Department of Physics Colloquium

Speaker: Dr. Robert A. Makin

Department of Computer Science
Western Michigan University

"Quantifying the Effects of Structural Disorder on the Electronic Properties of Semiconductors"

Open to the public, free of charge

Monday, October 23, 2023 - 4 p.m. – 1110 Rood Hall

Refreshments: 3:30-3:50 p.m., Bradley Commons, 2202 Everett Tower

Abstract: In the context of epitaxial semiconductor layers prepared for electronic devices, disorder is frequently an important consideration. One well-known model for quantifying disorder was developed by Bragg and Williams in the early 1930s, who were concerned with accurately describing the varying degrees of atomic ordering in metal alloys. In their formulation, a numerical order parameter (S) is defined as having a value between 0 (fully randomized lattice) and unity (fully ordered lattice). Traditionally this order parameter is measured using x-ray diffraction techniques, but recently our group has demonstrated that electron diffraction, Raman spectroscopy and electron microscopy are equally viable experimental methods for measuring S. Further building on this framework, it is possible to employ spin-based modeling in conjunction with cluster expansion theory to show that material properties, that are dominated by pair-wise interactions, exhibit a linear dependence on S^2, provided that composition is properly accounted for. Our group is currently using these methods and frameworks to quantify the impact of disorder on the electronic properties of nitride semiconductors that we grow via plasma-assisted molecular beam epitaxy.

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WESTERN MICHIGAN UNIVERSITY

Department of Physics Colloquium

Speaker: Dr. Kirk Korista

Professor of Astronomy, Department of Physics
Western Michigan University

"Sir Arthur Stanley Eddington – With Stars in His Eyes"

Open to the public, free of charge

Monday, November 27, 2023 – 4 p.m. – 1110 Rood Hall

Refreshments: 3:30-3:50 p.m., Bradley Commons, 2202 Everett Tower

Abstract: The accomplishments of the early astrophysicist Arthur Stanley Eddington (1882-1944) are extraordinarily numerous, and yet in my estimation are often under-recognized for the magnitude of their impact. After a brief biographical sketch, I will discuss his brilliant insights on the inner workings of stars – *Eddington's Standard Model*. These have implications for how we communicate useful physical understanding of stars to our students in the modern day. {Today, a virus of misconception, with its several variants, has become pandemic, infecting astronomy education about stars *at all levels*.} I will conclude with a summary of Arthur Stanley's several other important contributions to astrophysics.

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WESTERN MICHIGAN UNIVERSITY

Department of Physics Colloquium

Speaker: Dr. Morgan Loechli

Department of Physics
Kalamazoo College

"Modeling Spatial Variations in Carbon Exchange Using Diurnal and Seasonal Cycles in Remotely Sensed CO_2"

Open to the public, free of charge

Monday, December 4, 2023 – 4 p.m. – 1110 Rood Hall

Refreshments: 3:30-3:50 p.m., Bradley Commons, 2202 Everett Tower

Abstract: Have you ever wondered why CO_2 levels in the atmosphere vary by location and time? To answer this question, we analyze data from a network of ground-based spectrometers called the Total Carbon Column Observing Network (TCCON) and from a satellite called the Orbiting Carbon Observatory-2 (OCO-2). Notably, when viewing the northern hemisphere as a whole, TCCON's seasonal cycle amplitude (SCA) appears smaller than that found using OCO-2 data, suggesting site-specific biases. To understand what is causing these biases, we look for correlations between SCA and other factors. What we see highlights the role of both large-scale atmospheric dynamics and local-scale carbon exchange in determining what atmospheric CO_2 looks like at a given place and time. These insights illuminate challenges in upscaling TCCON observations and deepen our understanding of spatial variability in observed SCAs.

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WESTERN MICHIGAN UNIVERSITY

Department of Physics Colloquium

Speaker: Dr. Paul Gueye

Associate Professor of Physics
Facility for Rare Isotope Beams
Michigan State University

"What if we could shrink ourselves and have discussions with nucleons?"

Open to the public, free of charge

Monday, January 22, 2024 - 4 p.m. – 1110 Rood Hall

Refreshments: 3:30-3:50 p.m., Bradley Commons, 2202 Everett Tower

Abstract: Particle accelerators have enabled scientists to get some insights about the interactions between protons and neutrons in nuclei. The use of electron and rare isotope beams are unique complementary techniques that provide powerful magnifying tools for such goal. Over more than a quarter century, the 4 GeV and now 12 GeV (un)polarized electron beam of the Thomas Jefferson National Accelerator Facility (Newport News, Virginia, USA) has dramatically enhanced our understanding of the microscopic nuclear world. On May 10, 2022, the Facility for Rare Isotope Beams (East Lansing, Michigan, USA) started its highly anticipated experimental nuclear astrophysics program, opening a new window in our ability to further extend our knowledge toward the proton and neutron driplines. Technological advancements required to achieve these milestones have also provided powerful imaging and therapeutic tools, crossing boundaries to other fields. This talk will provide some brief reviews on the role and successes as well as future prospects of nuclear physics experiments and theories at these facilities as they pertain to my journey in basic and applied nuclear physics, including programs to broaden participation for workforce development in nuclear science.

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WESTERN MICHIGAN UNIVERSITY

Department of Physics Colloquium

Speaker: Pablo Giuliani, Ph.D.

Facility for Rare Isotope Beams
Michigan State University

"Life is Too Short for Slow Computations"

Open to the public, free of charge

Monday, February 19, 2024 – 4 p.m. – 1110 Rood Hall

Refreshments: 3:30-3:50 p.m., Bradley Commons, 2202 Everett Tower

Abstract: We will discuss machine learning and dimensionality reduction strategies to help overcome computational barriers, particularly within Bayesian uncertainty quantification, and for accelerating scientific discovery, particularly within nuclear physics. These methods remove redundancies from complex models and go straight to the point, much like this abstract does.

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WESTERN MICHIGAN UNIVERSITY

Department of Physics Colloquium

Speaker: Dr. Manqoba Hlatshwayo

Quantum Applications Engineer
National Quantum Computing Centre (UK)

"The Quantum Computing Promise"

Open to the public, free of charge

Monday, March 11, 2024 - 4 p.m. – 1110 Rood Hall

Refreshments: 3:30-3:50 p.m., Bradley Commons, 2202 Everett Tower

Abstract: The field of quantum computing has attracted a lot of attention and investment due to its promise to substantially speed up complex calculations, especially for problems that are deemed intractable for classical computers. This talk is a brief status update on how far along the field has advanced towards realizing that promise. It will cover recent advances in quantum hardware development, quantum algorithms, and applications. It will also include a discussion of selected open problems and opportunities for students and researchers. Finally, we will discuss WMU's research efforts in applications of quantum algorithms in nuclear physics, in particular our recent work [1,2].

[1] JF. Novak, MQ. Hlatshwayo, E. Litvinova, "Response of strongly coupled fermions on classical and quantum computers," *in preparation* (2024)

[2] MQ. Hlatshwayo, JF. Novak, E. Litvinova, "Quantum benefit of the quantum equation of motion for the strongly coupled many-body problem," *Phys. Rev. C* **109**, 014306 (2024).

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WESTERN MICHIGAN UNIVERSITY

Department of Physics Colloquium

Speaker: Dr. Frank von Hippel

Senior Research Physicist, Professor of Public and International Affairs (Emeritus) and Co-founder
Program on Science and Global Security, Princeton University

"The continuing risk of nuclear war and how physicists, acting as citizen-scientists, can help reduce it"

Open to the public, free of charge

Monday, March 18, 2024 - 4 p.m. – 1110 Rood Hall

Refreshments: 3:30-3:50 p.m., Bradley Commons, 2202 Everett Tower

Abstract: With the end of the Cold War and the disintegration of the Soviet Union, the public, including most physicists, and Congress, assumed, the danger of a nuclear war had ended as well. Unfortunately, that has not been the case. Indeed, the danger of accidental nuclear war may be increasing. US and Russian strategic missiles remain in a launch-on-warning posture in an era when hackers have penetrated some of our supposedly most secure computer systems and China appears to be moving toward a similar posture. Both Russia and the United States have committed to hugely costly programs to replace their nuclear weapons with new systems designed to maintain that status quo for the remainder of the century. Meanwhile, an offense-defense nuclear arms race is developing between the US and China, which is building up the number of its nuclear weapons that can reach the US as the US increases the number of its ballistic missile interceptors – nominally to defend against North Korea. In the past, independent physicists have played leading roles in informing Congress and the world about the dangers and offering ideas for how to reduce them – both unilaterally and through agreements with our adversaries. The American Physical Society has supported the Physicists Coalition for Nuclear Threat Reduction during its first two years to help renew the engagement of physicists and other physical scientists and engineers with Congress and the public on nuclear-weapons issues. Following the colloquium, there will be a discussion of opportunities to contribute to this effort.

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WESTERN MICHIGAN UNIVERSITY

Department of Physics Colloquium

Speaker: Dr. Ramakanta Chapai

Postdoctoral Fellow
Argonne National Laboratory

"Consequences of Electronic Correlations in Kagome Metals"

Open to the public, free of charge

Monday, March 25, 2024 - 4 p.m. – 1110 Rood Hall

Refreshments: 3:30-3:50 p.m., Bradley Commons, 2202 Everett Tower

Abstract: Metallic materials with a Kagome lattice have emerged as a new frontier in Condensed Matter Physics in recent years. Key features in their electronic band structure include Dirac points, van Hove singularities (VHS), and flat bands. In this talk, I will discuss some insightful cases of a Kagome superconductor CsV_3Sb_5 (CVS), where a complex interplay exists between superconductivity, charge density wave (CDW), and a non-trivial topology. Through the measurement of magnetic quantum oscillations in fields up to 86 T, we have identified the fundamental 'building blocks' of the reconstructed Fermi surface, comprising 'hyperbolic hexagon' and 'triangular' pockets within the CDW state in CVS. These pockets are characterized by sharp corners and strong variations of the Fermi velocity, arising from the proximity to the VHS. I will demonstrate that the observed unconventional transport behavior, such as non-monotonic magnetoresistance and apparent anomalous Hall effect, can, in a semi-quantitative way, be accounted for by the reconstructed Fermi surface structure. This versatile approach can be extended to account for the anomalous magneto-transport observed in a large family of metallic systems hosting singular features in their electronic spectrum. As I conclude the talk, I will briefly discuss anomalous features observed in the temperature dependence of upper critical field $H_{c2}(T)$ of CVS and propose an explanation based on Fermi surface reconstruction.

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WESTERN MICHIGAN UNIVERSITY

Department of Physics Colloquium

Speaker: Dr. Wendy Scott Beane

Presidential Innovation Professor and Associate Professor
Department of Biological Sciences, Western Michigan University

"Quantum Biology, Magnetic Fields, and the Control of Tissue Growth"

Open to the public, free of charge

Monday, April 1, 2024 - 4 p.m. – 1110 Rood Hall

Refreshments: 3:30-3:50 p.m., Bradley Commons, 2202 Everett Tower

Abstract: Several biological processes are known to involve sensing and responding to quantum phenomena, including photon capture during photosynthesis and the avian ability to sense the geomagnetic field during migration. It is not clear, however, whether this capability is restricted to a few highly specialized cell types or is a more basic feature of cell biology. Magnetic fields are known to interact with electron spin states, thus altering chemical reaction rates via changes in radial pair formation (the radical pair mechanism). Radicals such as reactive oxygen species (ROS) are well-established key regulators of cell signaling that control cell behaviors and tissue growth during development, regeneration, and cancer. Specifically, ROS signaling is known to regulate maintenance of the stem cell population and affect the cell fate of stem cell descendants. Our research tests hypotheses based on spin state theory and the radical pair mechanism that suggest *weak* magnetic fields (WMFs, <1 mT) can also influence cellular ROS levels. Our data reveal that depending on field strength, WMFs can be used to either promote (500 µT) or inhibit (200 µT) ROS levels, leading to subsequent changes in ROS-mediated gene expression, stem cell division, and regenerative tissue growth. Using the highly regenerative planarian model system, we have shown that WMF effects at wound sites are largely ROS dependent and have identified superoxide as one specific ROS involved. Together, these data highlight the possibilities of using WMF exposures to control ROS signaling *in vivo* and suggest that stem cells may act as endogenous quantum sensors. Because stem cells are not the only cell population sensitive to ROS signaling, these data further suggest that the cellular ability to respond to quantum phenomena may be more widespread than previously thought.

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WESTERN MICHIGAN UNIVERSITY

Department of Physics Colloquium

Speaker: Anatoli Afanasjev, Ph.D.

Professor, Theoretical Low-Energy Nuclear Physics (Computational)
Department of Physics and Astronomy
Mississippi State University

"Recent Progress in the Study of the Atomic Nuclei within Covariant Density Functional Theory: From Simple Systems to the Extremes of Nuclear Landscape"

Open to the public, free of charge

Monday, April 15, 2024 – 4 p.m. – 1110 Rood Hall

Refreshments: 3:30-3:50 p.m., Bradley Commons, 2202 Everett Tower

Abstract: The atomic nucleus is described as a system of nucleons which interact via the exchange of mesons in covariant density functional theory (CDFT). This is the state-of-the-art relativistic version of density functional theory. I will start my presentation from basis features of the CDFT and the illustration of the applicability of this theory to different physical phenomena. Then, I will consider the physics of charge radii which is in the focus of current experimental and theoretical efforts. Finally, new physical mechanisms at the boundaries of the nuclear landscape triggered by either extreme charge of nucleus of its fast rotation will be discussed.

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WESTERN MICHIGAN UNIVERSITY

Department of Physics Colloquium

Speaker: Dr. Pervez Hoodbhoy

Retired Professor, Quaid-i-Azam University, Pakistan
and Adjunct Professor, University of Brunswick

"Decay of the False Vacuum: Applications in Condensed Matter, QCD and Cosmology"

Open to the public, free of charge

Monday, April 22, 2024 – 4 p.m. – 1110 Rood Hall

Refreshments: 3:30-3:50 p.m., Bradley Commons, 2202 Everett Tower

Abstract: This talk will be a pedagogical review of tunneling phenomena in quantum mechanics and quantum field theory suitable for graduate students. Starting with a quick introduction to the Feynman path integral, I will develop the idea of instantons in QM, move to QFT, and then apply to phase transitions in condensed matter systems, tunneling between topologically separated QCD vacua, and the very early universe.

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