Oral Presentation Abstracts

PHYSICS

EFFECT OF THIRD-ORDER PHASE ON THE PHOTOELECTRON MOMENTUM SPECTRUM AND IONIZATION TIME DELAY IN A HYDROGEN ATOM AND DIATOMIC MOLECULE

Presenter(s): Aygun, James, Undergraduate, Physics

Mentor: Prof. Allison Harris

Any The recent development of attosecond laser pulses has allowed for the ability to probe the dynamics of electrons inside atoms and molecules. Attosecond lasers allow us to study photoionization, during which a short, high intensity laser pulse causes the emission of an electron from an atomic or molecular target. One long-standing question is whether photoionization is instantaneous. It has been recently demonstrated that the photoionization process does not occur instantaneously and that it requires a finite time (called the ionization time delay). Additional studies using sculpted laser pulses, such as Airy pulses, have indirectly indicated that the ionization time may be dependent on the pulse's spectral phase, allowing for control of electron dynamics on very short time scales. In order to directly determine the effect of the spectral phase on the ionization time delay, we have developed computational models for attosecond streaking. We will present results from our models for the ionization time delay in a hydrogen atom and a diatomic hydrogen molecule using Airy pulses with varying spectral phases. One consequence of the Airy pulse's spectral phase is that the temporal envelope of the pulse is asymmetric. To determine the effects of this asymmetry on the ionization time delay, we also use our models to examine the symmetry of the photoelectron momentum spectrum and compare results to those for symmetric Gaussian pulses.

ENVELOPE WINDS AS A LIMITING FACTOR ON SUPERMASSIVE BLACK HOLE FORMATION IN QUASI-STARS

Presenter(s): Campbell, Claire, Undergraduate, Physics

Mentor: Prof. Matt Caplan

Authorship: Claire Campbell, Andy Santarelli

Present-day supermassive black holes (SMBHs) have no known formation mechanism that explains their mass and abundance. Typical stellar core collapse is limited, and subsequent accretion onto even the largest of collapsed stars is not sufficient to form an SMBH within a Hubble time. An alternative method of SMBH formation is direct collapse, wherein a disk of pre-galactic gas rapidly infalls to its center. Direct collapse occurs in a quasi-star, a theoretical star-like gaseous envelope supported by BH accretion rather than nuclear reactions. In this work, we have created numerical models of these quasi stars using the stellar evolution code MESA. We use these models to test the effects of envelope winds on SMBH formation. We find that winds place realistic constraints on the SMBH seeds that may result from quasi-stars.

DIAGRAM GENERATION FOR SPINOR AMPLITUDE SUBROUTINES

Presenter(s): Gabriel, Minney, Undergraduate, Physics

Mentor: Prof. Neil Christensen

Authorship: Minney Gabriel, Neil Christensen

Fundamental particles are the building blocks of the physical world. Physicists have studied the interactions between fundamental particles using experiments such as those conducted at the Large Hadron Collider (LHC) and by using Feynman Diagrams alongside numerical techniques to predict the outcomes of these experiments. However, Feynman Diagrams introduce unphysical degrees of freedom into calculations, an aspect that greatly hinders the efficiency of numerical calculations of scattering amplitudes. Using constructive diagrams instead of Feynman diagrams offers the prospect of removing these unphysical degrees of freedom, which could greatly increase the scope of scattering amplitude numerical calculations. The algorithmic generation and preparation of expressions for numerical calculations using constructive diagrams poses many unique problems, such as the recursive generation of interaction topologies and the algebraic manipulation of expressions to remove singularities. Raptor is a program-in-development that aims to solve these problems.

ANALYSIS OF MINIMA IN THE COMPLEX PARAMETER SPACE LANDSCAPE OF NEURAL NETWORKS

Presenter(s): Hardaway, Alexander, Undergraduate, Physics

Mentor: Prof. R. Grobe

Co-Mentor: Prof. Q. Su

Minimizing the loss function in a high-dimensional search space is a fundamental challenge in neural network applications. The parameter space in these models is often large, resulting in multiple minima that correspond to similar loss function values. This non-uniqueness issue becomes especially problematic when the neural network has more neurons than necessary. In this presentation, we will examine the phenomenon of "minimum hopping," which arises from overparameterization, and demonstrate how different convergence paths emerge through machine learning techniques applied to simple function matching with binary sigmoid activation functions. We will also characterize various types of minima, analyze the probability of converging to each, and evaluate the efficiency of convergence. We acknowledge NSF support.

INHERITED LEARNING IN NEURAL NETWORKS AND ITS APPLICATION TO QFT VACUUM STATES

Presenter(s): James, Eyan, Undergraduate, Physics

Mentor: Prof. R. Grobe

Co-Mentor: Prof. Q. Su

The phenomenon of supercritical field-induced vacuum breakdown has attracted growing interest, driven by advances in high-power laser technologies. In quantum field theory, the vacuum is often described by the occupied Dirac Sea states, which form the foundation for theoretical calculations. Accurately determining these states in a fast and efficient manner is highly sought after. Traditionally, this involves diagonalizing the Hamiltonian, a process that becomes increasingly complex when dealing with the Dirac Sea. In this study, we introduce a novel approach using neural networks to determine these states. Moreover, by applying the concept of the so-called inherited learning, we capitalize on the similarities between neighboring states, allowing us to recover many Dirac states with greater efficiency. We acknowledge NSF support.

QUASI-STAR MESA MODELS – REFINING BOUNDARY CONDITIONS, IMPLEMENTING ENVELOPE ACCRETION

Presenter(s): Nichols, Lane, Undergraduate, Physics

Mentor: Prof. Matt Caplan

Quasi-stars are a promising supermassive blackhole progenitor as an extension of direct collapse. We have created new models of these exotic stars, using MESA, where we implement new envelope accretion schemes and boundary conditions. These modifications allow us to understand the range of black hole seed masses that may form under stable quasi-star conditions. In addition, new boundary conditions allow us to both have a more accurate calculation of these masses and to further understand the internal structure of these stars.

USING MACHINE LEARNING TECHNIQUES TO PREDICT MOLECULAR COLLISION CROSS SECTIONS

Presenter(s): Parker, Helen, Undergraduate, Physics
Mentor: Dr. Allison Harris

Molecular collision cross sections are needed in many fields, such as plasma physics, astrophysics, biophysics, and chemical physics. Currently, the primary methods to determine these cross sections are experimental measurements or theoretical models, both of which have challenges. Measuring experimental cross sections is time consuming and expensive and must be done separately for each molecule of interest. Theoretical methods to calculate cross sections are time consuming and come with significant theoretical hurdles due to the complexity of the molecules' nuclear and electronic structure. These challenges have resulted in limited availability of molecular cross sections, which in turn inhibits the accuracy of applied physics models.

We have developed machine learning techniques to help fill the gap in available cross section data. To date, we have developed and applied a simple artificial neural network with a single hidden layer, which takes inputs of the number of different atoms in the molecule and outputs the electron-impact ionization cross section for different projectile energies[1]. The model was trained using published experimental data for a handful of molecular targets and showed the ability to predict cross sections to within 30% of known values.

In this work, we aim to improve on our existing model by modifying the network to include two physical parameters on which the ionization cross sections are known to depend - the ionization potential and electric dipole polarizability. These modifications are made by either including the physical parameters as inputs to the network in order to provide additional identifying information of the molecule or by including them as outputs of the network to serve as constraints on the network's predictions. Preliminary data shows that there is limited, if any, improvement in the predictions for the cross sections using the updated networks, but the predictions remained in reasonable agreement with published experimental results. Further improvements to our model are planned, such as including molecular structure information as an input to the network.

1. Harris, A. L. & Nepomuceno, J. A data-driven machine learning approach for electron-molecule ionization cross sections. *J. Phys. B: At. Mol. Opt. Phys.* **57**, 025201 (2024).

NEW 1D MODELS OF QAUSI-STARS

Presenter(s): Santarelli, Andy, Graduate, Physics

Mentor: Prof. Matt Caplan

Authorship: Andy Santarelli, Lane Nichols, Claire Campbell

Supermassive black hole formation remains as an unsolved problem. Quasi-stars represent a newer but still viable channel that have been explored more in depth in recent years. In this work, we have created new numerical models using the 1D stellar evolution code, MESA, in order to further understand their structure and stability. We use our models to further explore winds, envelope accretion, and additional boundary conditions.

SCULPTED LASER PULSES ALTER THE ELECTRON DYNAMICS IN ABOVE THRESHOLD IONIZATION

Presenter(s): Sims, Samantha, Undergraduate, Physics

Mentor: Dr. Allison Harris

The development of attosecond laser pulses has allowed for the ability to probe the dynamics of electrons in atoms on their natural time scales. One important process in attosecond science is above threshold ionization (ATI), in which an atom absorbs more photons than are required for ionization. The excess absorbed energy is converted to the kinetic energy of the ionized electron and the corresponding ATI spectrum has proven to be a valuable tool in many applications. Traditionally, sine-squared and Gaussian laser pulses are used when studying ATI. Sculpted laser pulses, however, have unique advantages over traditional laser pulse shapes. In particular, sculpted pulses can have more complicated envelope functions with multiple peaks, carry quantized orbital angular momentum, or exhibit self-acceleration, self-healing, and limited diffraction. These unique features allow for the possibility of enhanced control over electron dynamics and may alter the energy and momentum of the ionized electron. We calculate photoelectron energy and momentum spectra for ATI of hydrogen using Gaussian and Airy laser pulses with identical power spectra, but differing spectral phases. We solve the 3D time-dependent Schrödinger equation using the well-established solver QPROP. Our results demonstrate that the third order spectral phase of the Airy pulse can extend the rescattered electron plateau cutoff without increasing pulse duration or intensity. This feature may lead to new opportunities to study higher order effects in laser-atom interactions or offer greater control over ionization dynamics.

MOLECULAR DYNAMICS SIMULATIONS OF THE VORTEX-LATTICE INTERACTION IN NEUTRON STAR CRUSTS

Presenter(s): Smith, Nevin, Undergraduate, Physics

Mentor: Prof. Matt Caplan

Superfluid neutrons in the inner crust of neutron stars (NS) form quantized vortices that carry the angular momentum of the superfluid. These vortices are pinned in low-energy regions of the rigid ion lattice of the crust. During the spin down of NS, glitches have been observed where these stars temporarily increase their angular momentum in discrete intervals. During this period, the trapped vortices cause the angular speed of the inner crust to lag that of the outer crust. The vortices experience tension and stress causing unpinning and re-pinning; although the physics of this phenomenon is not well studied. We develop an empirical model to study a Gaussian well moving through an ion lattice using MD simulations. Confirming our predictions, we observe a “slip” point in the lattice deformation, such that the initial lattice reforms. We claim variations in the energy, timescale, and timestep of the system lead to complex frustration in our results.

ISOLATING DIFFUSION COEFFICIENTS OF LATTICE DEFECTS IN COULOMB CRYSTALS

Presenter(s): Webb, Levi, Graduate, Physics

Mentor: Prof. Matt Caplan

Authorship: Levi Webb, Dany Yaacoub

The diffusion coefficients of Coulomb crystals, as applicable to stellar astrophysics, have seldom been studied to a satisfactory level. Molecular dynamics (MD) studies such as this inform our understanding of the macroscopic properties of stellar remnants, such as white dwarfs and neutron stars. We use the MD code LAMMPS to simulate small Coulomb crystal lattices of varying temperature and screening length, then introduce defects by either inserting (interstitials) or removing (vacancies) particles. By tracking the propagation of these defects and their interactions with the surrounding lattice, we determine their diffusion coefficients. This research enhances current understandings of defect-driven diffusion in strongly coupled plasmas, thereby influencing knowledge of the thermal and mechanical evolution of the dense matter within white dwarfs and neutron star crusts.

USING NEURAL NETWORKS TO SOLVE ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS

Presenter(s): West, Carter, Undergraduate, Physics

Mentor: Prof. R. Grobe

Co-Mentor: Prof. Q. Su

Conventional approaches to solving ordinary differential equations (ODEs) and partial differential equations (PDEs) are often constrained by issues of spatial resolution and computational time, especially as dimensionality grows. However, neural network algorithms offer a promising solution to these challenges. In this presentation, we explore how these advanced techniques can be leveraged to efficiently solve both basic ODEs and PDEs in physics, overcoming traditional limitations. We acknowledge NSF support.

UNIVERSAL DIFFUSION IN COULOMB CRYSTALS

Presenter(s): Yaacoub, Dany, Graduate, Physics

Mentor: Prof. Matt Caplan

Diffusion coefficients for crystallized Coulomb plasmas are essential microphysics input for modeling white dwarf cores and neutron star crusts. Solving for diffusion coefficients require running large molecular dynamic simulations with thousands of particles over millions of timesteps. The diffusion in a crystallized plasma has been largely ignored and is often taken to be zero in stellar evolution simulations. We find that not only is this incorrect, but we find that the diffusion in a crystallized plasma can be modeled completely using a universal scaling law independent of screening. Our simulations also show that the dominant mode of diffusion in a Coulomb crystal is through the formations of defects in the lattice created due to thermal fluctuations.

NITE OUT!

Presenter(s): Cummings, Tanaya, Undergraduate, Accounting

Mentor: Dr. Livia Stone

Authorship: Tanaya Cummings

The nightlife of college students marks the beginning highlights of their young adulthood. Where they choose to mingle under the dim lights are formative of their night out experiences. This aims to showcase the juxtapositions between two ‘nite out’ cultures: classic bar goers and alternative house show scene.

MOTIVATIONS

Presenter(s): El Houmaidi, Ghali, Undergraduate, Sociology/Anthropology

Mentor: Dr. Livia Stone

Interview series of dedicated Illinois state University (ISU) students ranging from the fine arts to sports pertaining to the underlying motivations behind their work. This work has been elaborated as part of ANT-385 at ISU with the help of Professor Livia Stone.

RIOT -- 2024

Presenter(s): Johnson, Apollo, Graduate, Sociology/Anthropology

Mentor: Dr. Livia Stone

An ethnographic view of a counterculture music festival, from an attendee's point of view. Filmed and edited by Apollo Johnson.

RABBIT HOLES WITH ALEX: THE FACE OF GOD

Presenter(s): Koch, Alexander, Graduate, Sociology/Anthropology

Mentor: Dr. Livia Stone

Authorship: Alexander Koch

What do you imagine when you picture the face of God? A bearded man? An ephemeral light? Or something else entirely? In this video essay using filming and editing techniques learned from ANT 385/496 (Visual Anthropology) I host a personalized discussion of the Christian “Face of God.” Ranging from my own opinions to tracing historical iconography, the film encourages watchers to engage with the idea of face of God.

REVOLUTION IN THE WIND: THE REBIRTH OF BANGLADESH

Presenter(s): Rahat, Mustafizur, Graduate, Sociology/Anthropology

Mentor: Dr. Livia Stone

This documentary is a personal story about the 2024 July Revolution in Bangladesh. It combines my own experiences with the perspectives of Bangladeshis living abroad. The goal is to show the emotions and intensity of the movement while connecting what happened in Bangladesh to the experiences of the Bangladeshi community at Illinois State University (ISU). The film follows a personal essay style, with my voice guiding the audience through important events and themes. It is both informative and reflective, sharing my journey in a way that helps others understand the movement on a deeper level.

TRANSFERS IN TRANSITION: COMMUNITY COLLEGE STUDENTS IN THEIR FIRST SEMESTER AT A 4-YEAR

Presenter(s): Reft, Eleanor, Undergraduate, Sociology/Anthropology

Mentor: Dr. Livia Stone

Authorship: Eleanor Reft

This is an ethnographic interview-based film, done for a college anthropology class, about transfer students from various community colleges in their first semester at a 4-year institution. Since transferring to a 4- year institution myself, I had been experiencing some difficulties in adjusting socially. When faced with a film assignment for my media and visual anthropology class, I wondered if I could turn that difficulty into a research question. Realizing that I could shed some light on the experiences of transfer students, I reached out to friends and new acquaintances to see if they would be interested in being interviewed. Inspired by Jean Rouch and Edgar Morin's "Chronicle of a Summer" (1961) and Xun Sero's "Mamá" (2022), I hoped to make this film feel intimate and personal in its approach to ethnographic research. I believe the result is an honest, candid film about the shared ups, downs, and hopes of college transfer students

REDEFINING THEATRICAL PRACTICES FROM COLOMBIA'S INDIGENOUS

Presenter(s): Alexander, Michelle, Undergraduate, Theatre, Dance, and Film

Mentor: Dr. Le'Mil L. Eiland

Authorship: Michelle Alexander

La Yonna, a traditional dance of the Wayuu, and *La danza Jepa*, a dance adaptation of the traditional healing movement of the Emberá-Chami, are both Columbian dance practices built upon ancestral indigenous customs that are performative in nature. While these dances can be seen today at native dance conventions and competitions in Colombia, they are history and culture preserved. These matrilineal tribes demonstrate different ways that culture survives under oppressive structures and further expose the falsehood behind the claim that "Spain brought theatre to South America". These two distinct dances from Colombia present the power behind femininity in their cultures. Practices common to indigenous populations pre-colonization seldom utilized the word "theatre" to define them, however, does that mean they are not theatre? The theatre zeitgeist often leaves dance or "ritualistic" performances out of its definition despite the rich history of their conceptual integration. By including their practices as part of the "theatre canon", we further debunk the assertion that femininity is a "weak" or "demeaning" trait, as has been previously pushed by feminine stereotypes in theatrical spaces (i.e. the ingenue, the damsel in distress, the blonde, etc.). For these dances to best dispel the misconceptions that theatre was brought to South America by the Spanish, we must first review and revise the definition of 'theatre'. This research seeks to highlight the importance of indigenous and gender studies as it pertains to theatre with the goal of encouraging cultural compassion and diversifying the canon.

EVALUATING APPLIED THEATRE INTERVENTIONS: A CASE STUDY OF THE ASUBOA PROJECT

Presenter(s): Igwe, Fredrick, Graduate, Theatre, Dance, and Film
Mentor: Dr. Derek Munson
Authorship: Fredrick Igwe

The efficacy of applied theatre remains a subject of debate, with some arguing that it fails to bring about meaningful change, while others, drawing on Augusto Boal's philosophies, view it as a powerful tool for transformation. A key issue fueling this debate is the challenge of evaluating impact, as no universal method exists to measure outcomes. My research highlights the necessity of context-specific metrics to assess applied theatre's effectiveness. I developed an evaluation framework for the Asuboa Project, one of my earliest applied theatre experiences in Africa that measures short- and long-term impacts at both community and individual levels. Using the Asuboa Project as a case study, my research traces the development, practice, and influence of applied theatre and argues that meaningful assessment requires evaluation tools tailored to specific contexts.

DARK WATER: THE TRANSFERENCE OF TRAUMA BY OSMOSIS

Presenter(s): Lecouris, Jon, Undergraduate, Theatre, Dance and Film
Mentor: Prof. Li Zeng
Authorship: Jon Lecouris

In the film Dark Water (Hideo Nakata, 2002), a recently separated woman and her daughter are haunted by visions of a ghostly little girl. The mystery and tragedy surrounding the spirit literally seeps into the apartment inhabited by the mother and daughter in the form of water leaking through their ceiling and coursing through the apartment building's pipes. As Yoshimi attempts to build a happy home for herself and her child, she quickly finds that they have moved into a haunted house, a "sinister double of the perfect domestic space [women are] supposed to aspire to" (Le Fouillé). As the film unfolds, events occur that force the audience to question Yoshimi's sanity and the reality of the ghostly happenings. As we learn more about Yoshimi's own tragic childhood and history of mental illness, viewers must "question the reliability of their narrator, and, through the possibility of madness, encapsulate the trauma manifesting itself physically in the domestic space" (Le Fouillé). If the viewer reads the apartment building itself as a metaphor for the body of the mother, the dark water of the title as the medium through which trauma seeps into Yoshimi's life, and the ghostly girl as the physical manifestation of Yoshimi's unaddressed subconscious suffering, then one can unlock the secrets of what is much more than a simple haunted house tale.

PERFORMING THE AESTHETIC-SELF/IDENTITY IN "MANODZI" MUSIC VIDEO

Presenter(s): Quashigah, Lawrence, Graduate, Theatre, Dance and Film
Mentor: Dr. Derek Munson
Co-Mentor: Dr. Bruce Burningham
Authorship: Lawrence Quashigah

This paper joins the conversation on identity construction and performance but with a focus on aesthetics as a means of expressing and performing identity. A particular focus for that matter is on a selected Ghanaian music video, "Manodzi" by Ghanaian Artist, Stonebwoy featuring Beninese-French Singer, Angelique Kidjo. Extant literature on this topic has shown that identity is performed through actions for a specific audience. Also, the essence of identity is debated among scholars to include concepts such as, importance, salience, social construction, ethnicity, religion, culture and mutual construction. There has been minimal research on how the aesthetic self/identity is portrayed in Ghanaian music videos. Nonetheless, the paper shows that the concept of aesthetics is viewed by scholars from the points of personal values, cultural backgrounds, self-perception and pursuit of beauty, art and craft, rhythm and design and as abstract ideas. The aesthetic self is performed through concepts like aesthetic preference, taste and practice in performing the self- identity. Using the theories of aesthetics and semiotics, the paper examines how Stonebwoy and Angelique Kidjo perform levels of aesthetic identities in the "Manodzi" music video. The study concludes that Ghanaian and African arts were used symbolically to depict aesthetic identity by Stonebwoy, Angelique Kidjo and other performers in the music video.