# The Nova Herald

Volume 9 schoolnova.org Spring 2019

## SchoolNova – 15th Anniversary

*By Marina Polonskaia, Executive Director and Principal*

In the end of March 2004, almost exactly 15 years ago, I received a call from my friend. She was wondering whether I would agree to talk to the director of an enrichment program in NJ who would like to open a branch of her school in the Stony Brook area. At that time my twin daughters were 4 years old, and they attended a small Russian school located on the grounds of Brookhaven National Lab. The school had only one teacher who taught two subjects — math and Russian language to about a dozen of Russian children ages 4 – 7. I talked to the director of the NJ program and must say that her offer was very tempting. The fact, that classes were running only on Sundays made it possible to combine our full time jobs with teaching at the school. But the most important factor for us was that opening an enrichment program would give us an opportunity to follow a long Eastern European tradition to teach all who are eager to learn. I accepted an offer.

An open house took place on April 15, 2004. Forty-six families came to support the idea of opening a weekend enrichment program on the campus of Stony Brook University. On the next day we held several interviews with potential teachers who were willing to join the school right away.

In September 2004 classes in Math, Physics, Russian Language and Visual Arts were opened. All Math and Physics teachers were faculty at Stony Brook University. Our first Art teacher previously taught a small group of students in her home, and she invited all of her pupils to the new school. The first teacher for our youngest students also brought a few children she and her friend were teaching at home to the school. Members of the Russian school from BNL became part of the new program as well.

Back in 2004, the founders of SchoolNova could not have imagined what it would become 15 years later. What started out as a small group of 7 instructors teaching 4 subjects to 62 students has grown into a big enterprise with more than 40 teachers and over 500 students. We now offer nearly a dozen subjects to choose from, including an 11-year-long Math program, a 7-year-long Science

*Continued on page 4*

First day of school, 2004

## Listening to Music of Celestial Spheres

*By Alexei Tkachenko, Physics teacher*

It has become a cliché to say that we live in an era of revolutionary changes in science and technology. However, if we pick almost any time period within the last 300 years, we could safely say the same. Sure enough, the three centuries of industrial and scientific revolution are just a blink of an eye when compared to the history of human civilization, not to mention the history of life on Earth, the Earth itself, or the age of the Universe.

So, what has set the things in motion? Why, after so many centuries of being stuck with horsepower and sailboats, we are now in the midst of the mind-blowing changes, when a new technology of yesterday becomes obsolete almost overnight? We can trace this back to the 1600s when a handful of scientists found a new way of exploring and understanding the laws of Nature. My story, however, is not so much about them. It's about how music and harmony were the triggers for this revolution. It is also about Galilei, not the famous Galileo, but his father Vincenzo. He was an influential lutenist and composer of the 1500s, but more importantly, a music theorist. In fact, more than a theorist.

If you ever played the guitar or a violin, you might know that the pitch of the sound depends on the length of the string and on its tension. When you shorten the length of a string by half, its pitch shifts exactly by one octave. To produce an interval called perfect fifth, the string's length must be shortened by the factor of 3/2. But what about the tension? In the 1500s, musicians believed that increasing the tension force in the string twofold would do the same as shortening it by the factor of two. As were common in those days, no-one would try to check this: the notion of an experiment was rather foreign. Vincenzo Galilei (apparently, helped by his older sun Galileo) has performed such experiments and came up with a remarkable discovery. To shift the tone by an octave, the tension needs to be increased four-fold rather than two-fold, and perfect fifth would be produced if the tension is multiplied by 9/4 (which is 3/2 squared). This was the first ever discovery of what we now call a non-linear scaling law: the pitch depends on the length of the string (L) and tension force (T) as $\boldsymbol{L/T^2}$.

Ironically, Vincenzo discouraged Galileo from studying mathematics, and instead sent him to the University of Pisa to learn medicine, much more lucrative profession both then and now. Once, being bored with his study in the library, young Galileo was entertaining himself by shaking the lantern hanged from the ceiling. By using his own pulse as a timer, Galileo noticed that the period over which the lantern oscillates back and forth does not depend on how strong it swings. Decades later, this principle was used to build the first pendulum clock. But back then, this was a moment when the Duchy of Tuscany has lost its future doctor (probably, quite an average one), gaining its most famous scientist. In just several years from that event, Galileo would build the

*Continued on page 5*

## Conducting an original physics research in high school

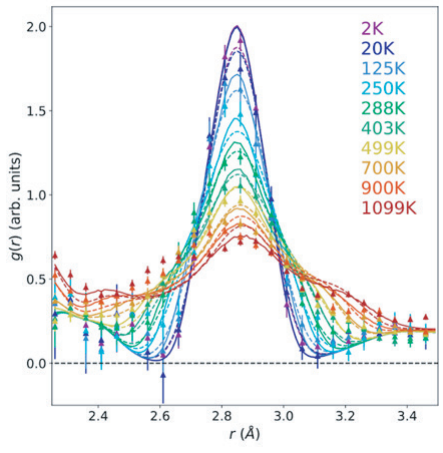
*By David Wendt, 12th grade, SchoolNova TA*

In elementary and middle school, I went to local universities (mostly Hofstra and LIU Post) and took weekend and summer classes for young students; here, I first discovered my passion for physics. Not until SchoolNova, however, did I first delve deeply into this fascinating field. Since 7th grade, I have been taking physics with Dr. Suchalkin and math with Dr. Kirillov at SchoolNova.

I discovered SchoolNova by participating in a math program at SUNY Old Westbury (the Institute for Creative Problem solving), where I met other students who, like myself, were motivated to delve into learning outside of school, and from whom I found out about many new extracurricular opportunities, including SchoolNova. Between the formal math and physics curriculum and the advanced math and physics problem solving clubs, SchoolNova has proven foundational for me, in and out of school. The conceptual and mathematical basis and thinking style that SchoolNova provided me has been invaluable in all of my pursuits since. In addition to the intellectual benefit, I have also gained much from involvement in the community centered around SchoolNova.

Now, as a physics TA (a job which I just began this year), I am able to both give back to the community and learn professional skills that will be extremely helpful in college and beyond. Spending time with both world-class professors and like-minded peers has been transformative, in that I have learned so much from those around me and this has helped me to form my goal of a career in physics and academia.

Between studying physics at SchoolNova, SigmaCamp, and independently in preparation for various competitions (mainly Science Olympiad, Science Bowl, and the USA Physics Olympiad), I had spent a great deal of time learning, and I was ready to begin contributing to science through research. In 10th grade, after several years of extracurricular physics and math (including summer programs at Brown University and Colorado State), I wanted to begin conducting original physics research. So, I applied to Brookhaven National Lab's High School Research Program, which provided me the opportunity to work with Dr. Zaliznyak for six weeks over the summer. Dr. Zaliznyak is also teaching mathematics at SchoolNova although he has never been my teacher, but we had an opportunity to meet weekly at school and talk about our results. Our research involved a phenomenon called "negative thermal expansion": Nearly all everyday materials expand when they are heated, and this is

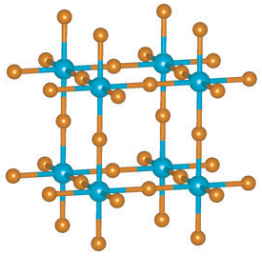



Continued on page 8

## High School Research Project: Negative Thermal Expansion of a Simple Solid

*By Igor Zaliznyak, SN Math and Physics teacher*

*This is the story on how a series of fortunate events could allow SchoolNova program to contribute to physics research…*



Crystal structure of ScF3. Thermal motion of F ions (smaller spheres) transverse to rigid Sc-F bonds pulls Sc atoms at the corners of the cubic lattice closer together.

Matching the thermal expansion of materials, or tailoring it such that it is near zero, is an essential task in manufacturing precision tools, watches, engines, and other applications that require dimensional stability of mechanical parts while operating in environments with varying temperature. So, finding materials with zero or negative thermal expansion (NTE) is an important technological problem. In fact, it's so important that the discovery of relative lack of expansion or contraction with temperature in nickel-steel alloys (known as the Invar effect) by Swiss physicist Charles Édouard Guillaume was awarded the 1920 Nobel Prize in Physics. These alloys are now widely used in industrial manufacturing and the Invar effect is closely related to the metallic and magnetic nature of these materials.

Much less common and less understood is negative thermal expansion in insulating ceramic materials, which hold promise for applications in electronics, optics, and medicine. Recently, a new family of insulating NTE ceramics was discovered, which is derived from scandium trifluoride, ScF3. This material has very simple atomic structure, where Sc atoms are located at the vertices of a simple cubic lattice with F atoms in between, on the cube's edges (see Figure). Such structural simplicity provided us with an excellent opportunity to understand the physical origin of the NTE effect.

There are numerous tools at a physicist's disposal that allow us to look into the atomic structure of materials and understand how that structure changes with temperature, material composition, pressure, and other environmental parameters. Among these are electron microscopes, x-rays, and scanning atomic force probes, but perhaps the most powerful tool is provided by scattering of neutron particles, which can be thought of as "neutron microscopes". The difference is that instead of a tabletop sized cathode, which provides electron particles in an electron microscope, a neutron microscope requires a nuclear reactor, or a giant powerful accelerator smashing protons into a heavy metal (tungsten, or mercury) target to obtain neutron beams for microscopic studies. In the past, one of the best such facilities was located at Brookhaven National Laboratory – the High Flux Beam reactor – which was permanently closed at the end of the last century. At present, the World's flagship neutron facilities are operated by the US Department of Energy's Oak Ridge National Laboratory in Tennessee, providing researchers from around the country and abroad with unique opportunities to answer important questions about the microscopic structure and atomic motions in materials. At Brookhaven, there is a group of scientists – to which I belong

Continued on page 5

## Join SchoolNova' Foreign Languages Program

*By Marleine Chiofalo, French teacher*

At SchoolNova, foreign languages classes have their ups and downs in number of students. Some classes in French, Spanish and Italian have been closed and opened, depending on the demand. Students are grouped first according to their level, then age group. Our biggest French class was 10 students in 2016. This year, we are only offering French and Spanish, with an average of 4-5 students per class. We have 5 French classes and 3 Spanish classes all of different levels from the beginners to advance.

We invite you to come and speak the language of your choice, in a relaxing setting. There are no grades or serious exams. We play games, sing and, of course, work on our grammar and vocabulary.

For those feeling confident about their skills, they participate in the annual national French contest. It is an optional competition where you earn medals and other small prizes. Oh! You also earn *le droit de frimer* for ranking in the top 10 :) Le Grand Concours at SchoolNova started in the year 2011. Since then, we have had 3 platinum winners. These are students who scored first (1st!) nationally. The past winners were (in chronological order): Dasha S. (2011), Sophia A. (2013) and Stefano T.-B. (2018). Bravo! Did I mention that as a teacher, I also have *le droit de frimer* and I get my own award? *Merci les élèves! ...* I have started *une nouvelle collection, bien sûr* :) Remember this contest is not an exam, but a fun way to see where you rank amongst other competitors in the nation who like and learn to *parler le français*. At the FLES (French language elementary school) level, we competed for the first time in 2012. So far, we have been the only school to participate in the French contest at such a young level in the county of Suffolk. Our youngest student is Alisa. She is 7 year old and in 2nd grade. Last year, she was a cheerful helper at the prize distribution, picking out the names for the French raffle. *Bien joué,* Alisa! This past February, she participated for the very first time in the contest... *Rendez-vous à la distribution des prix en mai!*

PS: I was going to translate the French vocabulary, but instead… why don't you join a class and learn these words and some more next year?


## Advanced English classes - What do we like to read?

*By Kara Palumbo, English teacher*

This year in Advanced English A (grades 5-7), students worked on analytical skills while reading classic literature. As with most years, I begin my classes with Edgar Allan Poe. It is always fitting because his work aligns well with the Fall season. After learning about the author, students read and analyzed Poe's "The Tell-Tale Heart," and held a mock trial for the main character as their final assignment. They then read other classic works such as, "The Gift of the Magi," and "The Lottery." Even though these stories are at a higher reading level than most of the students, they all worked hard to analyze and understand each story by asking questions and participating in class discussions. Recently, these students learned the art of poetry. They were taught how to write over ten different forms of poetry. This is where I saw my most timid students shine. Since they could tap into their own creativity and write freely, I found they not only enjoyed this portion of the class, but they were excited to show off their work. Every student will be submitting one of their poems at the end of the year to be published by SchoolNova. Next up will be essay writing. To make this a bit less stressful for the students, I let each class vote on what story they would like to read next, knowing that the chosen story would be the basis for the essay. Advanced English B (grades 8-10) began the year by analyzing a piece of fiction and nonfiction. After reading Roald Dahl's short story "Lamb to the Slaughter," and an excerpt from the diary of John Wilkes Booth, students were asked to write a compare/contrast essay addressing the topic of revenge. The process of writing this essay began with understanding how to write a proper thesis statement and then construct an essay that fully supports their claim. This is something that we are working on with each piece of writing that is assigned. Advanced English B was also given an opportunity to tap into their creative side by competing in the Scholastic Arts and Writing contest. Where often students submit their works to the Flash Fiction genre, this year we had some students take a chance and submit works in poetry, critical essay, and memoir. This past month, students were asked to do a research project on their own generation. This was one of the most interesting topics that I have had the pleasure to assign. This assignment began by telling the students what older generations thought of Generation Z. Then, Advanced English B had the opportunity to defend themselves. They learned how to properly cite reliable sources that would back up their claims. They were then taught MLA format so they could incorporate those sources in their own writing. Even though there were no winners in the Scholastic contest this year, I have to say that I have never seen a more determined or a harder working Advanced English B class than this year. They are always up for class debate/discussion, which transforms into some of the most powerful writing.

Very proud of ALL my hardworking students this year.

By Marina Polonskaia continued from page 1

and Physics program, 2 levels of computer science, 3 levels of chemistry, 2 levels of biology, a 10-year-long Russian program, 5 levels of French and 3 levels of Spanish, as well as classes in Visual and Performing Arts. This totals to over 90 classes! Every subject has its own curriculum developed by SchoolNova faculty. By agreement between us, we keep all our materials in an open access online. People from all over the world are using our materials.

In addition to regular classes, we host a myriad of science, math, and language competitions that are free and open to the community at large, and we have recently added math and physics clubs which are free for SchoolNova students. This year, one out of every ten classes is free of charge.

Over the last several years SchoolNova has opened 3 unique programs for high school students:

**Advanced Math and Advanced Physics clubs** — those clubs are open to the local community either for a nominal flat fee or completely free of charge. The Math Club is taught by A. Kirillov, Professor in the Math Department at Stony Brook University and the Physics Club is taught by A. Abanov, Z. Komargotki and S. Suchalkin, professors in the Physics Department, SCGP, and the Electrical Engineering Department, respectively. All instructors have extensive experience with Math or Physics Olympiads (up to the level of international physic's Olympiad, IPhO). The goal of those clubs is to confront students with problems that they already have the tools to solve, but which require more creative and out-of-the-box thinking than they are used to.

**CaféNova** — this is a new initiative aiming to bring together students from local high schools with graduate students, postdoctoral fellows and faculty of prestigious institutions such as SBU, BNL, and the Simons Center for Geometry and Physics, all in an informal setting. Rather than giving formal presentations, researchers in various fields are there to answer students' burning questions about research, education, life in academia, and to give advice about colleges and graduate schools.

**Junior Teaching Assistants program** — this very successful project, now in its fourth year, gives SchoolNova graduates an inside look at our teaching methods and philosophy. Teaching is a challenge unlike any other as it requires a deeper understanding of the subject and the ability to explain a concept in multiple ways. By becoming TA's, SchoolNova graduates gain invaluable experience that will definitely help them in their future.

In 2012 a group of SchoolNova faculty and a few parents have opened a week-long residential summer science camp for gifted middle school students — SigmaCamp. The main idea of the camp was very similar to the one we have at SchoolNova — to give motivated students an opportunity to learn math and sciences from professional scientists. A residential camp setting helps students to immerse in an environment where they are able not only to learn new things from real scientists in the team-taught classes, but more importantly be able to communicate with them outside the classroom. Many of SigmaCamp original faculty were lucky enough to attend similar camps while growing up — it was such an inspiring experience that we wanted to make the younger generation experience it as well.

The SchoolNova has changed over the years — we have now more teachers, more classes and more students. In 2012, we spun-off our branch from the New Jersey school and re-established ourselves as a local, independent institution — SchoolNova at Stony Brook. We became a nonprofit organization and in 2013 received 501(c)(3) status. Tuition is very reasonable and grew only 25% in over 15 years.

And the school remains the same — more than 20 teachers are at the school for at least 10 years, several teachers are part of the program from the very first day of the school and in 2015 a class of 12 students has graduated from the school after 11 years of being students here! Some families first joined us when they had only one child and now they come to the school with a third one. Few parents with advanced degrees in math and science have joined our ranks as teachers. I cannot fathom where we might be in another 15 years, but I want to believe that the school will be up and running and its ideas will prosper.

One of the testimonials from SchoolNova parents:

*"...Many schools offer private classes and enrichment programs. Now that we have moved to NJ and had to look for another school, I finally understand and can fully appreciate how unique and special SchoolNova program really is. The classes are small, the teachers are incredibly dedicated and caring, the actual lessons are very well organized, homework is posted online, teachers give out their emails and phones, director of the school is always helpful and approachable. The diversity of the classes offered in the curriculum is amazing, I have not found any other school anywhere in tri-state area with such a wide scope. It is a real gem in Long Island, I know people drive for an hour and more just to have their children attend the school..."*

**How Can You Help SchoolNova:**

SchoolNova at Stony Brook is a nonprofit 501(c)(3) tax-exempt organization and is qualified to receive tax-deductible bequests, devises, transfers or gifts. Contributions from individuals, foundations and corporations are welcome.
You can donate through the PayPal Giving Fund (no fee), by sending us a check or through Fidelity Investments. (School's account # Z47924238).
You can also donate via Facebook (no fees): Use DONATE button: facebook.com/schoolnova/ and Benevity Causes portal.

If you would like to make a donation towards a specific area, please let us know!

If you would like to give a substantial donation and discuss how it will be used, please email Marina Polonskaia.

**How Your Employer Can Help?**

If you cannot make a donation yourself, please take a few minutes of your time to see if the organization or company you work for donates any money to charitable organizations. Sometimes organizations or companies match the donations of their staff to some charitable organization. If you need proper documentation from SchoolNova proving that the organization is non-profit, please let us know and we'll send you documentation.

**Contact person: Marina Polonskaia, director@schoolnova.org**

By Igor Zaliznyak continued from page 2

– who conduct research using these flagship scientific facilities at Oak Ridge.

When large negative thermal expansion was discovered in ScF3, I and my Brookhaven colleague Emil Bozin set out to understand its microscopic nature using neutron scattering. We employed the technique of total scattering and pair distribution function analysis, which provides experimental measurement of specific inter-atomic distances in the material, and how they evolve with temperature. Our experiments provided puzzling results – while the distance between some atoms decreased when the material was heated, in accord with negative thermal expansion, the scandium-fluorine distance increased, while positional correlations between nearest fluorine atoms seemed to disappear. And, with the amazing efficiency of experimental tools at our disposal, after just a week-long experiment we had A LOT of data to analyze.

It is at this point that a lucky opportunity emerged, provided by providential coalescence of three science outreach programs: the SchoolNova academic enrichment program, the Sigma Camp week-long summer science camp, and the Brookhaven Summer Student Internship program. David Wendt, a School Nova student who also attended my Semilab course on the Physics of Radioactivity at Sigma Camp, applied for a Brookhaven Lab internship and reached out to me about a possible science project. Knowing David, I immediately realized that this might be tremendously productive collaboration, with great chance of pushing our NTE project to completion and this is indeed what happened.

I first set David a "modest" (in fact, quite ambitious) goal of developing a simple model for the probability distribution of the nearest F atoms, which independently vibrate as a result of thermal motion constrained by rigid Sc-F linkages. For this, David had to apply the profound math and physics knowledge he had learned at SchoolNova and Sigma Camp, and more. He also needed to learn Python programming, as the end result of the project was supposed to be a script that plots the probability distribution obtained from his model. David attacked the problem vigorously, and by the end of his Brookhaven internship not only had learnt Python and implemented my simple model, he also developed a more sophisticated, realistic model of F pair distance distribution and engaged in comparing it with our experimental data.

Our ambitions grew in parallel with David's successes, and when the internship ended we decided to continue work on our ScF3 project, meeting on Sundays at SchoolNova for discussions and communicating and sharing documents via Google Drive. It was a full year of continued research. At some point, our discussions with David at SchoolNova – in another stroke of luck – attracted the attention of my friend and Brookhaven colleague Alexei Tkachenko, who also teaches at both SchoolNova and Sigma Camp. Alexei, a theorist in the field of complex soft matter systems, such as biomolecules and nano-particle assemblies, enthusiastically joined us in working out a more rigorous theoretical understanding of the NTE phenomenon in ScF3. At the end, our collaboration was extremely successful. Thanks to David's modeling and analysis of the data, we were able to understand the physical mechanisms of NTE and develop a simple theory, which provides an astonishingly accurate quantitative description of NTE.

What we learned is somewhat surprising: thanks to the specific geometry of the atomic crystal lattice and unique properties of Sc-F bond, NTE in ScF3 has the same physical origin as a more common, positive thermal expansion: atomic thermal motion. Moreover, the reasons why ScF3 and solids with similar network crystal structure shrink when heated are essentially the same as for rubber and polymers, soft matter systems commonly known to show NTE, an effect called "entropic elasticity". It originates from the competition of atomic thermal motions, which increase with the increasing temperature, and electric interactions between atoms, which secure the crystal's stability. Our results thus uncovered a unifying picture of the NTE phenomenon across soft and hard condensed matter. That these findings are unexpected can be already inferred from current Wikipedia entry describing NTE: "Rubber elasticity shows NTE at normal temperatures, but the reason for the effect is rather different from that in most other materials. ... Cubic Scandium trifluoride has this property which is explained by the quartic oscillation of the fluoride ions." Our work with David reveals that the reason in both cases is the same. So far, this work has earned David a well-deserved place in the top 300 projects in the Regeneron Competition. Once the manuscript describing our results is published, the Wikipedia entry will have to be corrected, too.

---

By Alexei Tkachenko continued from page 1

most powerful telescope of that time, and the world would never be the same. Among other things, Galileo is credited for his discovery that all falling objects have the same acceleration in gravity (if air resistance can be neglected). He was the first to measure the time it takes to fall from various heights. This led to another discovery of a non-linear scaling law: the distance (d) traveled in gravity was proportional to time (t) squared: $d=gt^2/2$ ($g=9.81 m/s^2$ is gravitational acceleration on Earth).

The shadow of Vincenzo Galilei appears in our story once again, when Johannes Kepler, another Founding Father of modern Physics, is set for a long trip across Europe. He needs to go back to his native town, to build a legal defense for his old mother standing a trial as an accused witch (a harsh accusation for those times). On this trip, Kepler reads a book on music theory by Vincenzo. According to his own account, this book inspired Kepler to relate the period of orbital motion to the radii of the orbits. For centuries, the notion of "celestial music" was very common, and the connection between astronomy, geometry, and music was rather natural to Kepler. Ironically, his own book called ***Harmonices Mundi*** ("Harmony of the world") led to the demise of this old, Pythagorean, approach to science, and to the birth of Physics as we know it. Driven mostly by wrong arguments, Kepler discovered the Third Law of Planetary motion. Once again, this was a non-linear scaling law: for period (T) and radius (R) of an orbit, Kepler found that that $T^2$ is proportional to $R^3$. The final step was made by Newton half a century later, who realized that the gravitational acceleration measured by Galileo, and the planetary motion governed by Kepler's laws, can all be explained by the same universal law of gravity. Guess what? This was another non-linear scaling law. The force of gravity between two masses is **inversely proportional** to the distance between them, **squared**.

This year marks 400 years since Kepler's ***Harmonices Mundi*** was published. It also marks 100 years of the total solar eclipse on May 29, 1919. During the eclipse, Einstein's theory of General Relativity was experimentally proved, making him an instant celebrity and cultural icon. Einstein's theory superseded Newton's, just like the new technologies of today seem to supersede each other faster than they appear. But what is 100 years, or 400? Just a blink of an eye.

# The importance of problem solving in learning Physics

***SchoolNova Advanced Physics Club and Physics Competitions***

*By Alexander Abanov, Math and Physics teacher, on behalf of APC* organizers *(apc@schoolnova.org)*

Is it possible to become a physicist by listening to public talks about physics research frontiers? Or by sitting through classes and doing end-of chapter homework problems? Or by reading popular science articles? No way! Physics research is not just reflections about concepts and ideas. It is equally about applying those ideas to probe the laws of the Nature and to make specific predictions about those laws. In order to develop our skills in applying physics concepts we solve problems.

At SchoolNova we offer a 5 year Physics course covering topics from elementary mechanics to modern physics. But still there is not enough time to practice solving physics problems. To remedy this, last year we started two physics problem solving clubs: for middle and high school students. The idea was to get a better understanding of physics by applying physics laws to solving carefully chosen "beautiful" problems. The concept of "beautiful" or "elegant" problem is subtle and requires a separate article. Making or even selecting such a problem requires an acquired taste and more often than not such jems are buried in textbooks among many boring and essentially incorrect problems.

To remedy this problem, last year we started two physics problem solving clubs: for middle and high school students. The idea was to get a better understanding of physics by applying physics laws to solving carefully chosen "beautiful" problems. The concept of "beautiful" or "elegant" problem is subtle and requires a separate article. Making or even selecting such a problem requires an acquired taste and more often than not such jems are buried in textbooks among many boring and essentially incorrect problems.

The Advanced Physics Club (APC) for high school students this year was run by physicists having an extensive experience with Physics Olympiads (up to the level of international physics olympiad, IPhO). One of us, Dalimil Mazac, was a two-time winner of IPhO gold medal. The APC this year was sponsored by SchoolNova and the Simons Center for Geometry and Physics and was absolutely free of charge for all high school students who signed up for the club. We contacted some of local schools to invite as many as high school students as possible and were solving problems with them on Sundays. We used problems from competitions all over the world. Some of them can be found on the SchoolNova APC page:

**schoolnova.org/nova/classinfo?class_id=adv_phy_club&sem_id=ay2018**

A few of APC meetings were devoted to solving problems from leading US Physics competitions: **"F=ma"** and **"PhysicsBowl"**. Both contests are run by the American Association of Physics Teachers (AAPT) with the registration fee paid by SchoolNova for all students who would like to participate. This year we had F=ma exam on January 23, 2019. It isa 75-minute exam with 25 multiple-choice questions focusing on mechanics. You can find more information about the exam here:
**www.aapt.org/physicsteam/2019/pracexam.cfm**

This year one of club's students advanced to the next stage exam, by invitation only: USA Physics Olympiad (USAPhO), on April 2. **We wish him a success!**

The PhysicsBowl competition is a 40-question, 45-minute timed, multiple-choice test. SchoolNova will run this year's test on April 3, 2019. If you are interested you can find more details about exams here: **aapt.org/programs/physicsbowl/**
If you would like to write the exam with SchoolNova you can still register here (subject to seat availability):
**schoolnova.org/nova/node/478**

To conclude I would like to say that it is not easy to find high school students who are motivated enough to spend time (as busy as they are) to solve Physics problems on Sundays. However, it is definitely worth it! We are planning to continue the club next year and to advertise it more widely therefore we need your help. If you are interested in learning how to solve physics problems (and you should!), please, spread the word out. The more club participants we have next year the more successful this program will be. More details about the club can be found here:
**schoolnova.org/nova/physics_club**

## 3rd SchoolNova Math and Science Festival 2019

*You are invited to celebrate the beauty of Math and Science!*

**What:** math games, science experiments, puzzles, hands–on activities, fun competitions and exciting demonstrations.

**When:** Sunday, May 5th, 1:00 – 3:00 pm

**Where:** SchoolNova – Plaza-level of the Physics and Astronomy building, 1st and 2nd floors of SCGP and if a weather allows – entire area between those two buildings.

If you have friends who are not SchoolNova students – invite them to the Festival! There will be no need to sign up: students can move between stations or stay at their favorite one as long as they want.

Even though the festival runs until 3pm, there will be no snacks provided by SchoolNova due to Stony Brook University regulations, so please be sure to bring some snacks and water for your children.

The Festival is **free of charge and open to everyone,** including those who are not current School Nova students.

# CaféNova

*By Zohar Komargotski, Advanced Physics club instructor*

*CaféNova is a new initiative from the founders of SchoolNova at Stony Brook.*

The idea of CaféNova is to bring students from local high schools together with graduate students, postdoctoral fellows and faculty of prestigious institutions such as Stony Brook University, BNL, and Simons Center for Geometry and Physics, all in an informal setting.

Rather than giving official presentations, professors and researchers in various fields are there to answer students' burning questions about research, education and an everyday life in academia.

The presence of graduate students and postdocs is very important – they provide the high-school students with a more tangible and concrete projection of themselves to the near future. The high-school students who are likely to participate in CaféNova are already well aware of their interest in science and hence would be often interested in the path taken by the graduate students and faculty in their early career, and especially their engagement with science during school years. This may provide the high-school students with some invaluable information and encouragement in certain cases.

Some high-school students may not have sufficient self-confidence to pursue a career in science. For this it is very important that they see the wide range of talents, which are useful in academia, where almost everybody can find his or her calling. The high-school students will also see that working as a researcher is very different by nature from the routine studies in high school.

Another element often missing from the high school curriculum is the emphasis that science is open ended and there are crucial and challenging open problems in all fields of science. By interacting with the faculty members and graduate students alike, the high school students can learn that in fact we do not understand 85% of what the universe is made of, that we do not know what happens in Black Holes, and we do not know why there is an apparent rapid explosion in the available forms of life at the beginning of the Cambrian, among dozens of other at least equally interesting open questions. The high school students can appreciate that they can contribute something, perhaps they can elucidate some of these open questions!

The final part of the session – playing some mathematically rich games and free interactions with other students and faculty is perhaps the most important part – one-on-one discussions and board games lead to a certain additional release of the tension and can provoke more personal experiences. Typically, high-school students are rarely able to engage (or have access to) with graduate students or faculty members in their field of interest. This kind of ability to spend some time with a possible projection of your future self can be really informative.

Very important facet of this gathering as a whole is that it provides scientifically inclined students with a supportive environment and space, where they can meet on a regular basis other like-minded high-school students, make new friends, and have a good time.

---

During our past meetings we had many distinguished professors from Stony Brook University introducing wide variety of topics.

On January 15th, featured guests were professors Harold (Hal) Metcalf and Eden Figueroa of the Department of Physics and Astronomy of Stony Brook University presented topics about atomic, molecular, and optical physics (AMO) with applications to quantum information technology.

From left to right: professor Harold (Hal) Metcalf, professor Eden Figueroa, professor Zohar Komargodski, professor Neelima Sehgal

Next meeting, February 5th, professors Zohar Komargodski, Neelima Sehgal and Sergey Dubovsky discussed cosmology, black holes and quantum field theory.

On March 5th, our guests were math professors Anthony Phillips, Alexander Kirillov and Robert Hough from Mathematics Department of Stony Brook University. They discussed "most beautiful" math formulas, history of math of XX century.

From left to right: professor Sergey Dubovsky, professor Anthony Phillips, professor Alexander Kirillov, professor Robert Hough

By David Wendt continued from page 2

what we are used to; there exists a certain group of materials, however, that actually shrink upon heating, and this is the behavior we set out to explain. With some computer modeling and data analysis, we were able to test a hypothesis about its origin being bond rigidity, and we emerged with results confirming our ideas.

Specifically, we analyzed the material ScF3, which both undergoes negative thermal expansion (NTE) and has a simple cubic crystal structure, making it an ideal candidate for study. Neutron scattering experiments had already been performed at Los Alamos National Lab and Oak Ridge National Lab by colleagues of Dr. Zaliznyak, and my role was to analyze the data, create a virtual model based off of the hypothesis, and compare the two to determine the accuracy of the hypothesis. The neutron scattering data was in the form of a "pair distribution function," or PDF, which was a measure of the distances between pairs of atoms. In the graph to the right, the PDF, g(r), is shown with triangles and error bars, and it essentially quantifies the probability of finding a pair of atoms (here, two fluorine atoms) at a certain distance. The solid lines show my model of what the distance distribution should be based on the hypothesis that the Sc-F bonds in ScF3 are semi-rigid instead of being more like springs, as would be expected in such an ionic compound. The relative agreement between model and data confirms the hypothesis.

While a majority of this work was completed over the first summer of our collaboration, we continued to work during the following two years, culminating in a scientific paper that has been submitted for publication to a high-profile physics journal. I cannot wait for it to be accepted, and I am sure it will be one of my proudest moments yet. This experience will surely provide a foundation on which I will build in the future, as my long-term goals are (as of now) to pursue physics as a career, hopefully as a professor and researcher.

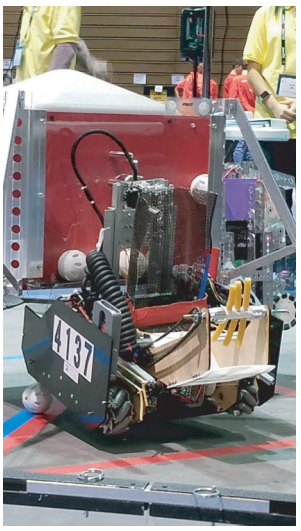
I will soon take my next steps this coming fall as I will be attending Stanford University, studying physics.

### A list of annual community events offered, hosted and sponsored by SchoolNova:

**AMC 8** – American Math Contest coordinated by MAA – November
**AMC 10/12** – February
**Le Grand Concours** – National French contest coordinated by AATF – February and March
**F = ma** – National Physics competition coordinated by AAPT – February
**PhysicsBowl** – National Physics competition coordinated by AAPT – April
**Math and Science Festival** – Spring
**Math Kangaroo Olympiad** – March
**Advanced Problem Solving clubs** – Math and Physics – every Sunday from September to May
**CafeNova** - first Tuesday of every month from October to May

## Islandbot Robotics club

*By Alexander Kirillov, Islandbot coach, SN Math teacher*




Islandbot Robotics club, mentored by SchoolNova teachers Alexander Kirillov and Corina Mata is still going strong after 11 years!

As before, we participate in First Tech Challenge (FTC) robotics competition, building, programming and driving robots and competing against other teams on Long Island - and most importantly, having fun!

This year was a challenging year for us, as half of the team were high school seniors - and thus, busy applying to colleges. But they still found time for our weekly meetings - and lot more meetings in the days before the competitions, sometimes staying up until 3am to debug a tricky piece of code, or make another revision to the design of our sweeper, which had to collect balls and cubes off the floor.

In the very first qualifying championship we participated this year, we got the main award - the Inspire Award - and advanced to Long Island Championship, which took place on March 9 in Syosset. FOr that championship, we redesigned most of our robot, as we were not quite happy with its previous performance. Unfortunately, we didn't have enough time to properly test and troubleshoot our redesign, and didn't do as well as we hoped in the Championship: we were eliminated in the semifinals. So this is the end of the season for us - but we are already thinking about the new season (and in particular, about recruiting new team members to replace our graduates).

Below is a couple of photos from this year competitions; more photos are available in our facebook page:
facebook.com/islandbots

## Theater news - Russian studio “Dragonfly”

*By Nadya Shavarina, “Dragonfly” Director, SN teacher*

The 2018-2019 season continues to be quite intensive for our theater. We visited the International theater festival in Washington with the play "The Cat Who Walked by Herself".

We also presented a spring premiere based on the poems of G. Oster "Very Malicious Advice". This was a fun musical with original music and lyrics by Larisa Pokryvailo and Olga Kosobokova.

Our theater participated in School Nova's holiday event with "The Musicians of Bremen".Young actors performed the twelve songs from the famous cartoons and records of Gladkov and Entin, and Irina Butkevich conjured and created our incredible set decorations.

Right now we are working on a new show, an unusual and challenging play "The Pillow's Soul" by Olzhas Zhanaydarov. We are planning to take this play to the International Theater festival in Washington this June.

"The Musicians of Bremen"

G. Oster "Very Malicious Advice"

## PhysicsBowl 2019 at SchoolNova

The 2019 exam will be given on April 3, 2019
Division I is for first-year physics students
and Division II is for second-year physics students.
www.compadre.org/psrc/items/detail.cfm?ID=391

## Students are welcome to the following events hosted by Stony Brook University:

– Public lectures at the Simons Center for Geometry and Physics are given by leading scientists coming to the campus. The lectures are announced on the Center's website scgp.stonybrook.edu/ and also by posters. In particular, public lectures in the Della Pietra lecture series are described on the Center’s web site:
scgp.stonybrook.edu/scientific/public-lectures/della-pietra-lecture-series

The next few public lectures are:

– Public Lecture: Wednesday May 8 at 5:45pm (reception in the lobby starts at 5pm). The talk will be given by Prof. Charles Kane from UPenn. Dr. Kane is a theoretical condensed matter physicist best known for theoretically predicting the quantum spin Hall effect and what would later be known as topological insulators.

– Upcoming exhibition in the Simons Center Art Gallery: “Kolam: An Ephemeral Women’s Art of South India”.
Opening of the exhibition is on Tuesday, March 26, 2019.

Artist Talk: 5:30 pm, Kolam: An Ephemeral Women’s Art of South India, by Claudia Silva, Della Pietra Family Auditorium, SCGP 103 (reception in the lobby starts at 5pm).

– Lectures on Astronomy, Physics, Geosciences, Ecology and Evolution are given almost every Friday night during school year. These lectures are targeted to the general audience and are given by faculty of the University on topics related to their research. Schedules and information can be found at:
physics.sunysb.edu/Physics/WorldsOfPhysics/2018-19/

– SchoolNova is hosting several national math, physics, and language competitions. Links to these and other activities recommended by SchoolNova can be found on the SchoolNova web page: schoolnova.org/nova/activities


Like us on Facebook!
www.facebook.com/schoolnova

## Math olympiads

As in the previous years, SchoolNova, in collaboration with Stony Brook University math department, offered American Math Contest (AMC). This contest is the entry level of the math competitions which lead to the USA Math Olympiad, which in turn is used to select student to represent the US in International Math Olympiad.

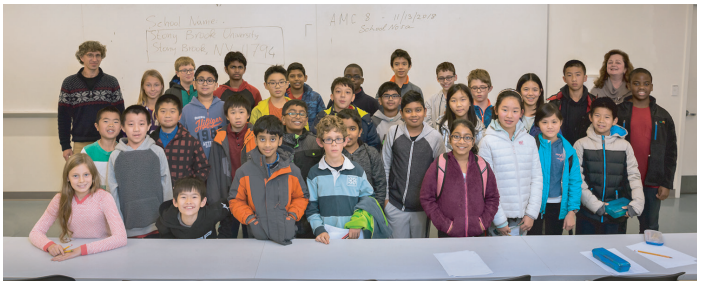
SchoolNova offered AMC 8 (for students in grades 8 and below) in October and AMC 10/12 in February. Each competition was open to all comers, not just SchoolNova students. We had about 40 students in each of the contests, some coming from far away for this opportunity.

Students who performed well in AMC10/12 (top 2.5% from AMC 10 and top 5% from AMC 12) are invited to the next level, the American Invitational Math Exam (AIME). This year, 4 of the students taking AMC10/12 with us qualified for AIME. The AIME contest was given on March 13; we do not have the results yet, but we hope that one of these students will qualify for the next round, the USA Math Olympiad.

This year, we also participated in another contest: Harvard-MIT Math Tournament (HMMT). This highly competitive math competition takes place annually in Boston; all teams have to travel there, participating in several rounds of problem solving. There are more teams applying for HMMT than they can host, so all teams wishing to participate are entered in a lottery. This year, we won the lottery and so in November we traveled to Boston for HMMT.

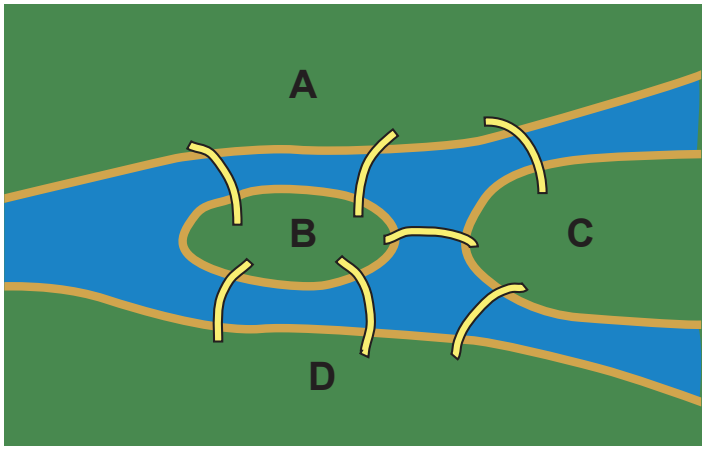
It was a fun but intense event, with many different rounds of problem solving, and the competition was fierce. Our team were 53rd (out of 150 teams) in the team round, which is a very respectable result - but we hope to do better next time!

For your enjoyment, here is one of HMMT problems:
*Abbot writes the letter A on the board. Every minute, he replaces every occurrence of A with AB and every occurrence of B with BA, hence creating a string that is twice as long. After 10 minutes, there are $2^{10} = 1024$ letters on the board. How many adjacent pairs are the same letter?*

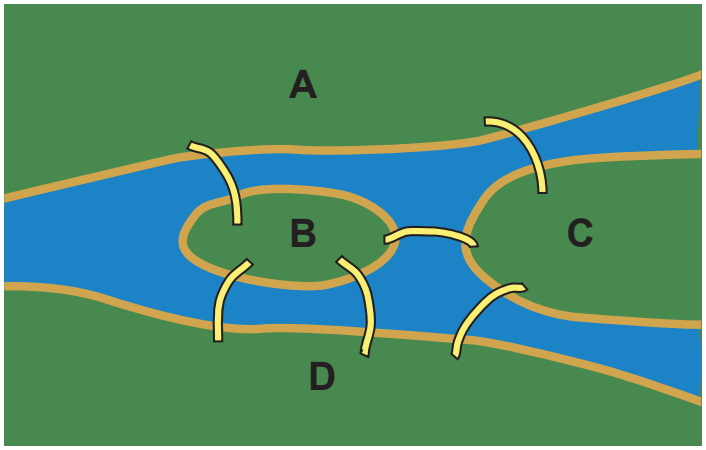


## Challenge Time

1. This is a map of a city with islands and bridges. Is it possible to complete a walk in this city so that you walk on each of the seven bridges exactly once? (You may start anywhere you like, and you do not have to come back to the starting point.)




2. Once, flood destroyed one of the bridges between river bank A and island B; the new map is shown below. Is it now possible to complete a walk in this city so that you walk on each of the seven bridges exactly once?




**Thank you for your support!**

We would like to thank everyone who was generous enough to donate time, money and corporate stocks to SchoolNova! We sincerely appreciate your support and help!

Special thanks to the Simons Center for Geometry and Physics and to the Departments of Physics & Astronomy and Mathematics for providing space for SchoolNova's competitions and special events.