Name(s)
Caden Annison

Project Number
J1801

Project Title
Determining if Concrete Is a Liable Screen against Galactic Cosmic Radiation

Abstract

Objectives/Goals
The objective of this experiment is to create a detector, and measure and differentiate natural secondary cosmic particles above and below concrete with steel reinforcement.

Methods/Materials
Plastic rectangular fish tank, black felt, black card stock, 11 gauge steel, styrofoam cooler, block of dry ice, heating pad, video recorder, molding clay, categorize and count each type of secondary particle detected above and below concrete.

Results
Once the particle detector had reached its max efficiency, nine total 30 second trials were recorded above concrete. This same process was used again below concrete with steel. The secondary particles detected were categorized into comparable charts, with a section pertaining to one of the four possible outcomes from the chamber: electron/positron, alpha particle, muon, and unidentifiable. With concrete acting as a shield, almost all secondary particles were able to be screened. While almost all particles were screened, muons remained present. These accounted for more than 70% of below concrete occurrences.

Conclusions/Discussion
Being under six inches of concrete with reinforced steel in comparison to being above greatly reduces secondary particles. Although muons proved to be able to penetrate extremely well when compared to other highly interactive secondary rays under concrete. Therefore, occupants below six inches of concrete with steel reinforcement are still vulnerable to muons. This result is a step towards reducing and even stopping the negative effects of cosmic rays on certain types of highly sensitive technology and protection for astronauts against high energy particles in space.

Summary Statement
After measuring and categorizing the secondary particles created by galactic cosmic rays with and without shielding, I found muons were not as susceptible when screening secondary particles.

Help Received
I built the particle detector myself and researched all information on my own. I received a brief overview of how a cosmic ray works from a PHD student at Stanford University, which led me to continue further research of my own. I received help from a parent obtaining all the necessary materials, handling the dry

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
John Bailey; Bobby Ikeda

Project Number
J1802

Project Title
Density Fluctuation Relative to Temperature

Abstract

Objectives/Goals
This experiment is to test how temperature affects the density of various liquids through a measure of buoyancy. We predict that while most liquids have a predictable rate of increased density at lower temperature that water is an anomaly having its greatest measure of density just prior to the point of freezing.

Methods/Materials
A freezer, ice, and salt to cool and super-cool the liquids. A stove, pan, and Pyrex container to heat and hold heated liquids. A plastic vessel, coins, paperclips, thermometer, and scale to conduct measurements.

Results
The hypothesis for water was supported by our data, and there was a peek at 4 degrees Celsius, but the hypothesis for the other liquids was only partially supported. Although the density was always higher at 0 degrees Celsius than at 65 degrees Celsius the measurements of density tended to fluctuate along the temperature scale.

Conclusions/Discussion
Our data showed that there was an anomaly with the density of water relative to temperature that was inconsistent with other liquids. We feel that inconsistencies in the data in regards to the other liquids was primarily due to our inability to precisely and consistently control the conditions of the experiment. Understanding the anomaly in water density has implications to engineering, as well as, maritime travel and commerce.

Summary Statement
We tried to demonstrate that while most liquids have a predictable rate of increased density at lower temperature that water is an anomaly having its greatest measure of density at 4 degrees C. prior to the point of freezing.

Help Received
We received general advice from our GATE teachers and from my father who assisted in controlling the temperatures during the experiment.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Maya A. Basu

Project Number
J1803

Project Title
Predicting the Interference Pattern from a Double and Triple Slit Experiment with Geometry

Abstract

Objectives/Goals
My objective is to confirm or refute equations I have derived predicting the interference pattern from double and triple slit experiments.

Methods/Materials
I wrote a program in Google Spreadsheets which graphed the interference pattern for two and three slits over varying experimental parameters. I built a clear Acrylic water wave table, and shone a light through the table. The light projected the wave patterns as shadows below. I created waves using a solenoid oscillating with two and three pointed attachments I designed and 3D printed. The solenoid was controlled by an Arduino through a relay, and powered by a DC power supply. The Arduino ran a program I wrote, allowing me to control the wave frequency. I measured the least and greatest distances between the innermost interference areas 5 cm from the point of emanation over various frequencies, to compare with my predictions.

Results
I compared my predictions with the measurements from the wave table for both the double and triple slit setup over various frequencies. 75% of the data points matched the prediction, and 100% of the data points were within the margin of error introduced through the measurement process.

Conclusions/Discussion
I set up my experiment to disprove my equations, which predict the interference patterns of double and triple slit experiments over varying experimental parameters. In contrast, the data I took supports my hypothesis by showing that my equations accurately predict the interference patterns resulting from double and triple slit setups.

Summary Statement
I derived equations using analytic geometry and trigonometry that predicted the interference patterns resulting from double and triple slit setups, and validated them with data taken from my physical experiments.

Help Received
My dad showed me how to use Google Spreadsheets as a programming environment.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Michael E. Dahlgren

Project Number
J1804

Project Title
Impact Forces

Abstract

Objectives/Goals
I wanted to determine if two objects of equal mass and each traveling the same speed would each experience an impact force equal to a third object of equal mass traveling at twice the speed hitting an immovable object.

Methods/Materials
A duel arm pendulum swing was built to collide soda cans into each other and then into a solid object giving me results with repeatable outcomes and consistent measurable speeds. A camera using slow motion along with a grid was used to formulate and verify mph. The length of the soda cans were measured before and after each impact to determine the stopping distance which allowed me to calculate the amount of force applied to each can. The above process was repeated four times for each speed used.

Results
2 soda cans colliding into each other at 4 mph measured a stopping distance of 10/32 in. while 1 colliding into a cinder block at 8 mph measured a stopping distance of 26/32 in. Therefore, they do not have the same impact forces. In this case, 2 x 4 mph collision does not equal an 8 mph collision, thus proving my hypothesis correct that the impact force will be greater on the one object going twice the speed. A single car collision into a solid wall at 80 mph will have more damage than two 40 mph cars hitting head on.

Conclusions/Discussion
The results showed that the impact forces were the same for the two objects traveling 4 mph when added together and the 8 mph collision into the solid object, however the energy was split between the two-object collision and therefore the stopping distances were not equal. This supported my hypothesis that a single car collision will have more damage. This project helped me understand how damage and injuries occur between moving objects and how crumble zones built into newer cars can absorb energy and save lives.

Summary Statement
To disprove that a two car collision will have the same impact force as one car hitting a solid wall at twice the speed

Help Received

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Adrian S. Derderian

Project Number

J1805

Project Title

Probing Photons with Polarizers, Counting Them with Cosines

Abstract

Objectives/Goals

The objective of this project studies the effects of introducing photons into polarization sets. Specifically, this project applies and extends Malus' Law, which states that when polarized light traverses a polarizer, the intensity of the departing light will equate to the intensity of the incoming light multiplied by the cosine squared of the angle between the transmission axis of the polarizer and the initial plane of polarization. Further, it derives new mathematical equations based on extending Malus' Law.

Methods/Materials

The intensity proportions of the Equiangular Polarizer Configuration and the Two Polarizer Configuration were calculated using a flashlight, green laser, and LUX meter with varying numbers of polarizers. In total, 152 trials were conducted. F-tests and t-tests, were conducted to test the statistical significance of certain treatments of data. Also, six Java classes were coded to simulate each polarizer configuration. Equations were derived to calculate the intensity proportion of each of these sets using calculus.

Results

It was found that the measured data from the Two Polarizer Configuration supported Malus' Law when the reflections caused by imperfect polarizers were taken into account. Further, a statistical t-test was used to compare the experimental and theoretical results, which resulted in the acceptance of the null hypothesis, confirming Malus' Law.

Additionally, the intensity proportion of the Equiangular Polarizer Configuration was compared to the computer simulation output, and there appeared to be a pattern that described the propagation of error as the number of polarizers increased. Because imperfect polarizers reflect a constant percentage of light, the theoretical intensity proportion must be multiplied by the light reduction proportion for every polarizer to align with the experimental results. After researching the literature, the proportion turned out to be related to the HN value. Since the light reduction proportion was calculated to be 0.8, the polarizers were therefore equivalent to HN-40 quality.

Conclusions/Discussion

Overall, the results supported Malus' Law while new mathematics was derived extending it. The Java programs successfully simulated novel polarizer configurations, which may have applications in the construction of adjustable brightness in windows. In conclusion, this project confirmed Malus' Law and revealed some previously unknown concepts.

Summary Statement

This project confirms and expands upon Malus' Law by measuring the intensity of light traversing various polarizer configurations.

Help Received

I collected the experimental data, coded all six (6) Java programs, and conducted the t-test and F-test. My Java mentor taught me Java since I was 10, while my mother taught me how to perform the t and F tests.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Jennifer A. Dick-Peddie

Project Number
J1806

Project Title
The Effect of an Object's Velocity, Size, and Mass on the Diameter and Depth of Its Impact Crater

Abstract

Objectives/Goals
The objective of this study is to understand how the size, mass, and velocity of a meteor relates to the size of the crater it makes upon impact.

Methods/Materials
I used direct measurement, using a caliper, to identify the diameter and depth of impact craters made by objects of different size, mass, and velocity, after impacting a surface made of packed flour and topped with cocoa powder.
Materials included: Balls of different weights, sizes, and densities; box, flour, cocoa powder, tape measure, caliper, notebook, graph paper, hook and string, rod.

Results
Experiment #1: The larger and heavier object created a wider and deeper impact crater than a smaller object of the same density, traveling at the same speed and same drop height. Experiment #2: The heavier object of the same size created a deeper crater, on average, when dropped from the same height. Experiment #3: Objects traveling at higher velocity upon impact create wider and deeper craters than objects with lower velocity, everything else being equal.

Conclusions/Discussion
When a meteor strikes a planet, it will likely cause a crater at the impact site. The faster the object is moving, and the larger or heavier the object is, the greater the crater size will be. The velocity and the mass of the meteor are the greatest factors that predict impact crater size. I was happy to see the results of these experiments were consistent with the research findings, and support the hypothesis. Knowledge of this topic is important for scientists for many reasons; one of them is to understand impact size and be able to identify those space objects that are large enough to be a threat to Earth.

Summary Statement
This project demonstrated that objects with greater mass, higher velocity, and greater density will create wider and deeper impact craters than smaller and slower moving objects.

Help Received
My parents helped me set up the materials for the experiments, and took pictures during the process. I conducted all of the experiments and documented the results.

Name(s)
Arijit Ghoshal

Project Number
J1807

Project Title
The Effect of the Thickness of Reeds on the Timbre Produced by Woodwind Instruments

Abstract

Objectives/Goals
The objective of this experiment is to determine how the physical properties of a reed relate to the timbre (or quality of sound) produced by a musical instrument. Notes from instruments have multiple frequencies: the fundamental, which is the primary note, and several overtones. Overtones are frequencies that are an integer multiple of the fundamental frequency. Timbre, or quality of sound, is characterized by the number and loudness of overtones in the sound. My hypothesis was that thinner reeds would create more overtone because they would vibrate faster. This would produce a bright and punchy tone, such as a square wave, which is full of overtones, would. Thicker reeds would create fewer overtones because they would vibrate slower. This would produce a mellower sound, such as a pure sine wave would.

Methods/Materials
Three reeds of different thicknesses were played on a clarinet and a saxophone. Two notes (B flat 3, 233.08 hz, and F5, 698.46 hz) were played on each reed on each instrument. The resulting sounds were analyzed using a software called Visual Analyser. To find the difference in timbre produced by different reeds, the frequency spectrum of the sound was examined. The frequency spectrum is a graph showing all the overtones present in a sound and their respective loudness.

Results
For the lowest note tested, the thinnest reed produced around 37 overtones on the clarinet and 34 on the saxophone, while the thickest reed created 22 overtones on the clarinet and 27 on the saxophone. For the highest note tested, the thinnest reed made 15 overtones on the clarinet and 14 on the saxophone, while the thickest reed produced 11 overtones on the clarinet and 12 on the saxophone. In addition to this, the thinnest reed had a greater loudness for most of the higher overtones.

Conclusions/Discussion
My hypothesis was proven correct. The results indicate that the thinnest reeds create more overtones in the sound, while the thickest reeds created fewer overtones. The thinner reed, which makes a bright, punchy sound, could be used for jazz playing, while the thicker reed, with its soft and mellow tone, could be for classical playing. Using this data, musicians who play reed instruments can find out which reed to use based on their sound preference.

Summary Statement
This experiment shows that the quality of sound and the number of overtones produced by a reed instrument is dependent on the thickness of the reed used.

Help Received
I received advice and ideas from my science teacher Mrs. Sujatha Raghu, and mentors at the school science club, Tsing Bardin and Edmond Pelta, as well as from my parents. My mother and sister helped me with the board.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Amara J. Kelley

Project Number
J1808

Project Title
The Muon Detective

Abstract

Objectives/Goals
To build a working particle detector and test for baseline particle count flux based on elevation and protected locations such as caves and overpasses with sufficient density to shield levels of particle bombardment. I was inspired by a National Geographic article where scientists were able to identify a hidden chamber at the Great Pyramid in Giza. Using muon detectors they found anomalies in particle count which identified a hidden void in what should have been solid stone. I built a detector using the CosmicWatch website and collected data at specific locations to establish a baseline particle count. Once a baseline was established I tested locations to identify the effects of particle flux with shielding as a factor such as in a cave or under a highway overpass.

Methods/Materials
The components and software to build a working particle detector. Once the detector was built and tested, I monitored particle counts at locations in various conditions and at different elevations. I determined averages for each location and identified any anomalies which did not correlate to the predicted condition/elevation. After learning all of this, I used the detector to do home experiments with different materials (plastic, water, gravel) to model potential shielding options.

Results
Elevation and density of ceiling (inside of a cave or under a highway overpass) did affect the count. Higher elevation equaled higher count and a thicker density of ceiling equaled a lower count. Weather was also a factor. Heavy rainfall equaled a slightly lower count and snow equaled a slightly higher count. There were also specific days that experienced higher counts which seemed to coincide (plus or minus a day) with solar flares. Temperature and time of day were not factors.

Conclusions/Discussion
After monitoring and recording counts at locations, I created a predictable model which helped determine profiles for locations as well as ideas for shielding people from major cosmic ray events. From these results, I eliminated certain variables that I originally thought might affect average count. I also discovered an anomaly in my local area with a higher than expected average count that could be attributed to background radiation from a power plant.

Summary Statement
I built a working particle detector and tested locations based on elevation and conditions to determine average particle bombardment levels as well as investigated particle shielding materials.

Help Received
My parents helped with muon detector build and drove me to the data collection locations. Tyler Hooker at the HSU Physics Dept assisted with software and troubleshooting.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Alex Puga

Project Number
J1809

Project Title
Vibrating the Oil-Water Mixture to Infer Water Cut

Abstract

Objectives/Goals
This experiment is based on the fact that Water Cut measurement continues to be a challenge in the oil industry. The purpose of this project is to determine what type of correlation exists between the total water percentage in an oil-water mixture and the frequency emitted by a vibrating tuning fork in that medium, as a means of testing a possible alternative to current Water Cut measuring technologies; and if this relationship can be used to infer the Water Cut in a given mixture.

Methods/Materials
For this experiment, tap water and Motor Oil were utilized. A Rosemount 2140 Level Detector, a tuning-fork like device, was used to measure the vibration frequency of the tuning fork when immersed in different volumetric oil-water ratios. Multiple readings were taken for each ratio, and later graphed in Excel.

Results
It was confirmed that there is a correlation between the vibration frequency of a tuning fork and the Water Cut in the target medium. As the Water Cut increased, the frequency emitted by the tuning fork when immersed in the medium would decrease. The equation and graph generated by Excel showed that the correlation between frequency and Water Cut is polynomial.
This relationship can be used to infer the Water Cut in a given oil-water mixture by measuring the frequency of the tuning fork. However, this method of measurement appears to have some limitations in the upper Water Cut levels - that is, values greater than 90% Water Cut.

Conclusions/Discussion
Water Cut measurement continues to be a challenge in the oil industry. In fact, technology is still seeking for and developing alternative methods of measurement that are simpler and accurate, as quick and precise Water Cut measurement is essential to the oil industry for many reasons. This project serves as an alternative method for the measuring the Water Cut of an oil-water mixture by using the frequency of a vibrating tuning fork to infer the water percentage in the target medium. In addition, this technique could also be used to determine the interface level in a three-phase separator.

Summary Statement
The frequency at which a tuning fork vibrates in an oil-water mixture can be used as an alternative method for determining the Water Cut (water percentage) in that mixture.

Help Received
A Rosemount 2140 Level Detector was utilized in this project with the help and supervision of my father.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Devin Ross; Sadie Stout

Project Number

J1810

Project Title

How Fast Is the Universe Expanding?

Abstract

Objectives/Goals

The goal of our experiment is to use spectrographs to find how fast the universe is growing. We hypothesize that the universe is expanding at a rate of 80 km/sec/Megaparsec because past results have shown an increase over time, so we predict there should be a proportional increase.

Methods/Materials

Using spectrographs from the Las Cumbres Observatory (LCO) database, we found observed and rest H, Fe, O spectra of Type 1A supernovae; calculated redshift to find the radial velocity; used distance modulus equation to find distance; made a Hubble Diagram indicating the expansion rate of the universe.

Results

We found the expansion rate is around 55 km/second/Megaparsec. Also, we discovered that the farther away the supernovae, the faster it is moving away from us.

Conclusions/Discussion

Our results did not support our hypothesis. To improve significance, we are continuing to find more supernovae to measure. If our results are accurate, then the expansion rate of the universe is decreasing, and will eventually stop. By showing galaxies are moving away from each other, our results also support the idea of the Big Bang. Future research could compare spectra between distant (therefore older) stars vs closer stars. We hope to continue this or other work on the FLOYDS Telescope in Haleakala, Hawaii.

Summary Statement

We used various internet resources to find and analyze the expansion rate of the universe.

Help Received

In progress - searching for astrophysicists to help use a spectroscope at UCSB, used FLOYDS spectroscope in Haleakala, Hawaii under the supervision of Mrs. Miller (science teacher) and Herbert Puhringer (astronomy teacher in Austria), visited Curtis McCully (astrophysicist) at the LCO

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)

Iris S. Shen

Project Number

J1811

Project Title

Does the Bow Tension Affect the Volume of the Sound Produced on a Violin?

Abstract

Objectives/Goals

The volume of a violin is an important quality that affects the way music is perceived by the audience. This experiment aimed to find how the tension of the violin bow affects the volume of the sound produced on a full (4/4) size violin.

Methods/Materials

First, the violin and bow were tuned and set up for the experiment. The bow was adjusted to various tensions (independent variable), and played on the violin while the volume of the sound (dependent variable) was measured. The tension was indirectly measured using vector summation. The volume was then measured for 4 trials on the A string of the violin and the results were recorded. Included in the materials were a full size violin and bow, violin shoulder rest, tuner, scale, tape, ruler, table, decibel sound meter (dBZ), and a piece of string.

Results

The lowest bow tension (23 14/41) yielded the lowest volume, while the highest bow tension (116 17/24) yielded the highest volume. The data shows the tendency of increased volume with increased bow tension.

Conclusions/Discussion

Results supported the hypothesis that the volume would increase as the tension increased. As the tension increased by ~400%, the volume in sound power increased by ~57%. This is most likely due to an increase in friction between the bow and the string causing an increase in the amplitude of the sound wave. The result also shows that the testing environment, including the temperature and humidity, can have a significant impact on the measurements.

Summary Statement

By accurately measuring the bow tension, its relationship with the violin volume was quantitatively studied within a controlled environment in this project. The results confirm the dependency of volume on the bow tension.

Help Received

I would like to thank Mrs. Alexander, Mr. Laky, Ms. Orosz, Mrs. Tsai, and my friends Diyya Ganju and Kieli Murray for giving me advice and feedback. I would also like to thank my mother for teaching me how to create a graph and my father for his advice and help during the experiment.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Nareg A. Simitian

Project Number
J1812

Project Title
Brachistochrone: The Shortest Time

Abstract

Objectives/Goals
The objective for my project was to find out the the path of least time between two points which are on a diagonal plain with the presence of gravity.

Methods/Materials
My method/procedure to test if my hypothesis was right was to build a life size model of the 3 different types of paths. These 3 paths would be a straight line, an abrupt sheer shaped path, and a brachistochrone curve. I made an L shaped wooden base 36 inches long and 24 inches high with 3 slots in which I could slide in and glue the 3 paths which were drawn out a cut on clear plexiglass. After making the model, I made 3 wheels which would be able to roll down the plexiglass and stop at the end of their path. With the help of my brother keeping track and recording the time with a stopwatch and a camera recording in slow motion with a sensor also recording the time.

Results
After doing the experiment I proved my hypothesis right. The Brachistochrone curve was the fastest curve between the 2 points. Because it provided just the right balance between short distance and a steep drop. Next came the steep shaped path as second fastest. Because after the wheel came down the steep portion of the curve, it began to lose speed and acceleration as it came down the flat sections of the path. Last came the straight line, many would think the straight line would be the fastest way down because length wise its the shortest, but because of it gradual slope it takes a longer time for gravity to accelerate the wheel to faster and faster speeds.

Conclusions/Discussion
Many accurate trials proved that the Brachistochrone curve would be the fastest way down point A to point B because a perfect balance of gravity's acceleration and a short path is needed for something to go from one place to another the fastest. Although I have not learned the fundamentals of calculus and geometry yet it is worth mentioning that this project has many mathematical values behind it like calculus and geometry.

Summary Statement
From the three paths, straight line, brachistochone curve and the steep curve it was clear that the brachistochrone was the fastest

Help Received
I did all the research and the experiments by myself. I received help from my dad to make the model. As he has the right tools I needed.

CALIFORNIA SCIENCE & ENGINEERING FAIR
2018 PROJECT SUMMARY

Name(s)
Leo Tuncer

Project Number
J1813

Project Title
How High Can You Jump?

Abstract

Objectives/Goals
The objective of this study is to measure vertical jump using the accelerometer of a mobile device. I am a volleyball player and work hard at improving my vertical jump and wanted to be able to document my progress.

Methods/Materials
I used the accelerometer inside my phone, Physics toolbox suite (accelerometer application), App inventor 2, a camera taking a slow motion video of the jump, spring, PCS pipes and planks for the jumping simulator. Following steps are followed:
1) Measure free-fall time using Physics toolbox suite. 2) Write an app using App Inventor 2 that calculates the height of my jumps by measuring hang-time. 3) Take a slow motion video of me jumping in front of a measuring tape while, at the same time, measuring my jump height with the app I wrote. 4) Verify accuracy of the app by comparing the data captured on video to the data from my application. 5) Build a jumping simulator out of wood to replicates my jump to make more measurements in a shorter period of time.

Results
By determining the time I was in the air and knowing that the acceleration of my jump was going to be 9.8 m/s (gravitational pull), I could solve; Distance = ½ * acceleration * time ^ 2. Since half of hang-time is used for jump-distance, Jump-height = ½ * acceleration * (time/2)^2
My application could measure 80% of the time within 3% of my actual jump height, after correcting for heel to toe offset. The application could measure the jumping simulator jump height (rebound) more accurately.

Conclusions/Discussion
For jumps over 10 inches statistically significant deviations were noted, indicating hand movement (reflex to jump higher) may be a factor and that measurements should be independent of hand movement. Another factor is the heel to toe offset making it very unpredictable to measure the actual jump height using the slow-motion camera.

Summary Statement
Estimating height of a jump using an accelerometer

Help Received
I designed the project and programmed the app myself after an internet search on techniques and laws of physics related to vertical jumping. My dad reviewed my results. While building the jumping simulator, my dad set-up power tools, and helped me use them safely.

Name(s)
Krithi V. Koodli

Project Number
J1899

Project Title
Distinguishing between Binary and Non-Binary Stars Using Machine Learning

Abstract

Objectives/Goals
My engineering goal was to classify stars as binary or non-binary stars using machine learning. When the classifier is given a feature, it should accurately label the star, and its predictions should have an accuracy of at least 85%. It should be able to predict the labels of stars which are yet unknown.

Methods/Materials
I found data sets from the Binary Star Database and Kepler Mission Stars to use for binary and non-binary stars, respectively. I chose the feature of orbital period, which is much smaller for binaries on a galactic scale, to train the model on because it was available or could be calculated for both data sets. Orbital period also distinguishes binaries from non-binary stars. Even though non-binary stars do not orbit and do not have an orbital period, using a hypothetical orbital period would allow the model to distinguish the two types of stars. I trained and tested both a KNeighbors Classifier and a Decision Tree Classifier and measured their cross-validation accuracies. After this, I tested it on only binary stars to measure its prediction accuracy. Subsequently, I tested it on stars whose labels were unknown. I used Python 2.7 with Sci-kit-learn to code the model.

Results
Using cross validation, I determined that the accuracy of the model was 97% and 91% for the KNeighbors and the Decision Tree, respectively. I then used the KNeighbors to predict on 4000 binary stars and determined its accuracy as 99%. The accuracy was sufficient, so I tested the model on data (using HYG database) where the stars' labels were unknown. Out of 200 tested, 51 were predicted to be binary stars. Through an independent verification, I have determined that at least two of the 51 stars are most likely binary.

Conclusions/Discussion
The model met the engineering goals and was able to accurately predict the label of stars. The model had an accuracy of 97% on both types of stars and an accuracy of 99% on only binary stars. The model was able to predict the label of unclassified stars, and two of the 51 predicted stars are likely binary stars. The final algorithm had a sufficient accuracy to be implemented in databases to scan for binary systems. This expands our knowledge of physics and astronomy by providing a novel method to distinguish binary and non-binary stars using the orbital period, and to find overlooked binary stars. I will continue to verify the binary stars predicted by the model.

Summary Statement
My project created a model that classified stars as binary stars or non-binary stars by training and testing on the orbital period feature, and it predicted the label of unclassified stars in stellar databases by using machine learning.

Help Received
I received help from my brother, who helped me troubleshoot some of the errors I received in the process of creating the model