Spring 2022 Colloquium Series

Date: Thursday, April 14, 2022
Speaker: **Corey Gray (Caltech) [ASTRO]**

Title: *A Blackfoot Code Talker For Einstein*

Abstract With a cast of characters including Albert Einstein, a pair of black holes, over 1000 scientists, a Nobel Prize, and one's mother, get the down low on a scientific discovery a century in the making (actually 1.3 billion years)! The first direct detection of gravitational waves in 2015 is a story which made history at the speed of light and changed the lives of many just as fast. Follow the journey of a kid who grew up outside of LA to working at the Laser Interferometer Gravitational wave Observatory (LIGO). Learn what it has been like to be a Niitsitapi (Indigenous person) in physics. Additionally, learn about how a shy, quiet, and reluctant public speaker has come to embrace science communication by connecting science with Blackfoot culture and recruiting Sharon Yellowfly (his mom) to work with him, and why it is vitally important for all of us to share our story and to make science personal.

Hosts: Ray Frey and Tien-Tien Yu

April 21 - **Cris Niell (UO, ION)**

Title: **Neural circuits and computations for vision**

Abstract: Our visual system takes in photons, and through an extended sequence of neural computations, creates a representation of the world around us that can be used to enable a wide range of behaviors. Importantly, our visual system is not just a passive detector. Rather, we move our head and eyes to acquire information, and likewise, the types of computations that are performed on the incoming information depend on our current goals and actions. Research in the Niell lab seeks to determine how neural circuits in the brain enable such a range of visual capabilities, using a combination of electrical recordings, optical imaging, and computational analyses. I will present results from experiments in the laboratory mouse that quantify how visual information is encoded in the activity of neurons and how this is modulated in different behaviors, as well as new approaches to measure neural activity and visual function in animal’s that are freely moving. Finally, I will present a new research direction studying the completely different, yet largely unexplored, visual system of the octopus.

Host: Richard Taylor
May 5 - **Serena Eley** (Colorado School of Mines) [CM]
Host: Hailin Wang and Tien-Tien Yu

**Virtual Talk Only**

**Title:** Resistance is Not Futile: Pinning Down Elusive Vortices in Superconductors

**Abstract:** The electromagnetic properties of many seemingly disparate condensed matter systems are dictated by the dynamics of inlying elastic media, including charge density waves in materials with highly anisotropic band structure, domain walls in ferroelectrics, skyrmions in magnets with strong spin-orbit coupling, and vortex matter in type-II superconductors. In these systems, competition between disorder, elasticity, thermal energy, and driving forces from currents can engender elastic or plastic deformations and determine phase boundaries between the two regimes. In superconductors, the motion of vortices also introduces unwanted dissipation that is disruptive to applications, for example, limiting the current-carrying capacity in wires and causing energy losses in microwave circuits. Fortunately, material defects can immobilize vortices, acting as vortex pinning centers, which engenders dramatic improvements in superconductor material properties and device operation. This has motivated decades of research into developing methods of tailoring the disorder landscape in superconductors to increase the strength of vortex pinning. Yet efficacious materials engineering still eludes us. The electromagnetic properties of real (disordered) superconducting materials cannot yet be reliably predicted, such that designing superconductors for applications remains a largely inefficient process of trial and error. In this talk, I will discuss major open questions in vortex physics and our efforts to understand the complex interplay between vortex elasticity, vortex-vortex interactions, and material disorder. I will cover results from studies of a wide variety of materials, specifically discussing the effects of incorporating artificial pinning centers and anisotropy on the critical current, thermally-activated vortex motion (creep), and vortex phases. Lastly, I will present our proposal of the existence of a universal minimum realizable creep rate that depends on material parameters. This limitation is of both fundamental and technological significance: it provides new clues about the interplay between material parameters and vortex dynamics and about how to engineer materials with slow creep.
May 12 - John Toner (UO)
Host: John Toner

Title: Birth, Death, and Flight: the hydrodynamics of Malthusian flocks

Abstract: I'll present the hydrodynamic theory of ``Malthusian Flocks": moving aggregates of self-propelled entities (e.g., organisms, cytoskeletal actin, microtubules in mitotic spindles) that reproduce and die. Long-ranged order (i.e., the existence of a non-zero average velocity $\left< \vec{v} (\vec{r}, t) \right> \neq \vec{0}$) is possible in these systems, even in spatial dimension $d=2$. Their spatiotemporal scaling structure can be determined exactly in $d=2$; furthermore, they lack both the longitudinal sound waves and the giant number fluctuations found in immortal flocks. Number fluctuations are very persistent, and propagate along the direction of flock motion, but at a different speed. I'll also present recent results for the three-dimensional version of this problem, which required the first full blown dynamical renormalization treatment of a flocking system in its ordered phase.

May 19 - Ben Safdi (Berkeley) [HEP]
Host: Graham Kribs

Title: Detecting Axion Dark Matter (Virtual Talk)

Abstract: The quantum chromodynamics axion is one of the most sought-after beyond the Standard Model particles at present because of its possible connections with the strong-CP problem, dark matter, and ultraviolet physics such as Grand Unification and String Theory. However, axions are notoriously difficult to probe in the laboratory because of their weak couplings to matter. In this talk I will overview multiple recent advances that will help accelerate the search for axions. On the theoretical side, I will present the results of recent simulations of axion dark matter production in the early Universe after the Big Bang that narrow the possible mass range of the axion. I will then describe a novel laboratory detector setup, called ABRACADABRA, that is sensitive to axions connected with Grand Unification. I will show that the up-coming DMRadio project, building off of the successful ABRA-10 cm experiment, will cover some of the most motivated regions of axion parameter space in the coming years. We may soon know if axions exist within the spectrum of fundamental particles.
Title: Quantum Telescopy: Very Long Baseline Interferometric Imaging using Entangled States as a Nonlocal Oscillator

Abstract: Recent proposals suggest that distributed single photons serving as a ‘nonlocal oscillator’ can outperform weak coherent states as a phase reference for long-baseline interferometric imaging (VLBI) of faint astronomical sources. Such nonlocal quantum states distributed between telescopes can, in-principle, extend the effective size of a telescope array in the visible spectrum beyond what is possible using conventional techniques, allowing increased spatial resolution. (Analogous to the Event Horizon Radio Telescope array that recently imaged black holes.)

In a tabletop experiment by our group, photon interference between a nonlocal single-photon oscillator and light from a model “star” has been implemented, enabling reconstruction of the source spatial distribution with increased usable signal per source photon detected in coincidence with the nonlocal oscillator photon – the first instance of quantum-enhanced sensing in this context.

June 2 - Karin Fisher (AO Sense)
Host: Brian Smith

Title: I can use my PhD in industry!? An atom interferometer gravity gradiometer for earth science

Abstract: Atom-interferometric sensors exploit the wavelike properties of atoms to detect inertial forces (e.g., gravity) through matter-wave interference, enabling them to achieve unparalleled sensitivity and accuracy compared to conventional sensors. One promising application is for the measurement of Earth’s time-varying gravity (TVG) from low-earth orbit. Precision TVG measurements advance our understanding of many of Earth’s processes, including water storage and transport, land ice mass evolution, and ground movement resulting from earthquakes and glacial isostatic adjustment (ground movement due to the ice age), to name a few. The 2017 ESAS Decadal Survey targets measuring the equivalent of a 1 cm change in water table height with ~200 km spatial resolution by mapping Earth’s gravity gradient from space. Measurements at this level could enable forecasting of floods and droughts, improved quantification of climate impacts on water cycle, ice sheets, and coastal vulnerability, risk assessment of natural hazards, land management, and water management. A high-sensitivity atom interferometer gravity gradiometer can meet this challenging goal.

In this talk, I will discuss the collaboration between AOSense and NASA Goddard Space Flight Center to develop an atom interferometer gravity gradiometer for mapping Earth’s TVG from space. I will present the current status of a terrestrial proof-of-concept instrument and discuss the planned transition to a space instrument. I will additionally discuss what it is like to work on physics R&D projects at a for-profit company.