CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Vikram A. Balaji

Project Number
S1801

Project Title
Resonance in Different Materials

Abstract

Objectives/Goals
To determine whether density has an affect on the resonant properties of a soundboard.

Methods/Materials
I obtained three different pieces of wood for use as a soundboard. I determined the density of all three pieces. A piece of wood was placed flat on two pieces of foam, and was kept in a silent room. A digital sound level meter was placed one-foot away from the sound board. The digital sound level meter was placed perpendicular to the grain of the wood. The amount of sound produced was measured in decibels, and there were seven trials conducted.

Results
The data showed that the sound board with the lowest density had produced the most amount of sound. It also showed that the other two pieces of wood, with varying densities as well, had produced similar amounts of sound.

Conclusions/Discussion
The data proves that there is a correlation between density and resonance, but it also shows a discrepancy. The similar sound produced by the two woods shows that there are other factors affecting the properties of a soundboard. The molecular structure of the wood and layering of cells might be a reason for similar sound. The amount of water in the wood might be another reason for the result.

Summary Statement
This experiment tested whether there was an affect on resonance for different densities of soundboards.

Help Received
Mother helped me assemble poster board, and conduct initial research.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Namrata R. Balasingam

Project Number

S1802

Project Title

A Kinetic Monte Carlo Study of the Scalability and Variability of the Forming Voltage of Transition Metal Oxide ReRAMs

Abstract

Objectives/Goals

Resistive random access memories (ReRAMs) are currently under intense investigation because they are promising alternatives to flash-based non-volatile memories, which are not expected to scale to dimensions below about 20nm. "Forming" is a relatively high-voltage process that is used just after manufacturing to functionalize the ReRAM device, by creating a conductive filament whose resistance is then modulated to encode "0" or "1" memory states. Since forming is a one-time process and since the underlying physics is stochastic in nature, statistically meaningful experimental characterizations of the forming voltage (V_f) are difficult to perform. I have addressed this problem using a novel simulator that I developed. Even though forming is a one-time process, it is important to characterize it because it determines the overall scalability of this emerging technology.

Methods/Materials

My simulator captures one of the unique aspects of ReRAMs: mixed ionic and electronic transport. I treat the electronic effects--both current flow and temperature rise due to Joule heating--using equivalent resistor networks, and oxygen vacancy generation and ion migration using kMC. The distribution of vacancies determines the linear/nonlinear elements of the resistor network, and the heat generated by electron flow in this network in turn determines the vacancy/ion generation rates that drive kMC. The strong coupling between electronic, thermal and ionic effects allows my simulator to closely reproduce the experimentally observed rapid increases in current at the V_f threshold.

Results

I characterized the forming voltage and its statistical variability as device dimensions and forming conditions were varied: (1) V_f vs thickness, (2) V_f vs. width, (3) V_f vs. maximum allowed current at forming, (4) V_f vs. temperature and (5) V_f vs. voltage ramp rate.

Conclusions/Discussion

I found that the critical voltage at which the filament forms depends linearly on thickness and roughly logarithmically on width. I motivate the thickness dependence using an effective field argument, and then offer a plausible statistical argument to explain the width dependence. I also found that forming at an elevated temperature can both reduce the average V_f, as well as the variability in V_f.

Summary Statement

I developed a novel kinetic Monte Carlo (kMC) simulator that possesses physics-based realism as well as speed, and used it to investigate the forming process in ReRAMs, and project V_f trends in deeply scaled (~10nm) memory cells.

Help Received

I would like to thank my advisors Dr. Dipu Pramanik, Mr. William Abb and Mr. Ronald Nicoletti for their valuable guidance throughout the course of my work.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Vikas C. Bhetanabhotla

Project Number

S1803

Project Title

Identification of Satellite Galaxies around Milky Way Galactic Analogs Using Machine Learning Algorithms

Abstract

Objectives/Goals

The Milky Way (MW) is host to a population of two dozen satellite galaxies. However, observed properties of these MW satellites differ significantly from those predicted by the Lambda Cold Dark Matter Theory (LCDM), constituting the discrepancy at the center of the Dwarf Galaxy Problem. To investigate this discrepancy, we extend our cosmological context and study satellite populations of MW analog host galaxies within redshift < 0.01, selected to resemble the MW in luminosity and environment. Studying such analogous satellite populations and their properties will yield insight into their correlation with the LCDM model, which can be used to determine where and why the MW satellites break off with the LCDM model. A significant obstacle is the detection of these MW analog satellite galaxies against a large background of faint galaxies and stars: spectroscopic follow-up is expensive, and so accurate classification of satellite candidates based on photometric and morphological data is important.

Methods/Materials

We compile a machine learning training set containing photometric and morphological data for the MW analog satellite populations, and train a Neural Network (NN) and Support Vector Machine (SVM) classifier on a pre-processed version of the data set. We measure effectiveness of the algorithms in terms of purity and completeness of classification.

Results

Through a series of experiments with the classifiers, we find the SVM to achieve 93% completeness and the NN to achieve 97% completeness for a fixed 10% purity. We also find the photometric data to be the most informative in classification.

Conclusions/Discussion

We thus present a more accurate method of identifying MW analog satellite galaxies among a large sample of background galaxies, a major stepping-stone in solving the Dwarf Galaxy Problem.

Summary Statement

My research presents a new method to identify pure samples of Milky Way analog satellite populations with accuracy in identification of 97%; this method can be used to solve the Dwarf Galaxy Problem.

Help Received

This research was conducted at the Stanford University astrophysics department, where I worked under the guidance of a professor and two postdoctoral fellows. I received guidance from my professor throughout the project and help from the postdoctoral fellows in learning necessary techniques.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Nithin Buduma

Project Number

S1804

Project Title

Evaluation of Anisotropic Kondo Systems CeNiSn and FeSi as Topological Insulators Reveals Anomalous Transport Behavior

Abstract

Objectives/Goals

A topological insulator is a material that acts as an insulator in bulk but contains metallic surface states. Topological insulators comprise one of the most novel fields in material science, offering drastic improvements in data storage. However, there currently exists no method to narrow down the search for these valuable materials. In 2010, Dzero et al. hypothesized that certain Kondo systems may display behavior characteristic of topological insulators. However, the only known Kondo topological insulator to date is SmB6. In order to further investigate the potential of Kondo systems to be topological insulators, my study aimed to test CeNiSn and FeSi.

Methods/Materials

Before testing for topological insulating behavior, a plain resistivity test was done on CeNiSn to test the purity and integrity of the sample in use. Current flows directly through the voltage contacts in the plain resistivity test. Afterwards, wedge tests were performed on CeNiSn and FeSi to look for topological insulating behavior. Unlike the plain electrical resistivity test, the current flows perpendicular to the voltage contacts. All measurements were done in a PPMS between 2K and 300K. I studied results of the wedge test to look for coalescence of the three resistivity curves at low temperatures. This would indicate the existence of a maximum resistivity, or metallic surface states.

Results

The graph of plain resistivity for CeNiSn showed behavior characteristic of a semiconductor with no suppressed minimum, which may indicate extremely slight impurities. Although the materials did not express the predicted topological behavior at low temperatures, the electrical resistivities turned out to be negative and almost zero at relatively high temperatures for both the materials.

Conclusions/Discussion

These anomalous transport phenomena may have been due to the anisotropic behavior of these substances, and more research must be done to determine the effects of random crystal orientation on electrical resistivity. Also, the directionality of current flow may have affected the results of the wedge test when compared to the results of the plain electrical resistivity test. The results presented have a number of applications, such as high-power electromagnets in use for MRI/NMR, and cryoelectronics currently being developed. This anomalous transport behavior is invaluable information and is something that must be further investigated.

Summary Statement

Determining the effectiveness of two anisotropic kondo systems, CeNiSn and FeSi, as topological insulators.

Help Received

Used lab equipment at UCSC offsite lab under supervision of Dr. Ramirez and graduate student Ms. Jennifer Trinh

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Cameron Chaffey

Project Number
S1805

Project Title
Alien Atmospheres: Searching for Exoplanet Bow Shocks

Abstract

Objectives/Goals
The goal purpose of this project is to detect the predicted bow shock of extrasolar planet Hat-P-20b by looking at the way its magnetic field reacts with different wavelengths of light.

Methods/Materials
By measuring the light intensity of the transit of this planet in front of its host star with two different light filters and plotting the data, the resulting light curves can be compared to find signs of a bow shock. A planetary bow shock would interact with light in the near ultraviolet wavelengths, and cause either an early ingress or late egress in that wavelength compared to the near infrared wavelengths.

Results
Performing this process on Hat-P-20b produces two light curves that show signs of a bow shock and a substantially late egress.

Conclusions/Discussion
A review of these light curves show that abnormalities in the data make it difficult to conclude that there is a detected bow shock around HAT-P-20b. More measurements are needed to confirm this detection.

Summary Statement
The goal purpose of this project is to detect the predicted bow shock of extrasolar planet Hat-P-20b by looking at the way its magnetic field reacts with different wavelengths of light.

Help Received
Used data from Faulkes Telescope North under supervision of Dr. James Armstrong.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Jennifer J. Choi

Project Number

S1806

Project Title

How Do You Frustrate Total Internal Reflection? The Mysterious Evanescent Wave

Abstract

Objectives/Goals

Frustrated total internal reflection (FTIR) is a concept used very often in modern day to create touch screen technology. The goal of this study was to examine the effect of the distance from the interface and the different wavelengths of the source light on the decay of evanescent waves and FTIR.

Methods/Materials

Two wavelengths, red laser light (635 nm) and microwaves (2.85 cm), were tested. The red laser#s critical angle for total internal reflection in a glass prism was found, and the intensity of the evanescent wave at increasing distances from the interface was directly measured with a photometer at a different incident angle. Prisms filled with styrene pellets were used to test the decay of the evanescent wave through FTIR for microwaves. After measuring the critical angle of one prism with the microwave emitter and receiver, a second prism was added and the voltage of the refracted wave in FTIR was measured with a multimeter at two different incident angles.

Results

All the data of the relative intensity as a function of distance were fitted with an exponential decay function; the graph for the red laser required two exponential functions, while both graphs for the microwaves only required one function. Decay length of the evanescent wave was obtained through this fit. For both wavelengths, the evanescent wave decayed exponentially with distance. The red laser decayed much faster than the microwaves for both angles. Between two incident angles in the microwave, the intensity for the greater incident angle decreased faster.

Conclusions/Discussion

Decay lengths obtained from the fit of experimental data were compared to the values calculated by a theoretical equation. The experimental and theoretical values for microwave fit fairly well, while the values for the red laser did not. This is because the red laser has a shorter wavelength and decays very quickly, and to get more accurate measurement, the distance should be varied in the nanometer length scale. This experiment showed that the decay of the evanescent wave directly corresponds to the wavelength of the light source. As for multi-touch screen technology, the sensitivity of touching and the allowed distance for touching depend on the wavelength of the light source. FTIR by a red laser requires a firm press for the touch screen and FTIR by microwave can be sensed even when the direct touch is not made.

Summary Statement

This experiment investigates FTIR and the evanescent wave and determines that the decay length directly corresponds to the wavelength of the light source, while further noting the relationship between FTIR and multi-touch screen technology.

Help Received

Parents helped with poster; Borrowed microwave emitter and receiver from Dr. Leung at CSULB; Dr. Li provided helpful comments and discussions.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Ezra B. Creighton

Project Number

S1807

Project Title

Engineering an HHO System to Safely Run a Four Stroke Engine with Water (HHO), Part 3

Abstract

Objectives/Goals

The world needs a clean, renewable source of energy that will fuel our existing four stroke engines. Ive proved before that HHO can safely run an engine without gasoline. Producing HHO requires electricity and space, not practical for use in a vehicle. The answer is a portable storage tank of HHO. I manufactured the HHO by using electrolysis to split the water molecules (H2O) into hydrogen and oxygen(HHO). The project is separated into four units: the production unit (where the HHO is produced), the compressor unit (where the HHO is compressed), the storage unit (the tank that stores the compressed HHO), and the engine unit (safeties that the HHO must pass through going to the engine). A lawn mower engine was used for testing.

Methods/Materials

Prototypes of each unit were modified, until they met the design criteria. The storage unit was connected to the compressor unit and filled with 30 psi of HHO from the production unit. The storage unit was then placed into a 3x3x3ft hole in the ground with a metal box positioned over it (this was in case the tank ruptured). Then, I sent a spark to the tank with an igniter so it would explode. This test ensures the tank would be safe should a flame reach it. After successfully completing that test, the storage unit was filled to same amount of HHO and connected to the engine unit. I then release the HHO into the engine while pull-starting it, and record run time.

Results

The first prototypes of the production unit were remodeled until prototype #4 could operate properly and rapidly. A few prototypes of the compressor unit were developed and prototype #3 functioned properly. The storage unit was filled with HHO and tested to see if the safety would work. Prototype #1 of the storage unit did not work properly and failed, so prototype #2 was made to work properly at 30 psi. The storage unit was filled again to test if it could run the engine. The engine unit had several problems initially and prototype #4 of the engine unit operated correctly as the engine was able to run successfully.

Conclusions/Discussion

My tests prove an HHO system can be engineered to run an engine safely! Therefore HHO could be used to replace gasoline. HHO can be produced for free if solar panels are used. When HHO is combusted in the engine, it turns back into water. If HHO was used to replace gasoline we would save money, fuel, and reduce emissions, therefore saving the environment.

Summary Statement

This project proves a homemade HHO system can be engineered to run an engine safely with water (HHO).

Help Received

My brother-in-law worked with me on my project. My sister helped me proofread my work. My Dad helped me get the pieces and let me use his engine and tools.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Shaiann M. Edmondson

Project Number
S1808

Project Title
Will the Gas Pass?

Abstract

Objectives/Goals
Determine how well MCU-2P and M-50 Gas Mask filters protect our troops in normal, wet, and alcohol-drenched environment.

Methods/Materials
MCU-2P and M-50 mask filters were tested using a Joint Service Mask Leak Testing (JSMLT) machine. Each filter was tested many times under normal, wet, and alcohol-drenched conditions.

Results
The M-50 mask filter proved more effective than the MCU-2P mask filters in all tested environments. Within the 3 given conditions, the normal (unaltered) filter performed best, allowing the least amount of particulate into the mask wearer. The wet filters (soaked in water) allowed more particulates than the normal, and the alcohol-drenched filter provided the least amount of protection for the mask wearer.

Conclusions/Discussion
The M-50 mask filters proved superior in all conditions to the MCU-2P mask filters.

Summary Statement
Show how well Gas Mask filters protect our troops in different environments.

Help Received
Used Air Force testing equipment under supervision of MSgt Earl Edmondson

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Kishan M. Ghadiya

Project Number
S1809

Project Title
Does Jupiter Harm or Protect the Earth?

Abstract

Objectives/Goals
Objective: to use Jupiter and asteroids data in relation to asteroids to find theoretical occurrences of asteroids in the solar system assuming Jupiter did not exist, therefore eliminating Kirkwood Gaps in the Semi-Major-Axis Distribution Histograms. I am to perform statistical inference tests to find the probability that asteroids occurred by chance alone, removing or including any influence of Jupiter on asteroids in my conclusion.
Hypothesis: NEO object asteroid occurrences would happen randomly, therefore eliminated Jupiter as a reason for asteroid occurrence

Methods/Materials
Materials: Computer, Graphing Calculator, Spreadsheet Program (Excel), and Internet Access.
Procedure: From many database websites, I first downloaded and cross-referenced many population distributions of all recorded asteroids in the solar system to create a final population distribution of over 620,000 asteroids and then plotted the population distribution on a histogram. I took the distribution and eliminated values of the 4 Kirkwood gaps and replaced them with theoretical values calculated from 5 linear regression lines of the highest R-squared value. I took a sample of 865 asteroids from the population distribution and set them aside as a separate distribution.I performed a statistical significance test of the sample to infer conclusions of the population distribution. My results will consist of two probabilities that represent the probability asteroids occurrence happened by chance.

Results
The probability of the first significance test of the original population distribution was 1.345x10^-85. The probability of the second significance test of the theoretical population distributions was 1.71x10^-90.
Confidence Intervals: I am 99.99% confident that the true mean value of asteroids Semi Major Axes will lie in between 1.4 AU and 1.9 AU.

Conclusions/Discussion
Because both probabilities are considerably small, and therefore relatively equal, it is safe to say my hypothesis was INCORRECT. My hypothesis stated, essentially, Jupiter played the only role in the occurrence of asteroids in Earth's space and removing Jupiter's influence (Kirkwood Gaps) would show that if any asteroid were to appear, then it would do so solely by random chance. However, both probabilities are the same and therefore show that another force besides Jupiter's is acting upon asteroids in the solar system.

Summary Statement
Alleging Jupiter did not exist, my project, by performing statistical inferences tests with NEO data to calculate probabilities of asteroid occurrence by chance alone, proves whether Jupiter's gravitational force indirectly harms Earth.

Help Received
Father helped with the display of project board and spreadsheet programming formulas.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Gwendolyn R. Gilbert-Snyder

Project Number

S1810

Project Title

Discovering the Magnus Effect by Rolling Spheres through Resistant Fluids

Abstract

Objectives/Goals

My project was to determine the effects of resistance on the trajectories of marbles and the difference between the ideal motion and motion with resistance.

Methods/Materials

I constructed a ramp that could be adjusted to different angles and that ended at the edge of a large tub. A marble was rolled down the ramp multiple times at each angle (15, 30, 45 degrees) and I used a camera with the lens open for several seconds to get a picture of the trajectory. I also took pictures while the marble's trajectory was being illuminated with a strobe light, so that the picture would show individual points in the marble's path that could be translated into data points. The experiment was repeated with the tub filled with water to increase the resistance.

Results

The results for the experiment taking place in air were as expected--the trajectory had the same general shape of a parabola (but compressed compared to the ideal parabolic trajectory) for all three angles, but the compression was greater for the smaller angles. The results for the experiment taking place in water, on the other hand, were shocking. The trajectories curved backwards so far that the marbles, initially moving to the right, hit the bottom of the tub (30 cm below their entrance into the water) to the left of their entrance point. The trajectories underwater were nearly uniform for all angles.

Conclusions/Discussion

The effect of resistance in air was simply the slight compression of the parabolic trajectory, resulting in the marble not traveling as far as it would ideally. In water, the extreme curvature was due to the Magnus Effect, a result of the marbles' spin causing different relative velocities on each side. This difference in velocities caused high and low pressure regions on either side that simultaneously pushed and pulled the marbles in a direction perpendicular to their direction of motion, resulting in a differently curved path through the water.

Summary Statement

The focus of my project was observing the effects of resistance on motion.

Help Received

Father helped construct apparatus and take pictures.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Michelle Guo; Andrew Zhang

Project Number

S1811

Project Title

Stellar Isotopic Abundances in the Milky Way: Insights into the Origin of Carbon and Neutron-Capture Elements

Abstract

Objectives/Goals

Elements heavier than iron are formed via two neutron capture processes: the rapid r-process that occurs in supernovae and the slower s-process that occurs in less massive stars. Isotope ratios in stars can reveal which process is a greater contributor to heavy metals in stars, since each of the processes creates each element at a unique isotopic ratio. The ratios produced by each process have been predicted by two competing models, the stellar and classical models. We evaluated the validity of these models by studying high-resolution spectra of twelve Milky Way stars, which were analyzed for the first time in this study.

Methods/Materials

To determine r- and s-process contribution, we measured carbon and europium isotope ratios in the stars by fitting observed spectra with synthetic model spectra. Generation of the synthetic spectra involved measuring the Doppler shift, resolution, and carbon and europium abundances. This study also presents a method to calculate the europium isotope ratio by modeling the shapes of absorption lines.

Results

Our results show that the ratio of 12C to 13C increases proportionally with [Fe/H]. The new results agree with the conclusions of Lucatello et al. (2006) and Frebel (2008), and show significant improvement in the reduced scattering of data points.

Conclusions/Discussion

Analysis of the obtained isotope ratios suggests that the carbon in most stars of the sample originated in supernovae. The range of europium isotopic ratios disputes previous theoretical predictions about the stellar and classical models of heavy element nucleosynthesis, and the work presents new insight into the origins of life in the universe.

Summary Statement

This work measured isotopic abundances using hyperfine model fitting, providing insight into star progenitor histories and relative contributions of different element creation sites in the Milky Way.

Help Received

Participant in SIP (Science Intermship Program) at UCSC under the supervision of Dr.Kirby and Prof. Guhathakurta

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Rui Ji

Project Number
S1812

Project Title
Projectile Motion

Abstract

Objectives/Goals
To determine the optimum degree to the maximum range.

Methods/Materials
CPO marble launcher
Photogate
Timer
Scissor lift
Marble
Graph paper
Carbon paper

Results
The optimum degree is 38º.

Conclusions/Discussion
The optimum degree is 38º.

Summary Statement
To determine the optimum degree to the maximum range.

Help Received
None.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Amely Joly

Project Number
S1813

Project Title
Allô? Is Anyone on the String?

Abstract

Objectives/Goals
I wanted to test my following hypothesis: Sound does travel fast through air, but it can travel as fast through the string. The length will not change the velocity, but the tension will. The larger the tension, the faster the sound will travel through the string.

Methods/Materials
In this project, I used a laptop with the LoggerPro software (v.3.8.5.1), four supports, two plastic cups, two microphones (Vernier), a nylon string, an analog function generator (ranging from 0.5Hz to 5MHz), a loudspeaker (Eisco), a pulley, a set of weights, a Vernier LabPro, electrical wires, plastic musical tubes, a Dual-Range Force Sensor (Vernier), and a small platform.

For my experiment, I found the frequency at which each tube, which corresponded to a musical note, resonated the most. I set up the same experiment for a string telephone. I varied the tension and measured the resonance frequency and the wave velocity on the string. Then, I varied the length, and measured the resonance frequency and the wave velocity on the string. I finally proceeded to plot my data into graphs on Excel and analyze them.

Results
By varying the tension, I found that the velocity augmented as the tension augmented. At about 7.5N, the velocity is 314m/s, which is 26m/s away from the velocity of the sound. In addition, when varying the length at a constant tension, I always obtained the same velocity. So, the tension applied did vary the velocity, but the length of the nylon string did not.

Conclusions/Discussion
In conclusion, my hypothesis is correct. From this, I gathered that sound can travel as fast through the string as through the air.

Summary Statement
Can the speed of sound through the string come close to the speed of sound through air?

Help Received

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Hayato S. Kato

Project Number

S1814

Project Title

Control of a Free Swinging Pendulum by the Force Created by Rotor Inertia

Abstract

Objectives/Goals

My project's objective was to figure out how inertia can be controlled, how it can be eventually used as a mechanism for balancing robots. This project looked for how much inertia can have an effect upon an object, the free swinging pendulum, and get the equation for it. It also looked for the most efficient method to maximize the amount of inertia created.

Methods/Materials

In order to demonstrate the power of inertia, the swinging time of the pendulum were used to compare the different variables. A disk was attached to the end of the pendulum, which was spun by a motor in order to create inertia. Experiments were done by using an IMU sensor to measure the angle. The control of the motors and the decision-making were done by a micro controller called Arduino. By comparing the stopping time of each different variable/algorithm, the most efficient method was found.

Results

It was discovered that the pendulum stopped faster when the motor was spun at the top. It was also found that the relationship between the amount of inertia created by the motor to "cancel" a force and the velocity of the swinging pendulum is linear. From these results, the pendulum's swinging time was reduced to about 1/5 of the free-falling time.

Conclusions/Discussion

My conclusion is that more inertia could be created by spinning the motor when the pendulum is beginning to fall. It was hypothesized that this is probably due to the slow reaction speeds of the current motor, which takes time until the motor reaches that speed. If inertia is created more when there is a greater change in motion, it means more inertia can be created when the motor spins longer: in this case, to be spinning from the beginning. From these collected results, I was able to write the stopping algorithm for the pendulum, ending up shortening the time up to about 1/5 of the free-swinging pendulum's stopping time. This clearly shows the powers of inertia; how much it can affect an object and how it can be freely controlled by the movement of a single motor.

Summary Statement

This project's objective was to figure out how the force of inertia is most efficiently created; how it can be controlled to eventually be used in balancing robots.

Help Received

Father helped weld the attachment part of the pendulum and the motor, along as teaching me programming; Mother helped print binder

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Minkyung Kim

Project Number
S1815

Project Title
Speed of Waves on Strings

Abstract

Objectives/Goals
The objectives of this experiment is to calculate the velocity of a standing sinusoidal wave and to investigate the relationship between number of nodes and wavelength.

Methods/Materials
Different kinds of strings and different masses (tensions), generator, pulley, and vibrator are used in this experiment.

Results
Results include the datas of theoretical and empirical velocities, wavelength, frequency, tension, number of nodes, and mu of the waves on the strings.

Conclusions/Discussion
Conclusions conclude that there is discrepancy between the theoretical and empirical velocity, and will explain the reason.

Summary Statement
My project is about the Speed of Waves on Strings.

Help Received
worked in Ribet Academy's physics and chemistry laboratory.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Madeline M. Liao

Project Number
S1816

Project Title
Magnetic Fields on Mars and Beyond

Abstract

Objectives/Goals
My objective was to determine how the distance between magnetic poles and the number of them affect the magnetic field strength on a sphere.

Methods/Materials
Disk magnets representing magnetic poles were taped to the underside of a half of an eight-inch plastic sphere. One, two, three, and four magnets were used. The distance between the magnets started at 0 degrees and increased by 10 degrees for each setting. 20 grams of iron filings were poured from five centimeters above the center of the hemisphere. The hemisphere was turned upside down to allow excess filings to fall off. The mass of the filings remaining on the sphere was measured and showed the strength of the magnetic field.

Results
When graphed, my data points formed graphs that seem hyperbolic. As the distance between poles increased, the mass of the iron filings retained decreased, except for from 10° apart to 20° apart for trials with two magnets and four magnets, where the masses increased. The graphs of the two and four magnets decreased steadily and began approaching zero around 70°, while the graph of the three magnets approached zero much later around 110°.
As the number of magnets increased, the mass of the iron filings retained increased generally. Three magnets started out holding a lower mass of filings than the four magnets, but as the distance increased, it started holding more filings than four magnets.
Therefore, a more powerful magnetic field would be created with a greater number of magnetic poles placed closer together.

Conclusions/Discussion
Overall, my hypothesis was supported. The mass of iron filings retained decreased as the distance between the poles increased, and as the number of poles increased, the mass of the iron filings retained increased, generally speaking.
These results show that a more powerful magnetic field is created when the number of poles increases, and the distance between them decreases. If we were trying to make a planet with a weak magnetic field more habitable for humans, we would need to create an artificial magnetic field; the more poles we use and the closer they are together, the more powerful the magnetic field will be.

Summary Statement
How the number of magnetic poles and the distance between them affect the magnetic field strength on a planet.

Help Received
Kendia Herrington (MAVEN Educator Ambassador), and Diana Herrington provided equipment.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Michael M. Lu

Project Number
S1817

Project Title
Is There an Absolute Hot?

Abstract

Objectives/Goals
The objective is to determine whether or not the actual absolute hot temperature, if it exists, is confirmed by experimental data to occur at the theoretical absolute hot temperature (Planck Temperature, approximately 1.417*10^32 K).

Methods/Materials
Experimental temperatures found on the Internet were recorded on a spreadsheet. Then, using the equation (1/2)mv^2 = (3/2)kT, which was modified for relativistic velocities, I calculated the particle velocities at these temperatures. Finally, after verifying my calculations, I plotted my data and attempted to use appropriate curves to fit my data. From these curve fits, I approximated where an absolute hot temperature would occur according to experimental data (i.e. where the particle velocity approached nearly the speed of light).

Results
From power and logarithmic regressions as well as an average of these two regressions, I discovered that experimental temperature data revealed an absolute hot temperature that would occur several magnitudes of order below Planck Temperature.

Conclusions/Discussion
Planck Temperature may be too many orders of magnitude away from current experimental temperatures to be the actual absolute hot. From my experimental calculations and curve fits, I have found that there may be a clear relationship between my experimental temperature data and the speed of light as a limit to velocity. It seems that absolute hot temperature, if it exists, may occur at a temperature much lower than Planck Temperature.

Summary Statement
My project attempts to show that the actual absolute hot temperature, as determined by experimental data, may occur several orders of magnitude below Planck Temperature, the theoretical absolute hot.

Help Received
Mother helped me work with Microsoft Excel and prepare display board; Advisor helped with ideas and tips to continue my experiment and research

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Nayeli Martinez

Project Number
S1818

Project Title
Exposed: A Study of the Effectiveness of Waterproof Sunscreen

Abstract

Objectives/Goals
The objective of my project was to determine the effectiveness of waterproof sunscreen.

Methods/Materials
My materials included sunscreens (Banana Boat SPF 100, Block Up! 70, Sensitive Skin SPF 50), 2 ring stands with thermometer clamp, saran wrap, Vernier LabQuest2, two UVB probes. outdoor access, water, electronic balance, Tupperware, and two stirring rods.
My method was to place one sample of sunscreen underwater for 15 or 25 minutes while a different sample of the same sunscreen was not in water for that same time. After the time was up I'd place the sunscreen on the ring stand and measure the UVB penetrating through the sunscreen for both samples.

Results
The results I obtained clearly showed that the longer the sunscreen was soaked in water, the less effective it became. By using the UVB probes, I was able to determine that the samples placed in water let in more UVB than the sunscreen samples not placed in water. The samples of sunscreens placed in water for 25 minutes all rejected the null hypothesis by 99%.

Conclusions/Discussion
My data does support my hypothesis because I hypothesized that the sunscreens would lose effectiveness after being under water. The data I collected clearly shows that while under water, the sunscreen had lost effectiveness. Due to these results, sunscreen should be applied frequently if there will be time spent in water.

Summary Statement
To determine whether waterproof sunscreen is effective after being in water.

Help Received
Adviser guided me through the process of a science project.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Daniel C. Moon

Project Number

S1819

Project Title

YBCO Superconductor Magnet Repulsion Force: Vortex/Flux Pinning in Type-II Superconductors

Abstract

Objectives/Goals

Superconductors have "zero" resistance in electric current flows. When they are subjected to an external magnetic field, the surface eddy currents are persistent without any loss (superconducting). Thus, superconductors cancel the external magnetic fields and expel magnetic fields. This is called "Meissner effect".

Our experiment's goal was to estimate the magnitude of the force between superconductors and magnets due to the Meissner effect, and possibly how vortex/flux pinning could be observed between magnets and superconductors.

Methods/Materials

In my procedure, we accelerated down a ramp a cart with a magnet attached to the front towards a superconductor. The independent variable was the speed of the cart, and the dependent variable was the stopping distance of the cart.

Materials:YBCO (Yttrium, Barium, and Copper Oxide) Superconductors, Liquid Nitrogen (LN2), PVC pipes for LN2 reservoir, Plumber's putty, Neodymium magnets, Ramp, Low-friction track, Guiding rails, Carts

Results

By accelerating the cart down each position on the ramp and observing whether the magnet contacted the superconductor or not, we saw that the threshold for the repulsive force between the magnet and superconductor was when the cart was accelerated from the position of 2.5 inches from the start of the ramp. Out of 30 trials,the moving magnet struck the conductor 13 times, and was repelled 17 times. The average stop-gap distance (the distance from the superconductor at which the cart stopped moving) for the cart from position 2.5 was 5.5 mm.

Conclusions/Discussion

The force of the superconductor could be estimated by determining the work done by the force between the magnet and superconductor and the stopping distance of the cart. The force function within the magnetic field was defined as B^2/2mu0. Therefore, we could estimate the force between the magnet and superconductor as 11.6 Newtons. We are currently testing a two superconductor setup to observe and estimate the effects of vortex/flux pinning on a moving magnet.

Summary Statement

To observe and calculate the Meissner effect force between moving magnets and superconductors, and the effects of vortex/flux pinning.

Help Received

My Father helped construct the apparatus.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Aaron C. Ray

Project Number
S1820

Project Title
Temperature Dependence of the Indirect and Direct Bandgaps in TlBr from Cathodoluminescence Spectroscopy

Abstract

Objectives/Goals
The temperature dependence of the indirect bandgap in thallium bromide (TlBr) has been determined using variable temperature (5 K to 300 K) cathodoluminescence. The spectra include transitions associated with both the indirect (2.66 eV at 5 K) and the direct (3.0 eV at 5 K) bandgaps.

Methods/Materials
Measurements were made on detector grade materials which are nominally undoped. Cathodoluminescence spectra were taken with the samples mounted in a JEOL 840A scanning electron microscope with a liquid helium flow variable temperature stage. The light was collected by a parabolic mirror, dispersed with a ¼ m grating monochromator and detected with a cooled photomultiplier tube with response over the range from 300 to 900 nm. Spectra were taken about every 20 degrees between 5 K and 300K.

Results
19 data points were recorded between 5K and room temperature. The data clearly shows that the indirect gap peak moves to higher energies as the temperature rises. Luminescence emission around 3.0 eV fits with previous observations. The peaks at 3.02 eV and 2.66 eV are consistent with the reported low temperature values for the indirect and direct bandgaps of TlBr. Least-squares fitting analysis in Matlab was used to fit to three commonly used semi-empirical models. It seems that the direct gap is not appreciably affected by temperature, contrary to the results of previous measurements of the direct gap.

Conclusions/Discussion
It is interesting to note that the temperature dependence of the luminescence peak associated with the direct bandgap shows a significantly weaker temperature dependence compared to that of the indirect gap. The indirect bandgap emission shifts to an energy of 2.86 eV at 300 K while the direct gap does not appear to shift to the extent predicted by earlier measurements of the exciton absorption edge, and in fact stays constant within the accuracy of the measurements. Future work will have to be done to explain the difference in behavior of the direct gap.

Summary Statement
The project determines how temperature affects the indirect and direct bandgaps in thallium bromide.

Help Received
I used lab equipment under the supervision and guidance of Dr. Nancy Haegel at the Naval Postgraduate School as part of the Science and Engineering Apprenticeship Program.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Manjit Ruprem

Project Number

S1821

Project Title

Scientific and Technical Study on Dependent Factors for Wireless Power Transfer

Abstract

Objectives/Goals

Design and development of Wireless Power Transfer (WPT) system is a recent field of research. The goal of my research was to learn about the scientific principles and technical designs for an WPT system. The objective was to experimentally identify dependent factors and involved parameters for an WPT system. Prior to conducting the experiment, I made hypotheses that Power Transfer Efficiency (PTE) depends only on engineering design, 100% PTE is impossible, and PTE depends on source power.

Methods/Materials

Magnet wire to prepare coils (# 22 AWG, nylon coating); Spools for the coils; Soft iron sheets for the preparation of cores for the coils; Connecting wires; Center-tabbed step-down transformer; Multi-meter; Needle-nose pliers; Calculator; and LED. The methods and procedure follows three phases: the offline design phase to prepare the coils and the cores, the set-up and measurement phase to record data, and the computation and data analysis phase for reporting the results.

Results

The identified scientific and technical dependent factors are source voltage, number of turns in the coil, rate of change of magnetic flux, and the distance between transmitter and receiver. Scientific theory was established and a demonstration platform was developed for experimentation. The experimental results show that (1) the received power increases as the source voltage increases; (2) keeping the number of turns and rate of change of magnetic flux constant, the received power decreases as distance increases. The power at distance D3 is higher than at D2 (D3>D2) contradicting the theory. The rise in power at D3 is due to the effect of the structure of the coil and core, a dependent factor that significantly affects the effectiveness and efficiency of the WPT.

Conclusions/Discussion

Effective and efficient delivery of power plays a vital role. The underlying principles, methods, and procedure along with aspects of technical designs were studied, experimented, and demonstrated. The concluding remarks are based on observed experimental results: PTE depends on engineering design; PTE of 100% is impossible because the radiated magnetic flux at the source is omnidirectional. It is impossible to bring all the magnetic flux together; and it was confirmed that PTE depends on source power.

Summary Statement

The underlying principles, scientific theory, methods and procedures, and an experimental demonstration platform for the study of dependent factors for wireless power transfer system were established and validated.

Help Received

Brother helped with printing; Parents helped paste slides onto board.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Vidur Sanandan

Project Number

S1822

Project Title

Structural Parameters and Comparisons of Galaxies and Galactic Field Depths

Abstract

Objectives/Goals

Presented is a study of the structural parameters and model behaviors of galaxies with redshifts 0.8 to 2.0 and solar masses greater than 10^10. The goal of this study is to understand the studied galaxies' morphologies and evolutions. Additionally, this project hopes to understand how the depth of image fields affects the quality of the mathematical model fits created.

Methods/Materials

In order to study these galaxies, I first created mathematical models from images in the Hubble XDF (Extreme Deep Field), which were used to show that for the stated redshifts and masses, galaxies did not have a definitive shape to begin with, and that modern galaxies' shapes are not preexisting, which contrasts the notion that old galaxies are elliptical. Additionally, models created from the XDF were compared to models created from the Goods-South field. Next, I created models from ten simulated fields; the simulated fields were manufactured by using a poisson distribution to add noise.

Results

Graphs created from those comparisons show no association between the parameter outputs from the various image field depths. Moreover, when looking at only the data from the XDF images, it can be seen that there is an association between redshift and parameter output values.

Conclusions/Discussion

The field comparisons validate the entire observed field of galaxies, all of which are not nearly as detailed as the XDF, as perfectly useful for mathematical model fitting, and it opens new doors and new possibilities as astronomers are offered a much vaster number of galaxies that can now be modeled, and therefore their parameters understood, in full confidence that these prediction will be almost fully accurate. Moreover, the XDF data shows a definitive trend between the age of a galaxy and the geometries; as a galaxy ages, it gains definition. Thus, astronomers can understand how galaxies evolve.

Summary Statement

This project looks at how galaxies evolve and are imaged.

Help Received

Mentor gave general help; teacher helped solidify ideas

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Julienne Sauer

Project Number

S1823

Project Title

Quantum Locking: Applications towards Controlled Frictionless Spatial Motion

Abstract

Objectives/Goals

Quantum locking is a newly defined quantum effect which allows a Type II superconductor to levitate pinned in a strong magnetic field. This is very different than the traditional Meissner effect (levitation by repulsion) commonly used today. The purpose of this research was to study how the external magnetic field strength and superconducting area affect the weight a quantum locked superconductor can hold for push, pull, and shear strengths. Then research expanded into implementing quantum locking into a revolute, a prismatic, and a spherical joint.

Methods/Materials

Various configurations of neodymium magnets were used to create different magnetic field strengths. The cooled superconductor was placed in the magnetic field and quantum locked in place. Then non-ferromagnetic weights were added until the superconductor could hold no more weight and touched the magnet configuration. Both the weight and the superconductor were then weighed. Twelve trials were conducted for each magnetic field strength. Pull and shear forces were also measured in a similar method except weights were hung from the superconductor. Vizimag software was used to identify regions of constant flux around selected magnet configurations. This helped define areas that a quantum locked superconductor could travel through in order to create models for the selected joints.

Results

It was found that a quantum locked superconductor exposed to stronger magnetic field strengths was able to hold more weight and that the relationship was linear. Furthermore, a superconductor with a larger area could also hold more weight by affecting the slope of this linear relationship. Next, a t-test was conducted to analyze whether the differences between the push, pull, and shear forces were significantly different. Unexpectedly, there was no significant difference in the amount of weight held for each of these forces. Lastly, quantum locking was implemented into a revolute, a prismatic, and a spherical joint to spatially control the frictionless movement of objects.

Conclusions/Discussion

Quantum locking holds the potential to revolutionize countless technologies. By providing stable low energy non-contacting connections, this phenomenon has applications towards the improvement of magnetic levitation trains, the development of frictionless joints, new launch systems, and next-generation space systems for docking, object manipulation, and satellite formation.

Summary Statement

This project studies the properties that affect the amount of force a quantum locked superconducting sheet can withstand while pinned in a strong magnetic field and analyzes how this technology can apply towards non-contacting connections.

Help Received

My family provided a second set of hands during experimentation; Airgas provided me with liquid nitrogen and safety instructions; and KJ Magnetics provided me with various neodymium magnets and handling advice.

Name(s)
Manan A. Shah

Project Number
S1824

Project Title
A Study of the Effects of Solar Flares on the Magnetosphere of the Sun and the Propagation of Solar Pressure Waves

Abstract

Objectives/Goals
Solar events known as Coronal Mass Ejections (CMEs) regularly cause serious problems for electrical systems on our home planet, where the fluctuations of the solar magnetosphere eject billions of tons of particles into space and cause Earth's magnetic field to change unpredictably. While the association of solar flares with CMEs is currently "not clear" (NASA), it is hypothesized that a relationship between the two may exist. Such verification could potentially open undiscovered avenues in solar studies and revolutionize our conceptions of key heliacal activities.
This project is the first in the field to holistically explore the vast datasets available from SOHO and NOAA to assess cosmic activities and the solar magnetosphere. Furthermore, it is the only one that integrates the impact of high energy protons and electrons as well as the magnitude of specific solar flares when making predictions and confirmations of results.

Methods/Materials
In order to attain data from SOHO and NOAA, web scrapers were written to download datasets and convert the FITS (Flexible Image Transport System) files into CSV values. To test the significance of solar flares and high energy protons on the solar magnetosphere and CMEs, statistical analyses were conducted in the FATHOM Dynamic Data Analysis Software.
After extracting data from FITS files, an objective model was developed that accurately determined the relationship between energy release in conjunction with the size of solar flares on the ejection of coronal mass and fluctuation of the solar magnetosphere. The model then categorized both variations based on whether a strong solar flare existed on that specific day. Variance analyses were finally conducted on this refined set of data to obtain conclusive results.

Results
Correlations of 84.86% and 70.68% were calculated based on the analysis of variance between the magnetosphere fluctuation and flare magnitude as well as the magnetosphere fluctuation and electron flux.

Conclusions/Discussion
This analysis concluded that solar flares and high energy proton release result in massive fluctuations of the solar magnetosphere. These results allow for further understanding of the underlying mechanism of wave propagation and provide insight regarding the impacts of flares on CMEs. The great magnetosphere fluctuation induced by flares result in mass disturbance of the Earth's magnetic field and impacts our daily lives.

Summary Statement
This project analyzed data and developed an objective model that accurately determined the relationship between energy release and the magnitude of solar flares on the ejection of coronal mass and fluctuation of the solar magnetosphere.

Help Received
Parents helped with the board assembly. Science teacher and mentor Mr. Chris Spenner helped with FATHOM analysis software for large datasets.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Connor E. Tom

Project Number
S1825

Project Title
Time-Resolved Optical Study of the Surface States of the Topological Insulator Bi(2)Se(3)

Abstract

Objectives/Goals
The objective was to measure the spin lifetime of surface states on the topological insulator Bi2Se3 by a direct all-optical method.

Methods/Materials
A pump-probe femtosecond time-resolved optical study was performed on the surface of a (111)-oriented Bi2Se3 sample. The sample was cleaved in air at room temperature using the tape-method. The 828 nm pump was incident with controlled polarization states and varied with a photoelastic modulator. The second-harmonic (SH) frequency of the probe pulse at 414 nm generated at the surface was detected with a photomultiplier and lockin detection. The sample's in-plane orientation was set to obtain surface-specific signals due to spin-polarized states.

Results
An ultrarapid transient probe SH response was observed due to the pump. The signal sign changes when the helicity of the pump and the linear-polarization of the probe are reversed and provides a double-confirmation that the transient is due to spin-polarized surface carriers. The spin-lifetime is extracted from the data by curve-fitting with the measured pump-probe cross-correlation and model-fitting to be ~50 fs. A longer transient on the ~1 ps time-scale does not depend on the helicity of the pump and is due to field-screening. The change in field-screening in the ~1 hr after cleaving in air indicate that the surface Fermi level increases after cleaving.

Conclusions/Discussion
3-D Topological insulators, such as Bi2Se3 are a new class of materials in which surface electronic states are topologically protected from backscatter: the electrons moving in opposite directions have opposite spins and therefore backscatter requires spin-flipping. Here we have succeeded in unambiguously measuring the spin-lifetime of laser-excited carriers, but the lifetime is very short. This is likely due to the surface Fermi Level being in the bulk conduction band so that pump-induced spin-polarized surface holes are rapidly filled by bulk conduction electrons that scatter into the surface states. Observing a longer and protected spin-lifetime will require controlling the surface Fermi Level.

Summary Statement
Successful measurement of the spin-lifetime of laser-excited carriers in 3D Topological insulators, a new class of materials in which unique surface electronic states are topologically protected from backscatter.

Help Received
Used lab equipment at University of California Riverside.

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)

Samantha I. Wathugala

Project Number

S1826

Project Title

Dependence of Silica Sol-Gel Thin Film Material Properties on Fabrication Methods

Abstract

Objectives/Goals

To experimentally determine the dependence of refractive index (n) and thickness on easily varied synthesis parameters both in isolation and interaction with each other.

Methods/Materials

In this work, 175 thin films were synthesized varying the amount of water, aging time, spin speeds, temperature, and annealing times. The study was carried out in two phases, an axis terms phase, varying one parameter at a time, and interaction terms phase, using a full factorial (25) design of experiments. The thin films were characterized for thickness and n at three wavelengths of light using ellipsometry.

Results

Three models were developed for some of the parameters varied. For others, however, the relationships were too complicated to model accurately without more data, and some of the parameter values chosen were too extreme to offer meaningful results.

Samples that were spun-coat at temperatures cooler than room temperature, excluded from the models, were observed to have fairly consistent pores.

Conclusions/Discussion

High n thin film coatings such as those synthesized in this study are widely used in the field of optics, which touches many aspects of our lives. One application of thin film coatings is in optical biosensors, where increasing n and decreasing film thickness can increase the sensitivity of the biosensors, thus allowing detection of diseases in their early stages. Currently, researchers often settle for doping their films to modify the refractive index. This is not always optimal, as it could degrade other properties, such as increasing the absorption of the film. Before this project, there were no quantitative models researchers could follow to manipulate the parameters of the synthesis process without adding dopants to get the best film for their purposes. In addition to filling this need, the method this study discovered to synthesize porous sol-gels, spin-coating cold, is potentially a very simple and inexpensive route. Porous sol-gels are exciting in their own right for their applications in increasing the sensitivity of biosensors.

Summary Statement

Silica sol-gel thin films were synthesized with various recipes and characterized in order to develop a quantitative model that researchers can use to control the optical properties of the films when using them on their optical devices.

Help Received

Used lab equipment at University of Southern California under the supervision of Dr. Andrea Armani and Mr. Mark Harrison; father taught me MATLAB to help with analysis

CALIFORNIA STATE SCIENCE FAIR
2014 PROJECT SUMMARY

Name(s)
Isfar S. Munir

Project Number
S1899

Project Title
The Relationship between Air Properties and the Deflection Experienced by an Electric Arc, Year 2

Abstract

Objectives/Goals
This experiment is a continuation on a previous experiment which was aimed determining whether or not properties of the air, such as temperature and relative humidity, had any influence in the behavior of electric arcs. The results of that experiment was that temperature had a strong correlation with arc deflections in the x-axis. The purpose of this year#s experiment thus was to further explore this relationship and have the experiment as a whole undergo rigorous control testing to verify the previous results.

Methods/Materials
A Tesla Coil was used as the electric arc generator. A plant growth chamber capable of controlling both temperature and humidity to a high degree of accuracy was used as the vessel for the experiment. Data would consist of pictures of arcs taken from above the arcs. These pictures were then process through Microsoft Paint. Maximum deflections of the arcs from an ideal path of the arc were collected, as were areas bounded between the arc and the ideal path. Statistical analysis on this data was then done through Microsoft Excel.

Results
It was found that the relationship discovered in the previous year, which was an inverse linear relationship, was an incomplete one. The actual relationship closer approximates an inverse J-curve with deflection reaching a positive peak at the 25°C mark and then decreases in either side of this mark; the average deflection was negative at the 12°C and 45°C marks. The control testing showed that the relationship was not caused by mechanical asymmetries inherent to the Tesla Coil or the controlled environment chamber.

Conclusions/Discussion
When taken in conjunction with the results from the previous year#s experiment, this project very clearly shows that electric arc behavior is related to temperature conditions. It implies that electric arc behavior, what is currently thought of as a chaotic and unpredictable phenomena, is more ordered and something that can perhaps even be predicted if enough research is done into the specific initial conditions which affect arc paths. Future studies would focus on creating statistical distributions to account for the variances of arc behavior within a data set and on manipulating the arc to strike specific targets through the manipulation of air.

Summary Statement
This project showed the full nature of the relationship that exists between the deflection of electric arcs from an idealized path and temperature and that such relationships exists independent of mechanical asymmetries.

Help Received
Professor Randy Harris and Professor Cort Anastasio of UC Davis assisted in the data analysis portion of the experiment. Mr. Dennis Lewis of the UC Davis Controlled Environment provided the climate chambers used for the experiment.