Physics Colloquium with Zoe Yan (Princeton) [AMO]

Date: January 19th, 2023
Time: 4:00pm
Location: Willamette 100

Quantum many-body physics with ultracold molecules

Abstract: A central challenge of modern physics is understanding the behavior of strongly correlated matter. Current knowledge of such systems is limited on multiple fronts: experimentally, these materials are often difficult to fabricate in laboratory settings, and numerical simulations become intractable as the number of particles approaches meaningful values. In the spirit of Feynman, physicists can model diverse phenomena, from high-temperature superconductivity to quantum spin liquids, using analog quantum simulation. My research explores emergent quantum phenomena in pristine systems made of atoms, molecules, and electromagnetic fields. In particular, ultracold molecules are a promising platform due to their tunable long-range interactions and large set of internal states. However, this nascent platform requires new experimental techniques to create, control, and probe molecular systems.

I will report on efforts to create ultracold polar molecules, coherently manipulate their internal levels, and demonstrate second-scale coherence times in a molecular ensemble. To leverage the long-range, anisotropic dipolar interactions, we engineer dipolar collisions in a bulk ensemble using the technique of microwave dressing. Upon loading polar molecules into a 2D optical lattice, we study dynamics and thermalization in a variety of spin models relevant to quantum magnetism. Toward that end, we develop a novel readout modality – quantum gas microscopy – to perform site-resolved fluorescence imaging, enabling the measurement of quantum correlations and entanglement. The techniques presented here establish ultracold molecules as a compelling platform for quantum science and technology.

Host: Ray Frey

Also on Friday, January 20th at 3:00pm in Willamette 472, Dr. Yan will give a technical future-directions seminar talk.

Future directions for quantum simulation with atoms and molecules

Abstract: Ultracold molecules and atoms are in many ways “nature’s perfect qubits,” ideal for many applications in the quantum sciences. I will discuss exciting future research directions involving quantum simulation with the ultracold quantum gas toolkit, including realization of topological superfluids, molecules in the cavity QED regime, and cold atoms in optical bilateral systems.
A Massive Star is Born: How Stellar Feedback Limits Accretion onto Massive Stars

Abstract: Massive stars play an essential role in the Universe. They are rare, yet the energy and momentum they inject into the interstellar medium with their intense radiation fields and fast, isotropic radiatively-driven winds dwarfs the contribution by their vastly more numerous low-mass cousins. This stellar feedback dominates the energy and momentum budget in star-forming regions and galaxies, which has important implications for both star and galaxy formation. Massive stars form from the gravitational collapse of magnetized, dense, and turbulent molecular gas in giant molecular clouds (GMCs). During their formation, feedback from their intense radiation fields, collimated protostellar outflows, and stellar winds may limit their growth by accretion. In this talk, I will show a series of radiation-magnetohydrodynamic (RMHD) simulations of the collapse of massive pre-stellar cores into massive stellar systems to demonstrate how stellar feedback can limit accretion onto massive stars and disrupt their natal environments. I will discuss how outflows control the star formation efficiencies and dynamics of massive protostellar cores and how stellar wind feedback is likely responsible for quenching accretion onto massive stars that form from the collapse of isolated cores when they reach ~30 Msun. My results suggest that stars more massive than this likely form in regions within GMCs that are supplied mass via large-scale, high ram-pressure dynamical inflows in agreement with observations of massive star-forming regions. Hence, future studies of massive star formation require simulating the formation of massive star clusters that form via the gravitational collapse of massive GMCs, which host numerous massive stars, through the use of state-of-the-art RMHD simulations.

Host: Ray Frey

Also on Friday, January 27th at 3:00pm in Willamette 472, Dr. Rosen will give a technical future-directions seminar talk.

Sweating the Small Stuff: The Importance of Stellar Feedback in Star and Galaxy Formation

Abstract: Stellar feedback, the injection of energy, mass, and momentum by young (massive) stars into the interstellar medium, remains as one of the largest uncertainties in star and galaxy formation, and it touches upon all of the key scientific challenges for the next decade, as outlined in the Astro2020 Decadal Survey. These high-priority challenges are: (1) Unveiling the Drivers of Galaxy Growth, (2) Pathways to Habitable Worlds, and (3) New Windows on the Dynamic Universe. As an Assistant Professor at UO, I will lead an ambitious research program studying the formation of massive stars and massive star clusters (MSCs) in unprecedented detail with state-of-the-art numerical simulations to determine how stellar feedback affects star formation, sets the upper stellar mass limit,
leads to the dissolution and ultimate disruption of star clusters, and drives the chemical evolution within galaxies and the Universe. Additionally, I will also study the stellar dynamics of star clusters to determine how close-in massive binaries form, both of which have important consequences for massive star/binary evolution and in understanding the progenitors of gravitational wave sources. Additionally, I will utilize my numerical simulations to aid the interpretation of multi-wavelength observations of massive star and star cluster formation by producing synthetic observations. I will also discuss potential research opportunities for graduate and undergraduate students, and provide an overview of my teaching and mentoring philosophy, which emphasizes compassionate pedagogies, and my plans for diversity, equity, and inclusion and outreach efforts in the Eugene, OR community.

Physics Colloquium with Meridith Joyce (CSFK Konkoly Observatory Budapest Hungary) [ASTRO]

Date: February 2, 2023
Time: 4:00pm
Location: Willamette 100

The Ages of Stars and Other Stories: Redefining the Standard for 1D Stellar Modeling Across the Mass Spectrum

Abstract: Stellar models are the means by which astronomers infer the ages, masses, and distances of stars, thus setting the first rungs of the cosmological distance ladder and allowing us to peer into the history of our Galaxy and Universe. Recent advances in space-based instrumentation (e.g. Gaia, TESS, SDSS, JWST) promise high-precision data sets comprising millions of stars. However, astronomy has now entered an era in which observational precision eclipses modeling precision by a factor of 10. This means the barrier to more precise fundamental stellar parameters—and hence to progress in astrophysics as a whole—lies in the theoretical and computational domain rather than in the power of our telescopes. Using my studies of Betelgeuse, the Milky Way’s galactic bulge, and other stellar settings as examples, I will discuss the power, limitations, and future of stellar modeling.

Host: Ray Frey

Also on Friday, February 3rd at 3:00pm in Willamette 472, Dr. Joyce will give a technical future-directions seminar talk.

A Computational and Statistical Approach to Open Problems in Stellar Modeling

Abstract: The Mixing Length Theory (MLT) of convection was first applied to models of the stellar interior in the 1950s by Erika Boehm-Vitense. Seventy years later, it remains the default prescription for superadiabatic convection in stellar structure and evolution codes. However, a significant weakness of the prescription is that it relies on ad hoc calibrations of the convective mean-free path, typically denoted alpha_MLT, to the Sun. As the Sun is not
a reliable proxy for every star, this method introduces significant biases into models of non-
solar stars and dangerously obscures important numerical uncertainties in stellar evolution
calculations, leading astronomers to quote inappropriate precisions on fundamental stellar
parameters derived from stellar tracks and isochrones. Much of my work over the past five
years addresses this problem in two ways: The first approach concerns performing
convective calibrations to stars other than the Sun—for example, to stars with very low
metallicities and Alpha Centauri A & B—with the ultimate goal of building a data-driven
scaling relation to replace the solar MLT formalism. The second approach concerns the
rigorous treatment of numerical uncertainties in stellar models, using techniques such as
Monte Carlo simulations over variations in alpha_MLT. My initial explorations have shown
that such methods generate much larger and more realistic error bars on stellar ages. As
such, rigorous uncertainty analysis may ultimately lead to a reduction in tension between,
e.g., isochrone-based age determinations of metal-poor globular clusters and the Planck
age of the Universe.

**Physics Colloquium with Professor David Masiello**  (University of Washington) [AMO]

**Date:** February 9, 2023  
**Time:** 4:00pm  
**Location:** Willamette 100

**Nanometer-Scale Spatial and Spectral Mapping of Exciton Polaritons in Structured
Plasmonic Cavities**

Abstract: Exciton polaritons (EPs) are ubiquitous light-matter excitations under intense
investigation as test beds of fundamental physics and as components for all-optical
computing. Owing to their unique attributes and facile experimental tunability, EPs
potentially enable strong nonlinearities, condensation, and superfluidity at room
temperature. However, the diffraction limit of light and broad momentum content of fast
electron probes preclude the characterization of EPs in nanoscale structured cavities
exhibiting energy-momentum dispersion. Through an innovative combination of electron
beam and optical probes, I will show theoretically that these limitations can be overcome to
measure EPs in periodic nanophotonic cavities at their natural energy, momentum, and
length scales via lattice electron energy gain spectroscopy. With the combined high
momentum resolution of light and nanoscale spatial resolution of free-space focused
electron beams, lattice electron energy gain spectroscopy can expose deeply
subwavelength EP features using currently available monochromated, aberration-corrected
scanning transmission electron microscopes (STEMs). Time permitting, I will also discuss
the addition of polarization structure to the STEM electron probe and demonstrate
theoretically how this degree of freedom can be harnessed to characterize the 3D
polarization-resolved response field and local chirality of an optically excited target with
nanoscale spatial resolution.

Host: Ben McMorran
Physics Colloquium with Kayla Nguyen (University of Illinois)  [CMX]

Date:  February 16, 2023  
Time:  4:00pm  
Location: Willamette 100

Uncovering Chirality of Skyrmions in Polycrystalline B20 FeGe on Si

Abstract: Understanding chirality, the intrinsic handedness of a system, is important for future technologies using quantum magnetic materials. Of particular interest are magnetic skyrmions which are chiral and topologically protected, meaning that their spin textures can act as barriers from deformation in crystalline grains. However, most electron microscopy studies use Lorentz TEM or holography to investigate chirality in skyrmions in nearly perfect single crystals because Fresnel effects may cause signals from grain structures to be mistaken as magnetism when the two are comparable in size. In this work, we probe nanomagnetism of topological magnetic textures in sputtered thin film of B20 FeGe on Si to study the relationship between magnetic and crystal chirality. Using 4D-STEM, we find that the vorticity and helicity of these magnetic topological phases are coupled to the crystal chirality. Furthermore, our work shows that signals from magnetism can be disentangled from crystalline effects for sub-micron grains, enabling a new way to investigate topological magnetism in the presence of small polycrystalline grains. This methodology is important for spintronics and low-power magnetic memory technologies that rely on scalable techniques for large scale manufacturing of real devices.

Host: Ray Frey

Also on Friday, February 17th at 3:00pm in Willamette 472, Dr. Nguyen will give a technical future-directions seminar talk.

Probing Quantum Materials with Electrons

Abstract: Electron microscopy is transforming the physical sciences. Aided by a new generation of direct imaging detectors, cryo-electron microscopy won the 2017 Nobel Prize in Chemistry and resulted in significant advances in visualization of biomolecules. My vision is to develop new electron probes to make similar advances for quantum materials. The overall goal of my research is to investigate emergent physics in quantum materials by developing new experimental and computational techniques for electron microscopy. With these new approaches, my immediate plans include (1) probing for the first time natural order parameters in topological systems using a ‘Berry-phase’ detector, (2) determination of atomic and topological textures in three-dimensions and (3) mapping individual electron spins at sub-Angstrom spatial resolution in topological antiferromagnets. The ability to study magnetic orientations of every spin near a defect or visualize new topological textures in three-dimensions at angstrom resolution will enable profound advances in the field of microelectronics, spintronics and topological physics.
CAS Public Lecture by Nobel Laureate Dr. William D. Phillips  NIST and University of Maryland

Date:  February 21, 2023
Time:  6:30pm

Location: Straub Hall 156

Time, Einstein, and the Coolest Stuff in the Universe

Abstract: At the beginning of the 20th century Einstein changed the way we think about Time. Now, early in the 21st century, the measurement of Time is being revolutionized by the ability to cool a gas of atoms to temperatures millions of times lower than any naturally occurring temperature in the universe. Atomic clocks, the best timekeepers ever made, are one of the scientific and technological wonders of modern life. Such super-accurate clocks are essential to industry, commerce, and science; they are the heart of the Global Positioning System (GPS), which guides cars, airplanes, and hikers to their destinations. Today, the best primary atomic clocks use ultracold atoms, achieve accuracies better than one second in 100 million years, while a new generation of atomic clocks is leading us to re-define what we mean by time. Super-cold atoms, with temperatures that can be below a billionth of a degree above absolute zero, use, and allow tests of, some of Einstein’s strangest predictions.

This will be a lively, multimedia presentation, including exciting experimental demonstrations and down-to-earth explanations about some of today’s hottest (and coolest) science.

Host: David Wineland

Physics Colloquium with Kelsey Hallinen (Princeton University)  [BIO]

Date:  February 23, 2023
Time:  4:00pm

Location: Willamette 100

Population Dynamics in Complex Biological Systems

Abstract: Employing tools from statistical physics and complex systems, my research focuses on understanding collective behavior in biological systems. Using a mix of experimental studies and physics driven modeling, I have been able to elucidate rules and equations that can explain the complex, collective behavior in a variety of systems, from bacterial populations to neural networks. In this talk, I will discuss my previous research examining the dynamics in a mixed population of antibiotic resistant and sensitive bacterial cells as well as population decoding studies of neural signals in the small nematode C. elegans. Through these examples, I will demonstrate how my collective systems
approaches can generate insights into how groups of simple actors—such as bacterial cells or neurons—can lead to complex emergent outcomes. As I look towards my future work, I will apply these collective systems approach towards another complex system, bacteria in flow. I will discuss my preliminary results and future plans for studying bacterial adherence and dynamics in complex flow environments, inspired by clinical endocarditis infections.

Host: Ray Frey

Also on Friday, February 24th at 3:00pm in Willamette 472, Dr. Hallinen will give a technical future-directions seminar talk.

Physical and Molecular Bacterial Responses to Fluid Flow

Abstract: Endocarditis is an infection of the tissues of the heart and large bacterial vegetations are often found on the heart valves. From fluid mechanics studies, we know the fastest flow is in the narrowest channels, which leads to an interesting paradox: why do bacteria adhere to valves where they would also experience the highest flow? Drawing from my collective systems approach, I will discuss my preliminary work and future plans to study the currently unmet need to understand the dynamics of these complex infections. Utilizing a microfluidic setup, I have recapitulated the counter-intuitive bacteria adherence in higher flow using *S. aureus* MRSA. I will discuss my future plans to study this system both through physics-driven approaches, such as altering the microfluidic channels, instituting pulsatile flow, and modeling the interplay between flow and genetic effects, as well as biological-driven approaches, such as genetic studies to examine the different genes and pathways being up- or down-regulated in the flow environment. Further, I will discuss my long-term plans to study the generality of the rules and behaviors seen in *S. aureus* when compared to behaviors in the other pathogens also implicated in endocarditis.

Physics Colloquium with Yingying Wu (MIT) [CMX]

Date: March 2, 2023
Time: 4:00pm
Location: Willamette 100

Towards Ultralow-Power and Scalable 2D Topological Spintronics Using Quantum Devices

Abstract: The current electronics industry is facing challenges both from the fundamental physics limit of silicon on the small scale, and the new demand for big-data applications on the large scale. Spintronics, utilizing spin degree of freedom, is a promising for future beyond-CMOS devices and systems, thanks to their low power consumption, nonvolatility, and easy 3D integration. The emerging 2D magnets can preserve single-phase magnetism even in monolayer (~0.8 nm) limits, and thus they are promising to further scale down devices. They have a sharp interface and atomically thin nature, promising for designer
quantum devices and more functionalities (e.g. stacking order, twist angle, thickness, and voltage control).

In this talk, I will discuss 2D spintronics with quantum devices on skyrmions and antiferromagnets, and their potential applications. I will begin by presenting my observations of real-space topological spin textures – magnetic skyrmions, in 2D devices. This work represents the first report of skyrmion lattice imaging in 2D layered magnets. Building on this, I will present my findings on the vertical imprinting of skyrmions onto neighboring layers in a 2D ferromagnet/2D ferromagnet system, demonstrating new functionality for skyrmion-based spintronics. I will then discuss the exchange coupling and voltage controlled 2D antiferromagnetism in devices, a step towards energy-efficient and fast spintronics. In addition, future work on quantum devices is motivated that would focus on energy-efficient control in magnetism, for neuromorphic and quantum computing.

Host: Ray Frey

Also on Friday, March 3rd at 3:00pm in Willamette 472, Dr. Wu will give a technical future-directions seminar talk.

2D Topological Spintronics for Neuromorphic and Quantum Computing

Abstract: The field of 2D topological spintronics based on 2D magnets is an emerging area and holds great potential for the development scalable, fast and energy efficient devices. In this seminar, I will present my future research plans for 2D topological spintronics, focusing on the fundamental new physics as well as their applications in neuromorphic and quantum computing. I will outline my five-year research plane and discuss strategies for standing out in the current research community. In addition to my research plan, I will also cover topics such as my future lab, funding opportunities, teaching commitments, service activities and diversity, equity and inclusion initiatives.

Physics Colloquium with Yvette Cendes (CfA Harvard) [ASTRO]

Date: March 9, 2023
Time: 4:00pm
Location: Willamette 100

Tuning in to the Radio Transient Sky

Abstract: Advances in time-domain and multi-messenger astronomy are providing a fresh view of the dynamic universe, with transient phenomena holding enormous potential as probes of extreme physics at cosmic scales. Radio observations of transients provide a particularly powerful probe of outflows and jets, as well as the local ambient medium shaped by the progenitor system. With the unprecedented sensitivity of the VLA, ALMA, MeerKAT, and other radio interferometers it is now possible to probe the physics of transients across a
wide range of phenomena. In this talk, I will give an overview of recent developments in time-domain radioastronomy to unravel questions in fundamental physics, focusing on two research areas: Tidal disruption events (TDEs), where a supermassive black hole shreds a star, and the search for (natural) radio emission from exoplanets. I will describe how, in both cases, radio observations are providing critical insight that is not accessible at other wavelengths, and will pay a key role in the future of the field.

Host: Ray Frey

Also on Friday, March 10th at 3:00pm in Willamette 472, Dr. Cendes will give a technical future-directions seminar talk.

The Upcoming Radio Transient Revolution
Abstract: Transient radio astronomy is about to undergo a period of exponential growth, as new electromagnetic and multi-messenger facilities come online. In this talk, I will discuss several contributors to this upcoming revolution, beginning with the commencement of LIGO O4 in May 2023 and the future of gravitational waves as multi-messenger probes for electromagnetic counterparts. I will then discuss the transformation expected from the upcoming Rubin Observatory, which will begin science observations in 2025 and is expected to find millions of transients a year, and the excitement behind new radio telescopes under construction with the Square Kilometer Array (SKA) and next generation VLA (ngVLA). Finally, I will discuss my ideas for future projects with undergraduate and graduate students in both the near and far future, and my plans to contribute to mentorship and equality and inclusion efforts in the University of Oregon community.

Physics Colloquium with Professor Wes Campbell (UCLA) [AMO]

Date: March 16, 2023
Time: 4:00pm
Location: Willamette 100

Prospects for Designing Customizable Qubits from Organic Molecules

Abstract: An optical cycling transition in a molecule is an electronic transition in which the upper state preferentially decays back to the original rovibrational state (or states) from which it was excited. Because the laser-induced fluorescence can be repeated many times with a nearly deterministic final internal state, these transitions are useful for laser-driven applications such as Doppler cooling and quantum state preparation and detection of qubits. I will discuss recent progress toward endowing molecules as large as polycyclic arenes with optical cycling centers and how this progress may continue even when the species involved are so large that rotational lines are no longer optically resolved.

Host: David Wineland