CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Ryan M. Beam

Project Number

S1801

Project Title

Testing How Infill Affects the Conductivity of 3D Printed Heat Shields

Abstract

Objectives/Goals

The objective is to determine how the density of an object (in this case, a 3D Printed "heat shield") affects the rate at which heat travels through it.

Methods/Materials

24 3D printed heat shields (designed in Solidworks, made with printrbot simple metal 3D printer), 3 of each infill/density ranging from 0-70% solid, increasing in 10% increments. Arduino and Thermocouple for measurement of heat. Heat gun to provide consistent temperature levels. Computer with serial monitor to observe results. Timed how long it took for the back of each shield to reach 85 degrees fahrenheit, starting at room temperature, when the front of each was subjected to heat of 400F.

Results

My test allowed me to conclude that the less dense an object is, the more effective its performance as a heat shield. Not only did the 0% and 10% solid shields last longer, the temperature of the back of these shields rose steadily and slowly, whereas shields with higher densities survived for significantly smaller periods of time, and temperatures spiked quickly near the end.

Conclusions/Discussion

I devised an experiment that allowed me to test how density/infill affects a heat shield's effectiveness, using 3D printing to manufacture otherwise identical discs that were subsequently subjected to high temperatures. With repeated trials, I was able to determine that lower density shields were significantly more effective than their denser counterparts.

Summary Statement

I designed, manufactured, and tested heat shields with various infills, in order to determine how support structure density affects insulative properties.

Help Received

None. I designed and built my own materials, excluding the computer and heat gun, and performed the experiment by myself.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Ashley Cao; Janaki Patel

Project Number

S1802

Project Title

Falling for You: Calculating the Trajectory of a Falling Samara Seed

Abstract

Objectives/Goals

In this experiment, we hoped to create a mathematical model of the trajectory of a falling helicopter samara seed. By utilizing tracking programs like Tracker 4.95, as well as high speed cameras and basic kinematics equations, we believed that it would be possible to apply collected data to already existing helical equations to create the model.

Methods/Materials

Using a high speed camera filming at 240 fps, we filmed the fall of samara seeds from both the top and side view. We then uploaded the videos to the Tracker 4.95 program and tracked the seed at multiple points for each frame of every video. We subsequently uploaded the data into a Microsoft Excel file and applied physics principles and equations to calculate the translational angular velocity, terminal velocity, and acceleration, using such equations to derive a model for the helical fall of the samara seed.

Results

Unfortunately, we were unable to create a mathematical model for the helical trajectory of the seed#s fall; however, we were able to calculate many different values to describe the movement of the seed both rotationally and translationally.

Conclusions/Discussion

There were indeed trends in the data, showing different relationships between the angular velocity and the translational velocity as well as the terminal velocity of both. Our inability to derive an equation for the fall is perhaps due to the lack of a z-dimension as well as external factors like air resistance.

Summary Statement

We utilized tracking programs, high speed cameras, and basic physics principles to derieve the trajectory of the helical fall of a samara seed.

Help Received

Over the summer, two fellow high school students at Stanford Pre-Collegiate Summer Program enaged with my partner ina discussion that built the fundamental idea of this project; however, the experiment design and data were all conducted seperatley, months later, at home. We recieved no assistance froma

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Dominic H. Catanzaro

Project Number

S1803

Project Title

Quick Aligning Telescopes

Abstract

Objectives/Goals

The goal of my project was to develop an efficient method of aligning an optical telescope. Optical telescopes are expected to have a very small wavefront error in order to achieve high resolution. Wavefront errors in optical instruments are measured using an interferometer. The specific goal of this project was to develop a deterministic method of aligning a Keplerian telescope to a wavefront error that was limited by the wavefront error of the lenses in the telescope.

Methods/Materials

My approach to aligning the telescope was to associate certain aspects of the wavefront error with specific misalignments. I chose to characterize the aberrations as a result of specific misalignments of the telescope#s elements. Since the telescope is radially symmetric, there are only three unique degrees of freedom to misalign, one which is eliminated by changing the viewing angle. Using a computer model built in an optical design platform (Zemax OpticStudio), I predicted the aberrations as a function of misalignment and confirmed my model using an interferometer. I matched these misalignments to the coefficients of Zernike polynomials (orthogonal polynomials that can be used to describe wavefront error). Rotated misalignment resulted in a parabolic function describing a Zernike coefficient, and translated misalignment resulted in a linear function describing a different Zernike coefficient. I used linear algebra to fit three random misaligned points to a parabola, then determined the minima and aligned the telescope to that rotation. Then I took two misaligned translations, plotted them to a line, and solved for the location with minimized error.

Results

To test my method, I ran two separate tests on a telescope that was randomly misaligned to test both important degrees of freedom. Both tests succeeded in aligning the telescope better than I could by hand. Before alignment, the wavefront error of the telescope was almost six waves. After alignment, the wavefront error was only an eighth of a wave, and the only remaining aberrations were due to flaws in the lenses.

Conclusions/Discussion

The method I devised reached the accuracy goal, and was significantly more efficient than linearly adjusting the degrees of freedom in small steps. The process aligned the telescope to within the accuracy goal on the first iteration. The process is methodical enough that given future work, it could easily be automated.

Summary Statement

I devised a method to align a Keplerian telescope using measurements of the wavefront error.

Help Received

Brian Catanzaro (father) provided instruments and technical assistance in using instruments

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)
Maggie Chang

Project Number
S1804

Project Title
The Effect of Different Rosin Brands on the Intensity of Sound

Abstract

Objectives/Goals
Objective: The goal of this problem was to test to see if different brands of rosin would affect the intensity of sound.

Materials and Methods: Using five different brands of rosin as well as Audacity (online program), the intensity of sound was measured through the sound of a cello. Additionally, six separate bows were used during this experiment.

Results: The brand of rosin, Larica had the highest sound intensity compared to the other four. The Andrea rosin had the lower intensity of sound.

Conclusion/Discussion: It means that people who use the Larica rosin would have higher intensity and therefore would not need to exert as much force while playing than compared to musicians with the Andrea rosin. It proves that lighter rosin would generally have a higher intensity than compared to darker rosin.

Methods/Materials
Cello, 6 $35 bows, 5 brands of rosin (W.E. Hill and Sons, Andrea, Larica, Kaplan, Pirastro), Audacity, cloth. Measured intensity of sound through Audacity for each of the five rosin brands.

Results
Lighter colored rosin, such as the Larica, had the highest intensity of sound. Dark colored rosin, like that Andrea had the least. Based on preference, knowing the intensity of sound can allow for more knowledge on each product.

Conclusions/Discussion
The different brands of rosin, each with different color and components had effects on the intensity of sound. Knowing that the lighter colored rosin would produce a higher intensity, it allows for the knowledge on which product to buy. Based on preference, one would not need to exert as much force while playing than compared to musicians with the dark colored rosin.

Summary Statement
Using different brands of rosin, I was able to test to see how a specific brand of rosin, with the specific characteristic would affect the intensity of sound.

Help Received
None. I designed, built, and conducted the experiment myself.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)
Jennifer J. Choi

Project Number
S1805

Project Title
Entangling Time-bin Qubits Using an Optical Switch: Source Alignment and Mach-Zehnder Interferometer Construction

Abstract

Objectives/Goals
Quantum mechanics is an extremely relevant topic of the day as it is being used in technology to increase the speed of information processing and to improve the security of cryptographic systems. These advancements largely involve the process of entangling qubits, which are basic units of quantum information (quantum bits). While polarization entanglement has been utilized frequently in current optics research, time-bin entanglement remains more in theory and has not been as thoroughly explored. A long-term, multi-stage experiment was planned out with the purpose of verifying the theoretical set-up by attempting to generate entangled time-bin qubits in real-time.

Methods/Materials
Single photon detector, fiber laser, fiber cutter/splicer, light attenuators, optical fibers, nonlinear crystal, polarizing beam splitters, couplers, mirrors, iris diaphragm, function generator, phase modulator, MXA signal analyzer

The stages of the experiment included photon pair generation, time-bin qubit preparation, time-bin qubit entanglement with a switch, and measurement. Because of previous inefficiencies, the first stage is being reconstructed and retested to more efficiently generate photon pairs using a dual-Sagnac interferometer. The source is being built using free space components and aligned to maximize efficiency. An M-Z interferometer was built to test the functionality of the phase modulator, which is to be used in the third stage.

Results
The ideal laser settings to maximize efficiency were found. The M-Z interferometer was constructed and used to verify the functionality of the phase modulator. Some previous results suggested high loss, which is why the first stage is being reformulated to more efficiently generate photon pairs.

Conclusions/Discussion
Though various stages of the experiment were verified, the low efficiency of initial photon pair generation hinders the set-up from being fully assembled. Once the dual-Sagnac interferometer source is successfully aligned, all the components can be linked to generate time-bin qubits.

Summary Statement
My goal was to entangle time-bin qubits by creating a multi-stage experiment involving an optical switch.

Help Received
I would like to thank my research mentors, Professor Chee Wei Wong and Alvin Peizhe Li of the UCLA Mesoscopic Optics and Quantum Electronics Laboratory, for working closely with me and providing insightful discussions to help me carry out this experiment. I am also grateful to the Southern California

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)
Mariah G. Cox

Project Number
S1806

Project Title
Comparing the Effectiveness of Natural and Synthetic Insulating Materials

Abstract

Objectives/Goals
My goal for my project was to see which was the most efficient and safest insulating material for our animals. I tested synthetic materials and natural materials for insulating areas where animals are unsupervised because fiberglass can do real damage to animals when ingested. I wanted to do this project because we have had such bad weather this winter in parts of the country. I feel bad for those animals that can't come inside. In dog houses, chicken coops, and barns they use straw hay on the floors, why not use it in the walls?

Methods/Materials
I got ten 1-gallon plant containers. I used three natural materials which were cedar shavings, shredded paper, and straw hay. My synthetic material was fiberglass insulation with an R-Value of 13. I packed the containers till they were completely full around a 15oz tin can. I taped thermometers to plastic straws to keep them from touching the edge of the cans which would give me a false reading. I heated the water in a tea kettle and brought it up to 70 degrees Celsius. I added the hot water to the cans and recorded the temperatures every ten minutes for three hours. I repeated this process for each material.

Results
The shredded paper lost a total of 39.1 degrees Celsius. The straw hay lost a total of 37.3 degrees Celsius. The cedar shavings lost a total of 40.1 degrees Celsius. The fiberglass insulation lost a total of 37.9 degrees Celsius. Most heat loss happened during the first two hours. I could have stopped the test at two hours but I wanted my data to be as accurate as possible. I also compared the properties of the four materials. I found that fiberglass insulation is unsafe for animals. The natural materials tend to decompose and need to be replenished.

Conclusions/Discussion
I proved that what people use all the time for insulation in their homes is not the best you can use in a place where animals are unsupervised. The natural materials decompose. However, the natural materials and the fiberglass insulation were very close in their thermal capabilities. As long as the natural materials are kept dry and clean and replenished when necessary, they are the better insulator for an area where animals are unsupervised.

Summary Statement
I proved that natural materials insulate as well as synthetic materials and are safer for areas where animals are unsupervised.

Help Received
I designed and performed my experiment myself.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Gabriel Damon; Anita Ilango; Megha Ilango

Project Number

S1807

Project Title

Kinematics of H-alpha Emitting Stars in Andromeda

Abstract

Objectives/Goals

Studying emission line stars helps improve our understanding of stellar evolution, types of stars, and their environments (Prichard et al. 2016). In this study, we investigated the correlation of H-alpha emission line star velocities to their ages in order to increase our understanding of stellar populations by validating existing stellar evolutionary models for rare star populations and gaining physical insight into the nature of H-alpha stars.

Methods/Materials

We used a combination of spectroscopic and photometric diagnostic methods to remove a population of foreground Milky Way (MW) star contaminants from our data set. The H-alpha stars were selected from a sample of 5295 spectra from the Spectroscopic and Photometric Landscape of Andromeda's Stellar Halo (SPLASH) survey and accompanying photometric data from the Panchromatic Hubble Andromeda Treasury (PHAT) survey. Velocities of two classes of H-alpha stars, main sequence (MS) stars and asymptotic giant branch (AGB) stars, were analyzed through a novel Age-Velocity Difference Correlation (AVDC) method, which utilizes line-of-sight velocity differences (LOSVDs) in order to estimate the age of a rare stellar population.

Results

Histograms, weighted means, and weighted standard deviations of the LOSVDs were used to conclude that MS stars are more kinematically coherent than AGB stars, and that H-alpha stars are kinematically comparable to non-H-alpha stars of similar evolutionary phases.

Conclusions/Discussion

Our results showed that H-alpha stars are close in age to their non-H-alpha counterparts. Our AVDC method sets a precedent for the use of similar methods in predicting the ages of rare stellar subgroups.

Summary Statement

Using an age-velocity difference correlation method we created to analyze the kinematics of H-alpha emission line stars, we discovered that H-alpha stars are kinematically comparable and thus close in age to their non-H-alpha counterparts.

Help Received

We worked under the mentorship of Professor Puragra Guhathakurta through the Science Internship Program at UC Santa Cruz.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Shashank Dholakia; Shishir Dholakia

Project Number

S1808

Project Title

Searching for Exoplanets: A Novel K2-based Study of the Effects of Open Cluster Characteristics on Exoplanet Abundance

Abstract

Objectives/Goals

Almost all stars form within clusters. Open clusters contain stars that formed at the same time from the same materials, so they are invaluable laboratories for controlled studies of exoplanets. The characteristics of all planetary systems depend upon the composition of the progenitor cluster. As such, it is essential to understand exoplanets in clusters in order to understand whether Earth-like planets are unique or abundant. We therefore address the question "How do the characteristics of an open cluster affect the abundance of exoplanets around stars in the cluster?" We attempt to use the "crippled" Kepler mission to perform a large scale search for these planets.

Methods/Materials

The Kepler Space Telescope, designed to look for planets, failed in 2012. Scientists devised a salvage mission, the K2 mission, which allowed limited observations to continue. Since there existed no available algorithm to process the images taken by the K2 mission for open clusters, we developed a novel pipeline to search for the minute dips in brightness that occur as planets momentarily cross the faces of their host stars. The algorithm takes millions of images, searches for stars, and graphs each star's brightness. It then applies several processes to mitigate the effect of the flaws of the salvaged K2 mission and to reduce biases for the cluster survey. The algorithm then automatically searches for the characteristic dips. A slew of artificial transits was also used to test the efficacy of the algorithm.

Results

We find seven exoplanet candidates, one of which is a new discovery. Five are in Praesepe, one in M67, and one in Ruprecht 147. Praesepe has nearly ten times the prevalence of exoplanets that the other clusters have. Over 1600 stars were searched in total.

Conclusions/Discussion

The abundance of exoplanets in Praesepe is much higher than in the other clusters. The most notable characteristic of stars in Praesepe are their high proportion of elements heavier than helium on the periodic table. This indicates that the composition of the stars in the cluster has a measurable effect on the abundance of planets. This supports our hypothesis, and can be explained by the higher abundance of silicates which agglomerate to form planets. The major implication of this finding is that Earth-like planets have the highest chance of being found around stars with high proportions of elements heavier than helium.

Summary Statement

We developed an algorithm to search for planets in open clusters using the K2 mission, discovered an exoplanet candidate, and found that open clusters with higher metallicities might host more planets.

Help Received

We received advice on concepts regarding open cluster metallicity from our teacher, Mr. Iverson.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)
Kelsey C. Ewing

Project Number
S1809

Project Title
Thermal Effects of the Radiofrequency Electromagnetic Fields Emitted from Cellular Phones on the Human Body

Abstract

Objectives/Goals
This study examined the thermal effects of the radiofrequency and electromagnetic fields emitted from cellular phones on the human body. A potential causal relation was investigated: does the temperature of the human body increase when exposed to the radiofrequency and electromagnetic fields emitted from cellular devices? Such changes in thermal activity are significant because research studies have shown that although the radiofrequency and electromagnetic fields emitted from cell phones are non-ionizing, they have been found to cause thermal increases in the human brain. It was hypothesized that the model(s) of iPhone emitting the highest levels of the radiofrequency and electromagnetic fields would also result in the largest increase in body temperature.

Methods/Materials
Levels of radio frequency waves and electromagnetic radiation emitted from 4 iPhone models at pre-determined distances (50mm, 25mm, 10mm, 0mm) were measured utilizing an electromagnetic field (EMF) meter. Then, the internal and surface thermal effects on the subject's body at each given distance were measured using an ear thermometer, a digital infrared surface thermometer, and an infrared thermo-imaging camera. Multiple (640) trials were conducted using 4 phones, 4 distances, pre-exposure readings, and both sides of the head (left and right). Finally, surface and internal thermal measurements were cross-analyzed with the EMF data.

Results
Data was analyzed using Chi Square. Pick#s Theorem was used to map and analyze the surface thermal changes. Increases in surface temperature in the region closest to the antenna (orbitofrontal cortex and temporal lobe) significantly increased (95% CI, p=.004) after exposure. The iPhone 7 Plus yielded the largest increases in surface (4.5ºC) and internal (.9ºC) temperatures. The iPhone 7 Plus yielded the highest level of magnetic radiation (60 MG), while the iPhone 5 yielded the highest levels of electric radiation (300 v/m). The iPhone 7 and the iPhone SE emitted the highest levels of radio frequency radiation (.3 mW/cm2).

Conclusions/Discussion
Positive correlations were found between the magnetic radiation emitted from cell phones and increases in surface and internal temperature. No significant correlations were found between electric or radio frequency radiation and thermal change. This research project provides data that will allow cellphone users to protect their health as knowledgeable consumers.

Summary Statement
My project involves the testing and studying of the thermal changes caused by cellular phones in relation to the radiofrequency and electromagnetic fields emitted from each model of phone tested.

Help Received
Thank you to my advisor and mentor for prompting me to go further with my data analysis.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Rachel Guo; Justin Xie

Project Number

S1810

Project Title

Identification of Type Ia Supernova Explosion Mechanisms in Dwarf Spheroidal Galaxies

Abstract

Objectives/Goals

Through the fusion of nucleons to produce elements heavier than hydrogen and helium, stellar nucleosynthesis produces many of the elements in the universe. However, nearly all elements heavier than those of iron-peak elements, atomic numbers 21 through 30, are created through nucleosynthesis in supernova explosions. In this study, we determine the best theoretical supernova model appropriate for the stars in the dwarf spheroidal galaxies Sculptor, Fornax, Ursa Minor, and Leo II by calculating the abundances of iron-peak elements in these stars.

Methods/Materials

To determine iron-peak elemental abundances, we use Interactive Data Language to compare synthesized spectra with observed medium-resolution spectra, obtained from DEIMOS at Keck Observatory, and determine the best-fitting spectrum by way of a chi-squared minimization.

Results

Through inspecting the relationship between the iron-peak elemental abundances and the abundance of iron itself and by comparing them to previously hypothesized supernova model theories, we discover that the near-Chandrasekhar mass "n1" model, as predicted by Seitenzahl et al., most accurately represents the trends and patterns within our data.

Conclusions/Discussion

Our findings suggest that a low number of ignition kernels is characteristic of the mechanism behind Type Ia supernova explosions in dwarf spheroidal galaxies.

Summary Statement

Through inspecting observed iron-peak elemental abundances and comparing them to previously hypothesized supernova models, we conclude that a low number of ignition kernels is characteristic of the mechanism behind Type Ia supernovae.

Help Received

We programmed the algorithms on our own and reviewed our methods and solutions with our mentor, Dr. Evan Kirby from Caltech.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Erika Y. Hathaway

Project Number

S1811

Project Title

A Mathematical Study of the Effects of Magnetic Fields on Cosmic Radiation

Abstract

Objectives/Goals

The goal of this study was to understand and develop a mathematical and computational model of a typical cosmic radiation particle as it travels through time changing magnetic and electric fields.

Methods/Materials

Using Maxwell's equations and the Lorentz Force Law, equations for a particle path in three different fields situations (Uniform Magnetic Field & Zero Electric Field, Uniform Magnetic and Electric Field, Non-Uniform Magnetic Field & Induced Electric Field) were derived. A MATLAB program was developed to create a visual 3D model. The model was tested both by hand and computationally using random data sets.

Results

While there is a slight numerical error due to the use of approximation in anti-differentiation, the program was successful in modeling the path of a proton through a magnetic and electric field.

Conclusions/Discussion

In conclusion, I was able to develop a mathematical and computation model of a cosmic radiation particle through magnetic and electric field. This effectively set up a method to test different magnetic field shapes to find optimal shielding from cosmic radiation particles, which would be the ultimate goal in future projects.

Summary Statement

I was able to derive/create a mathematical and computational model of a cosmic radiation particle path as it travels through magnetic and electric fields.

Help Received

I was fortunate to have Dr. Ameesh Pandya (Professor at UCLA) check my MATLAB code for logical errors.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Sahil Hegde; Shawn Zhang

Project Number

S1812

Project Title

Using a Novel Methodology to Constrain the Supermassive Black Hole-Galaxy Coevolution and Analyze the Selection Bias

Abstract

Objectives/Goals

The primary objective of this project is to see if the convolution methodology truly reveals the supermassive black hole (SMBH)-galaxy coevolution. In doing so, we also directly compare stellar velocity dispersion and mass constructions to discover new inherent property correlations. Additionally, we evaluate the extent of the selection bias proposed by Shankar et al. (2016).

Methods/Materials

The only material we use is a laptop computer with Python IDE. Note that all Python modules are created by us. We utilize a modified convolution function that was previously proposed, though never executed or analyzed. We then construct number density models in relation to established galaxy properties, applying the convolution in the process. With those models and estimations in redshift evolution, we juxtapose evolutionary pathways to examine coevolution. Furthermore, we compile a 542 galaxy database to empirically analyze relations and the selection bias.

Results

We find evident concurrence in SMBH and galaxy growth histories, proving the existence of coevolution. Analyzing different black hole mass function constructions, we discover tight agreement between velocity dispersion and stellar mass properties. By testing biased and unbiased relations, we show negligible differences in our results.

Conclusions/Discussion

Using this novel methodology, we provide entirely new evidence on coevolution. The agreements in velocity dispersion and stellar mass express a stronger link between those two properties than previously believed. Our analysis then argues that Shankar's bias is actually not as impactful as he proposes. We conclude that the galaxy sample is a fair representation of the local universe and advocate that our number density and scaling relations have incredible potential to be employed in constraining relevant mechanisms for galaxy formation. Due to our novel convolution, property comparison, bias test, and evidence, we emphasize this very comprehensive study on the SMBH-galaxy coevolution.

Summary Statement

We use a novel convolution methodology to prove the supermassive black hole-galaxy coevolution, directly compare galaxy properties, and evaluate the selection bias.

Help Received

The work was conducted at UCSC where we discussed the implications with Dr. Aldo Rodriguez-Puebla, Prof. Joel Primack, and other astrophysicists. The hypotheses were pre-established, but all analyses and calculations were done by ourselves.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Jonathan (Jack) K.H. Inouye

Project Number

S1813

Project Title

Improving Solar Panel Efficiency: The Effects of a Liquid Cooling System on Energy Production

Abstract

Objectives/Goals

Solar is one of the primary sources of clean energy, with photovoltaic (PV) technology as the dominant source. Current PV panels have an efficiency of 15-20%, which demonstrates the need for additional technical advances and innovative solutions. Temperature is one of the main factors affecting PV cells. There is an inverse relationship between power output and temperature. As ambient temperatures increase, the power output of a PV cell decreases. This study investigated the ability to increase the efficiency of solar panels by decreasing the temperature using a liquid cooling system.

Methods/Materials

A system was designed to test the effects of reducing temperature on the power output of PV panels. A small solar panel was fitted with a cooling system. A piece of solid foam insulation with a coiled length of plastic tubing carved into it was applied to the bottom surface of the PV panel. This was hooked up to a pump which circulated cold water through the system. This test panel was compared with the same model PV panel (without cooling) in a closed system. Both panels were placed in a wooden box, separated by a divider, and sealed with a glass door. Each chamber contained identical temperature sensors to measure the ambient temperature and the temperature underneath each of the panels. Separate voltmeters measured the voltage and current generated by each panel. A halogen shop light was used as the light source.

Results

The results confirmed that, as ambient temperature increased, power output of both PV panels decreased. Readings also showed that the cooling system reduced the ambient and under-panel temperatures of the test PV cell. With respect to power output, although both panels showed a decrease as temperature increased, the test panel showed a significant improvement in power production over the control panel (approximately 50% efficiency increase).

Conclusions/Discussion

This study confirms that increased temperature does negatively affect solar panel efficiency, and that cooling the panel can counteract the decrease in power production. By designing a cooling system for the underside surface of a PV panel, it's efficiency can be significantly improved. Innovative solutions such as this can help the advancement of clean solar energy.

Summary Statement

This project investigated the ability to improve solar panel efficiency by reducing it's temperature using a liquid cooling system.

Help Received

None

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)
Sean A. Jansky

Project Number
S1814

Project Title
Chromatic Chaos: Measuring the Velocity and Energy of a Monochromatic Light

Abstract

Objectives/Goals
Through which media does a green monochromatic light (laser of 450nm) travel the fastest? I am attempting to measure the speed and energy of light as it travels through a medium using Snell's law and equations for energy conversion.

Methods/Materials
Thing glass contained (2cm max.), laser (450nm), protractor, solar cell, 4 primary (+ green) dyes, Multi-meter. Simply place the container with dyed water perpendicular to the laser. Then measure ten angles and project the laser through the material, noting the initial and refracted angle, as well as the voltage output on the Multi-meter. Use Snell's law to compute velocity.

Results
Basically, a green laser was definitely the fastest through a green medium (independent of the control or clear medium), and maintained the greatest energy through this medium as well. Green contained the fastest velocity (215,255,928.4 meters per second) and energy (0.19 volts and 3.04E-20 Joules) of any trial due to its relatable wavelength to that of the original laser.

Conclusions/Discussion
This projects helps understand how light travels, and what exactly impedes its travel. Light travels constantly at the speed of c, but is merely "slowed down" due to the time it takes to be absorbed by the bonds in the dye, propelling electrons to higher energy levels, then being re-emitted as another beam with less energy. Green media retained the most energy and velocity because the light was transmitted rather than absorbed, increasing time and losing energy

Summary Statement
My project is to measure how contrasting and relating wavelengths interact and modify the speed and energy of a monochromatic light

Help Received
I completed the experimenting on my own, but received help to understand Physics topics from Mr. Schoor, teacher at Villa Park

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Jae Yoon Kim

Project Number

S1815

Project Title

Saving the World, One Asteroid at a Time: A Comparison of Different Methods of Orbital Determination

Abstract

Objectives/Goals

Near-Earth Asteroids are of great interest to the astronomical community due to their large sizes and proximity, as well as giving great insight of how the solar system was formed. Asteroid 1866 Sisyphus is the largest member of the Apollo-class of asteroids, and, with a minimum orbit intersection distance of 0.1 AU, could plausibly be perturbed into an Earth-crossing orbit at some point in the distant future. Thus, it is imperative that the orbits of Near-Earth Asteroids be determined very precisely to allow accurate integration of the orbit into the future.

Methods/Materials

The orbital elements of 1866 Sisyphus (also known by its provisional designation, 1972 XA) was determined by using the Gaussian, Laplacian, and Lambertian methods.

An artificial Neural Network was also trained using

JPL's data to test the validity of these methods.Positions were selected from a series of observations performed at the Sommers-Bausch Observatory in Boulder, Colorado, with the 16 and 18-inch reflectors over the month of July 2016. A Python program was then written to determine the orbital elements with each method, and jackknifing was utilized to combine the calculated values. Values calculated by the Jet Propulsion Laboratories will be compared to the calculated values from each method to check its validity.

Results

Summary Statement

I showed that the Gaussian method of orbit determination is more accurate than the Laplacian, Lambertian methods, as well as the Artificial Neural Network in predicting the orbit of a Near Earth Asteroid.

Help Received

I designed the experiment myself, and did all of the data gathering and implementation of the math myself. I received help from the staff at CU-Boulder Sommers Bausch Observatory in learning how to operate the equipment. I used the open source data from JPL's minor Planet center to train my neural net.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Richard K. Korshkov

Project Number

S1816

Project Title

Quantum Levitation and Diminishing Electrical Resistance in Unconventional Superconductors

Abstract

Objectives/Goals

The objective of this experiment was to analyze how superconductors can be used to decrease the amount of power loss due to power transmission and to reveal how quantum levitation is achieved within superconductors. The problem with the current power transmission system is that a significant amount of money is being lost due to the inherent resistance of aluminum and copper power lines. Superconductors would eliminate this problem, as long as the critical temperature was high enough to be used in everyday life.

Methods/Materials

This experiment was conducted using two different types of superconductors, a YBCO block and a niobium wire, both obtained from a commercial source. The YBCO block was used to demonstrate quantum levitation and the niobium wire was used to reveal the decreasing electrical resistance within a superconductor as it is cooled. Neodymium magnets supplied the magnetic fields, to show quantum levitation. Copper and aluminum wire, were used as controls for the electrical resistance test. Liquid nitrogen was used as the coolant for both the electrical resistance and quantum levitation portions of the experiment.

Results

As the superconductor increased in temperature, it began to lose its superconductivity and lost levitation height. It took approximately 357 seconds for this superconductor to lose all superconductivity and lost a total height of 11 mm. The superconducting wire had an initial resistance of 10.8 Ohms at room temperature and a final resistance of 3 Ohms at the temperature of liquid nitrogen. The electrical resistance data revealed a downward trend of resistance with a decrease in temperature, and a sharp decrease in resistance as it reached the temperature of liquid nitrogen. This revealed that the wire was starting to superconduct, and was beginning to approach its critical temperature. Both controls showed a decreasing resistance with decreasing temperature, however, the did not have the sharp decrease in resistance like what was seen within the superconducting wire.

Conclusions/Discussion

This experiment proved that the use of superconductors to decrease electrical resistance, is a viable method of making energy transfer more energy and cost efficient, saving billions of dollars. It also revealed the short amount of time that a superconducting state is maintained at room temperature, even with a high temperature superconductor.

Summary Statement

Unconvention superconductors can be used to eliminate the 15% energy loss to dissipation during electrical transmission, saving billions of dollars.

Help Received

Dr. Boaz Almog provided guidance in designing and carrying out the experiment, in addition to providing materials. Adam Lane oversaw the construction of the scientific research/paper.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)
Andrew T. Land

Project Number
S1817

Project Title
Measuring Planck's Constant: Adventures in Watt Balance Land

Abstract

Objectives/Goals
Significantly reduce the measurement uncertainty for Plancks constant h attainable on a home-built watt balance by optimizing the laser detection system.

Methods/Materials
Inspired by the work of the mass metrology team at NIST, a fully functional watt balance instrument has been constructed. Custom coils were wound, a knife-edge main bearing was machined, electronics for detection and control were built. A floating battery powered supply was built to provide reverse bias on the photodiode detector, allowing higher intensity lasers to be evaluated. Four different lasers were evaluated for best performance in the shadow sensor detection system. The watt balance approach compares measurements made in force mode (static balance) and velocity mode. For a given system configuration, a measurement of h involved: calibrating the shadow sensor; n=10 replicate measurements of BLv in velocity mode and BLf in force mode. For force mode, 0-A-0 and A-B-A type measurements were compared.

Results
A baseline was established by measuring Plancks constant h with the system in stock configuration:
h = 6.67 E-34 J s, precision 0.3%, accuracy 0.7%, uncertainty 0.7%.
Uncertainty arising from the shadow sensor response was clearly the limiting factor in overall measurement uncertainty for h.
Lasers for the shadow sensors were evaluated for sensitivity, linearity, beam profile, noise and drift. The best overall performance was achieved with a raw laser diode with no focusing optics. The calibration of the shadow sensor was compared with a simple numerical model for the diode laser Gaussian beam profile, with a 3rd order polynomial giving the best fit.
With all improvements in place final results attained were:
h = 6.64 E-34 J s, precision 0.2%, accuracy 0.2%, uncertainty 0.25%.

Conclusions/Discussion
A home-built watt balance apparatus to measure Plancks constant h has been constructed and refined. Multiple system enhancements (knife-edge bearings, alignment, shrouding) helped with reliable operation, and improvements to the shadow sensor (optimum laser, floating bias supply, cubic calibration fit) improved the overall measurement uncertainty for h by almost x4.

Summary Statement
Measurement uncertainty for h was improved by almost x4 relative to NISTs published value for a home-built system, refining the shadow sensor response was the major factor in this improvement.

Help Received
Thanks to my dad for subsidizing the necessary materials, helping me with the data acquisition and the poster graphics. Thanks to Gramps for gifting me the data logger and the voltage reference.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

David A. Lipman

Project Number

S1818

Project Title

Algorithmic Search of the Automated Planet Finder Spectra to Identify Extraterrestrial Laser Signals

Abstract

Objectives/Goals

This project analyzes the spectra of 157 stars, collected by the Lick Observatory's Automated Planet Finder (APF) telescope, to search for potential laser signals from extraterrestrial civilizations.

Methods/Materials

Spectra were analyzed to identify narrow peaks meeting the criteria for an artificial laser signal: Full width half maximum (FWHM) close to the telescope's point spread function value of 0.05 A, with Gaussian photon count in both the spectral and spatial dimensions, and at a wavelength that does not correspond to known emission lines for the host star or to atmospheric airglow lines. Pixel-by-pixel analysis of each spectrum was performed to identify peaks 3 standard deviations above the median. A simulated Gaussian curve was fitted to each peak to isolate highly Gaussian peaks with FWHM less than 0.075 A. False positives resulting from cosmic ray events were eliminated through a multi-step analysis process. The redshifts of stars containing candidate signals were calculated. Redshifted candidate signals were compared to known spectral emission lines and non-redshifted values compared to a database of atmospheric airglow lines to rule out natural phenomena.

Results

Three candidate laser signals were identified: HIP50583 at wavelength 3870.02 A, HIP39064 at wavelength 3870.06 A, and KIC8462852 (Tabby's Star) at wavelength 4357.42 A. The two candidate signals at 3870 A correspond with a cometary CN emission line, however it is highly unlikely they are due to comets, as the spectra for the stars were recorded on different dates. The Tabby's Star candidate corresponds closely with a krypton emission line at 4355.48 A which is redshifted by an equivalent amount to the star's underlying spectrum. However, krypton emission lines are not characteristic of this star type. The signal was only found in one of the two Tabby's Star spectra, further supporting the suggestion that it could be artificial.

Conclusions/Discussion

Although it is not possible to definitively conclude that the 3 candidate signals are of extraterrestrial origin, they meet the criteria for how a laser signal from an extraterrestrial civilization would appear. Currently, the APF has only recorded single spectra for each star, so each of the candidate signals requires follow-up observations to verify its existence.

Summary Statement

I developed an algorithm to analyze high resolution stellar spectra in order to identify potential extraterrestrial laser signals.

Help Received

I developed the algorithm myself after having been inspired by a tutorial on the Breakthrough Listen Initiative's website. One of the Breakthrough Listen scientists answered a few of my initial questions.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)
Emily E. McDermott

Project Number
S1819

Project Title
Light Absorption: A Project to Dye For

Abstract

Objectives/Goals
The objective is to understand how light is absorbed by pigments.

Methods/Materials
Different concentrations of food coloring were contained in small vials. Light was shown through them and the amount of light let through to the other side was measured by the analog light meter. A spectroscope was then used to identify what light waves were being absorbed.

Results
When graphed, the light was shown to be absorbed nonlinearly. More dye absorbed more light, but, with the smaller concentrations of dye absorbing more light per particle than the heavier concentrations. After a certain concentration, there is a point where light will still shine through, though adding more food coloring will have no effect.

Conclusions/Discussion
The ratio of pigment concentration to light is nonlinear. This means the electrons in the dye's atoms absorb certain energies of light more quickly than others, but once they are absorbed they can no longer be absorbed again.

Summary Statement
I meausered the amount of light that escaped through different consentrations of food coloring.

Help Received
My father gave me ideas for this project, I then relied on him for financial support.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Isabel E. O'Malley-Krohn

Project Number

S1821

Project Title

In Search of Planet 9: Locating through Computer Modeling

Abstract

Objectives/Goals

Recently, two Caltech researchers, Batygin & Brown (2016), found possible evidence of the elusive Planet 9. This discovery began a race among astrophysicists to prove or disprove the theory or, as in NASA's case, actually spot the potential planet in the sky. I aimed to input parameters of the possible ninth planet in our solar system into a computer program to support or refute its existence.

Methods/Materials

Computer, Matlab, notebook. Created/Found physics equations to model our solar system with and without Planet 9. Wrote code and ran two separate simulations.

Results

The results do not support the hypothesis; the percent error of the data is greater with Planet 9 than without and although the system oscillates on the z-axis, it is either the same as astronomical data nor is it above the margin of error.

Conclusions/Discussion

The computer model was truer to astronomical findings when Planet 9 was not a force in the system. The fact of z-direction oscillation does suggest some anomaly in that direction. This means Planet 9 either exists, just not where the parameters placed it, or does not exist at all.

Summary Statement

Using Batygin & Brown's proposed parameters, I wrote a computer program that models Earths solar system with and without planet 9 and found Planet 9 may exist but not with my specified parameters.

Help Received

Michael Saccone - UC Santa Cruz

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)
Avi S. Patel

Project Number
S1822

Project Title
Confirming the Coevolution of Supermassive Black Holes and Dark Matter Halos by Analyzing the Structure of Galaxy Bulges

Abstract

Objectives/Goals
I have reexamined the coevolution between supermassive black holes and dark matter halos by utilizing a unique method through a series of correlations. The first correlation is a relationship between the masses of supermassive black holes of galaxies and their respective galaxy bulge masses. The second correlation is a relationship between the masses of galaxy bulges and the circular rotation velocities of the galaxies. Using these two correlations, an indirect relationship between supermassive black holes and dark matter halos can be accomplished for all galaxies.

Methods/Materials
Data for supermassive black hole and galaxy bulge masses in solar masses is obtained from Kormendy & Ho (2013), and the MASSIVE Galaxy Survey. Data for the circular rotation velocities (km/sec) of galaxies was obtained from Bovy et al. (2012), Schulze & Gebhardt (2013), Sun et al. (2013), Kormendy & Ho (2013), and Saliba et al. (2015). In order to represent the galactic dark matter halos, I use circular rotation velocity because matter on the outskirts of galaxies is influenced by hypothesized dark matter halos that cause matter to rotate around the galactic centers at higher velocities than theoretical values suggest. Microsoft Excel was used for data analysis. For the first correlation, galaxy bulge mass(x-axis) is plotted against supermassive black hole mass(y-axis). For the second correlation, the circular rotation velocity(x-axis) is plotted against the galaxy bulge mass(y-axis), the data is segregated by galaxy morphology (Ellipticals, Spirals, or Lenticulars), and then the R^2 values are identified for each set of galaxies.

Results
The first correlation of supermassive black hole and dark matter halos of galaxies displayed a direct relationship for all galaxies with an R^2 value of 57.00% . The second correlation of the galaxy bulges and circular rotation velocities of galaxies showed an R^2 value of 61.95% for lenticular galaxies, and insignificant correlations for spiral and elliptical galaxies.

Conclusions/Discussion
My study demonstrates that my hypothesis was partially correct. There is a coevolutionary relationship between the supermassive black holes and dark matter halos for only lenticular galaxies. This finding demonstrates a greater understanding of dark matter and its influences on baryonic matter in galaxies as they evolve.

Summary Statement
I demonstrated a coevolutionary relationship between supermassive black holes and dark matter halos for lenticular galaxies through utilizing their galaxy bulges.

Help Received
Mrs. Messenger guided me through the research process. Mr. Messenger assisted me by providing feedback.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)
Nicholas A. Perez

Project Number
S1823

Project Title
Using Specific Heat Capacity to Engineer a Thermal Evacuation Suit to Address Heat Transfer Processes

Abstract

Objectives/Goals
To engineer a high heat conduction thermal evacuation suit that also addresses superheated penetrating gas. Suit will allow a person to escape a fire of temperatures reaching 980 degrees Celsius and convection heat of 32kph for five minutes without causing any permanent damage to the user.

Methods/Materials
Tested various silica for heat reflection and insulation. Modified sodium polyacrylate to achieve the highest amount of insulation while retaining full mobility. Once ideal combinations were found, I created prototypes and tested them on temperatures of up to 980 degrees Celsius and superheated penetrating gas up to 32kph. Recorded their times and temperatures to find their specific heat capacity and compared it against the current bunker gear used by firefighters. Test was designed to last five minutes in a scenario that would have the user exposed to 980 degrees Celsius in fully immersed flames and superheated gas. Independent variables: different types of silica fabrics, sodium polyacrylate compound, and Magna Nomex. Dependent variables: time of fire/heat resistance and superheated gas. Controlled variables (constants): propane torch, heat gun, charcoal briquettes, measurement tools (laser digital thermometer, Oneida digital thermometer probe, and anemometer), construction materials, and time exposed to open flame.

Results
The best light-weight full mobility thermal evacuation suit has the right balance of silica thickness and sodium polyacrylate compound with a safety layer of Magna Nomex. This combination addressed a full immersion fire of 980 degrees Celsius with superheated gas while allowing full mobility without harming the user for five minutes.

Conclusions/Discussion
Refrasil UC100-48 has the ability to be a high heat insulator and a shield from direct flame. The sodium polyacrylate compound proved to be a superior insulator and barrier to superheated gas. All silica are semi-conductors. Silica stops open flame from penetrating, but it conducts heats up to 400 degrees Celsius. The sodium polyacrylate compound is a high heat insulator, which effectively delays heat transfer. The compound also blocks any superheated gas due to its strong ionic bonds. The combination of silica and sodium polyacrylate compound produced latent heat graphs that had uniquely long plateaus that reached up to two minutes.

Summary Statement
To engineer an evacuation suit that addresses high intensity heat and superheated gas so that it allows the user to self-rescue with no bodily injury.

Help Received
Henry Modregon helped me understand the different properties and assisted me in testing the various materials. Captain Jaime Phillips provided me with first-hand accounts on the field.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)
Ritu R. Raj, Jr.

Project Number
S1824

Project Title
The Effect of Operating Temperature on the Efficiency of a Solar Cell

Abstract

Objectives/Goals
The objective was to study how the operating temperature of a solar cell effects it's power efficency.

Methods/Materials
3 solar cells, 1 on metal plate, on suspended in air with wooden dowels, one suspended in air with fan underneath, Infrared thermometer, metal plate, plywood, wooden dowels, Ammeter, voltmeter, panel mounted fan. Measured the temperature of each solar cell after sitting in sun for 30 min, amperage and voltage were recorded and wattage was calculated.

Results
The solar cell on metal plate had the highest temperature and lowest power efficiency, the one suspended in air had second highest temperature and second lowest power efficiency, the solar cell suspended in air with fan underneath had the lowest temperature and highest power efficiency.

Conclusions/Discussion
Over ten trials, it was found that as the operating temperature of the cell increases, the power efficiency decreases, representing an inverse relationship between operating temperature and power efficiency.

Summary Statement
The project tested how the power efficiency of solar cells are effected by operating temperature.

Help Received
None, I designed, created, performed, and analyzed the results myself.

CALIFORNIA STATE SCIENCE FAIR
2017 PROJECT SUMMARY

Name(s)

Raymond D. Ramlow

Project Number

S1825

Project Title

A Critical Analysis of Four Orbital Determination Methods under Varying Viewing Geometries

Abstract

Objectives/Goals

The objective of this project is to determine the efficacy of four methods of preliminary orbit determination (those of Olbers, Gauss, Herget and Laplace) under differing observational inputs.

Methods/Materials

A laptop, Python 2.7 with Numpy and PyFITS, MPC orbital data and several remote telescopes were used. All orbital determination methods and analysis were implemented in Python. Sample orbits for selected minor planets were used to generate lists of positions, and triads of these positions were then used to regenerate the orbital elements using the four methods while varying the characteristics of the triads used. Error from the original orbit was determined.

Results

The method of Herget was more accurate than other methods under all circumstances, with percent error from the original orbit falling under 1% for 80% of trials in which the orbit converged. For the Gaussian method, this value was 71%; for the Laplacian, this was 63%; for the Olbers, this was 55%. The Herget and Gauss methods performed especially well when the time intervals between observations in a triad were increasingly uneven.

Conclusions/Discussion

Methods of preliminary orbit determination are useful in providing orbits from limited data (3 observations) and are therefore important in determining the orbits of faint near-Earth asteroids that are only briefly observed. This project concluded that the method which produces the least error is the Herget method, and that this is what should be used in such circumstances.

Summary Statement

The Herget method is deemed to be the most accurate of four methods of preliminary orbit determination analysed.

Help Received

All necessary programs were written myself, and the methodology is my own.