CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Isaac Anchanattu

Project Number

S1701

Project Title

Measuring Road Quality Using Vibration Analysis

Abstract

Objectives

The objective of this project is to find the quality of a road by use of the process of vibration analysis. I believe that a frequency with a higher than average amplitude would indicate a poor road quality.

Methods

In my project, I used an accelerometer (x,y, z-axis) and a vibration analysis tool, as well as a car that would be used to travel on the roads I am testing. First, I collected accelerometer data for each individual road being tested. This data would be converted to its component frequencies through the use of the vibration analysis tool. The tool would categorize and calculate the road unevenness, in terms of bumps per distance, using these component frequencies.

To separate component frequencies, I used a DFT algorithm implemented through a python program. Iterate this process a number of times to enable the production of more accurate results.

Results

I was able to come up with a scale based on the number of bumps/distance that could measure road quality that is termed Road Roughness Index (RRI). This Road Roughness Index took only values that were in the 75th percentile of the amplitude values. Relatively speaking, a higher road roughness index correlates to poorer road quality, while a lower road roughness index correlates higher road quality.

Conclusions

Through the process of vibration analysis, I was able to establish a reasonable measure of road quality in the form of the Road Roughness Index to quantify the quality of the road. Establishing this Road Roughness Index will help prioritize roads that are most desperately in need of repairs, could be useful as part of a navigation system.

Summary Statement

I used the process of vibration analysis to measure the road quality using a road roughness indicator (RRI), with a simple and cost effective method.

Help Received

My parents drove me around to allow me to collect data necessary for the project, and helped me review and guide me through the project.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Caden Annison

Project Number

S1702

Project Title

Changing the Rate of Electronically Detected Muon Occurrences by Modifying External Variables

Abstract

Objectives

The purpose of this study is to determine how different variables effect the rate of muons passing through a specific space.

Methods

Built two electronic muon detectors using free online instructions (cosmicwatch.lns.mit.edu), sourced all components necessary including the Arduino Nano, scintillator, and photomultiplier. Used open source code by "Spencer Axani." Once two detecters entered coincidence mode, multiple trials were conducted in different environments, and the data was compared.

Results

After conducting trials by using concrete, steel, and metal foam screening, testing different altitudes, changing the angle of the detectors, and looking at heat, humidity, pressure, visible climate conditions (rain, overcast, clear), and time of day, it was discovered that many specific variables can mildly impact the rate of incoming muons. Data showed that higher elevations, warmer temperatures, and a horizontal detecting direction showed an increase in events, while humidity, pressure, visible climate conditions, and time of day showed no obvious trends. Shielding showed a slight reduction in occurrences from the average number of events.

Conclusions

As variables such as elevation and temperature increase, so does the number of muon occurrences. Based on data from different angular measurements, most muons at sea level are traveling in near vertical direction because the farther the detectors were rotated from horizontal, the lower the count rate became. Concrete is more efficient as a shield to muon radiation than metal foam, but metal foam is a greater screen than 11 gauge steel. Humidity, pressure, visible climate, and time of day, had little to no impact or obvious trends.

Summary Statement

Using a scintillator coupled to a photomultiplier, I determined that variables like elevation, temperature, specific shielding, and detecting direction impact the rate of muons traveling through a specific area.

Help Received

Through email, I received help from Spencer Axani, who is a PHD student at MIT, who was able to help me identify physical problems in my detectors through photos while building them.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Hayden Barrett; Andrew Gonzales; Logan Ryan

Project Number

S1703

Project Title

How Do Different Wavelengths of Light Affect the Energy Production Efficiency of a Solar Panel?

Abstract

Objectives

We wanted to learn how to get the most efficiency out of the production of energy from the solar panel.

Methods

We used clear, colored films to cover the solar panel. We used a lux meter to measure the amount of lux from the films and sun and we used a battery pack to measure the amount of energy produced by the solar panes.

Results

The results of our experiment is the red panel used the energy it was given the most efficiently. For the colored filters, the yellow produced the most energy, but the regular sunlight (the control) produced the most energy overall.

Conclusions

Our results were not supported by the hypothesis. This helps us expand our knowledge by learning that with limited light, the red filter had the best energy efficiency per lux.

Summary Statement

This project showed how to produce the most electricity under all conditions of light by using different colored filters to test their energy outcome and energy efficiency.

Help Received

Name(s)

Maximillian Bhatti

Project Number

S1704

Project Title

High-Stratospheric Testing of Novel Cosmic Ray Shielding Composites

Abstract

Objectives

Cosmic rays are an unsolved problem in space exploration. While manned Mars missions are possible with current propulsion systems, the threat of cosmic radiation has not been addressed. Without a shielding system in manned spacecraft, astronauts will be exposed to extreme levels of radiation. The goal of the project was to develop a practical shielding system for interplanetary spacecraft to negate risks using both theoretical and experimental data.

Methods

A total of 9 materials were investigated. The project was composed of an computational and experimental phase. The computational phase utilized an ESA supercomputer to run 26 simulations, which tracked the materials shielding ability. The simulation ran inside of an application published by ESA, in which I defined particle characteristics and material geometry and chemical composition. These simulations were used to formulate a hypothesis going into the experimental phase, which will be composed of one or more balloon launches. A GPS tracked detector suite I designed (HADES), will float to 29km of altitude. The operating conditions will expose HADES to cosmic ray primaries. The detectors used are Geiger tubes and the flight computer is distributed across two Arduino boards which I programmed. Ground evaluation was completed, but due to bad weather the launch has been delayed

Results

The results from preliminary computational analysis were used to predict the outcomes of the coming experimental phase. Results from the proton simulations were consistent with the current literature, and Polyethylene (PE) was the most effective, due to its low nuclear charge, leading to less secondary radiation. Composite materials and graphite also performed well against proton flux. Against 10^11eV Oxygen HZEs, Aluminum failed to provide shielding, as secondaries actually increased the experienced dose; Boric Acid and PE performed best. When exposed to 10^14eV Iron HZEs, Ammonium Chloride provided the best shielding, with 80% of the dose shielded, while PEEK* increased the final dose by 182% due to delta rays.

Conclusions

The goal of the project was to test various novel technologies, such as lightweight hydrogen salts, as candidates for cosmic radiation shields. The need for a practical, lightweight shielding system is great with manned deep-space missions planned. A detector suite (HADES) was built and successfully ground tested, while computational simulations were used to form predictions for experimental data. All systems are ready and tested for launch, and HADES will take off as soon as an appropriate launch window is found.

Summary Statement

The goal of the project is to develop a practical shielding technology for manned spacecraft using both computational data and experimental data taken from the upper stratosphere.

Help Received

I asked some questions of a JPL scientist about how scientific balloons work in person after a public lecture.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Isaac Broudy

Project Number

S1705

Project Title

Developing and Calibrating a Linear Polarimeter for Astrophysical Tests of Beyond Standard Model Physics

Abstract

Objectives

The objective of this study was to develop an autonomous, functional, and low instrumentally biased optical polarimeter for Standard Model Extension studies.

Methods

The optical polarimeter was made from 3D printed PLA plastic, an achromatic polymer half wave plate, and a double calcite savart plate. The half wave plate was driven by a step motor and monitored by a rotary encoder and photodiode. This was ultimately controlled by an Arduino Uno. Python scripts were made to automate the control of Arduino and data analysis pipeline. The optical polarimeter was placed on a 90mm Stellarvue refractor telescope, with an Astrodon V Band filter and a ZWO ASI 178mm CCD camera. This was important in calibrating the polarimeter, reproducing published polarizations, and Standard Model Extension tests.

Results

A compact and easily reproducible optical linear polarimeter was constructed for astrophysical measurements. The linear polarimeter was calibrated through the measurements of unpolarized standard star observations. This allowed for the measurement of an instrumental bias of 0.00154 fraction of polarization. Two astronomical bodies were then measured to reproduce published result. The optical linear polarimeter is to be used in Standard Model Extension studies to come.

Conclusions

I was able to develop, calibrate, and automate an optical linear polarimeter for astrophysical tests of Standard Model Extensions. The optical polarimeter was almost entirely 3D printed making it easy to mass produce them for future studies. The linear optical polarimeter was made so that data acquisition is fully autonomous, along with an automated data analysis pipeline. The instrumental polarization measured was a polarization fraction of 0.00154, comparable to that of other polarimeters. This demonstrated that this optical polarimeter could perform Standard Model Extension studies.

Summary Statement

A linear optical polarimeter was successfully constructed and calibrated with astronomical measurements, to be used in Standard Model extensions.

Help Received

I was mentored by Dr. Brian Keating and Dr. Andrew Friedman of Center for Astrophysics and Space Sciences at UCSD. I was additionally provided with materials and acess to lab facilities.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Rebeca Castro

Project Number

S1706

Project Title

Biomechanics of the Golpe

Abstract

Objectives

Every flamenco dancer begins by learning basic steps such as the golpe which means, the stomp. This is performed by having a slight bend at the knees for balance, a straight back, then raising your knee straight up and then bringing it back down to create a stomping noise. Recently I learned the same noise can be achieved by standing up straight, kicking your ankle back, then bringing it back to its initial position. The latter method is said to reduce injuries, which is beneficial because injuries are so prevalent in this form of dance. If evidence supports this, the new method may reduce injuries common in flamenco dancers.

In this experiment I performed trials of both styles of the step measuring the different normal forces on the force plate produced by each style. I graphed the results and was able to compare the maximum and minimum measured forces from the graphs of both styles and found that the average range of normal force applied for the original style is 254.4N ± 5.0N and the average range of normal force required for the new style of the step is 183.3N ± 5.0N. There is a difference of 70.9N ± 5.0N in the average range of force measured in the original step versus the new style of step.

Additionally I had someone try both styles of the step without them knowing the purpose of the measurements to see if my knowledge of the experiment greatly influenced the results. After analyzing that data I found that the difference between maximum and minimum for the original style is 510.3N ± 5.0N, and the average difference between maximum and minimum normal forces for the new styles was 265.6 ± 5.0N. There is a difference of 255 ± 5.0N in the average range of force measured in the original step versus the new style of the step.

This means that in the original style of the step there is a greater average range of normal force required to create the original movement necessary compared to the new method of the step where the change in force is not as large. I concluded based on these results that such a distinct reduction in force from the original style s abrupt raising and dropping of the knee has a greater risk of injury than the new style.

Methods

In this experiment I used a PASCO 2-Axis Force Platform and recorded the data through the Sparkvue app on my phone. I initially stood on the plate before recording so the plate could measure the normal force of my weight. I did this before the stomping step began to see the normal force of no movement compared to when stomping began. Then I began stomping with the intention of applying a consistent force with the first method where my knees are bent and my weight is at the back. I did multiple trials and tried to have consistent precision between each trial. Then I followed a similar procedure, but I measured the normal

Summary Statement

After measuring the normal force required for the traditional golpe step and the new golpe step, I found that the new style required less normal force overall and therefore may reduce injuries.

Help Received

My instructor Mr. Hamilton provided the force plate and also guided me throughout the process of taking measurements. Ms. Lepore and Ms. Blomberg helped me prepare for my project for the fair.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Jonathan Inouye

Project Number

S1707

Project Title

Improving Solar Panel Efficiency with Thermoelectric Generator Units Using the Seebeck and Peltier Effects

Abstract

Objectives

Although solar is one of the primary sources of clean energy, current photovoltaic (PV) technology has an efficiency of only 15-20%, and temperature is one of the main factors affecting efficiency. As the ambient temperature increases, the power output of a PV cell decreases. The objectives of this study were two-fold: (1) to investigate the ability to convert the wasted heat energy from a solar panel into usable energy through the addition of thermoelectric generator units (Seebeck Effect), (2) to try and increase power output by using the thermoelectric generator units in the opposite orientation to decrease the solar panel temperature (Peltier Effect).

Methods

Thermoelectric generators (TEG) create voltage when there is a temperature differential between the two sides of the device; this is known as the Seebeck Effect. Conversely, when voltage is applied to the same device, a cooling effect occurs through heat transfer in the TEG (Peltier Effect). A small solar panel was tested in a closed system so that temperature readings could be obtained above and below the panel. To test using the Seebeck Effect, TEG units were attached to the underside of the solar panel; temperature, voltage, and current measurements were recorded when the panel was exposed to a light source. To test the Peltier Effect, the same TEG units were placed in the opposite orientation on the underside of the panel. A 9V battery was used as the power source; temperature, voltage, and current measurements were recorded.

Results

The results from the Seebeck Effect tests confirmed that, the excess heat could be converted to usable power. Although the overall amount of power generated was small, there was a significant increase in power as the temperature increased. With the Peltier Effect configuration, the goal was to increase solar panel efficiency by decreasing the temperature underneath the panel using the TEG. The peak temperature under the panel using the Peltier Effect was significantly lower (nearly 23°C). Unfortunately, a corresponding increase in power production was not observed.

Conclusions

Although the study did show that the excess heat could be converted to power using the Seebeck Effect, and the temperature under the panel could be significantly decreased using the Peltier method, due to the constraints of the system, the results were not as profound as hoped. The goal is to improve the overall results by creating a hybrid system which can take advantage of environmental conditions resulting in the increase of the TEG temperature differential.

Summary Statement

This project investigated the ability to improve solar panel efficiency by using thermoelectric generator units to increase power production using the Seebeck and Peltier Effects.

Help Received

None

Name(s)

Faith Inverary

Project Number

S1708

Project Title

Solar Controller: How Varying Weather Patterns Affect Light to Heat Conversion within Solar Ovens

Abstract

Objectives

The objective of this project was to determine how varying weather patterns and colder temperatures would affect multiple solar ovens with different reflective mediums within.

Methods

Multiple cardboard boxes, reflective mediums, and crafting materials were used to create four solar ovens. The design implemented a side door echoing a convection oven door and a panel reflector atop the base. Each oven-like base contained a different type of reflective material in its interior: aluminum foil, Mylar film, white semi-gloss, or foil tape. In each trial, the four solar ovens were placed outdoors for three hours, each oven containing oven/meat thermometers and rice/chickpeas cooking within. Periodically, the temperature in each cooker, the temperature of the external environment, and different weather patterns (wind, precipitation, and humidity) would be recorded.

Results

After several trials, results revealed that Mylar film had the most dramatic temperature difference in a majority of the trials, deeming the project's hypothesis as correct. Weather patterns of wind and precipitation didn't have much of an effect on any cooker, except for their extremes. If it was too windy or it ended up raining, it prohibited the ovens from cooking and converting sunlight. Comparatively, low to mid-range humidity and external temperature had a stronger effect on the ovens' efficiency. All ovens cooked the staple foods relatively well.

Conclusions

The project results contribute to the building efforts of finding more efficient ways to cook food or pasteurize water without electricity or natural cooking resources. More information will be accessible on what materials are most efficient in a wider range of weather patterns, so a person can heat their resources more efficiently.

Summary Statement

I found out how weather patterns affected light-to-heat conversion within different homemade solar ovens.

Help Received

I built the solar ovens and experimented by myself. My science teachers, Mrs. Bowles and Mrs. Bickel, reviewed my work.

Name(s)

Philip Kabranov

Project Number

S1709

Project Title

Accretion Analysis through Profile Decomposition of T-Tauri Stellar Spectra Using Nonlinear Least Square Minimization

Abstract

Objectives

The accretion shock theory states that Standard T Tauri stars are surrounded by circumstellar disks that gradually accrete onto the stellar surface. Energy is radiated from both the disk and the position where material falls onto the star. The objective of this research is to develop an algorithm for decomposing T-Tauri spectral lines into a Broad Component (BC) and Narrow Component (NC) to support the accretion shock theory. Lines with large widths, BCs, arise in the extended magnetosphere. Narrow lines, NCs, are more likely to be produced in the region of the accretion shock.

Methods

Spectras were obtained from the European Southern Observatory (ESO) Science Portal. The existence of the BC and NC was found through the decomposition of an appropriate spectral line. The 5875.743 Å line, corresponding to strong He I emission, was investigated. Spectral decomposition was carried out via non-linear optimization to fit a function with two Gaussian curves, one for the BC and one for the NC. It is implemented using the AstroPy and SciPy libraries, particularly scipy.optimize.curve_fit, which utilizes the Levenberg Marquardt algorithm.

Results

The NC and BC were modelled using tuples (a1, m1, c1) and (a2, m2, c2) representing Gaussian functions. Accretion shock caused by the free fall of the disk matter was modeled using spectral decomposition into a BC and NC over 170 observations. The approximation error within 0.2% and 5%.

Conclusions

The experimental results support the theory for accretion shock/emission spectra origin. The low value of the approximation error is consistent with the presence of narrow and broad components, corroborating the accretion shock theory. Further research can focus on and evaluate the excess of flux in several T-Tauri stars.

Summary Statement

Developed and implemented a Python algorithm for decomposing a spectral line to support the accretion shock theory through identification the broad and narrow components in the observed spectrum from a T Tauri star.

Help Received

I was directed towards the ESO database and AstroPy library by Citizen Science Initiative, a volunteer group launched by Evergreen Valley College. However, I designed and implemented the data processing software to investigate the spectra on my own, outside of this institution.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Wonjin Ko

Project Number

S1710

Project Title

A Novel Method of Dielectric Nanopores for Electrophoresis Measurements of Nanoparticles

Abstract

Objectives

The objective of this study is to detect particles other than DNA by increasing the translocation time of the particle and increasing sensitivity through the use of hydrogel.

Methods

Materials: Norcada 30 nm TEM Grid, Teflon Box, AgCl electrodes, 10nm Au particle, LabView, Clampfit Software, Oxygen Plasma Cleaner, Op Amp (OPA2134PA), Resistor 4.12 M ohms, 1k ohms, 1 M ohms, 1 M KCl Buffer, Silicon gasket, Faraday Cage, Exopatch

Procedure: Created 30nm pore via dielectric breakdown and then translocated Au particle via electrophoresis while trapping the particle using hydrogel to increase the sensitivity of the pore as well as to increase the dwell time. The results were compared to those of a control group without hydrogel.

Results

Au particle was measured using 30nm pore. However, the machine could barely detect the sudden fluctuation of resistance as a result of translocation. However, by blocking the other side of the pore using a hydrogel which acts like a fishnet successfully increased the sensitivity and the translocation time.

Conclusions

The detection rate of nanopore for short particles was almost impossible. However, using PEG hydrogel successfully detected Au particles by increasing the translocation time. This shows a promising application for detecting various particles using the combination of dielectric nanopores and hydrogel

Summary Statement

By utilizing solid state nanopores and hydrogel, we successfully demonstrated potential for detecting various particles with very small concentration

Help Received

My mentor directed me to relevant published papers and explained the science of electrophoresis . He also helped me design the circuit diagram and code LabVIEW, as well as providing the necessary materials.

Name(s)

Krithi Koodli

Project Number

S1711

Project Title

A Novel Method of Distinguishing Rocky Planets from Uninhabitable Gas Giants Using Unsupervised Clustering

Abstract

Objectives

The objective is to develop a method of distinguishing rocky planets from gas giants. My engineering goals were to create a model using the Kepler data, confirm the model s validity by comparing its output to known planetary frequencies, and compare its predictions to 50 exoplanets that have been classified.

Methods

I used exoplanet data from the Kepler database. To classify exoplanets into the two categories, I needed to identify features in the data which could distinguish them. The main method of distinguishing between rocky and gas planets is to measure their densities. However, finding the density of a planet is difficult, as it requires finding the mass, which cannot be found from orbital equations. As a result, 900 exoplanets in the Kepler data have a measured density value, making their use in all 11,000 exoplanets infeasible. However, if I was to find rocky and gas planet clusters using density as a feature in the 900 planets, I could use them as a reference to evaluate clusters created by any feature for which data is available. Any feature that can distinguish between the two types of planets would have similar clusters to the density. I applied this to nine exoplanet features, and using the KMeans algorithm, I found that the most valid features were the planetary radius, stellar effective temperature, and orbital eccentricity.

Results

In order to determine the best feature, I applied the KMeans algorithm to the full Kepler data. I found that the frequencies of rocky planets and gas planets predicted by each feature were: 17% and 83%, 35% and 65%, and 38% and 62%, for the eccentricity, temperature, and radius, respectively. I then compared these to the frequencies observed by astronomers: 40% and 60%. Since the radius was closest to the actual frequency, I chose to use it to distinguish the exoplanets. I then tested the radius-based model on the 21 exoplanets that have thus far been confirmed to be rocky planets, and 29 exoplanets that have been confirmed to be gas planets. The model was able to accurately classify 100% of the rocky planets and 93% of the gas planets. This is a combined accuracy of 96% for the model s predictions, which thus validated the model. After completing my original plan, I found research which I am using to further validate my model.

Conclusions

The model met the engineering goals and could successfully distinguish rocky and gas planets. The radius is a strong feature for such a distinction, and it can be applied to exoplanetary data. I augmented the Kepler data with my model s predictions for each planet, which can be found at https://sites.google.com/view/exoplanetsorter-predictions.

Summary Statement

I designed a method of distinguishing rocky planets from gas giants by analyzing the Kepler exoplanet data.

Help Received

I researched and found the method myself, and my family and my mentor, Mr. Mostarshed, helped me review my results.

Name(s)

Alexander Kwon

Project Number

S1712

Project Title

Synthesis and Analysis of Strontium Titanate (STO): Can It Replace Silicon for Power Electronic Applications?

Abstract

Objectives

The objectives of this project were to grow the metal oxide strontium titanate (STO), analyze its structural and electrical properties at various temperatures, and compare those properties to silicon, the current leading semiconducting material. The main hypothesis is that as STO is cooled, its electron mobility and conductivity will be better than those of silicon.

Methods

Multiple STO samples were synthesized, each taking approximately 10 hours to grow. Each STO sample was grown using molecular beam epitaxy, a thin-film deposition technique in an ultra-high vacuum environment. Electron beam evaporation was then used to deposit electrically conducting contacts onto each STO sample. As for STO analysis, x-ray diffraction was used to measure sample thickness and lattice spacing, and atomic force microscopy was used to identify surface defects. PPMS DynaCool was used to cool down the STO samples from 300 K to 2 K, and dilution refrigeration was used to further cool down the STO samples from 1 K to 0.01 K. Resistance and electron mobility were measured through Hall measurements as dependent variables of temperature change.

Results

X-ray diffraction confirmed minimized lattice spacing, and atomic force microscopy confirmed smoothness of STO samples, thus optimizing the electron mobility of STO. All STO samples had electron mobilities that were less than silicon except at very low temperatures. STO was found to have superconducting properties between 0.01 K and 0.28 K.

Conclusions

Silicon possesses higher electron mobility than STO at room temperature. However, STO possesses potential benefits over silicon: wider band gap, lower lattice spacing, higher dielectric constant, and superconducting properties. Due to these benefits, STO shows promise in high voltage power electronic applications. Future work includes increasing the critical temperature of STO and continuing to optimize its properties.

Summary Statement

This project analyzes the structural and electrical properties of strontium titanate and compares them with known properties of silicon.

Help Received

I worked under the supervision of Kaveh Ahadi and Nick Combs (graduate students) at the Stemmer Research Group at the UCSB. The research reported here made use of shared facilities of the UCSB MRSEC (NSF DMR 1720256), a member of the Materials Research Facilities Network (www.mrfn.org).

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Patrick Rim

Project Number

S1713

Project Title

How Far to the Stars?

Abstract

Objectives

There are multiple techniques used to find the distance to stars using observational data. Which of the two commonly used methods- spectroscopic parallax and period-luminosity (P-L) relationship of a Cepheid variable star- is more accurate in calculating the distance to stars when using data obtained from the Earth s surface?

Methods

I used a Newtonian telescope with a 6 aperture and analyzed the pixels on the deep-sky images taken with a DSLR camera with a CMOS sensor using astronomical imaging software in order to calculate the apparent and absolute magnitudes of the stars. For distance measurements with the spectroscopic parallax method, I pointed my telescope towards four stars with established distances and took images of them with a camera capable of discerning the starlight received by each pixel on its CMOS sensor. I found the apparent magnitudes of the stars using data obtained from astronomical image analysis software and their absolute magnitudes using Wien s Law and main-sequence fitting. Then, using the distance modulus equation, I found the observed distance to the stars. For the distance measurements with the P-L relationship of a Cepheid variable star method, I observed the periods of four Type I Cepheid variable stars with established distances. Using the P-L relationship equation, I found the apparent magnitudes. I repeated the process of analyzing images of these stars in order to find their absolute magnitudes, as well as finding the distance to these variable stars using the distance modulus equation. I then compared the observed distances obtained from both methods to the established distances and found which method was more accurate in measuring distances to stars.

Results

The distances to the stars calculated using the spectroscopic parallax method were fairly accurate but the distances calculated with the P-L relationship was markedly more accurate when compared to the established distance values.

Conclusions

The P-L relationship of a Cepheid variable star method produced more accurate measurements of distance to stars than the spectroscopic parallax method when compared to established values and is, therefore, the more accurate method in determining distances to stars when using data obtained from the Earth s surface.

Summary Statement

By measuring the distances to stars using two different commonly-used methods, I discovered which method provides more accurate results.

Help Received

Name(s)

Nikita Salunke

Project Number

S1714

Project Title

Effect of Epitaxial Compression on Structural & Electrical Transport Properties of 3D Topological Dirac Semimetal Cd3As2

Abstract

Objectives

Three-dimensional topological Dirac semimetals (3D-TDSM) have been increasingly studied in the areas of materials science and condensed matter physics due to their unusual three-dimensional linear electronic band dispersion and non-trivial band topology. Devising a method to tune the band dispersion of 3D-TDSMs could revolutionize the field of electronics. This study aimed to determine if an epitaxial compression could alter the electronic transport properties of Cd3As2, a 3D-TDSM.

Methods

In the study, Cd3As2 thin films were grown on (In(x)Ga(1-x))Sb buffer layers deposited on a GaAs substrate. Specifically, since the Cd3As2 lattice parameter lies between that of GaSb and InSb, the concentration of indium and galium in the buffer layer were varied to induce an epitaxial compression in the Cd3As2 thin film during growth. The following four indium concentrations were each deposited onto its GaAs substrate: 0.76 In (lattice match), 0.74 In (0.195% lattice mismatch), 0.70 In (0.483% lattice mismatch), and 0.66 In (0.661% lattice mismatch).

X-ray diffraction readings were used to determine the lattice parameter of the films and assure the crystal/film quality. Additionally, atomic force microscopy served to confirm the surface morphology of the expitaxially compressed Cd3As2 thin films. Further, X-ray diffraction readings confirmed that Cd3As2 can be epitaxially strained up to a 0.661% lattice mismatch via a reciprocal lattice space map.

In order to study the low temperature electrical transport properties of the Cd3As2 thin film, physical property measurements were taken on the DynaCool machine. Specifically, Hall Bars were prepared on the thin films in the clean room and were then placed in the DynaCool to determine the sheet resistance, mobility, and sheet density of the epitaxially compressed thin films at variable temperatures.

Results

The study found that the heteroepitaxial films exhibited differing electrical transport with the lattice match thin film having the highest mobility. The change in mobility, sheet resistance, and sheet density of the heteroepitaxial films suggests that the band dispersion of Cd3As2 had changed.

Conclusions

Thus, the study confirmed that an epitaxial strain can be induced in Cd3As2 thin films and that this expitaxial strain may yield an altered band structure through growing the thin film on variable (In(x)Ga(1-x))Sb buffers. Collectively, this study demonstrated that epitaxial compression can be used successfully to alter the electronic transport properties of 3D-TDSM thin films.

Summary Statement

This study shows that an epitaxial compression can be used to alter the electronic transport properties of Cd3As2, a three-dimensional topological Dirac semimetal.

Help Received

This research is conducted at University of California, Santa Barbara Materials Research Lab under the guidance of Doctoral Student Manik Goyal.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Kayenne Scaletta

Project Number

S1715

Project Title

Designing the Perfect Coaster

Abstract

Objectives

The goal of this project was to determine how engineers design the "most perfect roller coaster"; that is, one that is safe, efficient, and thrilling, all while having minimal effects on the human body. Through a model coaster, I wanted to determine the physics-related concepts engineers consider upon designing such rides because not only do they need to operate successfully, they also need to be tolerable for the human being.

Methods

A model coaster was first constructed from KNEX coaster pieces, which includes tracks, chains, and small bars and clips to connect the pieces together. In addition, a KNEX motor was included, which includes 2 AA batteries that are secured within the motor. Upon conducting research, several modifications were made to the design of the roller coaster for the purpose of understanding how the physics-concepts worked.

Results

Upon designing the most perfect roller coaster, it is absolutely critical that engineers apply the overall concept of physics into the development of such a ride. It is necessary that they consider the heights of the slopes, the steepness of the hills, and the radius of the loops, because all of these factors can actually determine the acceleration of the coaster car, the G-forces along the track, and the minimum speed in which the coaster car must travel at, in order to successfully complete the course. For example, if my model coaster were built proportionally to a larger scale, a human being would most likely remain conscious during the descent of the first hill because the 2.40 g's experienced, does not exceed the maximum 3 g's the human body can typically handle at this given point.

Conclusions

Through this project I discovered that there are not only certain speeds, but also maximum forces that the human body can handle at different periods of time. Upon descending a steep hill, engineers design more of a curved path leading into the next section of the track, ensuring the safety of the riders. I also discovered that there is a certain number of amps the motor needs to have in order to operate successfully. Engineers have to consider factors as these because coaster cars do hold the life of anyone who steps inside. Coasters are not made for everyone, given that not everyone can tolerate and handle the adrenaline rush, the motion sickness, and the dizziness that they bring. Despite these effects on the human body, today roller coasters are not only more thrilling than ever before, they are much more safer, given the safety mechanisms, the restraints, and the simulation software that is utilized. Roller coasters are designed to meet the demands of the people s interests, all while taking into account safety precautions and what the human body can handle.

Summary Statement

I designed a model coaster for the purpose of determining how engineers incorporate physics-related concepts into the design of a coaster, ensuring that it's safe, thrilling, and most importantly, one that has minimal effects on the body.

Help Received

I received no outside help, other than lectures from my physics teacher during class periods. I did conduct research on the internet, but no mentors, professional scientists, or engineers were contacted. The entire coaster was built myself, and the calculations were that of my own as well.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Jimmy Shi

Project Number

S1716

Project Title

Magnetic Damping Study by Broadband Ferromagnetic Resonance

Abstract

Objectives

(a) Broadband (1 GHz to 15 GHz) microwaves are applied to magnetic samples and magnetic resonance occurs when the resonance condition is met; (b) High accuracy is achieved when the magnetic field is modulated and the corresponding response is detected; (c) Yttrium iron garnet (YIG) thin film sample is chosen because of its narrow resonance linewidth; (d) From the resonance peak width at different frequencies, the Gilbert damping parameter is determined; (e) A 5 nanometer thick (BiSb)2Te3 (BST) overlayer is deposited on YIG thin film and the Gilbert damping parameter is determined again and compared.

Methods

(a) Broadband (1 GHz to 15 GHz) microwaves are applied to magnetic samples and magnetic resonance occurs when the resonance condition is met; (b) High accuracy is achieved when the magnetic field is modulated and the corresponding response is detected; (c) Yttrium iron garnet (YIG) thin film sample is chosen because of its narrow resonance linewidth; (d) From the resonance peak width at different frequencies, the Gilbert damping parameter is determined; (e) A 5 nanometer thick (BiSb)2Te3 (BST) overlayer is deposited on YIG thin film and the Gilbert damping parameter is determined again and compared.

Results

At each microwave frequency, the magnetic resonance absorption can be fitted very well by a Lorentzian function. Extracted full-width at half maximum at different microwave frequencies is used to calculate the Gilbert damping parameter of the magnetic material. The 5 nanometer thick BST overlayer is found to have a significant effect on magnetic damping of YIG thin film. The Gilbert damping parameter is found to increase by a factor of four with the addition of the BST overlayer.

Conclusions

The experimental results indicate that strong atomic scale interaction between BST and YIG at the interface plays an important role in enhancing magnetic damping. The results also raise questions for future studies including whether the atomic arrangement in BST is important, how the relative concentration of Bi and Sb atoms in BST affect the results.

Summary Statement

This project is a study of magnetic damping of a magnetic sample influenced by a thin overlayer as a result of strong atomic level interaction.

Help Received

Mother helped me make the poster; father had discussions with me about data fitting. This project used lab equipment at University of California, Riverside under the supervision of Dr. Barsukov and with the help of the students of Dr. Barsukov.

Name(s)

Vivek Vijayakumar

Project Number

S1717

Project Title

Analysis of Molecular Spectra in Asymptotic Giant Branch Carbon Stars

Abstract

Objectives

The objective of this project is to study the spectral abundances of CN, C2, and C3 in the spectrum of two relatively low temperature classes of carbon stars, C5 and C6 N-type carbon stars, in order to see how temperature and age affect nucleosynthesis and dredge-up in these stars.

Methods

A R~17000 Littrow spectrograph, 115mm apochromatic refractor, and cooled monochrome camera on a German equatorial mount (GEM) were used to image spectra for 21 carbon stars, between 6460 to 6630 angstroms. The spectra were stacked, processed, calibrated, and analyzed in IRIS, a self-made PixInsight script, and RSpec.

Results

The measurements showed that C6 N-type stars had higher spectral abundances overall over C5 N-type stars, with every single compound tested demonstrating a higher mean abundance by approximately 2.5 standard deviations, after band correction.

Conclusions

The measurements provide evidence that C6 N-type stars have higher average spectral abundances. This demonstrates that their characteristically lower temperatures facilitate the creation of these compounds. The spectra also lack the H-alpha spectral line, a normal absorption line in most stars that indicates the presence of hydrogen, showing these stars to be all hydrogen-deficient. CN is of especially higher concentration than most carbon stars in both types, demonstrating the dredge-up of nitrogen characteristic of C5-6 N-type stars.

Summary Statement

I measured the spectral abundances of three carbon compounds to determine how temperature and age affects the abundance of carbon in a specific type of carbon stars.

Help Received

I conducted the observations myself, using my equipment. I asked Francois Cochard of Shelyak Instruments for advice on troubleshooting the spectrograph, and had Kin Searcy of the San Diego Astronomy Association review some of the material.

Name(s)

Andrew Wang

Project Number

S1718

Project Title

Dusty Spacesuit Charging and Arcing: Implications for Human Exploration of the Lunar Terminator and Far-Side

Abstract

Objectives

The Moon is devoid of a global magnetic field and atmosphere and is thus directly exposed to space plasma and solar radiation. Due to the emission of photoelectrons and collection of ions and electrons from the plasma, the lunar surface and any objects on it become electrically charged. Charging combined with the lunar dust environment raises concerns of electrostatic discharge hazards that would imperil astronauts on future lunar exploration missions.

Methods

In order to investigate charging and discharge behaviors and interactions with the dusty plasma environment, experiments were conducted in a vacuum chamber at USC to simulate lunar surface conditions. A plasma with properties similar to the average solar wind conditions was generated by an electron bombardment gridded ion thruster. The first experiment tested the effects of lunar regolith dust on spacesuit material GoreTex and the second experiment quantified charging dangers on a simulated astronaut arm.

Results

The results show that while a clean spacesuit would not typically experience electrostatic discharge in plasma, the combination of lunar dust deposition and high voltage charging significantly increases discharge and arcing occurrences, which could lead to spacesuit breakdown, equipment failure, and endangerment of astronauts lives.

Conclusions

Experimentation and analysis suggest that charging will pose a severe risk to astronauts at the lunar terminator or lunar far-side. This experimentation provides further insight into not only lunar exploration hazards but also other extraterrestrial operations. Under certain conditions, satellite repair to future asteroid mining could also be hindered by the dynamic space plasma charging environment.

Summary Statement

Through laboratory experimentation and further analysis of data, I showed that the dusty plasma charging environment on the lunar surface would be dangerous towards astronauts during future lunar exploration missions.

Help Received

Experimentation was independently conducted using vacuum chamber facilities located at the University of Southern California's Department of Astronautical Engineering.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2019 PROJECT SUMMARY

Name(s)

Ian Weiss

Project Number

S1719

Project Title

Our Roads: A Large Thermoelectric Generator

Abstract

Objectives

A road setup produces a temperature gradient and creates an electrical charge through the Seebeck Effect and with that creating energy.

Methods

A thermoelectric power generation system, which I build through a pavement setup with coper pipes and a pumping system that then takes in heat from a source(the pavement) and outputs electricity (the warmed water pumping into a bowl) . It does this by using a thermoelectric module or plate, which needs a temperature difference from one side to the other to generate electricity

Results

The average temperatures over this testing period ran in the high 70 s and the energy production maintained steady in the 4-volt range, peaking at 4.3 volts when the high for the day reached 75 degrees Fahrenheit. My setup was able to harvest a consistent charge of 5 volts when temperatures reached above 80 degrees Fahrenheit, which is enough energy to charge an iPhone or power the average LED light requiring approximately 1.5 volts of energy. All in all my experiment was a success because I found a way to turn wasted heat energy into electrical energy, which can help protect our environment as our population grows.

Conclusions

Converting my system to a larger model, like a neighborhood street, would produce higher output. For example the street we live on measures 800 feet long by 35 feet wide., That gives us a square footage of 28,000 square feet. At the rate of 5 volts per minute for a 2 square foot area this would mean my street would be able to produce 70,000 volts per minute. Now imagine what an entire city could produce all while using clean solar energy and protecting our environment

Summary Statement

I created a thermoelectric generator that produced energy.

Help Received

None. I designed, build and ran this experiment at home.