CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Anoushka Bose; Julia Rathmann-Bloch

Project Number

S1701

Project Title

Toward a Better Model of the Extragalactic Background Light: The Value of Splines

Abstract

Objectives/Goals

Our research aimed to more effectively model the extragalactic background light (EBL), which is the sum of all the optical and infrared light that has been emitted since the stars lit up. Understanding the EBL has intrinsic importance, and it also allows us, for example, to estimate the rate at which the universe is expanding (the Hubble constant). However, because it is difficult to measure the EBL directly, we measure it through high-energy gamma ray interactions with the EBL. For gamma rays that reach earth, we can detect the light emitted by their particle showers using imaging atmospheric Cherenkov telescopes like those at VERITAS. Choosing splines, piecewise polynomial functions used for data interpolation, we developed a model of the EBL.

Methods/Materials

We considered over 20 types of splines. Because of their local control and linearity, we selected Basis Splines and Natural Cubic Splines to compare in more depth. We used CERN ROOT, a C/C++ data analysis environment, and the GNU Scientific Library to develop a spline interpolation method. We then applied it to gamma ray spectra from the VERITAS and other Cherenkov imaging telescopes, produced a model of the EBL, and integrated it into the 2015 Biteau & Williams data analysis protocol to assess our model.

Results

Our research produced two important results. First, that Natural Cubic Splines have improved local control when compared to the previous discipline standard of Basis Splines, which were used to model the EBL in 2008 by Mazin and Raue. Second, that Natural Cubic Splines model the EBL with at least as much accuracy, but with fewer parameters than the most recent approach in the field.

Conclusions/Discussion

The increased local control provided by Natural Cubic Spline interpolation mitigates excess noise and increases the accuracy of results using this type of data. Therefore, this method offers an improved approach to modeling the EBL.

With this research, we have also confirmed with greater confidence conclusions of previous models.

Summary Statement

We developed a spline interpolation protocol with which to analyze high energy gamma ray interactions with the extragalactic background light (EBL) and we produced an improved model of the EBL.

Help Received

We worked under the mentorship of Dr. Jonathan Biteau and Professor David Williams through the Science Internship Program at the University of California Santa Cruz.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Spencer M. Cheleden

Project Number

S1702

Project Title

Evaluation of Silver Based Astronomical Telescope Coatings

Abstract

Objectives/Goals

This project attempts to construct a multilayered coating, consisting of silver and other materials, for use in a telescope. The goals of this design are to maximize reflectivity of the telescope and to have a highly durable coating.

Methods/Materials

The coating lab at UCO Lick, University of California, Santa Cruz was the primary lab for this project. Various oxides, fluorides and nitrides, silver and aluminum were used for the coatings. Construct various combinations of these materials on top of silver and measure their optical and physical properties.

Results

The twenty materials originally selected were narrowed down to four for a final shortlist. These materials performed the best optically (when their reflectivity was tested) and physically (when subject to environmental stress).

Conclusions/Discussion

These results will be used in an upcoming paper about implementation of the coatings. This project gave the other researchers a material library from which to work.

Summary Statement

This project catalogues materials for use in astronomical coatings for use in reflector telescopes and their efficacy when combined with silver.

Help Received

Dr. Andrew C. Phillips of UCO LIck Observatories at the University of California, Santa Cruz provided the initial idea for this project. Mr. Brian Dupraw trained me to use the Coatings Lab at UCSC. I performed the sample production with Mr. Dupraw assistance and took all measurements by myself.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Jennifer J. Choi

Project Number
S1703

Project Title
Entangling Time Bin Qubits Using an Optical Switch

Abstract

Objectives/Goals
Quantum mechanics is a very relevant topic of the day as it is being used extensively in technology. These advancements largely involve the process of entangling qubits, which are basic units of quantum information (quantum bits). 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. The stages of the experiment included laser attenuation, photon pair generation, time-bin qubit preparation, time-bin qubit entanglement with a switch, and measurement.

Methods/Materials
In the first stage of the experiment, data was collected to attenuate the laser down to a single photon. The discriminator of the single photon detector was kept at 0.53 while the bias was varied in increments of 0.5 volts from 61.94 to 44.84 volts. A high-power fiber laser was also attenuated using ten light attenuators with loss of 8 dB each. In the second portion of the experiment, a Mach-Zehnder interferometer was constructed using fiber and two 50-50 couplers. Measurements of input and output power were taken from 1520 to 1560 nm. The structure was then used to test the functionality of the phase modulator, and MXA signal analyzer was used to find the peak intensity for each frequency and wavelength.

Results
The dark count (DC) and bias displayed an exponential relationship, while the DC and power displayed a linear relationship. The optimal bias amount was calculated to be around 54.94 volts. The optimal power to attenuate the laser was not found because the data did not include large enough DC values. The ratio of the output power to the input power versus the wavelength for the M-Z interferometer did not display the expected cosine or sine function. The functionality of the phase modulator was verified through recorded data.

Conclusions/Discussion
In order to find the optimal power input to obtain one photon per pulse, further must be done with a different number of attenuators. The results furthermore suggest that there is high loss, likely at the 50-50 coupler sites. DC variation also likely contributes to the discrepancy between theory and experimental results. In future work, a pump laser may be used rather than a fiber laser to decrease the loss from using fiber elements. We are also working on a setup to generate photon pairs through spontaneous parametric down conversion.

Summary Statement
I planned and carried out parts of a multi-step, long-term experiment to generate time-bin entangled qubits in real time and verify the entanglement.

Help Received
I would like to thank my research mentors, Dr. Yongnan Li and Professor Chee Wei Wong 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 would also like to thank Alvin Li for the

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Mariah G. Cox

Project Number
S1704

Project Title
The Effects of Building Materials Used in Sound Wall Construction

Abstract

Objectives/Goals
The objective was to see which building material is the most effective in sound wall construction. I thought that the slab of concrete would be the most effective because in my research I had read that concrete is the only material that does not produce echoes. Of the three materials I tested it was also the most dense.

Methods/Materials
I built two wooden boxes to keep out the outside noises. I used a laptop to generate the sounds in one box and a sound meter to measure them in the other box. I did a control with no wall between the boxes. I tested each building material between the boxes with three different sounds ten times each. I placed ivy over each building material and repeated the three sounds ten times each.

Results
When I averaged out the ten trials on the Urban Traffic Sound, the concrete blocks blocked out five decibels more than the 4x4 wood and one decibel more than the slab of concrete. When I averaged out the Tornado Siren Sound, the concrete blocks blocked out ten decibels more than the 4x4 wood and the slab of concrete was about the same as the blocks. When I averaged out the 522Hz Sound, the concrete blocks blocked out thirteen decibels more than the 4x4 wood and sixteen decibels more than the slab of concrete.

Conclusions/Discussion
If I were to build a sound wall I would build it out of concrete blocks because they proved to be the most effective. A material that is more dense might not be as effective at blocking sound as a material that is hollow inside. The sound waves reflecting off the inside of the hollow material lose energy and are absorbed by the material.

Summary Statement
I tested three building materials with three different sounds ten times each to see which material is the most effective in blocking sound.

Help Received
None. I designed, built, and performed the experiments myself.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Shashank Dholakia; Shishir Dholakia

Project Number

S1705

Project Title

A Search and Exploration of Multi-Exoplanet Systems Using Novel Photometric and TTV Algorithms for the K2 Mission

Abstract

Objectives/Goals

To date, over 5000 exoplanet candidates have been discovered orbiting around stars other than our Sun. However, the vast majority of planet systems discovered are considered to be single planet systems. Our own Solar System is a multi-planet system, which is thought to have been necessary for the formation of life on Earth. Yet it is poorly understood whether multi-planet systems are commonplace or rare elsewhere in the universe. In this project, we use the K2 mission to search for and analyze multi-planet systems with the goal of finding out what types of multi-planet systems exist. We hypothesized that we would only find multi-planet systems with short period planets smaller than Neptune because the formation processes of larger planets would gravitationally clear out their orbits.

Methods/Materials

The two most successful methods for discovering planets by far-the transit method and radial velocity-are both optimized for finding single planet systems, which explains the apparent dearth of multi-planet systems. However, the TTV method, which searches for gravitational "tugging" on transiting planets by unseen planets in a system, allows for the unbiased detection of multi-planet systems. We developed a novel algorithm in Python which uses the TTV method to perform a scalable search for multi-planet systems. Our algorithm starts with images taken by the K2 mission and creates light curves, graphs of brightness over time, for each star. Our algorithm then times each "lap" of known, transiting planets as they orbit their host stars. Variations in these "lap times" indicate the presence of other planets in the system.

Results

We found 4 potential multi-planet systems of which 3 are new discoveries. One of the systems has multiple transiting planets and exhibits TTVs consistent with theoretical TTVs from n-body simulations. Another multi-planet system likely has two hot-Jupiters, which could be an unprecedented finding.

Conclusions/Discussion

Our results indicate that multi-planet systems are highly diverse, and confirm the need to revise current theories of exoplanet formation. The method used in this project is also particularly important because it is the only method that can be used with current instruments to find habitable planets around Sun-like stars. In the near future, we will continue to use our algorithm to perform one of the first large-scale surveys for multi-planet systems.

Summary Statement

We create and use a novel algorithm to search for multi-exoplanet systems using the "crippled" Kepler mission, and find 4 potential multi-planet systems, 3 of which are new discoveries.

Help Received

We developed all of the algorithm, came up with the idea for our project, and analyzed our results. Dr. Ann Marie Cody at the Kepler building at NASA Ames Research Center provided helpful tips and advice on certain reduction techniques, as well as gave opportunities for follow up observations with ground

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Blake H. Haist

Project Number

S1706

Project Title

Infrared Irradiation of Calcium Hydroxyapatite to Remove Calcified Plaque

Abstract

Objectives/Goals

Test the ability of Calcium Hydroxyapatite, found in many calcification diseases, to convert infrared light to heat to break up calcified plaques.

Methods/Materials

Used infrared and deep purple light to test suspensions' ability to convert infrared light and deep purple light to heat insulted in a modified evacuated chamber. Solution had various concentrations of Calcium Hydroxyapatite in PBS and in DI water. Negative controls of pure solvent as well as positive controls of concentrated wetted and dry samples where tested. After these tests a calorimeter was used to quantify the heat conversion of the more effective light source. A resistor circuit in a bread board, LED, deep purple laser, a modified vacuum chamber, calorimeter, and temperature probe was used.

Results

The controls provided the clearest heating results for the first step. Infrared light was converted to heat through, Calcium Hydroxyapatite, more efficiently than the deep purple light was converted, as predicted. The heating was then quantified with a calorimeter in multiple trials.

Conclusions/Discussion

The Calcium Hydroxyapatite proved to be an effective source for converting infrared light to heat. With an infrared laser this conversion could be used to break up plaques effectively.

Summary Statement

Calcium Hydroxyapatite demostrates an ability to convert infrared light to heat for plaque removal.

Help Received

Donations from Thorlabs, Best Value Vacs, and Old Fashion Country Butchers. Safety and technical advice from Shane Dultz, Bill McGuigan, Greg Cauchon, Able Magana, Dr. Nikki Malhotra, and Timothy Hoag.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Tommy Hartman; Alfryd van Bruggen

Project Number

S1707

Project Title

The Curious Motion of Rolling Cylinders

Abstract

Objectives/Goals

The purpose of our project was to identify and explain the differences in the rolling behavior between a cylinder half-filled with a granular material (sand) and one that is half-filled with a fluid (water).

Methods/Materials

We half-filled a cylinder with either water or sand and then rolled it down a ramp onto the flat ground to provide a reproducible velocity. Time-lapse photography was used to measure the distance travelled at each interval. Pictures of the rolling cylinder were taken to show the motion of the sand and water. Based on our measurements we derived an equation that described the physical properties of these motions.

Results

At high velocities, the sand was held to the outside of the cylinder by centrifugal force, but at low velocities the sand fell to the bottom due to gravity, making the cylinder stop. From theory and our knowledge of the properties of the cylinder, we calculated that the centrifugal force and gravity would be equal when the velocity of the cylinder with sand was 56 cm/s. From our experiments we determined that the velocity at which rapid deceleration occurred was 58 cm/s, within the experimental error of our theoretical value. The cylinder of water had an initial velocity higher than that of sand, but with rapid deceleration at first then slower. Both of the materials had the same velocity at which the linear deceleration changed, but with opposite directions.

Conclusions/Discussion

Although our theorem accurately predicted the motion of the cylinder half-filled with sand, the cylinder of water did not behave as predicted. The fact that the water had a higher initial velocity was due to the water having less rotational energy because it had less friction with the interior of the cylinder, allowing more potential energy to be converted to translational kinetic energy. The cylinder of water slowed faster at first, because at higher velocities the water was turbulent before settling. Once the water settled on the bottom, the deceleration was reduced.

Summary Statement

The characteristics of a rolling cylinder half-filled with a fluid or granular solid is specific and can be defined mathematically

Help Received

Designed and implemented the project ourselves but received some help to confirm the accuracy of our math.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Hao Yang He

Project Number

S1708

Project Title

Quantum Physics and Glow in the Dark: Observing Luminescent Radiation in Glow in the Dark Materials (Phosphorescence)

Abstract

Objectives/Goals

The objective of this experiment was to determine if the brightness of light affect the luminescence of phosphors? And which phosphor (Zinc Sulfide or Strontium Aluminate) would emit brighter light, persist longer, and how do they differ?

Methods/Materials

Phosphors(Strontium Aluminate and Zinc Sulfide), light sensor, LED flashlight, Logger/Lab Pro hardware & software(online sourced, obtained from teacher), and wood & cardboard for experiment setup. Exposed respective phosphors to LED light for 10 seconds and measured resulting phosphorescence on light sensor for 400 seconds in dark conditions. Brightness of the LED input light was changed between 480 lux, 300 lux, and 130 lux and tested on the phosphors.

Results

The average was taken for the initial t=0 luminescent value and the time it took for the phosphor to no longer shine. The brightness of input light is proportional to the initial luminescence and persistence of each phosphor. Strontium Aluminate emits more light and persists than Zinc Sulfide but only at high input brightness(480 lux). Zinc Sulfide is consistent in light emission and persistence but does not perform as well as Strontium Aluminate at high input brightness.

Conclusions/Discussion

The performance of the phosphors is consistent with electrons in atomic energy levels which absorb light energy and releasing photons as they drop down energy levels. The persistence of phosphors indicate an electronic state that holds electrons within energy levels for longer periods of time. The experiment also shows differences in performance between Strontium Aluminate and Zinc Sulfide. Strontium Aluminate requires a high brightness threshold to perform adequately whereas Zinc Sulfide requires a low threshold and then is consistent throughout. Such difference can be caused by the phosphor's manufacturing process and other elements it was mixed with.

Summary Statement

I exposed two different glow in the dark materials (phosphors) to different levels of light brightness and observed trends in initial brightness, brightness over time, and its emission persistence.

Help Received

I designed the experiment myself but had some help from my dad constructing the setup. I also got advice from my chemistry teachers.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
James S. Kok

Project Number
S1709

Project Title
How to Hide an Airplane: A Study of Radar Cross Section, Year 2

Abstract

Objectives/Goals
To determine why certain shapes are used in aircraft and which radar systems perform the best in detecting these aircraft.

Methods/Materials
Black box, 2 LED Lights, LUX meter, shapes and 3 aircraft all white

Results
Sphere shape provided most light reduction compared to the control, wedge provided the least. Wedge shape provided most reduction when compared to corresponding 2-D cross section, cylinder performed the worst. F-22 had the lowest RCS reading on monostatic test, A-10 had the highest. A-10 had lowest RCS reading on bistatic/multistatic test, F-22 had the worst.

Conclusions/Discussion
In the 1st test the sphere performed the best due to its rounded shape design reflecting the light all in random direction. In the 2nd test the wedge performed the best by reflecting the light in a 2 uniform directions. The F-22 performed the best in the monostatic radar test due to its curved stealthy design. The A-10 performed the best in the bistatic/mulistatic test due to its small compact design.

Summary Statement
This project was made to determine which geometrical shapes and modern aircraft have the lowest radar cross section reading when compared to a various radar systems.

Help Received
Mark Grubb (Instructor), Debbie Lewis (Instructor)

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Spencer A. Krock

Project Number

S1710

Project Title

Static and Dynamic Shielding to Advance the Protection of Spacecraft from Cosmic Radiation

Abstract

Objectives/Goals

The purpose of the study was to compare different cosmic radiation shielding methods and materials to protect spacecraft and crew.

Methods/Materials

A self constructed cloud chamber was used to view the radiation provided by 0.91 microcuries of Americium from a smoke detector which is below the U.S. Nuclear Regulatory Commission's recommended safe handling limit of 1 microcurie. Additionally, a radiation exposure handling protocol was instituted based on the U.S. Department of Health and Human Services report titled, "Toxicological Profile for Americium." This ensured that safe exposure, defined by the National Committee on Radiation Protection and Measurements (CCR, Title 17, Section 30265), was met. The sample radiation shielding materials used in the study were made of carbon fiber, Kapton, a computer hard drive magnet, as well as a homemade electromagnet.

Results

In ranking the materials from least to most effective, the dynamic shields (computer and electromagnet) did not provide the protection described in research. The static shields (Kapton and carbon fiber) protected exceptionally well and blocked most visible radiation from penetrating the material.

Conclusions/Discussion

The tests showed that the static shields were the most effective in shielding from the radiation, and they could also potentially be used as dual use structural materials for spacecraft. Contrary to research, the dynamic shields did not show any means of protection from the radiation. However, the electromagnets in other research operated in different conditions. By comparing and looking at these materials and figuring out which work best in different situations we can travel further into space and the unknown.

Summary Statement

To test and compare potential shields to protect manned spacecraft from harmful cosmic radiation.

Help Received

The cloud chamber was built with assistance from my father, Dr. Kevin Krock. Also extraction and all close contact with the Americium was provided by Dr. Krock as well to minimize student exposure.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Samuel Munro; James Sunga

Project Number

S1711

Project Title

Effects of Added Weight and Tire Material on Climbing and Sliding Friction

Abstract

Objectives/Goals

The objective of this experiment was to show what kind of tires work best with different amounts of weight. If weight increases, then traction will increase no matter what tire material is tested. As long as weight is increasing, the tire material being used should not matter because of the equation F = μt W, where F is the force being exerted by the wheel,W is the weight,and μt is the traction coefficient or tire material.

Methods/Materials

The robot was built over the months of Nov. and Dec. 13 different weights were chosen. 0,1,2,3,4,5,6,7,8,9,10,15,and 20 lbs. Only added weight was tested. The 3 different tire materials were plastic, rubber,and a spray-on rubber. In the sliding tests, the robot was left to go down the ramp of 30° with different tires and weights on its own. In the climbing tests,current was applied to the motors to see how far it would go in 1 second with different weights and tires. The speed was recorded for each test in in/s with 3 trials for each combination of tire materials and weights.There were 234 tests total.

Results

For the sliding friction test with plastic wheels, speed decreased gradually, which showed traction was increasing. For the plastic wheel climbing friction tests the vehicle did not climb the ramp at all. The rubber wheel sliding tests were similar(did not slide down at all)except for the 20 pound tests,in which the weight overcame the lock. For the rubber wheel climbing tests, the vehicle traveled slow at first, then increased to 19 in/s where it then plateaued. For the sliding friction tests when the robot had rubber-spray coated wheels,it gradually slowed down as more weight was added. Finally,for the rubber-spray climbing tests,the robot's speed spiked and dropped sporadically.

Conclusions/Discussion

The original hypothesis was that increasing weight increased traction no matter what material was used. This was true for most of the tests. However, according to the climbing plastic test and the sliding rubber test,the experimental setup was slightly flawed.(The rubber did not slide downhill and the plastic could not drive up the ramp)Thus traction may actually have been increasing,but humans could not see it since nothing moved.That means is that there are three tests supporting the hypothesis,two tests that do not support the hypothesis,and one in which the data is invalid,which overall supports the hypothesis because 3/5 of the experiments support it.

Summary Statement

This project shows how the amount of weight and difference in tire materials effect the amount of friction and traction something has.

Help Received

We borrowed the robot materials and the testing surface from the robotics club. Other than that, everything was done ourselves.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Justin Nguyen

Project Number
S1712

Project Title
Behavior of Toroidally Confined Plasmas in Sub-Fusion Conditions

Abstract

Objectives/Goals
The objective of this study is to determine if a tokamak scaling law will still apply (in L-Mode) if reactor size is scaled down. Some goals include building an ultra-high vacuum capable chamber and producing a ICP within it.

Methods/Materials
Setup a Vacuum Chamber and pumped down to 10^-7 Torr. Using a RF generator (bought online) and a ion source (built by me using a car ignition coil, car battery and 555 timer circuit) a plasma was generated within the chamber. A Poloidal magnetic field was created with a coil which wound around the center solenoid. Used an langmuir probe (built by me with alumina tube, copper wire and tungsten lightbulb filament) oscilloscope and multimeter to measure plasma characteristics like electron and plasma current, number density, and other plasma parameters. Applied the tau e scaling law to my reactor to see if a correlation exists.

Results
The tau e scaling law does not stay true for extremely small reactors. The confinement time for my reactor was 8.2x10^-17.

Conclusions/Discussion
Small fusion reactors face many engineering issues that larger reactors do not necessarily have to encounter. In small reactors, magnetic confinement cannot be achieved to the same levels ass that of larger reactors due to the fact that there is superconducting material on earth that can handle the extreme heat fluxes of being very close to the plasma. Additionally, small reacotr sizes may introduce new forms of turbulence to plasmas, increasing instability and the amount of energy required to contain the plasma.

Summary Statement
I built a small scale tokamak to see if tokamak scaling laws will still apply when scaling reactor size down.

Help Received

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Minh-Thi Nguyen

Project Number
S1713

Project Title
The Effect of Dynamics on the Mass Functions of Globular Clusters

Abstract

Objectives/Goals
All star formation regions follow an initial mass function (IMF). For many years, it was assumed that there exists an universal IMF from one star forming region to the next. The objective of this project is to introduce a novel, unambiguous verification of IMF variation within a star region. We exploit the presence of multiple populations and mass segregation (dynamical evolution) in globular clusters and justify through N-body simulations.

Methods/Materials
Used series of N-body simulations through the Starlab software environment and kira integrator to model the 12 Gyr dynamical evolution of two star generations in multiple globular clusters over a range of various mass function slopes. Models reproduced the distribution of present day stellar masses of generations in the globular cluster. Used data obtained by Keck Telescope I to gain insight on chemical distribution of generations in GC 47 Tucanae.

Results
I created 5 different globular cluster models, each with 2 generations, with a specified input IMF for each generation. After evolving each model for a specific amount of time, I recorded the final mass function (PDMF) of each generation for each model. I found that the slope of each star generation's mass function evolves similarly to one another; the Generation 1 and Generation 2 of the GC experience the same dynamical evolution. If the slope of G1 < slope of G2 at t=0, then the slope of G1 < slope of G2 at the end of the evolution time, by nearly the same difference.

Conclusions/Discussion
I created five different globular cluster models to analyze the effects of dynamical evolution and mass segregation on the mass function slopes of two generations in globular clusters. Through the results, I conclude that the two generations of the globular cluster experience the same dynamical evolution. Evidence in the Globular Cluster 47 Tucanae suggests the existence of two different generations of different chemical abundances. This suggests that they have different Present Day Mass Functions. Through the model results, if the two generations differ in the PDMF, they would also differ in the IMF, thus allowing us to find the clearest evidence to date for IMF variation in the most extreme star formation environments.

Summary Statement
I analyzed the effects of dynamical evolution on the mass functions of generations in globular clusters through a series of N-body simulations to introduce a novel, unambiguous verification of IMF variation.

Help Received
I developed and ran the simulations and analyzed the results on my own personal laptop. I consulted Dr. Evan Kirby from the California Institute of Technology, who gave me insight on the development of my project. Dr. Sverre Aarseth from the University of Cambridge helped me understand the Nbody code for

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Hale R. Obernolte

Project Number

S1714

Project Title

The Relationship between Trajectories with and without Gravity

Abstract

Objectives/Goals

The purpose of this project is to discover a definite relationship between the trajectories of a projectile fired at the same angle and velocity both with and without gravity at any point of the trajectory.

Methods/Materials

This project is purely mathematical/theoretical and requires no materials.

Results

The result of this project is the equation (1-Te/T) * tan(x) * (Dh * Te/T) = Vi * Te + (1/2) * A * Te^2, a mathematically proven equation which displays that at X% (elapsed time) of a trajectory with gravity, the projectile will be at (100%-X%) of the vertical height it would be at if it was not acted upon by gravity.

Conclusions/Discussion

Manipulation and investigation of Projectile Physics equations yielded that at X% (elapsed time) of a trajectory with gravity, the projectile will be at (100%-X%) of the vertical height it would be at if it was not acted upon by gravity. This is a definite relationship between trajectories with and without gravity that not only allows us to easily determine the height a projectile would be at if it was not affected by gravity, but also enhances our general understanding of projectiles and their trajectories.

Summary Statement

By manipulating projectiles equations, I discovered that at X% (elapsed time) of a trajectory with gravity, the projectile will be at (100%-X%) of the vertical height it would be at if it was not acted upon by gravity.

Help Received

Both my High School Physics teacher (Mr. Joe Bradley) and Calculus teacher (Mr. Chris Leong) looked over my final project to confirm that all manipulations of equations were legitimate.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Matthew D. Sandoval

Project Number
S1715

Project Title
The Effect of the Magnitude of RR Lyr on Its Temperature

Abstract

Objectives/Goals
The objective of this study was to determine if there is a relationship between the magnitude of RR Lyra and its Temperature

Methods/Materials
Telescope, CCD Camera, Alpy Spectrometer, ISIS Spectroscopy Software, CCDSoft. Took a series of RR Lyra spectra along one pulsation cycle along with calibration images. Also took a series of photometry images and calibration images to use differential photometry and compare the temperature to the magnitude.

Results
There was a direct relationship between the temperature and the magnitude of RR Lyra.

Conclusions/Discussion
The results of this study support the research done by Sir Arthur Eddington and his theory of why variable stars pulsate. The direct relationship may provide a method for determining the temperature of RR Lyra based on its magnitude.

Summary Statement
I found that there was a direct relationship between the magnitude and temperature of RR Lyra.

Help Received
My mentor, Robert Buchheim, provided the telescope as well as other materials and software for my project. He also taught me how to do the data reduction on the images.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

Emma R. Schaefer-Whittall

Project Number

S1716

Project Title

Time to Score: The Physics of Penalty Kicks

Abstract

Objectives/Goals

I compared the speed of the fastest penalty kick with the time it takes the goalie to reach the goal post. I also tested how a player can kick it the fastest and how a goalie can get to the post the fastest.

Methods/Materials

I surveyed my soccer team for penalty kicks using an Adidas Smart Ball that measures speed. Each player kicked 3x for one, three, and five steps before kicking. I also measured the time it took for several goalies to reach the post during a penalty kick by counting the number of frames in a GoPro video. I compared the goalies' times with and without revealing the direction of the kick.

Results

Of the 12 kickers, the fastest one (61 mph) took five steps before kicking the ball. At this speed the ball would travel to the bottom corner of the goal in 424 milliseconds. All players that I tested kicked it the fastest when using their dominant foot. Of the four goalies that I tested, the fastest one could only reach the post in 767 milliseconds so it was significantly slower than the fastest kick. On average, the goalies are 2.3 mph faster if they know the direction of the kick. Two out of three goalies were faster going to the side of their dominant hand. Only the slowest kick (30 mph) will be saved by the fastest goalie.

Conclusions/Discussion

Out of all the kicks I tested, 78% would have scored against the fastest goalie. Any kick over 34 mph to the bottom corner of the goal will arrive before the fastest goalie. Based on these results, a goalie's only chance at saving a PK is to correctly predict the direction of the ball and begin moving before the ball is kicked. In the end, whether a PK scores is up to the kicker - the laws of physics favor the kicker. It is the kicker's "time to score".

Summary Statement

I measured the speed of players' penalty kicks and the speed of goalies to determine which is faster.

Help Received

None. I designed and performed the experiments myself.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Michael M. Steel, II

Project Number
S1717

Project Title
Stealthy Shapes: What Geometric Shapes Scatter the Most Electromagnetic Energy?

Abstract

Objectives/Goals
The objective of this study is to determine which of eight 3-D geometric shapes scatters the most light, by using a lux meter to measure reflected light.

Methods/Materials
Black-paper lined cardboard box, lux meter, led flashlight, various paper shapes.

Results
The shapes in order from ones that scattered the most light (reflected least light) to scattered least light (reflected most light) are:

Black Flat Face (54.07 lux Average)
2-inch V-Shape (114 lux average)
4-inch V-Shape (261 lux average)
2.5-inch W-Shape (699 lux average)
Crumpled Cylinder (844 lux average)
Cylinder (858 lux average)
1- inch WW-Shape (919 lux average)
3.5-inch W-Shape (946 lux average)
Flat Face (1297 lux average)

Conclusions/Discussion
It turned out that my hypothesis was partially correct. Both of the V-Shapes reflected much less light than the shapes without sharp edges such as the cylinder and flat face. However, I found that the W-Shapes and the WW-Shape reflected about the same, or more light than the cylinder, although all were less than the flat face. I discovered that it really depends a lot on the distance between the peaks on the shapes. The wider the shape was, the more light it reflects back.

Summary Statement
I showed that the amount of light reflected from an object depends on the shape of the object.

Help Received
I designed, built, and performed the experiments myself. My Physics teacher loaned me a lux meter for taking measurements.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Ethan M. Uetrecht

Project Number
S1718

Project Title
Assessing the Practicality of NEO Deflection Strategies Using Simulation, Year 2

Abstract

Objectives/Goals
In the absence of human intervention, a collision between a near-Earth object (NEO) and Earth is inevitable. In an attempt to predict and prevent possible collisions, scientists are currently detecting and monitoring NEOs and have proposed numerous strategies for deflecting them should they become a real threat. The purpose of this project is to determine the practicality of three selected deflection methods by simulating their overall effectiveness.

Methods/Materials
Two example NEOs were chosen for this project: the asteroid Apophis and the comet Tempel-Tuttle. Three selected deflection methods were examined: kinetic impact, solar ablation, and standoff nuclear blast. The trajectories of both Apophis and Tempel-Tuttle were modified to collide with Earth, and each of the three deflection methods was mathematically modeled and their effects on the NEOs were simulated.

Results
The kinetic impact method, which has a technology readiness level (TRL) of nine, was found to be successful in deflecting the asteroid but not the comet. The ablation method, which has a TRL of two, was found to be more effective than kinetic impact at deflecting the asteroid but was not able to deflect the comet. The standoff nuclear blast method, which has a TRL of six, was found to be most effective at deflecting the asteroid and was also successful at deflecting the comet.

Conclusions/Discussion
While each of these methods can be successful depending on the situation, no single method seems to be the best choice for all possible situations. This analysis contributes to understanding which method is appropriate in a given situation.

Summary Statement
The practicality of different NEO deflection methods was studied using simulation; it was found that the most practical method is dependent on the given situation.

Help Received
Mr. David Uetrecht mentored me and helped me write the Matlab simulation codes. My teacher, Mr. Peter Starodub, guided me through the research process.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Evan G. Vail

Project Number
S1719

Project Title
Examining Far and Near-Field Doppler Shifts

Abstract

Objectives/Goals
The objective of this project was to be able to determine how observed frequency shifts in a practical, classical Doppler effect setting at different distances between the emitter and moving observer (me, on my bicycle) and why.

Methods/Materials
I essentially attached my phone to the handlebars of my bicycle with the spectral analysis app opened, and rode my bike in a straight line in a parking lot. On that straight painted line I set up tape markers at different distances and later on I set up little clothes pin nubs on those markers to make a clicking sound as I rode over them. I set up my keyboard away from that line at different distances and would ride past as my father held a key on the board. I repeated multiple trials for different distances and saved the data on my phone before I transferred it to my computer.

Results
In the end, my results supported my hypothesis that larger, faster-appearing shifts would happen with the smaller observation distances and the opposite for the larger observation distances within each test distance. I had slightly off kilter results between some of the different test distances because of the fact that I'm a human and I was riding a bicycle, so I couldn't keep my speed exactly the same the entire time. I wrote a simple equation heavily based upon the classical Doppler Effect equation that I first used approximate the results from my individual runs. Once I saw that it worked accurately for these, I then used it to generalize what happens for different test differences and constant hypothetical speeds and it proved my hypothesis true.

Conclusions/Discussion
Today there are already tons of implementations of the Doppler Effect. Whether it's taking readings and measurements from blood, using redshift and blueshift to measure the spin of a galaxy, or navigation undersea, the Doppler Effect is extremely important. The experiment I have conducted this year demonstrates some of the basic principles of this phenomenon, and I discovered how sound frequency from our perspective shifts when you or the object making the sound is moving at different distances. This could be potentially important as I plan on using this new knowledge to find a way for police cars to track down illegal firework usage on July 4th.

Summary Statement
In this project I used sound from a keyboard, spectral analysis software on my phone, and the motion from my bike to analyze Doppler shifts at different distances from my frequency emitter.

Help Received
My father helped me in transporting me to conduct my experiment, in pressing the key on the keyboard to provide the sound for my experiment, and in providing the materials for my experiment.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Sydney A. Walthall

Project Number
S1720

Project Title
Radiation Shielding: Testing Simple Radiation Shielding Methods in a Cloud Chamber

Abstract

Objectives/Goals
The objective of my project was to determine what types of materials are most effective in blocking alpha and beta radiation. I hypothesized that all the tested materials would be able to block radiation, but that the aluminum foil and cardboard would work better than the paper, cloth, or plastic wrap.

Methods/Materials
A cloud chamber was constructed and a lead 210 (210Pb) needle radioactive source was obtained for this experiment. The cloud chamber was used to indirectly observe the condensation trails of radioactive decay particles from the lead 210 needle. To test each material, aluminum foil, cardboard, plastic wrap, paper, and cloth, the lead 210 needle was wrapped with the material being tested. The number and type of condensation trails formed by radioactive decay particles in the cloud chamber were counted and described. Each material was tested three times.

Results
All the radiation shielding materials tested significantly reduced the number of observed radioactive particles in the cloud chamber. Paper and plastic were the most effective at blocking radiation because no condensation trails were observed in those tests. A small number of radioactive particles were observed in the cardboard and aluminum foil tests, probably due to incomplete coverage.

Conclusions/Discussion
My conclusion is that radiation found in the natural world, alpha and beta particles, can be blocked by basic everyday materials, like clothes, cardboard and plastic.

Summary Statement
I conducted experiments in a cloud chamber to determine the ability of different materials to block alpha and beta radiation.

Help Received
I built the cloud chamber and conducted the experiment myself, and I used the Science Buddies website for instructions on how to build a cloud chamber.

CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)
Tamika C. Whitenack

Project Number
S1721

Project Title
Flute Frequencies

Abstract

Objectives/Goals
This experiment aimed to discover more about the nuances of flute playing. I am a flute player and wanted to find new ways to control the sound produced by the flute. I chose to look at the relationship between the angle of air into the flute has with the purity of frequency, which I observed as the different number of harmonics present.

Methods/Materials
Flute, airstream, Logger Pro equipment, protractor
Tested relationship between angle and purity of frequency by controlling the angle of air into a flute and measuring the resulting frequencies. Logger Pro equipment was utilized to collect the frequency data, and the number of frequencies and the amplitudes of these frequencies was collected for each different angle to determine the purity of frequency.

Results
The evidence supported the hypothesis and showed a trend of an increased angle resulting in a decrease in purity of frequency. These results are useful to flute playing because they show that the number of harmonics present can be controlled.

Conclusions/Discussion
Angle of air into the flute does have an effect on the resulting frequencies. The results are useful for controlling flute sound but might not be applicable to flute playing because this experiment did not evaluate the overall sound and tone of the flute, only the purity of frequency. From a musical perspective, the overall sound produced by the flute is the most important aspect of flute playing, and from this experiment I discovered that the best tone quality and the purity of frequency do not correlate. Further experiments could be performed to explore other factors that contribute to an ideal flute sound

Summary Statement
I investigated the relationship between the angle of air into a flute and the resulting purity of frequencies (measured by harmonics present).

Help Received
My Physics teacher, Mr. Fabini, helped me to form my project idea and research and provided me with the Logger Pro equipment.