Upsilon Lab *Winter 2019 Quarterly Report*

an Official UCLA Physics & Astronomy Department Sponsored Organization

Prepared by Krish Kabra, President & Grant Mitts, President

For Release on April 17th, 2019

"A lab for undergraduates, by undergraduates."

Mission

The mission of Upsilon Lab is to provide undergraduate students in the UCLA Physics & Astronomy department the opportunity to learn valuable skills to succeed in their future endeavors, whether in research, engineering, or other fields.

Quarter Highlights

- Eight active projects with thirty-nine active members. Read about their progress on **pages 4-10**.
- All of the current projects will continue into Winter 2019, along with two new projects. Additional project ideas for prospective managers. Interested in applying? Read more on **page 11**.
- We are expecting for around forty-five total members for Spring 2019. This represents an approximately-10% capture of Physics & Astronomy undergraduate majors.
- We received a small grant from the Physics & Astronomy Department for our in-house projects.
- Contact us through our website! **upsilonlab.pa.ucla.edu** or **upsilonlab.org**.

Winter 2019 Summary

The Winter Quarter saw a continuation of many of the projects from Fall Quarter as well as the addition of two new projects led by Ahmad Bosset Ali and Suyash "Sunny" Kumar.

We have also had a number of our members graduated from Upsilon Lab and move into laboratory research. From the managers and presidents, congratulations and continue the hard work!

In this time, we had thirty-nine active members, working on eight active teams with eight active managers, for a total of forty-seven department undergraduates involved directly in active projects.

Our eight active teams for this quarter are listed below. More information is included later in the report, on the respective project pages.

Advisory Board

The 2018-2019 Advisory Board is composed of two Department professors:

Prof. David Saltzberg, Chair

Prof. HongWen Jiang

We would like to profusely thank the Advisory Board for their help and advice throughout the quarter.

Pilot Waves

Sponsored by Prof. Seth Putterman

Managed by Alexander Tolstov

Project Description

Pilot wave theory is an alternative interpretation of quantum mechanics, originally created by De Broglie and later refined into Bohmian mechanics. This research group aims to replicate the hydrodynamic pilot wave results shown in the John Bush paper, Pilot-Wave Hydrodynamics, such as demonstrating a relationship between droplet movement, its radius, and bath acceleration. In order to do this, the group uses a speaker to vibrate a petri dish containing silicone oil to allow for the creation of droplets that remain on the surface without coalescing with the oil. The group also aims to see if the droplets are able to undergo double slit diffraction.

Quarter Project Highlights

During the winter quarter, the group worked in Prof. Puttermans lab, beginning the process of collecting data from videos of droplets. The first half of the quarter was spent on discussing and planning a process for accurate data acquisition of the droplets. Some members attempted to find the perfect frequency and driving amplitude to observe sinusoidal motion of a droplet in a bath, while others continued working on an image tracking program to observe the droplets. The second half of the quarter was devoted to collecting videos of the droplet in the sinusoidal motion. Team members worked on image processing and using Arduino servos. They were also tasked with creating a data collection set-up that would allow for videos taken to have clearer and more discernible droplets.

Quarter Membership Roster

Obed Camacho

David Su

Lucas Zhang

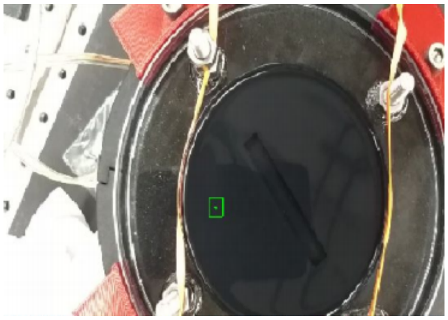

Figure 1: Pilot waves experimental apparatus showing oil droplets vibrating

PID with Microcontroller

In-House

Managed by Helena Huang

Project Description

A Proportional-Integral-Differential (PID) controller is a device used to make educated guesses with a systems history to predict its future and to control physical parameters using that knowledge. For example, most cars use PID controllers to control their speed they look at the current speed, where its going (derivative) and where its been (integral). In this project, team members will design a car together, and learn how to program a micro-controller (MCU), specifically an Arduino development board, to control the movement of the car so that it can solve a maze by itself. This will include how to interpret signals from a distance sensor, how to store and manipulate data for PID control, how to output a signal to control the motion of the car, and how to write algorithms for maze solving.

Quarter Project Highlights

Members continued to learn and practiced C++ coding on Arduino IDE. We went through functions, pointers, and structures. By designing and assembling a car for the project, members learned basic electronic skills and gained a better understanding of electronic components such as micro-controllers, ultrasonic sensors, and motors. We successfully implemented PID control to the car with one ultrasonic sensor at the front to have it brake before a wall without running into it. After attempts to make the car turn autonomously at a wall failed with one sensor, we added two more sensors to the car, and will be working on the software in the coming Spring.

Quarter Membership Roster

Hannah Boyer

James Snyder

Jason Jin

Matthew Zimmer

Yueyun Chen

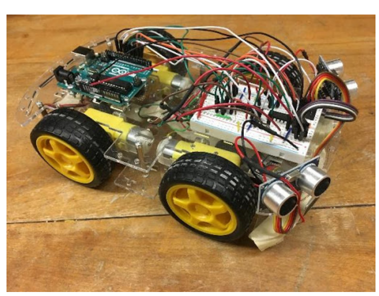

Figure 2: Built car fitted with ultrasonic sensors for automatic braking.

Cyclotron Motion Simulation

In-House

Managed by Jared Rivera

Github: https://github.com/jaredrivera2314/CyclotronMotion

Project Description

Cyclotron motion is the motion that charged particles undergo in a magnetic field such that they move outward in a spiral path. Team members use Python to simulate the motion of charged particles undergoing cyclotron motion. They will then apply this simulation to physical systems to predict outcomes of potential experiments, one example of which includes determining plasma wave behavior in the atmosphere using cyclotron accelerators, and another example being determining particle trajectories in a particle collider.

Quarter Project Highlights

This quarter we worked a bit on cleaning up the cyclotron code, and then began a test project on sensitivity analysis. The goal was to go through the entire model creation process from theoretical formulation, to pseudo-code, to visualized python models, to final data analysis and subsequent conclusions. We have begun applying this process to the classic introduction to chaos: the double pendulum. Our goal is to search the parameter space of the double pendulum to determine when the small-angle approximations in the Lagrangian formulation accurately capture the dynamics of the analytic model. We plan to quantify accuracy by testing conservation of mechanical energy, and hope to narrow in on the most sensitive and critical variables in the parameter space by performing Principle Component Analysis (PCA) on our results. Our goal is to have a deliverable report with good animated visualizations by the end of May, showing the teams upgraded proficiency in the Python environment, classical mechanics, and data abstraction.

Quarter Membership Roster

Umaima Afifa

Aanchal Singla

Christopher Ong

Sammy Durbin

Solar Batteries & Charging Analysis

In-House & Partnership with the UCLA Renewable Energy Association

Managed by Emma Peavler

Project Description

As the effects of non-renewable energy resources (i.e. coal, oil etc) are compounding the issue of global warming, the creation of practical and manufactureable renewable energy sources is necessary for the future of humanity. This experiment group will be designing, simulating and creating solar energy storage devices using lithium ion battery cells (18650) and various solar panels. In this experiment team members will learn and use basic programming knowledge to simulate the efficiency of various solar panels and optimize a design that allows for the maximum return on investment for each solar pack. Members will also be able to engineer and build the energy storage packs for optimized use.

Quarter Project Highlights

The Solar Team is creating an interface that allows the user to enter various characteristics of a solar cell (e.g. material name, efficiency, open circuit voltage, short circuit voltage, and maximum power) and returns values such as fill factor, total power output over some time interval, and an IV-curve. This group is also working on calculating the intensity of sunlight that reaches the Earth's surface so that a more accurate number can be used for the incident power on the cell. For Spring Quarter, the group aims to expand upon this interface to be interactive and perform more complex analysis of solar cells.

Quarter Membership Roster

Braden Lem

Chris Hernandez

Emma Esquivel

Raymond Ramlow

Julia Liu

Steven Chu

William Zhu

Efficient Electricity Generation

In-House

Managed by Mercedeh Khazaieli

Project Description

To meet increasing energy demands, scientists are researching electricity generation using novel methods such as thermoelectrics, photovoltaics, wave power, and other methods. Thermoelectric materials generate electricity from temperature differences between their layers, photovoltaics generate electricity using light, and wave power is a way to utilize wind waves to generate power. Team members will create simulations of these methods using Python, optimizing for maximized efficiency. These simulations can be used as a basis for actual power generators in the future.

Quarter Project Highlights

This quarter, the Efficient Electricity team focused on acquiring basic Python Skills from the Upsilon Lab tutorials. Most of the members were able to complete both tutorials and begin focusing on their project of interest. Scott Mackey analyzed data suggesting that the cost of operating nuclear power plants has increased notably in recent years while plant efficiency has stagnated and plans to run simulations to see if we are nearing a point where nuclear power is no longer financially viable in the future. Daniel Levi-Minzi completed the Python training and is interested in exploring hydro or nuclear energy methods. Joshua Wong began programming a simulation for osmotic power generation and has begun creating Python classes for electrodes and solutions. Lastly, Trey Knudsen continued looking into power output for vertical axis wind turbines. He looked into component forces on different wind turbine blades and if the turbine's motion could be optimized with them. Since much of the motion is experimentally optimized, he got a personal vertical axis turbine model and is planning on modeling specifically how its power output is affected by different wind sources and orientations. He has also begun brainstorming different uses for such turbines, such as possibly being used for related and current UCLA projects using high altitude balloons (as a clean energy source or as a way to detect wind direction directly).

Quarter Membership Roster

Scott Mackey

Siggi Galam

Joshua Wong

Trey Knudsen

Keqin (Kirsten) Yan

Daniel Levi-Minzi

Luming Zhou

Elementary Particle Detection

Sponsored by Prof. Nathan Whitehorn

Managed by PJ Smigliani

Project Description

Cloud chambers were used in the discoveries of the positron (1932) and the muon (1936) by Carl Anderson, who was awarded the Nobel Prize in Physics for his positron discovery. In this project, team members will learn about elementary particles, design and build a cloud chamber, and use it to detect muons reaching the earth. Team members can then choose to use it to observe the fluctuations in muon flux at high altitudes, which entails a field trip to a nearby mountain with the built cloud chamber. Members can also measure certain quantities such as the muons charge to mass ratio with the chamber. The cloud chamber may also be put on display in the Physics and Astronomy Building.

Quarter Project Highlights

This quarter the team attempted to run the cloud chamber and record the different conditions that lead to the most stable cloud of isopropyl alcohol. We learned that there are issues with maintaining an airtight seal when using metal and dry ice together. In order to deal with that issue the team built a sturdy frame for the cloud chamber and is experimenting with different types of flexible seals. While experimenting the team also started to learn and practice the theoretical components of the lab. This involved researching how to solve equations of motion for particles at relativistic speeds as well as continuing to learn to program in Python.

Quarter Membership Roster

Ethan Cochran

Claire Torres

Ryan Foundoulis

Efe Cakar

Zepyoor Ohanian

Solid State Simulation

Sponsered by Prof. Stuart Brown

Managed by Ahmad Bosset Ali

Project Description

The focus of our group is to simulate solid state Physics which seeks to establish generalized descriptions of materials properties, by observing specific atomic crystal formations, which can undergo phase transitions from a variety of factors, such as temperature or pressure. In our specific laboratory we sought to simulate various material properties, that are stochastic in nature, by using the Markov Chain Monte Carlo method of analysis. Simply put, we incrementally changed our observed system until it matches the energy or other factors in a process we would see occur in nature naturally. Utilizing the law of large numbers, we seek culminate our results and create accurate models of solid state phenomena.

Quarter Project Highlights

Since a large effort was already made to teach the underlying theory of solid state Physics, the main target this quarter was to simulate a phenomenon, and for us that was the Ising Model. This required us to have a background in statistics and coding. The main factor concerning statistics comes from the MCMC method we utilized, which involves basic statistical concepts such as precision and accuracy, identifying outliers, and determining the confidence of trends. Though the MCMC method had many specific logical properties that must be accomplished, these were not conceptually or mathematically difficult and were easily coded to accomplish the MCMC. Due to the groups seniority, learning coding fundamentals was not an issue, rather coding specific statistical processes had to be done. Mainly this included developing randomly filled matrices, as well as iterating through matrices while evaluating a cell compared to the overall structure. Though the code was initially done in C++, this only yielded us numerical results. In order to graph our simulations, we converted the code into Python, to use its pre-programmed functions. In essence, this quarter we simulated the Ising model in C++ from which we seek to move to more complex phenomenon next quarter, as well using Python to acquire graphs and simplifying our code.

Quarter Membership Roster

Xiaohe Shen

Kevin Wang

Maria Vincent

Jack Tulyag

Gwen Bayarbaatar

Satellite Launching and Motion Simulation

In-House

Managed by Suyash Kumar

Project Description

Due to the mathematical complexity of increasingly realistic physical systems, programming has become an indispensable tool in developing a greater understanding of physical phenomena through the creation of simulations. For example, solving Newton's Laws by hand to obtain the equations of motion can become extremely difficult, but creating simulations to perform numerical calculations to obtain a good approximation requires a few lines of code. The example that we focus on is the process of launching a satellite from the surface of the Earth. By performing numerical simulations of this classic physics problem, our members develop the skills to simulate more complex systems that would otherwise be difficult to envision.

Quarter Project Highlights

In the Winter Quarter, we practiced creating simulations in Python using the matplotlib and numpy libraries. Currently, we are constructing a 2-D simulation of a satellite's launch from the surface of a planet. Our first simulation was the most simplistic, with a planet of uniform density, no rotation, and no atmosphere to cause drag. Using our simulation we showed that, by treating our satellite as a simple projectile, there fails to be an orientation of launch that will result in a circular orbit. We investigated the physical principles behind this phenomenon as we developed our simulation. The next step in this project is to gradually increase the realism of the simulation. We plan on simulation the addition of thrusters to our satellite to replicate an actual launch. From there, we will add the Earths rotation and an atmosphere to our model.

Quarter Membership Roster

Clement Decker

Max Kroft

Karina Barboza

Chester Li

Spring 2019 Goals

We would like Spring 2019 to continue on with the same enthusiasm and dedication seen from our members and managers in the previous quarters. We hope to attract more active members and help them develop skills in a variety of ways. In order to do this, we require the help of fellow upper-classmen in the department to join the Upsilon Lab manager team so that we can continue spreading the skills and knowledge necessary to succeed in future career and research endeavours.

If you are interested in becoming an Upsilon Lab manager, please apply through our website:

upsilonlab.pa.ucla.edu/join-manager

Spring 2019 New Projects

We are excited to announce the addition of two new projects at the start of Week 4:

Modeling Quantum Systems with Machine Learning

In-House

Managed by Joshua Wong

As a physics undergraduate, we learn only the most basic of quantum systems, which is unrealistic for most physical phenomena. The goal of this project is to develop an understanding of machine learning and try applying it to these complex systems. This project will help members develop machine learning techniques using Python, and relate it to an important field of physics, Quantum Mechanics.

Raspberry Pi for High-Altitude Balloon Applications

In-house

Managed by Trey Knudsen

This project will have a team utilize a Raspberry Pi micro-computer in order control a high-altitude balloon (HAB). HABs are used primarily to collect measurements of the atmosphere at varying altitudes, including near-space! This can help study the weather and climate. Modern balloons generally contain electronic equipment such as radio transmitters, cameras, or satellite navigation systems, such as GPS receivers. Controlling the ascent of the HAB is crucial. This project will focus on developing software that can collect data from an internal measurement unit (IMU) and creating real-time methods to analyze the data.

Apply through our website at:

upsilonlab.pa.ucla.edu/join-member

Special Thanks

The Presidents would like to thank:

- The Physics & Astronomy Department for their support and funding in operating Upsilon Lab.
- The Advisory Board for their invaluable advice throughout the course of the quarter.
- Professors Putterman, Whitehorn, and Brown for sponsoring projects this quarter, as well as all of the professors who have sponsored projects in the previous quarters. And to all these professors for their willingness to help the department undergraduates learn about physics from a research perspective.