Winter 2022 Quarterly Report

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Summary

By Zooey Nguyen

This quarter we have two new astronomy-related project, which comes with opportunities for students to learn about astronomical data analysis and observation. With the temporary change back to remote learning, some fall-start projects were disrupted, meaning some projects were put on hold, including 2D Solitons and Quantum Circuits. The Binary Star Classifications project has been merged into the AGN Exploration project. We have an average of 5 participants in each of the three active projects.

Renewable Energy with Python, Arduino, and Machine Learning

Managed by David Gotler, Adam Stewart, Adison Guo

Overview

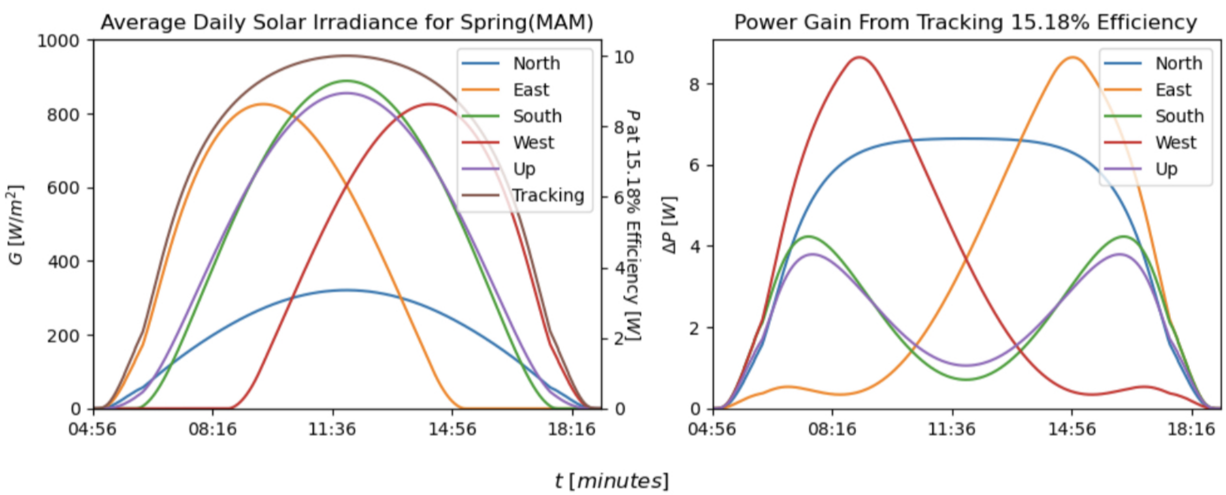
Global climate change is an issue of the utmost importance to be solved by today's scientists and brightest minds (that's us!!!). One aspect of this fight is in transitioning to renewable energies. Renewables such as wind and solar are not a constant source of electricity, so they are often supplemented by natural gas power plants in our current electrical grids. We seek to design and build a small-scale, hybrid, Solar-Wind energy cell to be tested for power output and practicality.

This Quarter

During the Winter quarter we designed and built a prototype solar tracker using 3D printed mounts, two servos to move in dual axes, four photoresistors and an arduino to determine the position of the sun. We tested multiple solar irradiance and photovoltaic simulation libraries in python and using matlab simulink, but ultimately decided to use the solarpy library in python.

The solar tracking unit consists of three printed parts to allow for movement in two axes of rotation; azimuth and altitude. We used two servos to rotate the two upper parts relative to the base in order to position the mounted solar panel such that incident light is normal to the plane. To determine the optimal direction we used four voltage dividers with a photoresistor and 10 kOhm resistor. From the measured voltage drops, we calculated the resistance across each photoresistor and used the difference in values in two respective directions (top-bottom,left-right) to update the position of the servos.

Using solarpy, we calculated the average daily solar irradiance during the spring (March, April, May MAM) incident on a normal plane in the directions North, East, South and West at a 45 degree angle and pointing directly up. If the panel is perfectly tracking the sun, then a solar vector should be normal to the plane at every point in time. This corresponds to the maximum beam irradiance. The minimum efficiency for a tracking solar panel to reach the maximum power rating of 10 W was calculated to be 15.18%; which is below the average efficiency of monocrystaline solar of 20-25%. The optimal placement for a fixed panel was found to be angled towards the south, where the optimal elevation angle depends on the declination of the sun varying throughout the year. The average power gain from tracking the sun vs a southward facing solar panel was found to be PS=2.202 W during the spring. Video of prototype tracker: https://drive.google.com/file/d/1zQ_ahX0ZPzPqkO5DWTFej29CPcQTRL96/view?usp=drivesdk



Average Daily Solar Irradiance for Spring(MAM)
Power Gain From Tracking 15.18% Efficiency
North
East
South
West
Up
Tracking
$G\ [W/m^2]$
P at 15.18% Efficiency $[W]$
$\Delta P\ [W]$
04:56
08:16
11:36
14:56
18:16
$t\ [minutes]$

Derivation of Active Galactic Nuclei Mass by Gravitational Redshift

Managed by Aki Hasegawa-Johnson and Isba Keshwani

Overview

Utilizing Georgia State's database of AGN distances measured with the reverberation method, we determined the value of both cosmological redshift and doppler redshift of light emitted from the AGNs. We used NASA's AGN database containing total redshifts of various AGNs, as well as the multiplicative sum equation for combining different sources of redshifts to solve for the portion of the total redshift that is caused by gravitational redshift. Utilizing the relativistic gravitational redshift equation we solved for the mass of an AGN that has data in both databases.

In order to verify that the calculated mass is accurate, or at least accurate enough to be acceptable, a mass vs. luminosity graph for the AGNs used in the project was plotted. The luminosity was calculated from the electromagnetic flux data from the SDSS. The relationship between luminosity and mass is a linear relationship. The relationship that we found in this experiment agreed with the accepted relationship found using other known methods; this proves that the method of calculation we used is viable, and the masses we calculated are accurate.

Another part of our project will be to use the raw data of AGN's to classify the AGN in their respective groups. AGN classifications have to do with how luminous they are, the width of their emission lines, and their radioactivity.

This Quarter

This quarter we worked on learning the basics of Python. We went over variable types (bools, ints, floats/doubles, lists/arrays), functions, loops, and basic syntax. We did some practice problems. We also learned from Dinc how to use matplotlib to plot data. In addition, we looked through data sites to try and figure out how they worked. Throughout, we explored ideas about what to research.

BINARY GROUP (prior to merge) The methods that we learned last quarter that we will carry onto this project are learning to use a software called TOPCAT. We downloaded csvs and VOtables from ESA Sky survey and were able to plot astrometric data in TOPCAT. This will be helpful in this project as well.

Radio Interferometric Imaging of Virgo A (M87) with the Allen Telescope Array

Managed by Adrian Lam

Overview

Radio Interferometry is an observation technique designed to produce astronomical images of unprecedented resolution. An important application of radio interferometry is the imaging of extremely small objects, a famous example being the M87 supermassive blackhole imaged by the EHT in 2020.

In a single telescope, the resolution of an image is ultimately limited by its size, known as the diffraction limit. In essence, radio interferometry works by combining the individual observations from many (i.e. an array of) smaller telescopes. In a radio interferometer, the final image resolution is then limited by the size of the telescope array, instead of the individual telescopes. This technique is known as aperture synthesis (https://en.wikipedia.org/wiki/Aperture_synthesis). To illustrate the difference, the M87 blackhole image has a resolution equivalent to an Earth-sized telescope!

In this project, we will perform interferometric imaging with the Allan Telescope Array (ATA) to image Virgo A, an extragalactic radio source with a characteristic jet originating from the aforementioned M87 supermassive blackhole.

The imaging experiments will be carried out on the Allan Telescope Array (ATA), a 42- element array of 6.1m radio telescopes.

The project is a collaboration between our team, the GNU Radio community and the SETI Institute. In particular, our work will be built upon the existing work of the GNU Radio community. Thanks to our generous collaborators, we will be allocated observing time on the ATA for the imaging experiment. Our team's main task is to process the raw telescope data to produce the final Virgo A image.

The project has 2 main milestones: The first milestone is to utilize our collaborators' existing software stack to process the observation data, producing the Virgo A image. The second milestone is to make improvements to the existing software pipeline.