

ISEF STUDENTS AT CERN

The Intel International Science and Engineering Fair (Intel ISEF), the world's largest international precollege science competition, annually provides a forum for more than 1,500 high school students from over 50 countries to showcase their independent research. The Intel ISEF is the premiere science competition in the world exclusively for students in grades 9–12. This year, Intel ISEF was held in Reno, NV. USA.

Eighteen students and two student teams won “best of” awards. Amongst these eighteen students, thirteen students gained the opportunity to go to visit CERN. According to the [Science News article](#), their projects concerned the following fields:

‘Ronit Abramson of San Diego won in cellular and molecular biology for her investigation of cell wall development in the marine microorganisms known as diatoms. Kevin Ellis of Vancouver, Wash., won in computer science for his development of a program that splits tasks among computer chips. In earth and planetary science, Marley Iredale of Sequim, Wash., won for her research into the history and risk of tsunamis in Discovery Bay, Wash. Alexander Kendrick of Los Alamos, N.M., won in electrical and mechanical engineering for designing and building a two-way, digital underground radio that could be used in cave and mine rescues. In materials and bioengineering, Scott Skirlo of Fairfax, Va., won for his research into the material properties of nickel titanium, or nitinol, under extreme hot and cold conditions.

Ryan Alexander of Plano, Texas, won in energy and transportation for his research into cheap and easily built devices that capture wind energy. In environmental management, Eliza McNitt of Greenwich, Conn., won for her work investigating the role of the pesticide Imidacloprid in the bee epidemic known as colony collapse disorder. Ashoka Rajendra of Sterling, Va., won in medicine and health for his research into therapeutic treatments for prostate cancer. In microbiology, I-Ching Tseng of Taichung City, Taiwan, won for her investigation of Styrofoam-digesting microbes from the mealworm digestive tract. Nilesh Tripuraneni of Fresno, Calif., won in physics and astronomy for studies of quark-gluon plasma, the superhot material created after the Big Bang.

In plant sciences, Mark Chonofsky of Lexington, Mass., won for his research on Taxaceae, the plant family that includes the species from which the cancer drug Taxol is derived. (...) In physical sciences, Erika DeBenedictis, and Duanni Huang of Albuquerque won for developing a new approach for identifying asteroids.’

Programme of the visit at CERN is available at the following url:

<http://indico.cern.ch/conferenceDisplay.py?confid=62155>

Further details about the projects of the thirteen winners of the ‘best of’ awards who will come to visit CERN are also available below:

CELL WALL FORMATION FROM MARINE DIATOM PROTOPLASTS: IMPLICATIONS FOR NOVEL TRANSFORMATION AND NANOTECHNOLOGY TECHNIQUES

*Ronit Batya Roth Abramson
Canyon Crest Academy, San Diego, CA*

Biosilification, or the biological processes responsible for silica deposition, is of growing interest in many fields of study from marine biology to nanotechnology. Since diatoms can so readily make three-dimensional intricate structures that exceed current synthetic methods, investigation of diatom cell wall development offers applications in microengineering, photonics, and nanotechnology. Diatoms also have shown potential as a source of lipids for biodiesel. However, diatom research is impeded because access to the cellular DNA is obstructed by the silica cell wall. In this study, the marine apochlorotic diatom *Nitzschia alba* was induced to grow without a cell wall using a silica-starved media, L+2%, consisting of 0.5% bacto-yeast extract, 1% bactotryptone, and 2% sodium chloride. Rapid agitation was necessary to induce frustule divergence. The resulting protoplasts were then harvested and transferred to an artificial seawater media with PDMPO, a silica fluorescence stain. The cell wall regeneration was observed for pattern and growth comparison after 24 and 48 hour time periods using an epifluorescence microscope. It was determined that viability was maintained through the protoplast procedure as evidenced by the complete regeneration of the cell wall with wild-type morphology through multiple generations. Further investigation is required to establish genes responsible for independent steps of cell wall formation but the implications suggest the potential for an alternative gene transformation technique and pave the way for further studies of diatom cell wall development.

Awards won at the 2009 ISEF

All expense paid trip to tour CERN - European Organization for Nuclear Research-CERN
Intel ISEF Best of Category Award of \$5,000 for Top First Place Winner - Cellular and Molecular Biology - Presented by Intel

2007 - CS018

PING ME! OPTIMIZING CODE FOR CLUSTER COMPUTING

*Erika Alden DeBenedictis
Saint Pius X High School, Albuquerque, NM, U.S.*

The objective of this project is to construct, use, and optimize a cluster computer to solve large problems and investigate how the structure of the problem determines the efficiency of the cluster. This area of computer architecture is important because it holds the promise of increasing the speed of calculation to enable applications of increased number, scope and complexity at a cost-effective price. Further, silicon computer chips will reach the physical limits of the material and the only way to improve computer speed will come from parallel processing. Cluster computing best represents the cost benefits of parallel processing. The objectives of this project were realized. A cluster has been constructed out of surplus desktop computers with varying speeds. A control networking program, based on Windows networking commands, allows the computers to communicate and distributes calculations accounting for varying computer speed. In addition, two applications have been parallelized and executed on the cluster, revealing the strengths inherent to cluster systems. The first application calculates the Mandelbrot fractal, involving a program structure that requires large amounts of data transfer for little calculation. The second, Solar Sim, calculates gravity-assist routes throughout the solar system and requires little communication and large amounts of calculation. While each application required different methods of program parallelization, both were optimized for the cluster with significant, linear runtime improvement demonstrated. Using cluster architecture produces meaningful results quickly and effectively, much more so than a single computer.

Awards won at the 2007 ISEF

Honorable Mention Award of \$200 - Association for Computing Machinery

2009 - EA010

EVALUATING TSUNAMI RISK IN DISCOVERY BAY, WASHINGTON

Marley Elizabeth Iredale

Sequim High School, Sequim, WA

The topic of this research was evaluating tsunami risk in Discovery Bay, Washington. The bay has no sand bar and the marsh at its head is a 'trap' for tsunami sediments. A study (2000) with similar goals was restricted by wood debris from a mill. In the fall of 2008 the site was excavated, which allowed access to more of the marsh. The purpose of this research was to determine a recurrence interval and evaluate the probability of tsunamis in the vicinity of Discovery Bay. Fourteen bores were done along four transects using a gouge auger. Samples were collected at each sand layer and sieve and diatom analyses performed. Results included: depth, elevation and thickness of sand layers; diatom identification; sieve gradation; development of boring logs and transect diagrams; stratigraphy analysis; analysis of age versus elevation; and the normal annual cumulative probability of tsunamis in Discovery Bay. Ten sand beds were verified as evidence of tsunamis. An average uniform rate of deposition model was developed with an average recurrence interval of 240 years (standard deviation 120 years). From a normal annual cumulative probability there is a range of 60-80% chance of a tsunami between 2010 and 2040. The average recurrence interval for Cascadia Subduction Zone-generated tsunamis is 500 years. Other potential tsunami causes may include local landslides or regional earthquakes. As tsunami inundation maps have been generated for Cascadia Subduction Zone-generated tsunamis (10m in height) and not local or regional sources (100m in height), these maps need to be reevaluated.

Awards won at the 2009 ISEF

First Award of \$1,500 - Association for Women Geoscientists

All expense paid trip to tour CERN - European Organization for Nuclear Research-CERN

Intel ISEF Best of Category Award of \$5,000 for Top First Place Winner - Earth & Planetary Sciences - Presented by Shell Oil

2008 - EM013

TRACING THE MIGRATION OF PESTICIDES THROUGH THE PRODUCTION OF SOUTHWESTERN CONNECTICUT HONEY

Eliza Helen McNitt

Greenwich High School, Greenwich

Continued use of pesticides and herbicides throughout both the agricultural and private sector has led to concern about the effects of these chemicals on common fruits and vegetables, and whether these often harmful chemicals are still present when the food is consumed. Most

research has focused on the growth and retail of typical agricultural products, however little work has been done to identify the presence of residual pesticides in the honey of *Apis mellifera* (the typical honey bee). This investigation seeks to verify the migration of five known pesticides, applied within a 30 acre radius within the Bartlett Arboretum (in Stamford, CT), to the honey product of a controlled bee-hive located within the Arboretum grounds. The five pesticides applied within the Arboretum are Dipel, Neem Oil, Insecticidal Soap, Imidacloprid, and Pyrethrins. Initial experiments based on ultrasonic-solvent extraction of honey, and the analysis of the organic layer against known samples of the five pesticides, with Attenuated Total Reflectance (ATR) Fourier Transform Spectroscopy (FTIR), proved to be non-specific and lacked sufficient sensitivity since all pesticides, and the neat honey samples exhibited an asymmetric C-O stretch at 1058 cm^{-1} . High Pressure Liquid Chromatography based analysis, with UV detection at 255 nm, indicates that components of Pyrethrins and Imidacloprid are not detectable in the organic honey extract. This same analysis points out, however, that components of BioNeem Oil are present in the final product of the Arboretum 2007 Fall Honey. The Analysis of Commercial Honey of unknown origin also revealed the presence of the Bio Neem Oil component as well as other additional compounds.

Awards won at the 2008 ISEF

Second Award of \$1,500 - Environmental Management - Presented by

2009 - EM016

SHEDDING LIGHT ON IMIDACLOPRID'S ROLE IN COLONY COLLAPSE DISORDER

Eliza Helen McNitt

Greenwich High School, Greenwich, CT

In recent years, honeybees have been inexplicably disappearing at an alarming rate in a poorly understood phenomenon called Colony Collapse Disorder (CCD). Continued use of new pesticides throughout the agricultural and private sectors has led to speculation that these compounds may play a role in the disappearance of the honeybee. Many entomologists suspect that Imidacloprid, a systemic pesticide introduced concurrent with the onset of CCD, plays a significant role in the hive collapse. This research seeks to provide analytical evidence that Imidacloprid plays a role in CCD, by tracing the migration of this pesticide in the pollination pathway of the honeybee. Samples of dead bees, pollen, bee bread, and honeycomb were obtained from the Bartlett Arboretum (Stamford, CT), where Imidacloprid was applied around the beehive. Organic components of each sample type were extracted using Acetonitrile & Water, and analyzed using High Pressure Liquid Chromatography. Analysis of dead Arboretum bees taken from the hive reveal the presence of 143 ppm of Imidacloprid within the "whole" ground insect. The extremities of the bees contained 141 ppm of the pesticide, with little/no internal traces of Imidacloprid within the bees. The presence of 55 ppm of Imidacloprid in the honeycomb further validates that at least a portion of the pesticide is being carried to the hive on the extremities of the honeybee. The absence of Imidacloprid within the pollen, bee bread, and bee bodies samples suggest that the Imidacloprid molecule is not being retained in its

original chemical form within the bee physiology.

Awards won at the 2009 ISEF

All expense paid trip to tour CERN - European Organization for Nuclear Research-CERN
Intel ISEF Best of Category Award of \$5,000 for Top First Place Winner - Environmental Management - Presented by Intel
First Award of \$3,000 - Air Force Research Laboratory on behalf of the United States Air Force

2009 - MI020

A STYROFOAM-DECOMPOSING BACTERIUM FROM MEALWORMS

I-Ching Tseng

National Taichung Girl's Senior High School, Taichung, Taiwan, CHINESE TAIPEI

Due to the properties of waterproof, light-weight and low-price, styrofoam is now widespread used in our daily lives. However, overuse of styrofoam caused a serious environmental problem. The observation that mealworms might be able to feed on styrofoam sparked a curiosity to answer whether mealworms could digest styrofoam, and if so, how could they remain alive. First of all, these mealworms were fed in different kinds of food to insure the mealworms can digest styrofoam. The results showed that mealworms can indeed feed on styrofoam only. The hypothesis of this study is that microbes inside the digestive tracts of mealworms are responsible for the decomposition of styrofoam. To further test this hypothesis, microbes from the digestive tracts of mealworms were cultured at 37 C in LB medium under anaerobic conditions. There were many kinds of microbes isolated. From those microbes, a kind of bacteria forming red colonies was confirmed responsible for decomposing styrofoam. The growth conditions and strain characteristics of the bacteria forming red colonies were further examined. These results imply that the red bacteria isolated from the digestive tracts of mealworms may shed light on solving the serious environmental pollution caused by styrofoam.

Awards won at the 2009 ISEF

First Award of \$1,000 and a plaque - American Veterinary Medical Association
All expense paid trip to tour CERN - European Organization for Nuclear Research-CERN
Intel ISEF Best of Category Award of \$5,000 for Top First Place Winner - Microbiology - Presented by Intel
Fifth Award of \$250 - American Society for Microbiology
Scholarship Award of \$1,000 - National Collegiate Inventors and Innovators Alliance/The Lemelson Foundation

2009 - ET012

GONE WITH THE WINDMILLS:AN ANALYSIS OF THE EFFECTIVENESS OF AN OSCILLATING WIND ENERGY GENERATOR

Ryan Cherian Alexander

R. C. Clark High School, Plano, TX

Can a windmill for developing countries be created using local materials, such as bamboo, and can a windmill be created using aeroelastic flutter that can gather energy more efficiently in the developed world? In the project, models were created of the actual windmills: the turbine, an lattice tubular design, the oscillators- a natural version constructed from bamboo and a normal wooden one, a four-oscillator model, a high altitude oscillator, and a Darius oscillator. The models were tested in different environments and with varying wind speeds. It was hypothesized that the field of normal oscillators, which use aeroelastic flutter and do not have to contend with much friction, would produce the most electricity and the results confirmed that hypothesis. Both the natural and the normal oscillator produced around 240% more power than current turbine designs. The Darius design produced around 400% more power and the High Altitude Oscillator, 582% more power. The field of oscillators produced an outstanding 819% more power whereas the lattice windmill produced about 180% more power than the conventional windmill. This experiment is evidence that these technologies can advance the efficiency and capabilities of wind-driven energy generation. This data is very accurate with a statistical confidence level of 99.9% and its findings can be directly applied to the real world. With the use of an electric "kit" containing the copper wire and magnets and local materials such as bamboo and leaves, developing countries will have access to clean, dependable, and cheap electricity.

Awards won at the 2009 ISEF

All expense paid trip to tour CERN - European Organization for Nuclear Research-CERN
Award of \$1,500 - PowerPlus Engineering, Inc.

All expense trip to Washington DC - United States Environmental Protection Agency
Intel ISEF Best of Category Award of \$5,000 for Top First Place Winner - Energy and
Transportation - Presented by Shell Oil

Scholarship Award of \$1,000 - National Collegiate Inventors and Innovators Alliance/The
Lemelson Foundation

2009 - PS027

PHYLOGENY OF THE TAXACEAE INFERRED FROM PHYTOCHROME SEQUENCES

Mark Adrian Chonofsky

Lexington High School, Lexington, MA

Taxaceae phylogeny, now increasingly important as some species are identified for anti-cancer medication, has long been in doubt. With the advent of molecular systematics, knowing the exact phylogeny of these groups has also become necessary. PHYP, PHYN1, and PHYN2 genes were sequenced for eleven Taxad species, and Bayesian, maximum likelihood, and maximum parsimony methods were used to infer phylogeny. Strong support was found for a monophyletic clade of Taxaceae and Cephalotaxaceae and for three lineages within it: Torreya and Amentotaxus (Torreyae Janchen); Taxus, Austrotaxus, and Pseudotaxus (Taxeae Janchen); and Cephalotaxus. Most importantly, strong support was found ($p = 0.95$ using Bayesian inference, parsimony bootstrap 0.94) for the Cephalotaxus lineage as

the most basal lineage. Software was developed to perform an SOWH test in order to check the maximum likelihood analyses. The test rejects the null hypothesis that Cephalotaxus and the Torreya are more closely related than the Torreya and the Taxa ($p < 0.01$). BEAST was used to estimate divergence times, and the analysis found that the common ancestor of Cephalotaxus is more recent than the common ancestors of the Taxa and Torreya. Sciadopitys dates to the Devonian.

Finally, maximum likelihood inference of types of selection indicates differences in the type of selection occurring on each exon in PHYN1. The conclusions are twofold. First, the Cephalotaxaceae and the Taxaceae are clearly shown to be monophyletic for the first time. Second, the data have implications for the ancestral range and type of selection occurring on the plants and genes involved.

Awards won at the 2009 ISEF

All expense paid trip to tour CERN - European Organization for Nuclear Research-CERN
Intel ISEF Best of Category Award of \$5,000 for Top First Place Winner - Plant Sciences - Presented by Intel

2009 - CS008

SYSTEM S: DESCRIBING STATE IN FUNCTIONAL LANGUAGES

Kevin Michael Ellis

Catlin Gabel, Beaverton, OR

This project introduces System S, an extension to the lambda calculus for describing state in functional languages. The descriptions of the state-changes in the formalism are represented by a type theory for System S. A type inference heuristic for this type theory and the limitations of the type system and reconstruction algorithm are discussed. The relationship between evaluation strategy, semantics, and types are discussed in relation to state. A novel evaluation strategy reliant upon this type theory is proposed. System S and related type theories are increasingly extended in granularity and expressiveness throughout the project, progressing from the simple System S to the double-smear System S, a variant specialized for mutable references. Practical considerations, such as recursion, conditional branching, and local state are taken into account. The project concludes with a practical application of this calculus: automatic parallelization. A working prototype of an automatically parallelizing interpreter for System S is presented. Novel optimizations for automatic parallelization are presented, including the use of a stochastic algorithm to optimize parallelizations. We used the interpreter to parallelize several test programs, achieving performance increases generally in the 20% to 30% range as a result of the parallelizations.

Awards won at the 2009 ISEF

All expense paid trip to tour CERN - European Organization for Nuclear Research-CERN
Intel ISEF Best of Category Award of \$5,000 for Top First Place Winner - Computer Science - Presented by Intel

2009 - PH313

A NOVEL APPROACH TO ASTEROID IDENTIFICATION USING IMAGE PROCESSING OF EXISTING DATA

Duanni Huang, Erika DeBenedictis, Chris Hong

La Cueva High School, Albuquerque, NM

Asteroids are dangerous objects for Earth, as evidenced by previous asteroid impacts that have had planet-wide effects. Asteroid orbits are easily perturbed, or changed, by the gravitational pull of other solar bodies. For this reason, it is vitally important to carefully track the motion of all potentially dangerous asteroids in our solar system. In this project, we analyze existing astronomical data for asteroid sightings. A large-scale analysis of existing image data could lead to identifying new asteroids, to better understanding the patterns in asteroid orbit perturbations, and to more effective ongoing observations. Our study begins with obtaining astronomical images for analysis and corresponding stars from a reference catalog. Using this data, we then compare the stars in the image to the stars in the sky by finding similar triangles between corresponding stars. This enables us to determine the exact location and orientation of the image in the sky. Any unknown objects that are in the image are then translated to a location in the sky, constituting one object observation. We can further analyze these observations to find previously unknown asteroids or to document perturbed asteroids. We have developed software to identify potential asteroid observations in astronomical images. We have made our methods versatile by investigating ways of making the image analysis techniques applicable to a wide variety of images. Our program has successfully been applied to a variety of astronomical images and has identified possible asteroid observations in these images.

Awards won at the 2009 ISEF

Scholarship Award of \$12,500 per year, renewable annually - Florida Institute of Technology

All expense paid trip to tour CERN - European Organization for Nuclear Research-CERN

Intel ISEF Best of Category Award of \$5,000 for Top First Place Winners - Team Projects - Presented by Science News

2009 - EE068

THE UNDERGROUND RADIO II

Alexander Kent Kendrick

Los Alamos High School, Los Alamos, NM

An Underground Radio can be used for cave and mine rescues, radiolocation, underground imaging, and detection of coal and petroleum and for monitoring an underground microclimate. In this project, I designed, built and tested in actual caves a new two way digital Underground Radio demonstrating an operational goal of a 300m range through limestone. This system enabled the first digital and deepest communication through rock in the history of Carlsbad Caverns (200m). By using an optimal frequency of 23.4 kHz, the radio is now able to send two way digital communication using a microcontroller with C and Assembly programs. The transmitter design was based on an efficient Class-E amplifier. A sensitive receiver circuit was designed to decode messages with a very low signal. Both the transmitter and receiver circuits were modeled by SPICE in order to optimize the performance. Field tests on the surface determined that the radio was able to receive digital text messaging at a range of 400m. The radios were then tested in three caves: Cottonwood, Black, and Carlsbad Caverns, New Mexico. Two way digital text messaging was established at 200m (650ft) in the Left Hand Tunnel. Based on the signal strength measurements in the caves, an attenuation rate of about 0.03 dB/m was measured. For my transmit power, antenna coupling and receiver sensitivity this attenuation rate results in a maximum underground range of about 275m (902ft) through limestone.

Awards won at the 2009 ISEF

All expense paid trip to tour CERN - European Organization for Nuclear Research-CERN
First Award of \$1,500 - International Council on Systems Engineering - INCOSE
Intel ISEF Best of Category Award of \$5,000 for Top First Place Winner - ENG: Electrical and Mechanical - Presented by Intel
Grand Award of \$1,000 and a framed copy of the first patent granted in the United States of America - Patent and Trademark Office Society
Distinguished Achievement Award of \$1,250 and a trip to the SEG International Exposition and Annual Meeting. - Society of Exploration Geophysicists

2009 - ME052

DOWN-REGULATION OF hTERT SENSITIZES CHEMOTHERAPEUTIC EFFECTS OF DOCETAXEL IN HUMAN PROSTATE CANCER CELLS

Ashoka Sanjaya Rajendra

Loudoun County Academy of Science, Sterling, VA

Telomerase allows for the immortalization of cancer cells through telomere maintenance and has been linked to the expression of cell cycle regulating mechanisms. A vital component of this enzyme, human telomerase reverse transcriptase (hTERT), was therefore the target of this study. In this study, the effects of the suppression of hTERT in combination with the chemotherapy treatment docetaxel on human prostate cancer cells (modeled by PC3) were researched. Docetaxel, a chemotherapeutic agent used in the treatment of prostate cancer is highly cytotoxic, and patients would benefit if lower doses of docetaxel could produce the effects of higher doses. PC3 cells were subjected to combination therapy by down-regulating hTERT expression using small interfering RNA (siRNA), and then treated with therapeutic or sub-therapeutic concentrations of docetaxel. The cytotoxic and growth inhibiting effects of docetaxel were substantially increased. Notably, 3nM of docetaxel in combination with hTERT down-regulation reduced live cell counts nearly two fold, and worked significantly better than 25 nM therapeutic concentration of docetaxel alone. Further experimentation identified higher caspase (apoptotic proteins) activity as one of the mechanisms responsible for the more effective combination treatment. A Caspase 3/7 assay and fluorescent microscopy results confirmed that in the combination treatment, the expression of caspase activity is far higher than siRNA or docetaxel alone. These results suggested that combination treatment with sub-therapeutic levels of docetaxel in the presence of hTERT specific siRNA produce the same or better effects as higher therapeutic concentrations of docetaxel alone, and this could ultimately benefit prostate cancer patients.

Awards won at the 2009 ISEF

All expense paid trip to tour CERN - European Organization for Nuclear Research-CERN
Intel ISEF Best of Category Award of \$5,000 for Top First Place Winner - Medicine and Health Sciences - Presented by National Institutes of Health

2009 - EN051

A STUDY OF THE DEGRADATION OF THE TWO-WAY EFFECT IN NiTi

Scott Alexander Skirlo

Thomas Jefferson High School for Science and Technology, Alexandria, VA

The purpose of this project was to examine the degradation of the Two-way effect in NiTi over several

thousand thermal cycles with respect to the hottest and coldest temperatures reached during thermal cycling. The Two-way effect exists only in trained shape memory alloy samples and consists effectively of the material remembering a hot shape and a separate cold shape. The memory of each shape will degrade with repeated thermal cycling. Knowing the impact of cycling temperatures is important for applications and for understanding the mechanisms of degradation. This study utilized stress-strain, resistance-temperature, strain-temperature, and strain-thermal cycle tests to measure the degradation and understand the development of the microstructure. The equipment for this study was constructed from scratch. The results show that the degradation of Two-way effect is largely insensitive to variations in the coldest temperature reached during thermal cycling. In contrast, changes in the highest temperature reached during cycling significantly altered the degradation path. By increasing the maximum cycling temperature, the rearrangement of the internal stress field causing the Two-way effect increased, resulting in faster degradation. Lowering the maximum cycling temperature subjected the trained dislocation array to less stress, better maintaining the Two-way effect. The number of dislocations generated during cycling did not appear to vary significantly throughout the tests, suggesting that internal stress rearrangement is the most significant factor in the decrease of the Two-way strain.

Awards won at the 2009 ISEF

All expense paid trip to tour CERN - European Organization for Nuclear Research-CERN
Intel ISEF Best of Category Award of \$5,000 for Top First Place Winner - ENG: Materials and Bioengineering - Presented by Intel

2009 - PH034

A RELATIVISTIC GENERALIZATION OF THE NAVIER-STOKES EQUATIONS TO QUARK-GLUON PLASMAS

Nilesh Tripuraneni

Clovis West High School, Fresno, CA

Quark-gluon plasma (QGP), the super-hot matter created after the Big Bang, has recently been shown in experiments to behave like a near-ideal liquid instead of like a rarified plasma as previously theoretically predicted. Here we study the hydrodynamic expansion of QGP by deriving a geometrically simple, causal, and relativistic formulation of the Navier-Stokes equations coupled to a simple QGP equation of state in order to study the effects of viscosity and other transport coefficients on QGP's dynamic evolution. Similarly, we also make some interesting predictions regarding bulk viscosity's effects on QGP's dynamics which may have implications for some puzzling experimental data regarding hydrodynamic "freeze-out" and also perhaps for cosmological expansion. Specifically we suggest cavitation, a violent bubbling, may be the mechanism by which QGP transitions into hadrons. We also find that QGP's dynamic expansion is highly sensitive to variations in viscosity but not to variations in other transport coefficients. This super-sensitivity may help support an accurate computation of the shear viscosity which may in turn be used study and test certain quantum theories and string theories experimentally.

Awards won at the 2009 ISEF

Honorable Mention Award - American Mathematical Society
All expense paid trip to tour CERN - European Organization for Nuclear Research-CERN
Intel ISEF Best of Category Award of \$5,000 for Top First Place Winner - Physics and Astronomy - Presented by Intel

Award of three \$1,000 U.S. Savings Bonds, a certificate of achievement and a gold medallion. - United States Army