Abstract: Reverberation mapping is a technique making use of echoes of light to determine the size, geometry and kinematics of objects that would be otherwise spatially unresolvable. It has been widely used for 30 years in optical astronomy to probe gas moving at thousands of km/s a few light days from supermassive black holes at the centers of galaxies.

However, the recent discovery of X-ray reverberation in AGN has opened up a new path to probing the most extreme, innermost regions around supermassive black holes. Time lags due to light travel time between the reflected and direct X-ray emission components are of the order of a few tens of seconds, corresponding to a size scale of the order of just a few gravitational radii. Hence, X-ray reverberation looks at gas on the verge of passing the black hole event horizon.

Since the initial discovery in 2009, more than a dozen more lags have now been seen, with the size of the lag scaling with black hole mass. While the initial discoveries involved time lags between two continuum bands, an exciting development has been the detections of lags between the direct continuum and the broad Fe Kα line, which has been seen in a handful of objects. Here, Dr. Cackett will present a look at X-ray reverberation lags and the implications and prospects for probing the geometry of the inner emitting region around supermassive black holes.
Abstract: This talk will summarize three recent efforts to constrain the first few moments of cosmic creation before and during the epoch of inflation. We will consider two means to explain a slight dip in the power spectrum of the cosmic microwave background for multipoles in the range of \( l = 10-30 \) from both the Planck and WMAP data. We show that such a dip could be the result of resonant creation of a massive particle that couples to the inflation field. For best-fit models, the epoch of resonant particle creation reenters the horizon at wave numbers of \( k^* = 0.00011 \pm 0.0004 \text{ h/Mpc} \). The amplitude and location of these features constrain the number of degenerate fermion species, their mass, and the coupling constant between the inflation field and the created fermion species. Alternatively, one can explain the existence of such a dip as due to a jump in the inflation generating potential. We show that such a jump can also resolve the excessively large dark flow predicted from the M-theory landscape. Finally, we summarize our efforts to quantify constraints on the cosmic dark flow from a new analysis of the Type Ia supernova distance-redshift relation.

Speaker: Kiyoshi Kato
Kogakuin University, Tokyo, Japan
October 9, 2015
“An Introduction to the World of Fundamental Particles”

Abstract: An introduction to the most fundamental building blocks of our world and how they behave based on the fundamental rules, for those who are not experts in particle physics. The essential tool to describe the subatomic objects is the quantum field theory (QFT). It is shown that the calculations in QFT involve large-scale computations and interesting mathematical problems to be solved.

Speaker: Alfredo Estrade Vaz
Central Michigan University
October 12, 2015
“Nuclear Structure and Astrophysics at the Edge of the Nuclear Landscape”

Abstract: The measurements of masses and decay properties of neutron-rich nuclei provide data on the evolution of nuclear structure of unstable isotopes at the limit of what can be reached by experiments, as well as new data for astrophysical models of r-process nucleosynthesis.

In recent decades, continuous developments in the capabilities of radioactive ion beam facilities and experimental techniques have made an increasing number of unstable isotopes accessible for experimental
research. The study of such isotopes provides a new light to understand the basic properties of the atomic nucleus, as well as critical data for diverse applications of nuclear physics. Our research involves experiments with sensitive experimental techniques that can be applied to neutron-rich isotopes very far from beta-stability. In particular, I will present the work of the time-of-flight (TOF) mass measurement collaboration at the National Superconducting Cyclotron Laboratory in East Lansing, including recent results on the evolution of the nuclear shell structure around N=28. I will also discuss our program of beta-decay experiments using the new Advanced Implantation Detector Array (AIDA) at the Radioactive Ion Beam Factory in RIKEN, Japan, to study isotopes relevant to nucleosynthesis during the rapid-neutron capture process (r-process).

**Speaker: Brian Saam**

**University of Utah**

**October 19, 2015**

“Hyperfine Physics in Alkali-Metal Vapors”

**Abstract:** Our laboratory focuses on optical pumping, the use of circularly polarized resonance light to produce large non-equilibrium ground-state spin polarization in alkali-metal vapors; as well as spin-exchange transfer of this polarization to the nuclei of certain noble gases (3He and 129Xe), for which there are many applications, including magnetic resonance imaging of the lung.

Although alkali-metals were all discovered by the mid-19th century, vapors of these Column I elements have been studied with particular intensity in the last 75 years, initially as pseudo-one-electron systems with easily accessed optical or near-infrared P→S transitions to the ground state having strong oscillator strengths. Currently, they are widely used in precision magnetometry, atomic clocks, and in gyroscopes; they are also of fundamental importance in the study of cold atoms, Bose-Einstein condensates, and atom interferometry—even some table-top searches for physics beyond the standard model. All stable alkali-metal isotopes have half-integer nuclear spin, and the ground-state hyperfine coupling to the valence electron generates a rich spin physics that is crucial to all of these areas of study. Our laboratory focuses on optical pumping: the use of circularly polarized resonance light to produce large non-equilibrium ground-state spin polarization in alkali-metal vapors. We also work on the technique of spin-exchange transfer of this polarization to the nuclei of certain noble gases (3He and 129Xe), which finds application to magnetic resonance imaging of the lung. We have worked most recently on characterizing magnetic-resonance frequency shifts in hyperfine transitions that result from interactions between the polarized alkali-metal vapor and the polarized noble-gas nuclei. These are studied optically with much higher sensitivity than inductive techniques; indeed, such shifts can be used as a sensitive probe of the noble-gas magnetization.
Speaker: Lei Fang  
Northwestern University and Argonne National Laboratory  
November 2, 2015  

Abstract: Topological insulators (TIs) are bulk insulators that possess conducting edges or surfaces due to topological invariance protection. TIs have remarkable quantum properties like back-scattering immunity and spin-momentum locking and find applications in the fields of energy, spintronics and quantum computing. This talk will begin with an overview of the basics of TIs and their relation to Integer Quantum Hall effect. The second portion of the presentation will focus on the mitigation of the bulk conductance of TIs. Our group invented a catalyst-free physical vapor deposition method and synthesized millimeter-long topological insulator Bi2Se3 nanoribbons. Angle-dependent quantum oscillation measurements on single nanoribbons show clear evidence of topological surface states. The design of TI-related quantum materials using the methods of tailoring structural motifs and theoretical theorems, like symmetry protection, will also be discussed. I will introduce our recent discovery of a graphene-beyond material [Pb2BiS3][AuTe2]. This material exhibits a wealth of interesting properties, such as the identical band dispersion to that of graphene, strong spin-orbit coupling and a highly cleavable feature that enables ultrathin layers down to nanometer scale.

Speaker: David Hoogerheide  
National Institute of Standards and Technology  
and National Institutes of Health  
November 20, 2015  
“Orientation of Dimeric Tubulin on Lipid Membranes Studied using Neutron Reflectometry”

Abstract: Membrane proteins play an important role in the modern treatment of disease, representing more than 70 percent of current drug targets. They are implicated in a variety of diseases, such as HIV, cancers and neurodegenerative diseases such as Alzheimer’s and Parkinson’s. Because these proteins are often unstable outside the two-dimensional hydrophobic environment of a lipid membrane, it is difficult to obtain structural information for them in their native lipid environment. In this talk, I will introduce the technique of neutron reflectometry (NR), which has emerged as one of the few techniques able to study the structure of membrane proteins in a physiologically relevant lipid environment. I will report on recent results in which the orientation of the structural protein tubulin on a lipid membrane was determined with NR, with implications for the interaction of tubulin with proteins of the mitochondrial outer membrane and the function of various tubulin-targeting anti-cancer agents.
Abstract: The failure rate of complex organisms is not a constant, but increases with age. Furthermore, the time dependence seems to be similar for a wide variety of systems. In this talk I will offer a scenario that explains these characteristics.

Abstract: The origin of the elements remains one of the largest unanswered questions in science today. While stellar burning is responsible for production of most of the elements lighter than iron, the production of heavier elements is relinquished to more exotic processes. The astrophysical r-process, for example, is responsible for nearly half of the elements heavier than iron and nearly all of the actinides. A discussion of observational signatures of the r-process and how these are reconciled with the nuclear physics input is presented. In particular, the variations in stars enriched in r-process elements is studied. One possible explanation is that partial explosion mechanisms in type II supernovae and hypernovae may result in the variations in astronomical observations. A fascinating result of this study is that the variations in r-process enrichment may be a signature of the nuclear equation of state. This signature complements other astronomical observations, which place lower limits on the stiffness of the nuclear EOS, in that it places an upper limit on the stiffness.

Abstract: The National Superconducting Cyclotron Laboratory and Joint Institute for Nuclear Astrophysics organize and conduct a host of different outreach programs, all geared to different audiences and goals. These
programs will be used as examples to illuminate the outreach philosophy in play and the methods behind successful engagement with the public.

Speaker: Manuel Bautista  
Western Michigan University  
February 29, 2016  
“An Atomistic View of the Universe”

Abstract: Astronomy, arguably the oldest of all physical sciences, has been the source of much of our current understanding of the fundamental processes that shape the physical world. Thus, it was through astronomical observations that atoms were recognized and their nature was understood. Since then, astronomy and atomic physics have progressed jointly and independently.

In this talk, I review such progress in astronomy and atomic physics up to the present. I show that atomic physics for astrophysics is today as vibrant and important as ever. Then, I describe some of the work we carry out at Western Michigan University. Finally, I discuss some pressing questions for the future, whose answers will require major theoretical and experimental advances.

*By convention, sweet; by convention, bitter; by convention, hot; by convention, cold; by convention, color; but in reality, atoms and void.* ~Leucippus 490 B.C.

Speaker: Philip Ugorowski  
Kansas State University  
March 16, 2016  
“Reactor Physics Code Validation Using Sub-miniature, In-core Neutron Detectors”

Abstract: As predictive simulation becomes increasingly important to nuclear reactor analysts, new methods will be needed to resolve the phase space of interest accurately enough to make predictions feasible. As part of this process, benchmarks are needed to validate methods beyond what is presently known. In particular, benchmarks that include coupled physics, such as neutronics and thermohydraulics, are needed to verify multiphysics methods for predictive simulation and, ultimately, safety analysis. Ideally, such benchmarks would be highly-resolved measurements in time and space. The proposed instrumentation will employ a 3-D array of detectors for capturing highly-resolved thermal and fast neutron flux distributions. Each detector also includes a thermocouple for simultaneous temperature measurements. The proposed instrumentation will be used to measure flux and temperature distributions for several steady-state and transient experiments. The results will be compared to simulations using SHARP, Relap-7 and PROTEUS from the NEAMS toolkit, paving the way for future evaluated benchmark efforts.
Speaker: Michael Lisa  
The Ohio State University  
March 21, 2016  
“The Physics of Sports: A Real Science Course for the Non-science Major”

Abstract: Ohio State University offers a one-semester course on the Physics of Sports, which satisfies a General Education Curriculum science requirement of all students. Scholarship athletes, business and liberal arts majors make up the majority of the ~80 students enrolled in the class, though interested sports enthusiasts from more technical fields join as well. The class is far from the “Physics for Poets” type of course that some expected, leading to some initial math-and-science-anxiety. It is gratifying when some of this anxiety is replaced by a self-confidence in many students that they can, indeed, handle and appreciate a “real” mathematical science course on material they already enjoy. While the underlying physics lies of course squarely in the realm of classical mechanics, and familiar topics must be covered, the course aims to be unique— not simply a standard classical mechanics class with sports examples. I will share some specific lessons learned and insights gained while developing and implementing this course over the past five years. This talk does not present physics education research.

Speakers: Ben Brown and Paul Pancella  
March 28, 2016  
“Electric Cars, Today and Tomorrow”

Abstract: This informal presentation will give perspectives on electric vehicles from two current owners. We will talk about practical aspects of their routine use in everyday life, economic and ecological impacts, and the many positive aspects of using electricity for transportation. Paul may throw in a little science, and we will include future prospects as time allows, along with opportunity for questions and discussion with the audience.

Speaker: Morten Hjorth-Jensen  
Michigan State University and University of Oslo, Norway  
April 4, 2016  
“Integrating a Computational Perspective in the Basic Science Education”

Abstract: In the last decades we have witnessed an incredible development of both computer hardware and software. Scientific problems that were previously solved on large special-purpose machines with special-purpose software can now be easily handled in general-purpose, interactive environments on standard PCs with
the bonus of immediate visualization of the results. Surprisingly, the use of computers to solve mathematical problems still has little impact on university education around the world, particularly at the undergraduate level. Given today's dominance of numerical simulations in research and industry, we think it is paramount to integrate numerical tools at all levels in the educational system in order to educate candidates with a proper computing competence.

A fundamental challenge to our undergraduate programs is how to incorporate and exploit efficiently these advances within the standard curriculum in mathematics and the natural sciences, without detracting the attention from many of the classical topics. This brings with it the major organizational challenge of how to get university teachers in a variety of different fields and departments to work together towards such a reform. Furthermore, if students are trained to use such tools from the earliest stages in their education, do such tools really enhance and improve the learning environment? In addition, and perhaps even more importantly, does it lead to better understanding and insight?

Based on experiences from the University of Oslo, Norway and Michigan State University, I will try in this seminar to outline several of these aspects and discuss how one can include computational topics in a coordinated way in various undergraduate programs in natural science.

Speaker: D. Ackermann
GANIL, Caen, France and GSI, Darmstadt, Germany
April 18, 2016
“Superheavy Nuclei - Stability beyond the Liquid Drop”

Abstract: The synthesis of new elements has reached up to Z = 118 with the IUPAC/IUPAP assigning recently the naming rights for the elements 114,115,116,117 and 118 to groups at the FLNR Laboratory in Russia and at RIKEN Laboratory in Japan. The A and Z assignment, however, is in some cases still based on indirect evidence. An experimental prove of Z could be the measurement of characteristic X-rays where attempts have been made with limited success.

The nuclei beyond fermium are solely stabilized by quantum mechanics. A charged liquid drop would fall apart due to Coulomb repulsion. This makes these systems ideal for nuclear structure studies. Decay spectroscopy after separation is used to investigate features like single particle trends or K-isomers for the deformed nuclei at Z=108 and N=152-162, providing direct links to the island of stability. The new SPIRAL2 facility presently under construction at the accelerator laboratory GANIL in Caen, France, will offer great perspectives for the field. An overview of the recent developments in SHN research, including a detailed discussion of the nuclear structure studies will be given.