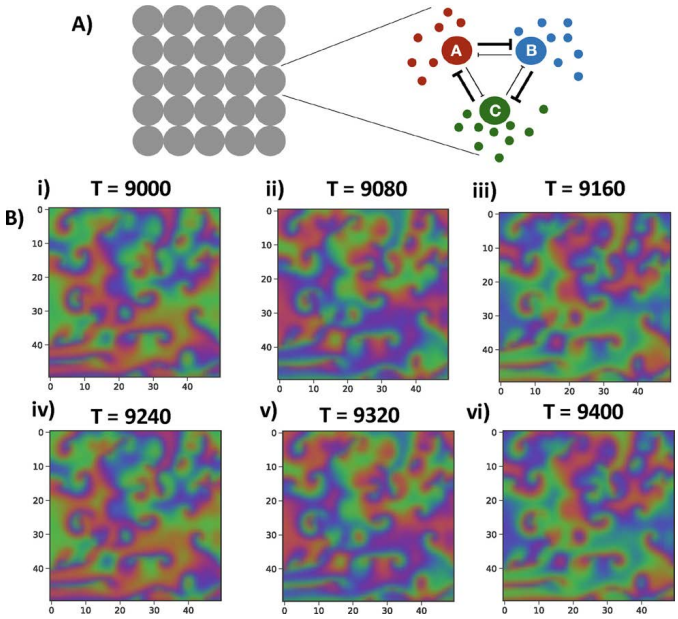
DIVYOJ SINGH BIOENGINEERING, MATHEMATICAL MODELING, BIOPHYSICS

Pattern Formation in Biology: Developing a Skillset to Study Various Phenomena

Nature has a fantastic ability to organize itself into intricate patterns, from the patterns on skins to spirals of flowers, showcasing the elegance of biological systems. Turing patterns, which involve the interaction of chemicals or morphogens, explain the formation of complex patterns like animal skin pigmentation with spots or stripes. Turing patterns are mainly studied through partial-differential equations and their instabilities. They have attracted the interests of mathematicians, physicists, and biologists alike.



What will we do?

We will first get used to partial differential equations and their computations (analytical and numerical). They are generally used to solve problems of spatiotemporal changes in populations of species. Then, we will use our understanding of PDEs to study oscillations in gene-regulatory networks.

We can also study any other system (biological/physical) of the mentees' interest.

Prerequisites:

Coding in Python (necessary)

TARUNA SCHUELKE BIOINFORMATICS, MICROBIAL GENOMICS, PHYLOGENETICS

Runaway Seaweed: Macroalgal-Microbial Mutualism Between Pelagic *Sargassum* and its Microbiome

Over the last decade, a seaweed called *Sargassum* has become a runaway seaweed in the tropical Atlantic Ocean, stretching from West Africa all the way to the Gulf of Mexico. This bloom has economic and environmental implications. When dead *Sargassum* washes ashore, it smothers marine animals to death, and cities in the Caribbean spend millions of dollars cleaning up decaying *Sargassum* from their beaches. Furthermore, blooms do not occur in isolation—when seaweeds bloom, their epiphytic associates proliferate with them. *Sargassum* harbors a diverse community of microbial epiphytes; I am investigating how these microbes help *Sargassum* meet its nutritional requirements and contribute to its proliferation. Using biogeochemical and genomic approaches, I examine how *Sargassum's* epiphytic community facilitates the generation, remineralization, and acquisition of nutrients (i.e., nitrogen, phosphorus, and iron).

Figure 1 displays the great Sargassum Belt that stretches from West Africa to the Gulf of Mexico.

What question the project addresses?

1. Are the microbes that live on *Sargassum* able to remineralize phosphorus from their surroundings?
2. Are the microbes that live on *Sargassum* able to acquire iron from their surroundings via siderophore production?

What would the RMP mentee(s) be doing on a day-to-day basis? What skills would they learn?

My undergraduate mentee(s) will mostly be analyzing metagenomic data and generating figures OR they will be mining data using online databases and generating a collection of sequences for alignments and tree building. They will learn how to analyze large genomic datasets using bioinformatics.

Are there any prerequisite skills you need them to have?

It is preferred that they have some experience with R, the command line, and the Linux OS.

TANDEE WANG HISTORY, CULTURAL STUDIES, SOCIOLOGY

Transpacific Histories of Asian America: Exploring Diaspora and Racialization

Since it began in 1968, the interdisciplinary and scholar-activist field of Asian American studies has provided crucial insights into the history of Asian diasporas, racialization, migration, imperialism, and capitalism in the U.S. Although earlier research tended to have a narrow focus on specific ethnic communities, attempting to contest the perpetual-foreigner stereotype in the process, more recent work has focused on questioning the relationship between U.S. imperialism and Asian American racialization. One of the most exciting developments in this vein is the advent of the "transpacific," an analytic framework that seeks to connect Asian American history with histories of both Asia and its diverse diasporas around the Pacific, in places such as Australia, Hawai'i and Latin America.

In this research project, students will develop a project that interrogates some transpacific dimension of Asian American history from the 1800s to the present. For example: How was "yellow peril" a discourse articulated transpacifically in places like Canada, Australia, New Zealand, and the U.S? How does our understanding of Japanese American internment change when we consider the deportation and subsequent internment of Japanese Latin Americans? What is the relationship between U.S. imperialism in places like the Philippines and Vietnam and diasporas from these places? How should Asian racialization be understood in relation to the incommensurate experiences of other groups, such as Black and Indigenous peoples in the U.S.? How have Asian diasporas resisted racist laws and attitudes, and reclaimed them for their own purposes? What does an Asian American perspective bring to larger questions of social and racial justice, such as anti-imperialism and police abolition, both historically and in the present? Students will be introduced to transpacific Asian American studies—including its diverse ethnic and geographic subjects—and a range of methodological approaches, including those used in history, English, literary and cultural studies, and sociology. It is suitable for any students with an interest in Asian American studies, critical race studies, or transnational American studies.

Figure 1—This racist cartoon image from 1880s Australia depicts the "Yellow Peril," demonstrating the transpacific resonances of Asian racial construction.

ETHAN MCGARRIGLE PHYSICS, CONDENSED MATTER, ENGINEERING

Stability of a Spin Microemulsion Phase Under Confinement

Simulations of Ultracold Quantum Matter: Bose Einstein Condensates
When matter is cooled to ultracold temperatures (< 1 Kelvin), the constituent particles (atoms, electrons, etc.) can behave collectively, yielding exotic states such as superfluidity and superconductivity. Both states are intimately linked to the phenomenon of Bose-Einstein condensation, where quantum mechanical effects dominate, and the system is described by a macroscopic "matter wave". This project focuses on collections of alkali atoms, such as ^{87}Rb, ^{7}Li, and ^{23}Na, which can be trapped and cooled into the Bose-Einstein condensate phase. These scenarios are highly controllable and allow for the precise manipulation of quantum matter, so there are growing technological applications in precision measurements (interferometry, atomic clocks) as well as quantum computation and quantum simulation. Currently, *new Bose-Einstein condensate phases* are an open area of research.

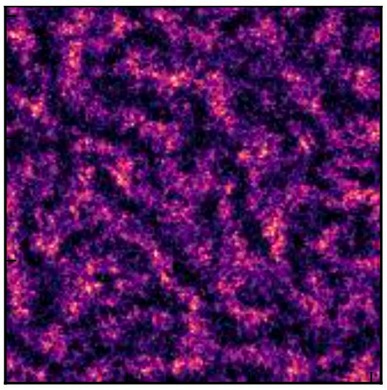


Figure 1: Predicted density profile of a spin microemulsion. Highlighted regions represent domains with atoms of the same spin state. Atoms of the opposite spin state reside in the dark, colorless regions.

We specifically focus on cases where the atoms' spin is important, such that novel, poorly understood magnetic condensate phases arise. Recently, we discovered a "spin microemulsion" phase (Fig. 1) in bulk systems of spin-orbit coupled, Bose-Einstein condensates (BECs); however, realistic experiments occur in confinement, where the atoms are trapped in a harmonic-like external potential. In order to realize this phase experimentally, we must study the effects of confinement. **This project will simulate spin-orbit coupled, Bose-Einstein condensates under confinement using our field-theoretic simulation methods, with the goal of finding conditions where the microemulsion phase is thermodynamically stable.** Confinement effects can alter the physics in quantum systems, so the student will study the quantum harmonic oscillator in the single-particle and many-particle settings. The student will become familiar with the literature on trapped spin-orbit coupled BECs and methods to simulate them. The student will learn how to run simulations in UCSB's computing clusters and visualize data (e.g. density profiles, properties) in a plotting software of their choice. The goal of the project is to investigate whether this microemulsion phase exists under confinement via trapping, or whether it is accessible only in "bulk".

Helpful Prerequisites: Physics, Computer Science (coding experience), Calculus

DINGYUE (KITE) LIU ECONOMICS, BLOCKCHAIN, DECENTRALIZED FINANCE

Slippage Tolerance in Decentralized Exchanges

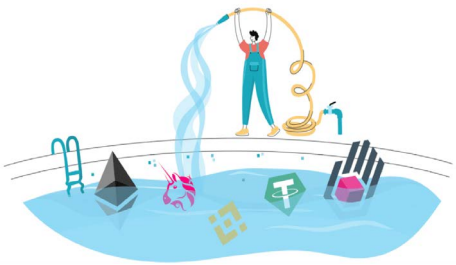
The Ethereum blockchain hosts decentralized applications, which create and manage digital assets. In recent years, we have seen the growth of decentralized finance (DeFi), an ecosystem of decentralized financial applications and protocols that enable complex, automated financial transactions.

We examine decentralized exchanges (DEX), a key DeFi component that supports the trading of tokens. DEX prices update continuously and automatically, creating unexpected price shifts for users as their swaps (trades) wait to execute. Users protect themselves from these price shifts by setting a slippage tolerance, which represents the maximum acceptable price increase. This setting is a double-edged sword: lenient tolerance can be exploited through sandwich attacks, which cost the ecosystem over $100 million annually, but stricter tolerance may cause unnecessary failures. Despite significant implications, the topic of slippage tolerance lacks rigorous academic study.

We have access to a big data set with all the transactions that have ever been made on Uniswap (Millions of transactions, billions of dollars of total trading volume). Using this big data, we can explore and answer important research questions.

Our primary goal is to turn this project into an academic publishing paper, and we will be glad if you can join us and be part of this project (see the following link to our previous paper with RMP students involved on related topic). https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4119827

Project research question:
In a previous research project, we performed a large-scale measurement of the impact of slippage tolerance settings on the health of the DEX ecosystem. We leveraged a recent modification to the default slippage setting of the Uniswap DEX to show a decline in sandwich attack victimization post-modification but also indicate the potential for further improvement. This project aims to extend on previous work and focus on this impact at the individual level. Are the retail traders better off? How are the attackers adjusting to the change?



Why you should pick our project:

- Gain experience with big data.
- Solve question using economic models.
- Learn about blockchain and new technologies.
- Be part of an academic paper (your name will be on publications from this project)

Preferred skill set: Passion in Economics, Experience with analyzing data, R