Name(s)
Samuel A. Alber

Project Number
S1801

Project Title
A Determination of the Optimal Dark Matter Model for the SPARC Galaxies

Abstract

Objectives/Goals
The main goal of this project is to provide one of the most in-depth analyses of the core vs. cusp controversy, which jeopardizes our current understanding of the universe, by analyzing 114 diverse galaxies. Although our accepted view of the universe, the CDM Paradigm, has had numerous important large-scale successes, I will show that it is inaccurate and thus incomplete at small scales. Finally, I will solidify arguments for the existence of dark matter, which is composed of theoretical particles that make up 85% of all mass in the universe but do not interact with light.

Methods/Materials
I analyzed 3 models that each predict the density of dark matter within a galaxy: the CDM-derived cusped NFW model as well as the cored Isothermic and Burkert models, derived from observations. I constructed a Python algorithm from scratch to read data on 114 galaxies gathered from the Spitzer space telescope (called SPARC galaxies), analyze it, and determine which of the 3 models best predicts the observed data for each individual galaxy. I also calculated a p-value, which is the probability that my results would be replicated if there was no dark matter.

Results
I found that 85% of the 114 SPARC galaxies preferred a cored profile and all galaxies except for one had a p-value of under 0.01, verifying the existence of dark matter. An unforeseen outcome was the diversity of rotational curves among galaxies with similar masses and asymptotic velocities.

Conclusions/Discussion
The extremely small p-values in my results provide important arguments for the existence of dark matter. Furthermore, CDM does not provide an explanation for the observed diversity of rotational curves. Finally, from the dominance of the cored profile over the cusped profile, it is implied that our current understanding of the universe (CDM) is missing a fundamental characteristic. However, by assuming that dark matter particles strongly interact with each other, galaxies can adopt cored profiles at inner regions while preserving the large-scale successes of CDM. Thus, new insight into what characteristics the dark matter particle could have is gained from my project.

Summary Statement
I demonstrate the inability of our current understanding of the universe to represent the small-scale structure of the universe and propose that strong self-interactions amongst dark matter particles could serve as a potential solution.

Help Received
I had some initial guidance in choosing a topic from a university professor and I met with him about once every week for 15-30 minutes, but implemented the idea by myself.

Name(s)
Rishabh R. Bose

Project Number
S1802

Project Title
Heat Transfer Measurements with IR and Visible Waves and Its Applications

Abstract

Objectives/Goals
Space cooling and heating represents a significant use of energy in buildings. My experiments were aimed at proving that reflectance and thermal emittance are two properties that determine a solid material's ability to minimize heat transfer. My experiments used a systematic study of absorption, emission, and scattering of electromagnetic waves, to achieve a better design of experimental and industrial applications, so that the power of radiative transfer can be tapped effectively. My project explored on how heat is absorbed and radiated in the form of electromagnetic waves and its effective applications.

Methods/Materials
Using the Planck-Einstein relationship and monochromatic lasers, an experimental value of Planck's constant was arrived at. A simple circuit was built to test the relationship between energy level and wavelength of color. Also, using Planck's formula and taking the derivative of the formula to isolate the wavelength variable, I arrived at a formula which related peak wavelength to temperature, validating a law known as Wien's Displacement. The final two experiments used the relations from the first three experiments and measured heat in both the visible and IR spectrums using both contact and non-contact sensors to determine the application of Planck's constant in its relation to peak wavelength and temperature of objects and their effects on radiant heat transfer.

Results
Both visible and infrared waves were used as part of my experiments. I experimented with five hypotheses to investigate some of the practical aspects and applications of the waves on different materials. Based on my first three experiments, the energy in the electromagnetic wave has a direct relationship with the frequency of the wavelength. For the last two experiments I used absorption and emissivity to study improvement of heat transfer efficiency.

Conclusions/Discussion
The aim of my experiments was to analyze how heat transfer is impacted by infrared waves and visible electromagnetic waves. I experimented how different materials may help in reducing energy consumption for cooling and heating building spaces. I observed that radiant heat transfer is a large component of the transfer mechanism and absorptivity and emissivity of a material has an impact on radiant heat transfer. Color and reflectivity impacts absorption of shorter electromagnetic waves.

Summary Statement
Based on my findings, materials which have a high reflectivity will have lower absorption and emissivity values in comparison to other materials.

Help Received
My father was my guide. My mother helped me with the printouts and display of the science board.

Name(s)
Isaac A. Broudy

Project Number
S1803

Project Title
Testing Special Relativity with High Resolution Differential Photometry of Eclipsing Binary Systems

Abstract

Objectives/Goals
This study used multi bandpass differential photometry of variable star eclipses to investigate potential variations in the speed of light (c), offering a test of special relativity.

Methods/Materials
Three eclipsing binary star systems (W Uma, UV Leo, and U Cep) were measured with four bandpass filters (luminance, red, green, and blue) in order to compare potential shifts between eclipse timings, signifying a shift in the speed of light.

To do so, I built an automated observatory for this study, featuring a 90mm refractor telescope with fully automated target and image acquisition. I developed and used a semi-automated image processing and analysis pipeline for photometric analysis.

All measurements were made over a 12 night period. Measurements were converted from instrumental magnitude to apparent magnitude through the use of AAVSO reference stars. Apparent magnitudes were then folded into a complete light curve representing a single period. Curve fits and first derivatives were used to calculate timing of each eclipse and confidence intervals for statistical analyses.

Results
This study did not measure any significant differences in the speed of light of different wavelength. All eclipsing minima, in all bandpass filters, occurred at the same time, within the resolving power of the system. This observation was found to be true across each of the three eclipsing binary star systems.

Conclusions/Discussion
It was predicted that light of differing wavelength could travel at differing speeds--potential explanations including interstellar medium or quantum permeability. This study; however, did not observe any such differences.

After analysis, it is not surprising that I failed to detect changes in c, given this system was determined to reach a 10^-7 level of precision, and the speed of light has been well-measured to 10^-9 . The automated system and analysis workflow; however, can be extended to stars orders of magnitude further away, readily enabling higher precision measurement beyond 10^-9. This offers the possibility of observing changes to c and potential violations of special relativity. For now; however, this study adds further evidence that the speed of light is indeed constant.

Summary Statement
I used differential photometry of eclipsing binary systems to determine that all wavelengths of visible light travel at the same speed, providing support towards the second postulate of special relativity.

Help Received
I received help from Dr. Brian Keating, Dr. Andrew Friedman, Dr. David Tytler, and Mr. Delwin Johnson of UCSD, Center for Astrophysics & Space Sciences; they provided valuable insight for planning and analysis of this research project. I also received help from Dr. Arijit Chakravarty with statistical analysis.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Isabella J. Catanzaro

Project Number
S1804

Project Title
Heat Transfer Optimization for Home Insulation

Abstract

Objectives/Goals
I became interested in learning about conduction, convection, and radiation in order to reduce the amount of energy to keep my house a comfortable temperature. If I reduce the emissivity of drywall inside the walls of my house, the walls insulate better and keep the inside of my house a comfortable temperature.

Methods/Materials
I created simulations in C# code of walls in various temperature regimes and found limiting radiation would limit the amount of heat transferred into the house. I then tested these results with an experiment consisting of a mock-up of a wall. I created three mock-up walls: a control with drywall, an experimental configuration with the interior faces of drywall painted silver, and an experimental configuration with aluminum foil laminated on the interior faces.

Results
The drywall that was laminated with aluminum foil had an R-value that was a factor of 2.6903 greater than the uncoated drywall and drywall coated with silver paint had an R-value that was a factor of 1.66 greater than uncoated drywall. In addition, the drywall laminated with aluminum was as insulating as pink fiberglass insulation.

Conclusions/Discussion
By making the drywall have a low emissivity, I was able to reduce the amount of heat transferred through the wall resulting in a more insulating wall. By reducing the amount of heat able to transfer through the wall it becomes easier to keep the inside room a stable temperature.

Summary Statement
By studing radiation, convection, and conduction from the interior to the exterior of a house, I designed and tested an improved method of insulating wall.

Help Received
I designed, built, programed, and performed the experiments myself. I used both the internet and textbooks on heat transfer to more fully understand the necessary calculations.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Yizheng Chen; Giang To

Project Number
S1805

Project Title
Affordable Quantum Entanglement Detector

Abstract

Objectives/Goals
Using gamma rays from Na-22 matter-antimatter annihilation, we can generate entangled gamma rays, we hope to design quantum gate using aluminum.

Methods/Materials
Geiger counter boards, Aluminum, Lead, Na-22, Geiger tubes, Arduino board

Results
Making a low-cost quantum gate. Using lead to block all radiation outside to maximize gamma rays detection result in the polarized states.

Conclusions/Discussion
Although there are more expensive quantum gates, we are able to make a less expensive one with substantial efficiency and precision.

Summary Statement
We are able to build affordable quantum entanglement detector

Help Received
I recognize my science teacher Mr. Brown as our adviser and he helped us for buying materials (radiation source).

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Aliya Earley

Project Number
S1806

Project Title
Which Magnet Type Performs Most Consistently across All Temperature Environments?

Abstract

Objectives/Goals
The objective of this project was to determine which magnet type performs most consistently across a variety of temperature environments.

Methods/Materials
Tested the performance of four magnet types in five different temperature environments. The temperature environments were achieved using an oven, steamer compartment, room at room temperature, freezer, and a cooler of dry ice. The performance of each magnet was measured using three tests: the first weighed the number of paper clips a magnet could lift, the second measured the distance at which a magnet attracted one paper clip, the third measured the amount of force needed to pull the magnet off of a steel plate. Each magnet type was tested five times at each temperature.

Results
Alnico magnets were least affected by temperature, while samarium magnets performed slightly less consistently, but still favorably. Ceramic magnets were visibly unstable when temperatures changed, and neodymium were the most affected overall, weakening dramatically when exposed to extreme temperatures.

Conclusions/Discussion
If a situation requires the most consistent magnet available, alnico is the best choice. However, alnico magnets also seem to be the weakest of the four magnets, so samarium may be a good option if magnets need to be relatively powerful but still stable in varying temperatures. The results of this experiment are relevant in the design of machinery (involving magnets) which must withstand both extreme cold and extreme warmth. Combined with other factors, such as the overall strength of each magnet type, this data can be helpful in determining the most efficient magnet for an application.

Summary Statement
This experiment shows that out of four magnet types tested, alnico and samarium magnets perform most consistently across a wide range of temperatures.

Help Received
My father helped acquire materials and assisted in the testing process. Bob Fabini (retired science teacher at my High School) gave advice on presentation of project procedure and results.

Name(s)
Milan Ganai

Project Number
S1807

Project Title
Achieving Improved Accuracy Model for Jet Energy Measurements in the Large Hadron Collider (LHC) Using Machine Learning

Abstract

Objectives/Goals
At LHC, the largest particle accelerator, the discovery of Higgs boson and confirmation of Higgs fields rattled the world in 2013, sealing a major unverified gap in SM. Energy measurements of jets produced by hadronization of quarks and gluons help to search for important rare physics processes beyond the Standard Model (SM). However, the pileup interactions cause inaccuracies in the measurements of jet mass and transverse momentum. I use machine learning (ML) to achieve improved accuracy in jet energy measurements by investigating more variables in the regression. My hypothesis is that ML will provide more accurate, robust, scalable and faster pileup mitigation than previous widely-used approaches at LHC.

Methods/Materials
The most used method at LHC today is area-based pileup mitigation, where a term proportional to jet area is subtracted from the measured jet transverse momentum and mass. Although it is an effective approach, it is inadequate in achieving the needed accuracy for next generation colliders due to its simplistic modeling. I propose a novel pileup mitigation methodology for jet energy measurements using TensorFlow-based machine learning. I investigated 11 most influencing parameters having high correlation with jet measurements and included them in regression training. The training set comprises ~350K full jets (with pileup) and hard jets (without pileup), generated using PYTHIA+FastJet software with varying center-of-mass energies and pileup contaminations.

Results
The error in transverse momentum using my approach was much smaller (mean = 0.53 and variance = 4.88) compared to the area-based approach (mean = -1.42, variance = 29.44). Similar results were obtained for jet mass measurements. Further, my approach is very robust, and performs better over a wider range of transverse momentum, ranging from 7GeV - 300 GeV. The proposed flow is also orders-of-magnitude faster than the area-based.

Conclusions/Discussion
I created and used a novel machine learning methodology to build a robust, scalable solution with better accuracy in predicting jet transverse and mass, thereby confirming and validating my hypothesis. Superiority of Deep Neural Network over linear regressors also shows that linear model used in previous area-based approach is inadequate and has limitation in achieving accuracy. Overall, my approach shows a great potential for exploring in next gen SLHC.

Summary Statement
I create and use a novel pileup mitigation methodology to improve accuracy in jet energy measurements by studying and using many variables in machine learning and achieve more accurate and faster solution than widely-used approaches at LHC

Help Received
I came up with the idea for the project, and developed the methodology and software flow, and analyzed the results. I presented it to my high school science teacher Mr. Leung, who encouraged me to pursue the project.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Leo Guo

Project Number
S1808

Project Title
Modeling an Ideal Structure of Energy Barrier to Minimize the Energy Loss of Electron Waves Undergoing Quantum Tunneling

Abstract

Objectives/Goals
The objective is to model a quantum tunneling barrier with a specific structure that minimizes the frequency of electron wave oscillations, which indicates the energy of electrons deflected by the barrier, thereby maximizing the energy of electrons that are tunneled through the barrier.

Methods/Materials
Through programming in C, 4 computer simulations were carried out. Stimulations 1 to 4 contain mathematical models of a rectangular barrier (horizontal function), triangular barrier (linear function), trigonometric barrier (sin/cos function), and a normal distribution barrier (Gaussian function), respectively. The emission height of an electron wave is initialized to be 0.5 units, and the height (potential energy) of all four barriers are set to 1000 units. By using Schrodinger equations, the behavior of electron waves was monitored throughout the simulation. Each simulation consisted of 1000 frames, and the frames were compiled into a GIF. Observation focused on the coordinate x=70 on the horizontal axis of the gif, and all four simulations were paused when oscillation of reflected electron wave occur at the coordinate. The frequencies of electron waves were calculated by dividing the number of oscillations over a period of 10 units. The barrier with the least frequency was determined to be the ideal structure for minimizing the energy loss of particles.

Results
My tests allowed me to conclude that the more a barrier is shaped similar to a uniform wave, energy loss of particles will be less. The rectangular barrier and triangular barrier produced oscillation of 29 cycles per second over 10 length units on the horizontal axis, while trigonometric barrier produced a relatively less oscillation frequency of 26 cycles per second, and N.D. barrier, modeled by Gaussian equation, resulted in a minimal oscillation frequency of 19 cycles per second.

Conclusions/Discussion
The results I obtained suggest that a smooth and normal-distribution-shaped energy barrier conserves a high percentage of potential energy for particles tunneled through it. This ideal structure can be applied to quantum microscopy to increase the efficiency of tunneling and imaging process. Furthermore, the Gaussian structured barrier can be implement in design of artificial light sources to decrease the waste of electricity.

Summary Statement
As the energy barrier is shaped increasingly similar to the shape of a wave packet, I found that the energy loss of the electron wave packets tumbled through it decreases.

Help Received
Richard Scalettar

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Jonathan K.H. Inouye

Project Number
S1809

Project Title
Solar Panel Productivity: Increasing Energy Production by Concentrating Incoming Light and Capturing Reflected Light

Abstract

Objectives/Goals
Photovoltaic (PV) technology is one of the primary sources of clean energy; however, most commercially available PV panels have an efficiency of only 14-16%. The way in which solar panels are currently constructed allows a significant amount of light to be reflected away. The silicon itself reflects a significant amount of light, as does the metal used to carry the electric current. This study investigated the ability to increase the productivity of a PV panel by concentrating incoming light and capturing light that is reflected.

Methods/Materials
A system was designed to compare energy production from a monocrystalline solar panel with the addition of: (1) a linear Fresnel lens to concentrate the incoming light, (2) a one-way mirror film on glass panels to capture the reflected light, and (3) actual mirrors placed at specific angles to capture reflected light. An apparatus was built to suspend a linear Fresnel lens over the solar panel which also allowed the addition of the one-way mirror panels and the angled mirrors in any combination while maintaining the light source and the solar panel in a fixed position. Measurements of light level, voltage, and current were obtained.

Results
The results showed that concentration of light using the Fresnel lens and capturing reflected light with mirrored surfaces increased energy production. Testing with the lens alone showed a 17% increase in power production over the solar panel alone. Addition of the one-way mirror panels also showed an increase in power production. One-way panels alone gave rise to a 14% increase over the solar panel alone. One-way panels + lens showed a 4% increase over the lens alone, an 8% increase over the one-way panels alone, and a 21% increase over the solar panel alone. Similar increases were seen with the angled mirrors. The combination of the one-way mirror panels + angled mirrors + Fresnel lens showed a 27% increase in power production over the solar panel alone.

Conclusions/Discussion
This study confirms that concentrating incoming light and capturing reflected light by the methods used in this project can increase power production in PV panels. While each of the methods used separately showed an increase in productivity, the combination of all three methods resulted in the highest increase in power production.

Summary Statement
This project investigated the ability to improve solar panel productivity by concentrating incoming light with a Fresnel lens and capturing reflected light with mirrored surfaces.

Help Received
None

Name(s)
Faith A. Inverary

Project Number
S1810

Project Title
Investigation of Specular Mediums and Their Effects on the Internal Temperatures of Solar Cookers

Abstract

Objectives/Goals
Solar cooking has shown to be an effective way to alleviate food and unclean water situations, giving people a way to cook their food and pasteurize their water. This project is attempting to find a reflective material that would effectively increase the internal temperature of a solar cooker.

Methods/Materials
4 16x12x12 boxes, 4 12x10x10 boxes, two large oven bags, Mylar film, aluminum foil, white semi-gloss paint, foil tape 5 thermometers, access to direct sunlight, computer paper (for insulation)

Cardboard boxes, different specular materials, paper insulation, and tape was used to create four solar cookers. The design was a combined attempt for a panel and box cooker. Each cooker either contained aluminum foil, Mylar film, white semi-gloss, or foil tape as the internal reflector. The four solar cookers were placed outside for three hours, each cooker containing a digital thermometer within. Every hour within the three-hour period, the temperature in each cooker and the temperature of the external environment would be recorded.

Results
My hypothesis that Mylar film would be the most effective in raising internal temperatures was correct. My results show that Mylar was the best material in Trial 1, 2, 4, and tied with foil tape in Trial 5. Aluminum foil and foil tape were on-and-off tied for the second highest throughout the trials, while white paint was consistently the lowest temperature.

Conclusions/Discussion
These results contribute to the building efforts of giving struggling communities a way to cook their food and pasteurize their water. Solar cookers are a simple way to prevent more disease and feed more people. It can also be used by people trying to lower their electricity and heat usage by using solar cookers.In the future, I could try to regulate external temperature of the solar cookers, so my results would be more consistent. I could also try to test which clear material would be more effective on the solar cooker instead of oven bags.

Summary Statement
My project is investigating the effects of four different reflective materials on the internal temperatures of solar cookers, to aid efforts in the solar cooking communities.

Help Received
The creation of the solar cookers and the experiment was performed with my own knowledge and help. However, my biology teacher, Ms. Palma, aided me with creating the project concept. My STEM advisors, Ms. Deragisch and Dr. Auld, also aided me with advice on how to improve my experiment with

Name(s)
Daniel S. Joo

Project Number
S1811

Project Title
Mapping the Sun's Differential Angular Velocity Using Automated Sunspot Detection and Tracking Tool

Abstract

Objectives/Goals
My objective is to create a software tool that detects and tracks sunspots from satellite images and confirm this tool by measuring the angular velocity of the Sun at different latitudes (I will compare this data with current literature).

Methods/Materials
Laptop Computer with Octave (free alternative to MatLab) installed. 5514 SOHO (Solar and Heliospheric Observatory) images.
I created a tool using Octave to process all 5514 images. The tool detects and tracks sunspots while accounting for the 3d spherical geometry of the Sun. With that, I measured the angular velocity of the Sun at different latitudes and times.

Results
As expected, the angular velocity of the Sun is faster towards the equator. The graph of angular velocity v. latitude aligns well with a second-degree function. My tool also showed that the angular velocity of the Sun at a certain latitude is not constant; it changes year to year. This is expected because the complex magnetic interactions within the sun affect the rotational velocity.

Conclusions/Discussion
My measurements of the Sun's angular velocity generally agree with current literature on the Sun, validating my tool. However, my tool still has flaws as indicated by small differences in data. If the tool becomes perfected, there will be a new potential to find new trends on the Sun's surface activity. This is because many of our ideas about the Sun come from hand-drawn images and human measurements, while my tool objectively analyzes satellite images pixel by pixel.

Summary Statement
I created a software tool that tracks sunspots and confirmed this tool by calculating the Sun's differential angular velocity.

Help Received
I received help from my mentor, Nader Satvat. He taught me how to use scientific tools like MatLab (Octave) and Excel.

Name(s)
Jonathan Kim; Samuel Lee

Project Number
S1812

Project Title
Systematic Analysis of Solar Activity and Developing Predictive Indicators Pertaining to Solar Storms Using MATLAB Code

Abstract

Objectives/Goals
The main objective of our project is to create a tool using MATLAB that will automatically analyze pictures of the Sun right before a solar storm occurred.

Methods/Materials
We used data captured by satellites from the Solar Dynamics Observatory, which is a NASA mission that was launched in 2010, and the Joint Science Operations Center database from Stanford. Our methodology was creating an image-processing code using MATLAB to analyze images of the sun 30 days prior at 12 hour intervals before a solar flare or coronal mass ejection occurred. We calculated the total area of sunspots which we correlated with solar activity.

Results
Our results indicate that the solar activity, which represents irregularities in the magnetic field on the surface of the sun, increased before solar storms happened.

Conclusions/Discussion
We learned that before a solar storm occurs, solar activity in the form of sunspot area increased. Therefore, we can use this as a predictive indicator that allows us to predict future solar storms.

Summary Statement
We created a MATLAB code that calculates the total area of sunspots on pictures of the sun and learned that the area of sunspots increased before a solar storm occurred.

Help Received
We got the idea to use the JSOC database and SDO satellite images from our project advisor.

Name(s)
Milagros Marquez

Project Number
S1813

Project Title
How Can We Use Magnetic Levitation to Odentify a Ground Cavity (Sinkhole)?

Abstract

Objectives/Goals
This project investigates how magnetic fields can be used in combination with small variations of Earth's gravitational field strength (due to the composition of Earth's crust at a specific location) to locate ground cavities (sinkholes).

Methods/Materials
The materials used were: magnets, wood Popsicle sticks, magnetic field sensor, table, electronic scale, hot glue gun, journal, pencil with eraser.

We created a wood stand. We then glued two magnets at the bottom of the wood stand. Next we created a support for the sensor and finally placed the remaining two magnets enclosed in a wood structure (but free to move/levitate) to the top of the sensor. The sensor is enclosed between the two sets of magnets.

Next, we started our measurements using the empty space under the desk as a simulation of cavity under the surface of the desk. Once we completed three trials we then placed 21 kg of rocks under the table in order to simulate land mass under the table and completed the same steps as explained above. A final step was to increase the amount of mass under the table to 45 kg and complete the same steps. We recorded our measurements and average calculations in the research paper.

Results
By creating the graph between the dependent and independent variables and by taking the line of the best fit, one can conclude that as we increased the mass (measured in kg) under the table the magnetic field strength (measured in mT) increased as well. This is called a linear relationship. We only tested masses values between 0 to 45 kg. We assume that this linear relationship will continue if we increase our scale.

Conclusions/Discussion
I concluded that my hypothesis was correct since I was able to identify and measure the relationship between slight changes in the composition of the ground and the magnetic field strength of my gravity magnetometer. Furthermore, I was able to further enhance the design of the gravity magnetometer by creating a 3D printed case for it.

Summary Statement
This project investigates how magnetic fields can be used in combination with small variations of Earth's gravitational field strength (due to the composition of Earth's crust at a specific location) to locate ground cavities (sinkholes).

Help Received
Mr. Incze, Physics teacher at Alisal High School

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Joy A. Meleika

Project Number
S1814

Project Title
How Sound Waves Get Affected by SDM (Sound Dampening Material)

Abstract

Objectives/Goals
The issue of sound pollution increases due to fast (also modified) cars, MRI machines being so loud, and houses being built near freeways more. The use of incisions, creating geometrical patterns, and taking out foam, will absorb and disperse greatest amount of sound for SDM.

Methods/Materials
Materials: 2" thick dense upholstery foam, eyebrow razor, decibel reader, sound tunnel (cardstock), speaker, different hertz frequencies.
Method:
1. Design geometric shape, use eyebrow razor to cut design 1" thick. (8)
2. Use 6 different Hz sound waves
3. Place sound tunnel on speaker
4. created configuration to have an equal platform
5. test each design and write down data (repeat for each foam 7 times per Hz, use mean of data)

Results
The triangular/ pyramidal design had the best sound absorption overall. From an engineering aspect, this would not be cost- efficient for manufacturing or consumers. The counterpart, hemispherical designs, are 96% as effective and cost efficient. The beneficial counterpart creates an accessibility of SDM for any and everyone suffering from Sound Pollution.

Conclusions/Discussion
The sound dampening foam expresses easy, cost-beneficial ways to dampen sound. The experiment displayed lower frequencies, throughout each foam, due to the incisions. The geometric shapes calculated created more absorption due to its specific number of sides. This data could, one day, help a manufacturing company create outstanding Sound dampening foam.

Summary Statement
From the Engineering aspect: the geometric pyramidal design absorbed the greatest amount of sound, but its counterpart, hemispherical design (96% as effective) is better for the manufacturing and cost-effective aspect.

Help Received
Samuel Meleika (Civil Engineer)

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Grady P. Morrissey

Project Number
S1815

Project Title
Building a Bench-Mounted Fiber Spectrograph

Abstract

Objectives/Goals
A spectrograph separates light into its component wavelengths in order to measure the relative intensity of each color. Spectroscopy can be used in astronomy to identify the chemical composition, movement, temperature, and magnetic fields of objects in space. When light encounters certain elements in its path, some of the photons are absorbed at certain wavelengths, resulting in dark lines in the spectrum. The goal of this project was to build a spectrograph optimized to see the Fraunhofer absorption lines in a solar spectrum.

Methods/Materials
I designed and built a spectrograph and connected it to my telescope that I built a few years ago. This design consists of a narrow entrance slit, a collimating lens, a diffraction grating, which disperses the light into its component colors, and a camera. Spectrographs are optimized for a balance between spectral resolution (the ability of the system to resolve spectral lines) and throughput (the amount of light that is imaged on the detector). This system was designed for high resolution in order to produce a Fraunhofer spectrum. The large instrument is connected to the telescope using an optical fiber in a "bench-mounted" configuration. I wrote a code in Python to analyze the spectra and produce a plot of wavelength versus intensity.

Results
The bench-mounted fiber spectrograph successfully images Fraunhofer lines in daylight, sunlight, and lunar spectra. The system also produces absorption and emission spectra of household light sources. All of the spectra are successfully plotted by the Python code.

Conclusions/Discussion
Optimizations to the system, particularly concerning the entrance slit, improve the Fraunhofer spectra beyond the design quality. The ability to obtain a lunar spectrum also demonstrates the capabilities of the spectrograph, which is optimized for a solar spectrum.

Summary Statement
I designed and built a spectrograph, connected it to a telescope I built a few years ago, and wrote a code in Python to analyze the data in order to ultimately see the Fraunhofer absorption lines in a solar spectrum.

Help Received

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Avi S. Patel

Project Number
S1816

Project Title
A Study of the Variation of Metallicities in Galaxy Clusters with Relation to their Morphologies

Abstract

Objectives/Goals
Galaxy clusters are celestial laboratories to study the evolution of the universe. The intracluster medium within galaxy clusters hosts an array of metallicities, like iron (Fe) and nickel (Ni), that can be analyzed through x-ray emission spectra. The goal of this research is to identify a correlation between the cluster abundances of Fe and Ni in relation to galaxy cluster substructures.

Methods/Materials
I used x-ray spectroscopy to analyze Fe and Ni abundances in galaxy clusters. I obtained a sample of 32 galaxy clusters with a redshift range $0.02 < z < 0.3$ from the Chandra X-ray telescope that have corresponding values for morphology parameters in Parekh et. al 2015. Through using the Chandra X-ray Observatory's Ciao Tools and SAOImage DS9, I created a thermal plasma emission model with a Bremsstrahlung Continuum model to obtain the abundances of Fe and Ni. Subtle inaccuracies in the galaxy cluster point source extraction required filtering the abundance data by correlating its temperature vs. abundance with Baumgartner et. al 2005. I then correlated the data with the updated morphology parameters (Gini coefficient, Moment of Light, and Concentration) in Parekh et. al 2015 using Microsoft Excel.

Results
After filtering the Fe and Ni abundance data, I developed three correlations between abundance data and each morphology parameter. After dividing data by dynamical state of the cluster, I found a correlation between each parameter and the Fe and Ni abundances for the non-relaxed clusters concluding that as a galaxy cluster becomes more disturbed in substructure, the Fe and Ni abundances increase.

Conclusions/Discussion
These galaxy clusters abundance and morphology correlations were expected based on the cluster cooling time simulations from Parekh et. al 2015. Applying my abundance data to these cooling time simulation results, they suggest that as the cooling times increase for these clusters, the Fe and Ni abundances also increase. This asserts that as galaxy clusters mature, processes, such as star formation and supernovae, also occur producing heavier elements such as Fe and Ni.

Summary Statement
By using x-ray spectroscopy to obtain galaxy cluster Fe and Ni abundances and relate them to cluster morphologies, this research concludes that Fe and Ni abundances correlate with galaxy cluster substructure parameters.

Help Received
Mrs. Messenger and Mr. Burns guided me through the research process and provided feedback.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Gautam G. Pradeep

Project Number

S1817

Project Title

Determination of the Orbital Elements of Near-Earth Asteroid 1999 LO28 Using the Method of Gauss

Abstract

Objectives/Goals

The objective of the research was to generate the orbital elements of the asteroid 1999 LO28 in order to better study its orbit and assess its potential threat for planetary collision.

Methods/Materials

Images of the asteroid were taken on 5 separate nighttime observation runs. The images were then reduced and aligned using CCDSoft Version 5. Images were then used to generate initial vectors of the asteroid from the Method of Gauss using a Python program. Once these vectors were determined, they were used to determine the orbital elements of 1999 LO28 in a Python program. I developed both programs.

Results

I compared the orbital elements that were determined for this near-Earth asteroid with the predicted corresponding values by the Jet Propulsion Lab (JPL). Five out of the six orbital elements were within one-thousandth of the JPL value.

Conclusions/Discussion

I determined how these calculated orbital elements would change over time, and it was found that the 1999 LO28 asteroid would never collide with the Earth, but will collide with the Sun in about 200 million years. The orbital elements I calculated were new information that had never been collected previously. This was then published in the recent Minor Planet Center report (MPC), which provides information used by space organizations such as NASA and SpaceX to program spacecraft to efficiently travel through space without collisions with asteroids like this.

Summary Statement

I determined the orbit of a near-Earth asteroid and assessed its potential threat to planetary collisions.

Help Received

I was able to use telescopes to collect data from the Frank Etscorn Observatory in Socorro, New Mexico. I gained access to these facilities through my research advisor, Dr. Adam Rengstorf, at the New Mexico Institute of Technology and Mining.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Vivek Vijayakumar

Project Number
S1818

Project Title
Analysis of Magnetic Flux Surrounding Chromospheric Filaments Using Fibril Structure

Abstract

Objectives/Goals
The project intends to find differences between fibril structure around quiet region filaments and active region filaments by calculating the magnetic flux around each.

Methods/Materials
Using an amateur setup consisting of an H-alpha (656.281nm) "eyepiece", 80mm refractor, equatorial mount, and high-speed monochrome camera, 48 images of ARFs and 76 images of QRFs were taken over a period of two months, with 8 ARFs and 9 QRFs being processable. They were captured in SharpCap, stacked in AutoStakkert!, processed in RegiStax 6, and analyzed in SAOImage DS9.

Results
Based on the 853 fibrils analyzed, and together 17 filaments, the average magnetic flux in ARFs is 736 ± 97 GWb, and in QRFs is 676 ± 86 GWb. The variations between magnetic flux in QRFs and ARFs is large however. The standard deviation between QRFs is 259 GWb, while it is 273 GWb for ARFs.

Conclusions/Discussion
There is a lot of variance in magnetic flux from filament to filament regardless of whether it is a QRF or ARF, indicating the large variance in behavior between individual filaments of the same type. Due to the similar magnetic flux of ARFs and QRFs, the data suggests that the mechanisms producing both filaments in filament channels are similar.

Summary Statement
The project intends to find differences between two types of filaments on the Sun's chromosphere by analyzing the magnetic flux around them, using fibril tracers.

Help Received
I used my own equipment along with some online software, captured the data myself, processed it, and did the computations myself. Solar astrophysicist Sara Martin reviewed the project, along with Kin Searcy of the San Diego Astronomy Association.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Andrew E. Wang

Project Number
S1819

Project Title
Investigating Charging and Electrostatic Discharge Risks for Astronauts on the Lunar Surface

Abstract

Objectives/Goals
The Moon is devoid of a global magnetic field and is directly exposed to space plasma and solar radiation, causing the surface and any objects on it to be charged by collection of ions and electrons from the plasma. Lunar dust is easily levitated, and dust deposition onto spacesuit and spacecraft surfaces was reported as a significant problem during the Apollo mission. Dust deposition creates non-uniform surface conductivity and results in differential surface charging. The objective of this study is to investigate whether electrostatic discharge will be a significant threat to astronauts and spacecraft during future space exploration at the lunar terminator.

Methods/Materials
An experiment was designed to study discharge on dusty spacesuit and spacecraft. In a vacuum chamber, two different sample plates were tested in a plasma (with properties similar to average solar wind conditions) generated by an electron bombardment gridded ion thruster. The first sample plate, consisting of an aluminum plate with Kapton tape at the edges, was used to simulate discharge on a typical spacecraft surface. The second sample plate, consisting of an aluminum plate with spacesuit material GoreTex at the edges, was used to simulate discharge on spacesuit. Three different test setups, ranging from a clean, dustless surface to a dusty surface covered by JSC-1A lunar regolith were considered.

Results
While clean surfaces under the test conditions are generally resistant to discharge, significant electrostatic discharge and arcing were observed for the dusty surfaces. Large biasing potential and more dust coverage both resulted in higher discharge rates. We also find that dust deposition both enhances differential charging, a necessary condition for discharge; and increases the number of triple-junction interface points between plasma, conductor and dielectric material, where discharge is triggered. Discharge occurs more frequently on "dirtier", high voltage surfaces in plasma.

Conclusions/Discussion
This research presents the first reported laboratory experiments on electrostatic discharge on dusty spacesuit/spacecraft surface in a simulated lunar plasma environment. The investigation suggests that because of the combined condition of dust coverage and high voltage charging at the lunar terminator, electrostatic discharge will pose as a serious risk to astronauts and equipment in future lunar missions in that region.

Summary Statement
I was able to utilize experimental results to determine that the lunar plasma charging environment will pose as a significant threat to astronauts in the lunar terminator region.

Help Received
William Yu from University of Southern California aided in experimental equipment understanding and enforcing proper safety procedures when operating lab equipment.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Natalie C. White

Project Number
S1820

Project Title
Balloon Based Observation of Sporadic Meteors from the Stratosphere

Abstract

Objectives/Goals
Meteors are small bits of material that enter the atmosphere at high speed and leave a trail of ionized gas. The objective of this work is to observe sporadic meteors from a platform in the stratosphere. At high altitudes, clouds and city lights will not interfere with the observations. Furthermore, meteors should appear about four times brighter when viewed from the stratosphere since the distance from the camera to the meteor is reduced by a factor of two.

Methods/Materials
A package of instruments including a high sensitivity, monochrome video camera with a fisheye lens was assembled and flown on a helium filled weather balloon at night. Telemetry of the GPS coordinates, altitude, and temperature was sent once per minute during the flight via a 2-m radio, received on the amateur radio network, and then posted online.

Results
Three hours of balloon based video was successfully recorded over the course of the flight. Examination of the video footage shows that observing conditions improve significantly as the altitude increases. Although, the brightest stars and the planet Jupiter are visible in the video, no meteors were found in the data from this flight.

Conclusions/Discussion
This work is a good first step toward the observation of meteors from the stratosphere. Ideally, the next flight will be conducted during one of the annual meteor showers at a time when the Moon is not visible to hamper the observations. The addition of a ground based station would make it possible to perform simultaneous observation from two locations, making it possible to use triangulation to obtain the meteor altitude.

Summary Statement
This project is a good first step toward balloon based observation of meteors from a platform in stratosphere which should provide improved viewing conditions due to the absence of clouds and reduced light pollution.

Help Received
David Bezinque used the 3D printer in the Physics Department at Fresno State to make my camera holder.

Name(s)
Andy Y. Zhu

Project Number
S1821

Project Title
Moth Eye Anti-Reflective Coating for Near-Infrared Astronomical Applications

Abstract

Objectives/Goals
Infrared observations are some of the most important observations, allowing rare AGNs, deeply embedded stars, globular clusters, low luminosity stars, and much more to be discovered and studied. When using infrared telescopes, they must be cooled to cryogenic temperatures (<100K) in order to limit the noise generated by the telescope itself. Most importantly, the materials must be transparent. Silicon satisfies the criteria, but due to its high index of refraction (n~3.42), the surface of silicon reflects 30% of all incident light. In order to use silicon in infrared instruments, an anti-reflective coating is needed to increase transmission. Biomimicry of moth eyes yielded a new coating, capable of satisfying all the above conditions.

Methods/Materials
To properly characterize, four tests were carried out: wavefront, scattered light, incident angle dependence upon transmission and upon reflection. In these tests, the physical deformities were measured with an interferometer and the effectiveness was determined. A baseline was also established in the function of the AR coating, specifically to traditional multilayered coatings.

Results
The results demonstrated nearly perfect manufacturing of the coatings, with data comparable to that of a mirror. However, the transmission of the moth eye AR coatings at 1.55 microns was suboptimal due to improper height of the corneal nipple array. The decrease in transmission when angled was insignificant before 20 degrees. When angled, the moth eye coatings produced similar results to a double layered AR coating.

Conclusions/Discussion
Because of these results, it was determined that this new AR coating has potential to be used in space based telescopes. With this, it paves the road to miniaturization of optical systems while increasing resolving power. Though more characterization must be performed at different wavelengths and heights, moth eye AR coatings are promising in advancing infrared astronomy.

Summary Statement
I characterized a new anti-reflective coating based on the nanostructures on moth eyes that holds potential for usage in space-based telescopes.

Help Received
Dr Jian Ge at the University of Florida provided materials and guidence on how to carry out standard astronomical research. I performed all the experiments and analysis myself.