a hundred scientific articles, and appeared in films and various TV shows about consciousness. With University of Arizona colleagues Jay Sanguinetti, John JB Allen and Shinzen Young, Hameroff is developing transcranial ultrasound ('TUS') for treatment of mental and cognitive dysfunction (TUS may resonate endogenous megahertz vibrations in brain microtubules). Penrose- Hameroff Orch OR is one of a group of major theories of consciousness in the Templeton World Charity Foundation project 'Accelerating Research on Consciousness', and is currently being tested experimentally.

The Orch OR theory of consciousness

Stuart Hameroff

In 1989, Roger Penrose linked the origin of consciousness to 'objective reduction' ('OR'), his proposed solution to the 'measurement problem' in quantum mechanics. OR is a suggested self-collapse of the quantum wavefunction occurring at time $t = \hbar/EG$, where $\hbar$ is the Planck-Dirac constant, and EG is the gravitational self-energy of the superposition, a separation in the fine scale structure of spacetime geometry. Such OR events would occur ubiquitously in the random microenvironment, resulting in disconnected moments of merely 'proto-conscious' experience, metaphorically like the random noise of an orchestra tuning up. For meaningful consciousness, OR would require brain mechanisms to collectively 'orchestrate' ('Orch') quantum computations leading to OR. The Penrose-Hameroff Orch OR theory suggests that self-organizing protein lattice polymers called microtubules inside brain neurons resonate and compute entangled superpositions of electron resonance dipoles (coupled to displacement of their atomic nuclei), resulting in 'orchestrated OR' conscious moments which can interface to, and supervene on neuronal functions (e.g. in dendrites and soma of layer 5 cortical pyramidal neurons). The feasibility of collective quantum states in biology has been viewed skeptically, but evidence supports Orch OR: 1) functional quantum states ('excitons') occur in photosynthesis proteins, 2) self-similar patterns of quantum resonances in microtubules repeat at multiple scales from terahertz to kilohertz, 3) anesthetics which selectively block consciousness appear to act via quantum interactions on microtubules, and 4) computer modeling suggests anesthetics act by dampening microtubule electron resonance dipole terahertz oscillations and superpositions. Further experimental studies to be described in this session are underway to look for excitons, interference and quantum optical effects which could support Orch OR, and test their sensitivity to anesthetics. Correlation of anesthetic potency in dampening quantum processes in microtubules, with their known potency in causing loss of consciousness in humans and animals, would validate the quantum biological aspects of Orch OR.

GREG SCHOLES
PRINCETON UNIVERSITY
Thursday, August 5, 2021
9:45 am – 10:30 am MST-Arizona

Greg Scholes is the William S. Tod Professor of Chemistry and Chair of Department at Princeton University as well as Director of the Energy Frontier Research Center BioLEC (Bio-inspired Light-Escalated Chemistry). Originally from Melbourne, Australia, he later undertook postdoctoral training at Imperial College London and University of California Berkeley. He started his independent career at the University of Toronto (2000-2014) where he was the D.J. LeRoy Distinguished Professor. Dr. Scholes is the Editor-in-Chief of the Journal of Physical Chemistry Letters, Co-Director the Canadian Institute for Advanced Research program Bioinspired Solar Energy, and a Professorial Fellow at the University of Melbourne. Dr. Scholes was elected a Fellow of the Royal Society (London) in 2019 and a Fellow of the Royal Society of Canada in 2009.

Biological quantum phenomena and the brain
Greg Scholes

A big question at the interface of fields is whether "non-trivial" quantum-mechanical phenomena underly function in biology—perhaps even relating to mysteries of how our brains work. I will outline the challenges and issues of the field, then describe some relevant recent studies of microtubules. Microtubules are long, slender cylindrical polymers of the protein α, β- tubulin that play a variety of intracellular roles, from acting as 'railroads' for macromolecular transport to providing mechanical forces for chromosomal segregation and forming cilia and flagella for cell motility. Microtubules bind to anesthetic molecules, provoking questions about the role of this interaction on anesthetic-induced consciousness loss. Anesthetics have been modelled to alter excitonic states within tubulin aromatic amino acids, leading to downstream effects on information processing and consciousness. However, experimental evidence for an exciton-based mechanism of action has remained elusive. New studies in this direction will be reported.

ALYSSON MUOTRI

UC SAN DIEGO

Thursday, August 5, 2021
10:30 am – 11:15 am MST-Arizona

Dr. Alysson Muotri is a professor at the Departments of Pediatrics and Cellular & Molecular Medicine at UC San Diego. He is also the Director of the Stem Cell Program and Archealization Center. Dr. Muotri earned a BSc in Biological Sciences from the State University of Campinas in 1995 and a PhD in Genetics in 2001 from University of Sao Paulo, in Brazil. He moved to the Salk Institute as Pew Latin America Fellow in 2002 for a postdoctoral training in the fields of neuroscience and stem cell biology. His research focuses on brain evolution and modeling neurological diseases using human induced pluripotent stem cells and brain organoids. He has received several awards, including the prestigious NIH Director's New Innovator Award, NARSAD, Emerald Foundation Young Investigator Award, Surugadai Award, Rock Star of Innovation, NIH EUREKA Award, Telly Awards among several others.

Complex neural networks spontaneously emerge from human brain organoids

Alysson Muotri

The complexity of the human brain, with thousands of neuronal types, permits the development of sophisticated behavioral repertoires, such as language, tool use, self-awareness, symbolic thought, cultural learning and consciousness. Understanding what produces complex neural networks during brain development has been a longstanding challenge for neuroscientists and may bring insights into the evolution of human cognition. Human pluripotent stem cells have the ability to differentiate in functional human brain organoids. We developed cortical organoids that spontaneously display periodic and regular oscillatory network events that are dependent on glutamatergic and GABAergic signaling. These nested oscillations exhibit cross-frequency coupling, proposed to coordinate neuronal computation and communication. As evidence of potential network maturation, oscillatory activity subsequently transitioned to more spatiotemporally irregular patterns, capturing features observed in preterm human electroencephalography (EEG). These results show that the development of structured network activity in the human neocortex may follow stable genetic programming, even in the absence of external or subcortical inputs. Our approach provides novel opportunities for investigating and manipulating the role of network activity in the developing human cortex.

JACK TUSZYŃSKI *(Chair, Panel and Discussion)*

UNIVERSITY OF ALBERTA, CANADA

Thursday, August 5, 2021

11:15 am – 11:25 am MST-Arizona (Opening Remarks)

PANEL PHASE

Dr. Jack Tuszyński obtained his PhD in condensed matter physics in 1983 from the University of Calgary. From 1983 to 1988 he was a faculty member at the Department of Physics of the Memorial University of Newfoundland in St. John's. He moved to the University of Alberta in 1988 as an assistant professor, between 1990 to 1993 he was an associate and then full professor at the Department of Physics. As of 2005 he has held the prestigious Allard Chair in Experimental Oncology at the Cross Cancer Institute where he leads an interdisciplinary computational drug discovery group. He is also a Fellow of the National Institute for Nanotechnology of Canada. Dr. Tuszyński held visiting professorship and research positions in China, Germany, France, Israel, Denmark, Belgium and Switzerland. He has published over 500 peer-reviewed journal papers, and 12 books. He delivered almost 400 scientific talks at conferences on five continents, half of which were invited presentations. He submitted 15 reports of invention, 21 patent applications and obtained 4 patents in the USA, South Korea, Japan and Singapore. His research has been supported by over 100 research grants from Canadian, US and European funding agencies. He is on the editorial board of almost 30 international journals including the Journal of Biological Physics. He is an Associate Editor of The Frontiers Collection, Springer-Verlag, Heidelberg. Current affiliations are: Professore Ordinario, DIMEAS, Politecnico di Torino, Allard Endowed Research Chair, Department of Experimental Oncology, University of Alberta. Full Professor, Department of Physics, University of Alberta.

Jack Tuszyński, Chair, Panel & Discussion

Prof. Penrose and Dr. Hameroff have collaborated on the fundamental issues in consciousness research. After more than two decades since its formulation and subsequent refinements by Penrose and Hameroff, the most complete theory of consciousness to date, the so-called Orch OR, is currently being subjected to careful experimental and theoretical scrutiny. Its main assumptions involve the presence of quantum interactions at the level of sub-neuronal protein assemblies, namely microtubules. While it is still not accurately demonstrated where these quantum interactions occur, the current understanding indicates a critical role played by the eight tryptophan residues in each tubulin dimer. The first step on the path to experimental validation of Orch OR is therefore to demonstrate the existence of these quantum effects and their long-range propagation, at least at the scale of a single neuron. The other crucial aspect is a sufficiently enough lifetime of such excitations required to elicit a physiological effect and to overcome thermal decoherence effects. The second conceptual pillar of Orch OR is the so-called spontaneous collapse of the quantum wavefunction due to gravitational self-interactions. In practical terms, it is predicted that the presence of anesthetic molecules will interfere with these quantum effects and provide a direct link between these laboratory investigations and physiological manifestations of consciousness. This panel discussion involving several top experts in the field will delve to the core of these issues and provide updates on both theoretical and experimental advances presently underway, which are aimed to critically examine the foundational aspects of Orch Or.

AARAT KALRA

PRINCETON UNIVERSITY

Thursday, August 5, 2021

11:25 am – 11:35 am MST-Arizona

Dr. Aarat Kalra is a postdoctoral scientist in the Scholes group at Princeton University. He is an expert on microtubules, and works to determine the feasibility of excitonic energy transport within these biological nanowires. Dr. Kalra has previously worked with approaches from both physics and biology to determine the relevance of physical interactions in biological systems. His experiments have shown that the electrostatic behaviour of microtubules is solvent dependent, and can regulate local chemical environment.

Light at the End of the Tunnel: Optical Signaling Through Microtubules

Aarat Kalra

While microtubules have been modelled to act as hotspots for classical and quantum information processing, experimental work distinguishing microtubules from other systems has been elusive. This talk aims to discuss the opportunities and experimental challenges in evaluating the feasibility of optical signaling via microtubules. We review work considering the viability of microtubules as long-range channels for excitonic transport through aromatic amino acids in tubulin. We also discuss optical signaling via microtubules, focusing on reports of microtubule ensembles and their arrays within centrosomes acting as infrared and ultraviolet light-sensors to direct cellular movement based on photonic cues. The feasibility of photonic communication by microtubules will help illustrate the prevalence of optical energy transfer in biology and show if photonics can play a role in information processing in the brain.

TRAVIS CRADDOCK

NOVA SOUTHEASTERN UNIVERSITY

Thursday, August 5, 2021
11:35 am – 11:45 am MST-Arizona

Travis J.A. Craddock, PhD is an Associate Professor in the Departments of Psychology & Neuroscience, Computer Science and Clinical Immunology at Nova Southeastern University. He serves as the Director of the Clinical Systems Biology Group at NSU's Institute for Neuro-Immune Medicine where he applies computational systems biology and biophysics methods towards the purpose of identifying novel treatments and diagnostics for complex chronic illness involving neuroinflammation. Dr. Craddock received his PhD in the field of biophysics at the University of Alberta where his graduate research activities focused on subneural biomolecular information processing, nanoscale neuroscience descriptions of memory consciousness and cognitive dysfunction in neurodegenerative disorders. Current areas of academic focus: Cellular information processes and molecular neuroscience. Biophysics of neuroinflammatory/neurodegenerative diseases: Alzheimer's, Parkinson's, Gulf War illness (GWI) and myaglic encephalomyelitis/chronic fatigue syndrome (ME/CFS). Systems neurobiology; Quantum neurobiology

Fano Resonances in the Resonance Raman Spectra of Tubulin and Microtubules Reveals Active Quantum Effects

Travis J.A. Craddock

Microtubules are self-assembling biological nanotubes made of the protein tubulin that are essential for cell motility, cell architecture, cell division and intracellular trafficking. The unique mechanical properties of microtubules give rise to a high resilience and stiffness due to their quasi-crystalline helical structure. It has been theorized that this hollow molecular nanostructure may function like a quantum wire where optical transitions can take place, where photo-induced changes in microtubule architecture may be mediated via changes in disulfide or peptide bonds or stimulated by photoexcitation of tryptophan, tyrosine or phenylalanine groups, resulting in subtle protein structural changes owing to alterations in aromatic flexibility. Here we present the Raman scattering spectra of microtubules and its constituent protein tubulin in both dry powdered form and in aqueous solution and determine if molecular bond vibrations show active Fano resonances which are indicative of quantum coupling between discrete phonon vibrational states and continuous excitonic many-body spectra.

ARISTIDE DOGARIU

UNIVERSITY OF CENTRAL FLORIDA

Thursday, August 5, 2021
11:45 am – 11:55 am MST-Arizona

Aristide Dogariu received his PhD from Hokkaido University and he is currently University Trustee Chair and Pegasus Professor at CREOL, the College of Optics and Photonics, University of Central Florida. His research interests include optical physics, electrodynamics, wave propagation, and complex media. Professor Dogariu is a Fellow of the Optical Society of America, the Physical Society of America and he is the recipient of the International Society for Optics and Photonics' G. G. Stokes Award.

Experimental and computational insights into the remarkable electromagnetic properties of microtubules

Aristide Dogariu

Irrespective of their intrinsic origin, most natural phenomena have scale-dependent manifestations. The interaction between parts leads to unique displays of their collective behavior at mesoscopic or macroscopic scales. For instance, nonlocal space-time fingerprints in the emitted radiation emerge due to long-range electromagnetic interactions in dipolar ensembles. We will discuss how long-lived temporal correlations can arise in complex systems because of the strong coupling between components and the interface with the environment. Our results show that, even in off-resonant conditions, the cooperative response of effective emitters leads to subradiant states that are protected from inherent disorder. The emerging spatio-temporal properties of radiation maintain reciprocity and depend on the system's microstructure. In particular, the remarkable structural symmetries of microtubules makes them act as veritable photonic matter with discrete spectra and delocalized excitations of electromagnetic fields.

M. BRUCE MACIVER

STANFORD UNIVERSITY

Thursday, August 5, 2021
11:55 am – 12:05 pm MST-Arizona

Professor M. Bruce MacIver explores the molecular and cellular mechanisms of sedatives and anesthetics and how these drugs alter higher nervous system functions to produce loss of consciousness. He was trained in neuroscience and pharmacology at the University of Calgary and began his career at Stanford over thirty years ago and has directed the Stanford Neuropharmacology Laboratory since then. Current research looks at the development of safer and more effective anesthetics using state-of-the-art electrophysiological approaches with in vitro brain slice preparations and freely moving animal studies. He is also using newly developed EEG analysis techniques in animals and human subjects to quantify brain states associated with the loss and recovery of consciousness.

Probing consciousness with anesthetics

M. Bruce MacIver

Anesthetics are excellent tools for studying loss and recovery of consciousness in humans and animals. They reliably produce a reversible change in conscious states that allows consistent measures to be made across subjects and species. Recent work shows how higher brain circuits are altered by anesthetics in drug-specific ways, with different circuit components being altered in unique ways by anesthetics from different chemical classes. Emerging data shows marked changes in circuit and information complexity underlie transitions into and out of conscious states. These changes result from actions at a spectrum of protein targets that differ, more or less, between anesthetics. Our results indicate that Objective Reduction occurs across multiple protein families that share the same quantum supporting protein sites that microtubule proteins have. Orchestration of OR is spread across many proteins involved in brain function. This theory is compatible with the multi-site, agent specific (MAS) theory of anesthesia.

ANIRBAN BANDYOPADHYAY

NATIONAL INSTITUTE FOR MATERIALS SCIENCE (NIMS), TSUKUBA JAPAN

Thursday, August 5, 2021
12:05 pm – 12:15 pm MST-Arizona

Anirban Bandyopadhyay is Principal Research Scientist at the National Institute for Materials Science (NIMS), Tsukuba, Japan. He earned his Ph.D. in Supramolecular Electronics at the Indian Association for the Cultivation of Science (IACS), Kolkata, 2005. From 2005 to 2008 he was ICYS research fellow at the ICYS, NIMS, Japan, and worked on the brain-like bio-processor building. In 2008, Anirban joined as a permanent scientist at NIMS, working on the cavity resonator model of human brain and design-synthesis of brain-like organic jelly. From 2013 to 2014 he was a visiting scientist at the Massachusetts Institute of Technology (MIT), USA. Awards include: Hitachi Science and Technology award 2010, Inamori Foundation award 2011–2012, Kurata Foundation Award, Inamori Foundation Fellow (2011–), and Sewa Society international member, Japan.

Triplet of triplet fractal resonance band of tubulin, microtubule and neuron membrane: Quantum optics & Microwave study

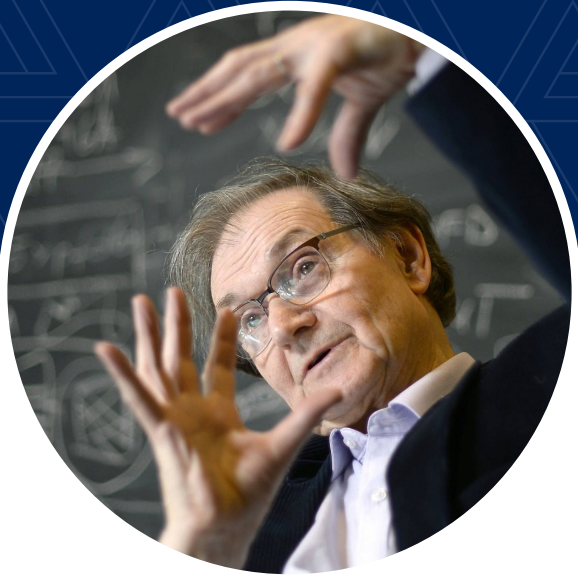
Anirban Bandyopadhyay

Orch-OR suggests Orchestration or synchronized resonant oscillations. We demonstrated that single tubulin protein, single isolated microtubule, and single neuron generate triplet of triplet resonance bands [1]. Electromagnetic resonance of filamentary bundles builds a new kind of energy transmission circuits in a neural network that does not follow synaptic junction pathways. These hidden circuits were thus far invisible to neuroscientists [2]. Using quantum optics and microwave resonance together we wirelessly give input and wirelessly take the output from neurons to find how exactly filaments and neuron membrane work together to regulate the precise timing of the neural network firing of the human brain. We mapped actin, beta spectrin, microtubule, membrane, and important components of a neuron using quantum-entangled vector vortex assemblies [3].

[1]. Saxena K. et al, Fractal, Scale Free Electromagnetic Resonance of a Single Brain Extracted Microtubule Nanowire, a Single Tubulin Protein and a Single Neuron", Fractal Fract. 4(2), 11. (2020). [2]. Singh P. et al, Electrophysiology using coaxial atom probe array: Live imaging reveals hidden circuits of a hippocampal neural network. Journal of Neurophysiology. https://doi.org/10.1152/jn.00478.2020 [3] Singh, P.; et al. Cytoskeletal Filaments Deep Inside a Neuron Are Not Silent: They Regulate the Precise Timing of Nerve Spikes Using a Pair of Vortices. Symmetry 2021, 13, 821. https://doi.org/10.3390/sym13050821

Discussion

12:15 pm – 12:45 pm



Science &
ROGER PENROSE

Live Webinar - hosted by the Center for Consciousness Studies

DAY 4

Friday August 6, 2021

9:00 am to 12:30 pm PST

A PRE-BIG BANG UNIVERSE: CONFORMAL CYCLIC COSMOLOGY

PAUL TOD

OXFORD UNIVERSITY, UK

Friday, August 6, 2021

9:00 am – 9:45 am MST-Arizona

Professor Paul Tod recently retired as the St. John's College's (Oxford) Applied Maths Tutor, giving tutorials in physical applied mathematics such as mechanics, waves and diffusion, quantum mechanics and special relativity, also in central subjects like differential equations and in pure subjects like differential or projective geometry, and lecturing on the same subjects. He is co-author of two books at the level of graduates or advanced undergraduates, based on lecture courses he had given in general relativity and in twistor theory. As an Emeritus Research Fellow he is part of the mathematical physics group in the Mathematical Institute. His research continues to be in various branches of differential geometry, particularly where it meets physics in Einstein's theory of general relativity. Professor Tod was a D.Phil. student of Sir Roger Penrose and has worked extensively on twistor theory and on Penrose's Conformal Cyclic Cosmology.

The mathematics behind Penrose's Conformal Cyclic Cosmology

Paul Tod

Penrose's Conformal Cyclic Cosmology is at once a radical new model of the universe, which will stand or fall according to its success in accounting for astronomical observations, and a very elegant mathematical or, better, geometrical idea. In this talk, which I aim to make accessible to non-specialists, I shall give a sketch of the mathematics behind it. This will involve thumb-nails of curvature, special relativity, general relativity and relativistic cosmology, and an indication of what can be done by conformal rescaling to make an infinite time pass quickly.

There won't be many, or possibly any, equations in the talk but these can be found, for example, in a set of lectures at arXiv:2102.02701.

BRIAN KEATING

UC SAN DIEGO

Friday August 6, 2021
9:45 am – 10:30 am MST-Arizona

Brian Keating is the Chancellor's Distinguished Professor of Physics at UC San Diego.
An cosmologist and author of more than 200 scientific publications, two U.S. Patents, and the best-selling memoir "Losing the Nobel Prize", endorsed by Sir Roger Penrose. Keating received his B.S. from Case Western Reserve University in 1993 and his PhD from Brown University in 2000. Later, he was a postdoctoral fellow at Stanford and Caltech, and in 2007 he received the Presidential Early Career Award for Scientists and Engineers for inventing the BICEP telescope. Keating was elected Fellow of the American Physical Society in 2016 and is Principal Investigator of the Simons Observatory collaboration in Chile. He is a commercial pilot with multi-engine, instrument ratings and is an honorary lifetime member of the National Society of Black Physicists.

Was there A Big Bang?

Brian Keating

Precision studies of the Cosmic Microwave Background have provided some of the most crucial tests of the Big Bang model of cosmology, explaining the composition of the cosmos, its age, and even the shape of spacetime itself. But what the Big Bang theory lacks is an explanation of the initial cosmic conditions — the origin of the universe itself. Upcoming observations of the CMB may give us an insight into whether or not a single big bang took place, or whether it might repeat again and again in cycles of unending time. I will review the evidence for and against competing models of CosmoGenesis including Conformal Cyclic Cosmology, Inflationary Cosmology, and Bouncin Cosmological Models.

KRZYSZTOF A. MEISSNER

UNIVERSITY OF WARSAW, POLAND

Friday, August 6, 2021
10:30 am – 11:15 am MST-Arizona

Krzysztof A. Meissner is a Professor at the Faculty of Physics at the University of Warsaw. Since 2008 he is a deputy spokesman of the OSQAR experiment at CERN aiming at discovery of axions. He collaborated with Gabriele Veneziano on O(d,d) symmetry, the first dynamical symmetry in string inspired gravity. The collaboration with Hermann Nicolai from Max Planck Institute (Albert Einstein Institute) in Potsdam lasting almost 20 years and still very active gave more than 25 joint published papers introducing an extension of the Standard Model of elementary particles, the Conformal Standard Model, and recently, based on an infinite hyperbolic E(10) group, the proposal was made for an explanation of giant black holes in the early Universe and the origin of most energetic cosmic rays observed on Earth. More than 10 years ago he started an on-going collaboration with Roger Penrose on the Conformal Cyclic Cosmology with a recent joint paper on the traces of the previous eon on the Planck CMB maps.

Black Holes and Conformal Cyclic Cosmology

Krzysztof A. Meissner

The talk will be devoted to possible traces, on the Planck satellite Cosmic Microwave Background maps, of black hole collisions and evaporation in the previous eon. The distribution, angular distances and intensities of rings and disks on the CMB maps may possibly give a hint on (dis) similarities between the subsequent eons.

VAHE GURZADYAN

YEREVAN PHYSICS INSTITUTE, ARMENIA

Friday, August 6, 2021
11:15 am – 12:00 noon MST-Arizona

Vahe Gurzadyan, DSci, Professor, had completed PhD in theoretical and mathematical physics in Lebedev Physical Institute in Moscow. Dr. Gurzadyan is currently the head of the Center for Cosmology and Astrophysics, Alikhanian National Laboratory, Yerevan, Armenia. He held visiting professor positions at the Sussex University, UK, La Sapienza University of Rome, had lectured in 4 universities in Japan. He chaired at conferences on galactic dynamics, on chaos, on relativistic astrophysics, he was among editors of International Journal of Modern Physics D (World Scientific, 2000-2010), currently of European Physical Journal Plus (Springer Nature). He has published a monograph Paradigms of the Large-Scale Universe (1994), among his edited volumes are Ergodic Concepts in Stellar Dynamics (1994), The Chaotic Universe (2000), Fermi e l'Astrofisica (2002), From Integrable Models to Gauge Theories (2003), Low Dimensional Physics and Gauge Principles (2013). He had introduced the concept of information panspermia and used astronomical methods in establishing the Ultra-Low absolute chronology of the ancient Near East civilizations in the monograph "Dating the Fall of Babylon" (Ghent and Chicago Universities).

Cosmological Constant, CCC, observations

Vahe Gurzadyan

The cosmological constant Λ denoted by Einstein as a universal constant, then abandoned and revived several times during a century, is now being associated to the observational indications on the accelerated expansion of the Universe. The Λ can be shown to possess features of a second gravitational constant, along with the Newtonian constant, as it is dimension-independent and matter uncoupled. When considered as the 4th fundamental constant along the 3 standard ones, the Λ leads to the emergence of a dimensionless combination (constant) relevant for "all cultures" as the Planck units, and which can act as scaling for information at the cosmological evolution. Also, Λ can be shown to influence the arrow of time, as at the decay of metastable states under generic perturbations for microcanonical ensemble. The cosmological constant and the arrow of time are deeply linked to the Conformal Cyclic Cosmology of Penrose, providing definite observable predictions for the cosmic microwave background radiation.

Discussion

12:00 noon – 12:30 pm