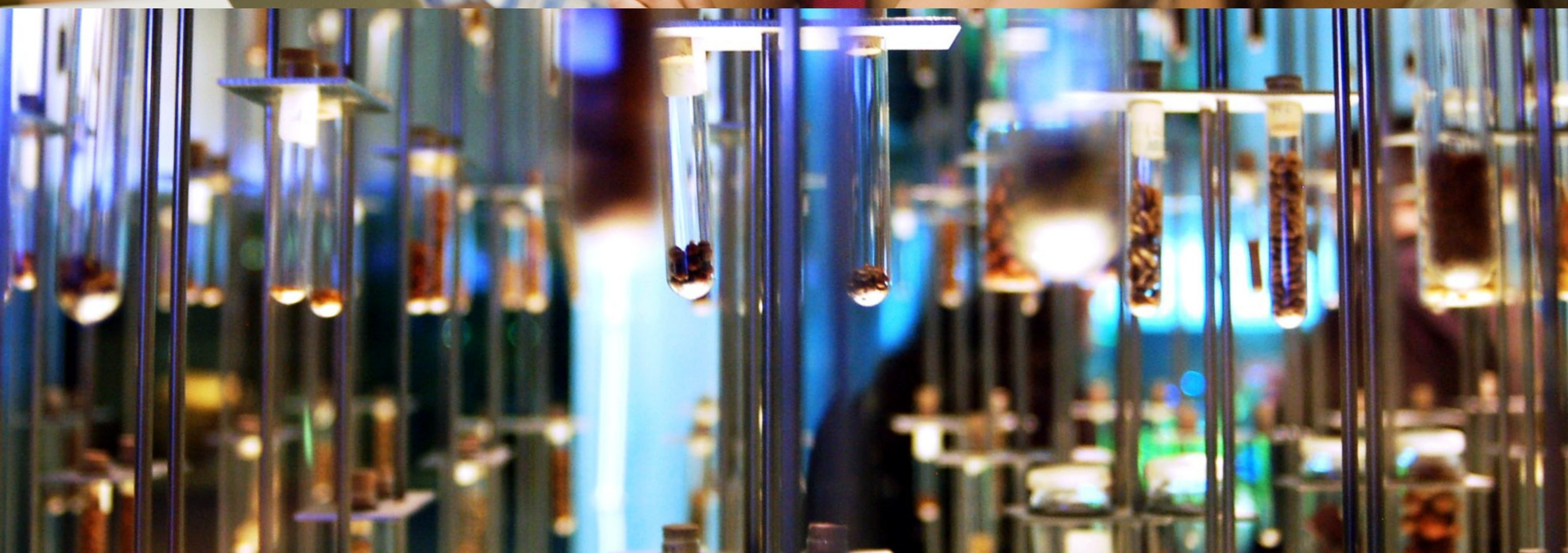
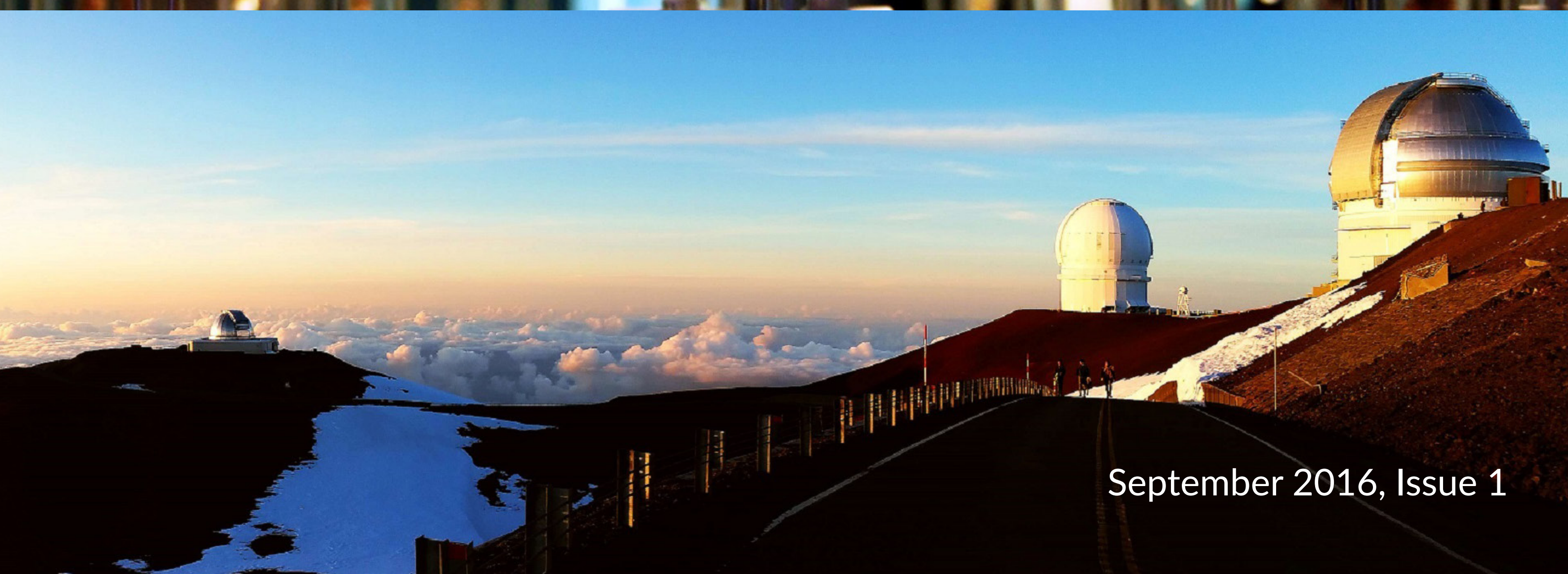
Pioneer® academics magazine





September 2016, Issue 1

Pioneer® academics magazine

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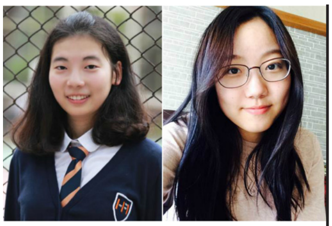

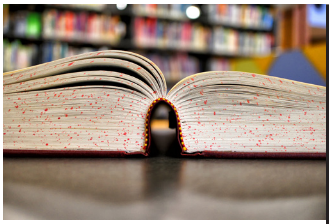

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From Pioneer to Publication:
Two Pioneer Scholars' Experiences with Neuroscience Research and Publication in a Leading Academic Journal

The widely respected journal *Anatomy & Physiology: Current Research* announced that two high-school authors are among the professors and Ph.D. scholars accepted for publication. This is a first for the journal.

This is not one of those extremely fortunate cases in which high school students interning at a lab tagged their names onto an article by Ph.Ds in that lab. Rather, the two high school authors selected the research topic and direction, the professor was inspired by their ideas, and the three accomplished it with seamless collaboration.

their curiosity about neuroscience, Pioneer admitted You Jin and Ming to work with Professor Jagmeet Kanwal of Georgetown University.

The paper You Jin, Ming and Professor Kanwal co-authored was *Brain Plasticity during Adolescence: Effects of Stress, Sleep, Sex and Sounds on Decision Making*. Their research investigated the neurology behind the increased plasticity – the ability to change and adapt to new situations – of adolescent brains and how adolescents make decisions. It helps explain why teenagers are difficult to deal with. Great news for stressed moms!

> *"It's not just a question of gaining knowledge from textbooks, but it is a question of direct communication between the student and the teacher."*

How did the collaboration come about?

You Jin Jung of Seoul, South Korea, and Ming Zhang of Guangzhou, China, were among 149 outstanding high-schoolers accepted into the Pioneer Global Research Program in 2015. They were selected by Pioneer from applicants all over the world based on their academic capability and their proven interest in advanced subjects. Based on

You Jin looked at the ways in which differences in personality and gender can affect individual adolescents' tendencies to take risks. She then analyzed the role gender plays in risk-taking tendencies, incorporating studies of the differences in how men and women react to stressful situations as well as the biochemical changes which occur in men's and women's brains when

faced with such situations.
Ming focused on the effects of stress and sleep on decision making in adolescents, concluding that stress and lack of sleep exacerbate the negative effects which uneven rates of development of three key parts of the brain during adolescence have on adolescent decision-making.

Both You Jin and Ming's research findings were incorporated into *Brain Plasticity during Adolescence: Effects of Stress, Sleep, Sex and Sounds on Decision Making*.

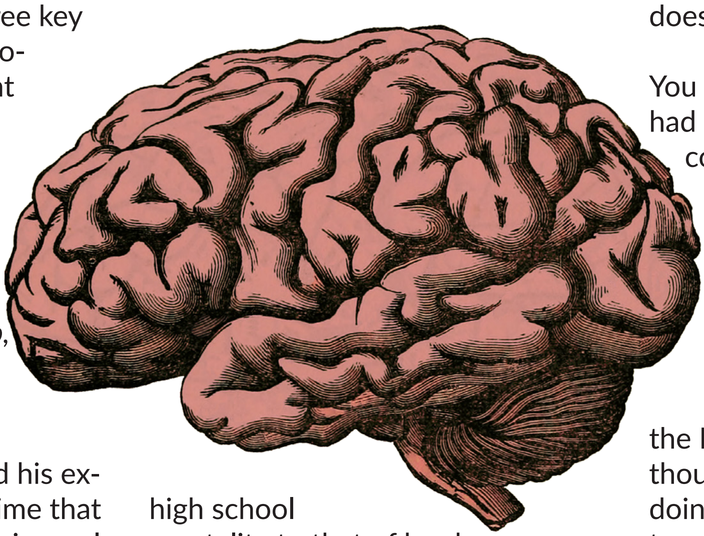
Professor Kanwal expressed his excitement: "This is the first time that we've published in a regular journal (meaning standards are for full-time researchers) with high school students. The topic was really initiated by the Pioneer students, and though it's not directly connected to my usual research, I was interested in it."

For the two young determined girls who inspired their professor, the experience was transforming. They competed to get into Pioneer out of undefined but strong interest in psychology and neuroscience. Accepted into the program, they first learned the foundations of neuroscience with Professor Kanwal in a small cohort. During the second phase of the program, they studied one-on-one with him and chose their paper topics independently. Both You Jin and Ming chose to research adolescent brains, a choice that sprang from a desire to better understand how they and their peers think and behave.

"I thought it would be fun to pick a topic that I can find personal connections in," Ming said.

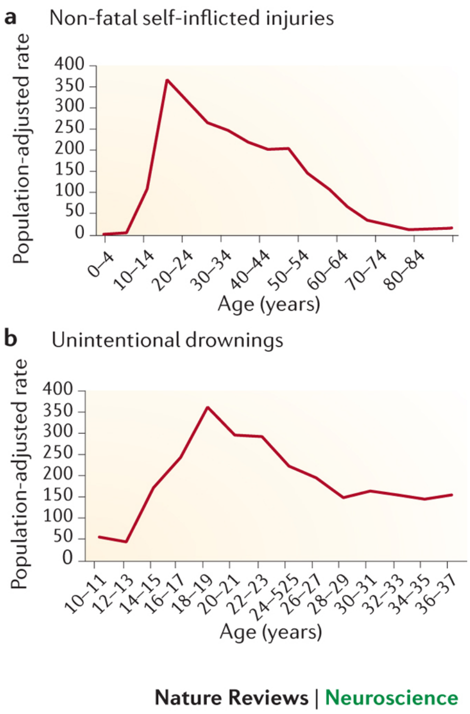
You Jin saw some fellow students acting in ways that would possibly endanger them, and she wanted to understand people's differences in risk-taking and how this is related to the physical characteristics of the brain at this age.

Collaboration brings teamwork and support, but it doesn't eliminate obstacles.Seemingly insurmountable challenges were overcome with Professor Kanwal's guidance, and You Jin and Ming evolved from a



high school mentality to that of hard-core scientists. You Jin, who will attend Columbia University in New York, and Ming, who will attend Oxford Unversity in England, now look forward to challenges like those encountered in Pioneer instead of feeling nervous about them.

How did You Jin and Ming do original work in science without a lab?



Risky behaviour, including non-fatal self-inflicted injuries (a) and unintentional drownings (b), increases between childhood and adolescence, peaks sometime in mid- or late adolescence and declines during the 20s. Data from the Web-based Injury Statistics Query and Reporting System (WISQARS).

Driven by strong interest, You Jin and Ming relied on critical thinking, creativity and expert guidance to achieve their scientific discoveries without lab work. Their success proves that original research work doesn't have to depend on labs.

You Jin: "Before I joined Pioneer, I had thought scientific research was conducting experiments. After I started the program, I realized that research can be more literary analysis. I really enjoyed reading different sources and putting them together."

Ming: "Before attending the Pioneer Research Program, I thought that research had to be doing experiments in labs. But it turned out that reading is definitely a very important part [of] research, because we need to learn about other people's work before we develop our own. Otherwise, we might repeat the works of others."

What challenges, particular to high school students, did they confront while writing the papers?

You Jin: "Understanding the online material was very challenging in the beginning. I would look for one chemical, but then find a whole explanation on the biological processes involving so many other chemicals. I had trouble distinguishing the important information from the unimportant. Then forming the outline was another challenge. I struggled with where my paper was going, and I had trouble setting the path to the right conclusion.

"I would always refer back to Professor Kanwal and contact him. He would always get back to me with great tips and new resources. For example, when I was starting to write my paper, I didn't know how to organize the paragraphs. He went through the outline with me many times and guided me on how to develop subtopics so that the paper flowed smoothly."

Why did Professor Kanwal decide to teach high school students in

Pioneer as a professor?

Professor Jagmeet Kanwal, Department of Neurology Georgetown University (Source: georgetownd.edu)

Professor Kanwal knows from personal experience how influential research can be: "Going far back, to when I was in high school and undergrad, I was always fascinated by animal behavior. And I still remember I watched a program on television that had to do with that research topic. I was just very intrigued by research..." Knowing how impactful inspiration is to a teenager, Prof. Kanwal believes firmly in Pioneer.

Prof. Kanwal: "I think that involving students in this kind of a program is extremely useful for them. I believe in personalized teaching, which is the focus of Pioneer. Usually, this type of teaching can only be possible in a doctoral training program.

"And if you look at what happens in doctoral training, it's that you have a very much one-on-one interaction. That is how you really understand how the student is thinking and how to improve that. So, it's not just a question of gaining knowledge from textbooks, but it is a [question of] direct communication between the student and the teacher. That's one important aspect I think that Pioneer provides to the students.

"Another aspect of it is that teaching is always a two-way process – I learn from the students that I teach as well, and that's very much true at the doctoral level. This is what's exciting about the Pioneer program with these outstanding high school students. Pioneer students go out and read very recent papers and they get to experience cutting-edge research that's going on, learn about it... those are really unique things that Pioneer provides."

You Jin Jung

Ming Zhang

How did Ming and You Jin react to getting published in the journal?

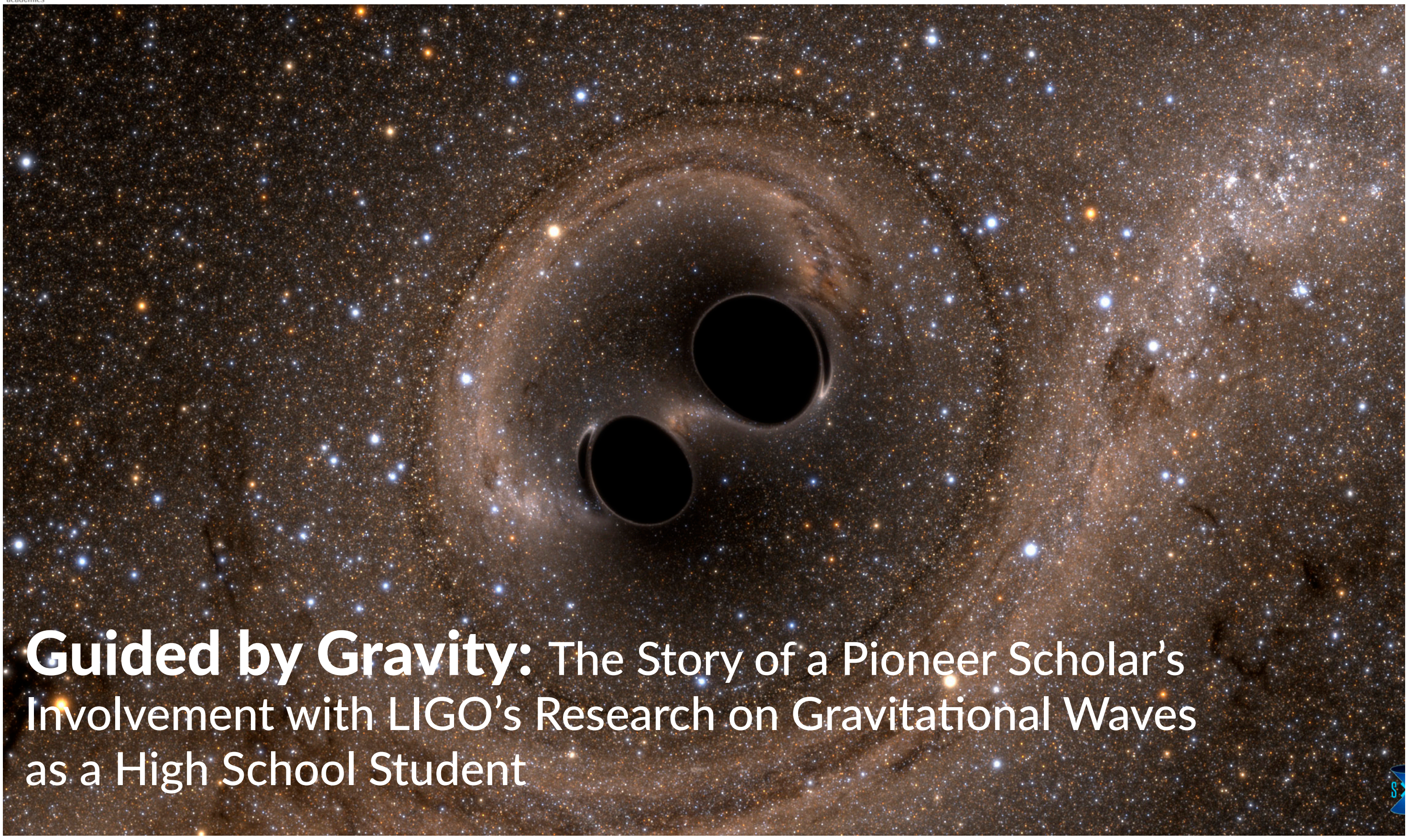
You Jin was elated. "When I first heard that my paper was published -- I was so happy! I went around telling my parents, grandparents, schoolteachers – I was so excited that I could barely sleep that day."

Ming: "My teachers were really excited when they learned about the publication of my paper. My counselor immediately asked me to take a formal picture for the school newspaper, and they actually wrote a whole report on this event. I'm the first student in my school to publish a paper in an international journal."

2015 Pioneer Research Journal Now Available Online

Pioneer Academics is pleased to announce the publication of the 2015 Pioneer Research Journal, which includes the work of select Pioneer Scholars from around the world. The articles featured in the journal are the final product of the Scholars' undergraduate-level research completed in the Pioneer Research Program. The papers cover a wide range of research areas, from a look at the neuroscience behind the increase propensity of adolescents to take risks, to the expansion of women's rights in Saudi Arabia, to a look at the effects of Greece's economic situation on the European Union, to the proving of the Nyquist-Shannon sampling theorem. The geographic distribution of the authors featured within the Journal is as broad as the range of topics. This year, the authors come from Spain, South Korea, the United States, the United Kingdom, Turkey, and China. You can access the complete journal at our website.

Guided by Gravity: The Story of a Pioneer Scholar's Involvement with LIGO's Research on Gravitational Waves as a High School Student



Two Black Holes Merge into One. (SXS, the Simulating eXtreme Spacetimes)

Unless you've been living under a rock, you will certainly have heard the news that gravitational waves were observed for the first time in February, and that Einstein predicted the existence of gravitational waves 100 years ago. You may also know that it was an organization called LIGO which observed the waves. In any event, you will know that it took years upon years of scientific effort – and funds – to prove the reality of this long-theoretical concept.

What you probably do not know is that last year, three Pioneer scholars – high school students – tackled this high-level, complex subject matter themselves – engaging in their own data analysis, programming their own computer models, and authoring their own research papers on the subject.

You may be wondering how it is that high school students were able to become involved with such a cutting-edge project. Surely they have a deeper understanding of this project, and the science behind it, than we do. Perhaps they can explain it to us in a way that we can understand? To see for ourselves, we interviewed one of the scholars. Meet Jinghong Liang, one of the high school scientists from Pioneer.

Jinghong is a senior at Beijing Number 4 High School, one of Beijing's most prestigious high schools. From the moment she discovered physics as a middle school student, she has been fascinated by the subject, and by astronomy as well. She has already begun to carve a name for herself as an eminent physicist, receiving prizes in the Beijing Primary and Secondary School Astronomy Observation Competition in 2013 and the Chinese National Junior and Senior High School Astronomy Olympiad the following year.

These deep-rooted interests prompted Jinghong to apply for the Pioneer Research Program. The program selects exceptional, motivated high school students from around the world to conduct research and, as high school students, write undergraduate-level research papers under the guidance and mentorship of experts in their chosen fields of study. After an intense application process, she had to decide on the specific focus and direction of her research. As it turned out, Jinghong's Pioneer professor was an expert in the field of gravitational waves.

Jinhong Liang

Though she did not know much about the field when she received her acceptance letter from Pioneer, it wasn't long after the program started before Jinghong was caught in gravity's pull. "I never thought I would be able to be involved in such a cutting-edge project," Jinghong explained excitedly. "I never expected that the professor would pull us into his actual research, let us analyze real data, and allow us to raise our own ideas about the LIGO project."

Which aspect of gravitational waves did Jinghong study? In order for us to properly understand her research, Jinghong first gave us a general introduction to gravitational waves and LIGO. First, Jinghong explained to us, in layman's terms, what makes gravitational waves and LIGO so special.

The Legend of the Gravitational Wave

Jinghong explained to us that gravitational waves are the epitome of Einstein's General Theory of Relativity. Moreover, the observation of gravitational waves constitutes an observation of the General Theory of Relativity in its entirety in the real world. Speaking of relativity, let's take a step back and review some of the basics of Newtonian mechanics.

Everyone knows the story of Newton and the apple – the story of the Earth's gravity. In Newtonian mechanics, mass produces force, i.e. gravitational force (G=mg). Using Newtonian mechanics, one can very accurately calculate and predict the motion of astronomical objects. The importance of this cannot be understated - it was Newtonian mechanics which enabled us to put a man on the moon. The fundamental premise of Newtonian mechanics is that speed does not have an upper limit; that is, there is no absolute speed, only relative speed. At a time when Newtonian Mechanics remained the prevailing theory of the day, a little-known patent examiner in Switzerland's patent office named Albert Einstein published a thesis – the Special Theory of Relativity.

The Special Theory of Relativity disproved the notion that speed does not have an upper limit, and posited that speed's upper limit is the speed of light. With this fundamental shift, Einstein completely rewrote the relationships between mass, energy, light, space, and even time.

"I never expected that the professor would pull us into his actual research, let us analyze real data, and allow us to raise our own ideas about the LIGO project."

The Special Theory of Relativity is "Special" because it does not take into account the effect of gravity on space and time. Despite this, its profound significance cannot be overemphasized. The equation $E=MC^2$, derived directly from the Special Theory of Relativity, has practically become Einstein's logo. The equation links together energy, mass, and light in an incredible defiance of the notion of space assumed in Newtonian mechanics. Moreover, in the Special Theory of Relativity, Einstein predicted that time is not absolute, refuting the commonly-held notion of time up until that point. In short, the Special Theory of Relativity radically transformed Newtonian mechanics, radically advancing the limit of human understanding.

LIGO Livingston (Caltech/MIT/LIGO Lab)

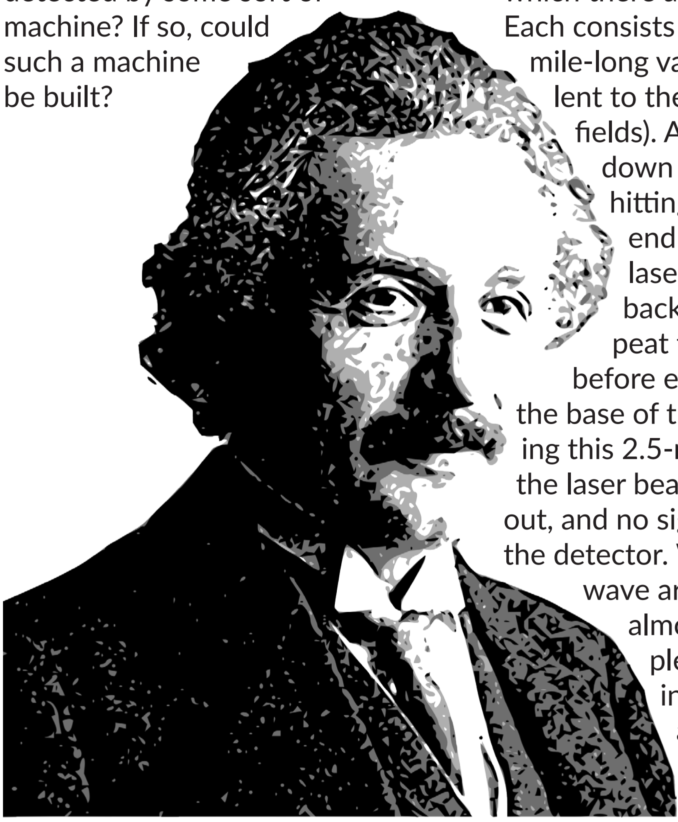
Eleven years later, at a time when many scientists continued to doubt the Special Theory of Relativity, Einstein published his General Theory of Relativity. The principles which Einstein did not take into account 11 years prior were now the central tenets of his theory – gravity causes space and time to warp, light can curve, and objects with very high mass cause time to slow down within the space they pass through. The General Theory of Relativity reduced the entire field of Newtonian mechanics to a simple tool for calculating mechanical motion; only the General Theory of Relativity can be counted upon to calculate and predict the broader movements and phenomena of the universe. To use an example that's closer to home, without making use of space-time warps as posited in the General Theory of Relativity, today's satellite-based navigation systems would be almost 10 kilometers off in all of their calculations.

This is where gravitational waves come in. Gravity can cause space and time to warp, and while accelerating, astronomical objects can cause space and time to ripple. These ripples are gravitational waves. This is also why gravitational waves are the epitome of relativity, and the essence of Einstein's entire scientific legacy.

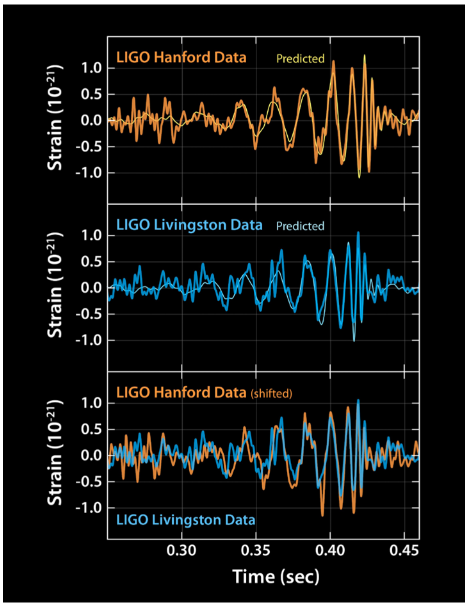
One might assume that gravitational wave are large and powerful, but they are actually quite weak. For instance, as the Earth orbits the sun, the two objects release an energy totaling 1.14x1036 joules; however, the gravitational wave they create emits an energy of only 200 watts. To put that into perspective, the power produced by a typical 30-inch household television is around 160 watts! It is for this reason that it is so hard to detect gravitational waves.

LIGO – A $620,000,000 Endeavor

How much energy must a gravitational wave carry for us to be able to detect it? (Hint: Trying to detect gravitational waves created by objects in the solar system is virtually impossible.) Can the waves be detected by some sort of machine? If so, could such a machine be built?



These were the questions which sparked the formation of LIGO in 1992, starting a new chapter in the search for gravitational waves. This chapter is reminiscent of Galileo's invention of the telescope 407 years earlier, a feat which enabled him to prove that the sun is at the center of the solar system and that the planets revolve around it.



Gravitational Waves, As Einstein Predicted (LIGO)

Unlike Galileo's discoveries, however, gravitational waves cannot be detected with a simple telescope. LIGO stands for Laser Interferometer Gravitational-Wave Observatory. The LIGO observatories, of which there are two, are massive. Each consists of an L-shaped, 2.5 mile-long vacuum tube (equivalent to the length of 44 football fields). A laser beam is sent down the length of the tube, hitting a mirror at the tube's end to create another laser beam which is sent back again. The beams repeat this journey 75 times before eventually returning to the base of the tube. After repeating this 2.5-mile journey 75 times, the laser beams cancel each other out, and no signal is received by the detector. When a gravitational wave arrives, it causes an almost imperceptible ripple in the space, causing the tube to extend and retract, thereby inciting a resonance from the laser beam, and in turn causing the detector to receive a signal.

As noted above, the radiation from gravitational waves is very weak. Additionally, the delicate LIGO detectors also receive interference from their surroundings. Passing trucks, barely perceptible earthquakes, and thunder and lightning can all create "noise," which effectively buries the gravitational waves so that they cannot be detected by the LIGO detectors or causes the LIGO detectors to mistake the source of the "noise" for a gravitational wave. This was the reason that two LIGO observatories were built, one in Richland, Washington and the other in Livingston, Louisiana. This setup enables LIGO physicists to pinpoint a gravitational wave's source, using the distance between the two observatories (1,865 miles) and the speed of the gravitational wave to determine the wave's source by triangulation. It was this method which enabled us to confirm the following: after circling around each other with a speed eventually reaching half the speed of light, two black holes 1.3 billion lightyears away from us merged together, releasing a tremendous amount of gravitational energy and thereby warping space and time to create a gravitational wave. After 1.3 billion years, this wave finally reached Earth, and was detected by LIGO.

Which aspect of gravitational waves did Jinghong research?

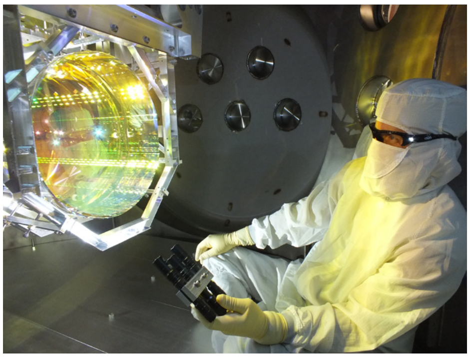
Following their small-group study of LIGO with their Pioneer professor, the three students in the Pioneer LIGO study cohort each pursued their own LIGO-related research topic of interest. While the other members of the cohort focused their research on LIGO-related data analysis and the energy of gravitational waves, respectively, Jinghong looked into how to differentiate the types of "noise" which interfere with the LIGO detectors' readings. Her thesis was titled *Analysis for Recovered Compact-Binary-Coalescence Hardware Injections*. To put this into layman's terms, she set out to evaluate the accuracy of the LIGO sensors' readings by looking into the types of man-made "noise" which interfere with them.

Could the signal from gravitational waves be that difficult to detect? Is it really that easy for "background noise" to interfere with the LIGO detectors' results?

Guaranteeing the accuracy of the LIGO detectors is the key to detecting gravitational waves and ensuring that the detectors will not make any "misjudgments." In addition to building two observatories, LIGO engineers took a series of other steps to ensure the accuracy and sensitivity of the LIGO detectors. From 1992, when LIGO was established, to 2002, when the LIGO detectors were activated, and all the way to 2010, the search for gravitational waves had proven fruitless. As such, the efforts were suspended for five years while the detectors were upgraded. In 2015, after the upgrade, the engineers found that the sensitivity of the sensors was 4 times what it had been before.

Sure enough, it wasn't long before the waves were discovered on September 14 of that year. After a short five months of analyzing and verifying the data, the findings were formally announced on February 11, 2016.

Throughout the entire time the LIGO machinery was operating, the LIGO engineers inserted add-ons – "hardware injections" – into the machinery at regular intervals to test the accuracy and sensitivity of the detection equipment. It was this effort on which Jinghong focused her research.



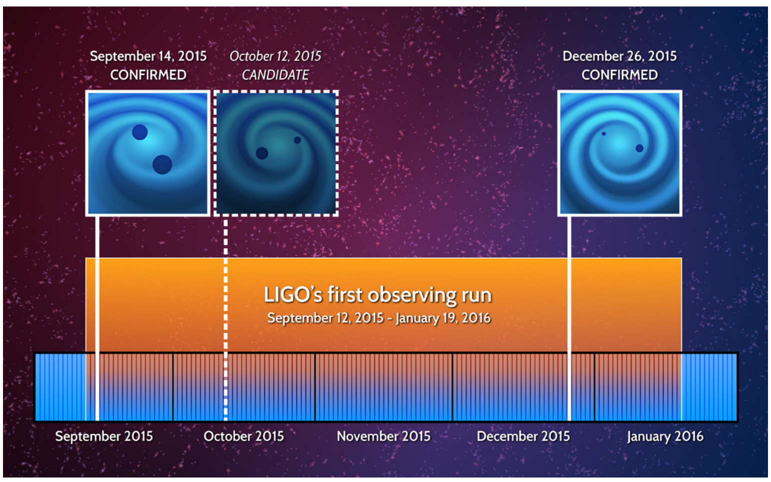
Inspecting LIGO's optics for contaminants (Matt Heintze/Caltech/MIT/LIGO Lab)

Jinghong's first step was to confirm the precise GPS times at which the hardware injections were made (this information has been made publicly available by LIGO). She then used the data to program a computer model through which she was able to remove the background noise, apply the Fourier transform, and more, to determine the ratio of the signals received by the LIGO detectors to the noise interference they receive, and a wave diagram depicting this information. Jinghong then compared LIGO's results to her own, verifying the effect the injections had on the detectors and their ability to increase the detectors' accuracy.

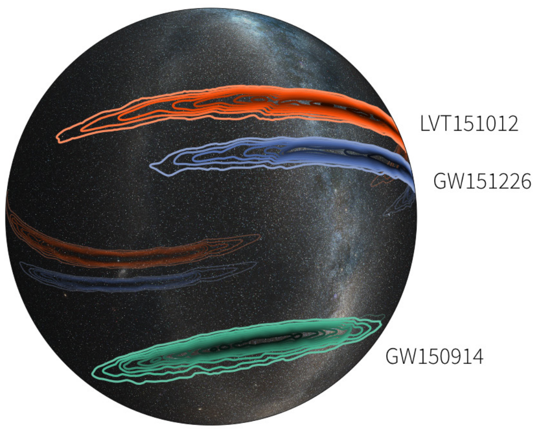
"Before the news on February 11, I had read all sorts of rumors and speculations," said Jinghong, smiling as she reminisced. "But the day the gravitational wave observation was announced, I was still shocked." Jinghong went on to tell us how eye-opening and life-changing her Pioneer experience was for her, and how proud she is to have been able to be a part of an important historical moment as only a high school student.

"Thank you, Pioneer, for giving me the opportunity to engage in such cutting-edge scientific research at such depth," said Jinghong. "It was a tremendously meaningful experience." "Although my research and thesis are finished, and the news of the observation of gravitational waves has already been released, I plan to continue my research of gravitational waves, and to explore the mysteries of the universe," she added. "More importantly, I will continue to use what I learned through Pioneer in my future studies and personal development."

After the interview, we sat in awe, thoroughly impressed that a high school student could discuss the scientific theories, methods, and history behind gravitational waves so eloquently. The interest that motivated her to partake in her research was clear to see, and it was evident that the opportunity to personally partake in cutting-edge scientific research continued to drive her forward and ultimately changed her world. After her remarkable journey with gravitational waves, we can't wait to watch Jinghong spread her "intelligence waves" throughout the world!



LIGO's First Observing Run (LIGO)



Mapping LIGO's Detections on the Sky (LIGO/Axel Mellinger)

2015 Pioneer Research Program: Selected College Admission Results

The following is a list of selected college admissions results from the Pioneer students who applied during the 2015 admissions season

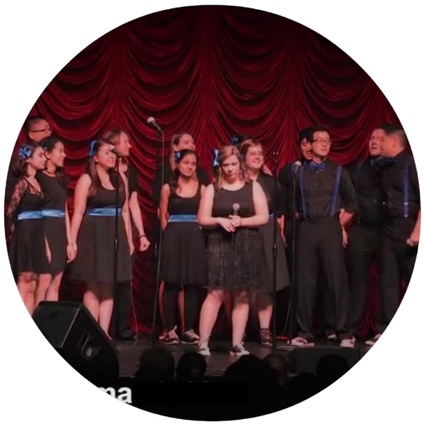
Research Program high school seniors who applied to college in 2015: 120 (includes sophomores from 2014 and juniors from 2015)
Average SAT Statistics: Critical Reading = 709, Mathematics = 782
Average TOEFL Score (International Students): 111
(Note: Scores above are not from when the students applied to Pioneer, but instead from when the students applied to college 1-2 years later)

U.S. Universities (alphabetical Order)	U.S. Liberal Arts Colleges (alphabetical order)	Non-U.S. Schools (alphabetical order)
Brown University (5)	Barnard College (1)	Bath University (2)
California Institute of Technology (1)	Bowdoin College (1)	Brighton & Sussex Medical School (1)
Carnegie Mellon University (9)	Carleton College (3)	Durham University (2)
Columbia University (3)	Claremont McKenna College (2)	Hong Kong Univ. of Science and Technology (1)
Cornell University (6)	Colby College (2)	Imperial College London (2)
Dartmouth College (2)	Colgate University (1)	King's College London (3)
Duke University (5)	Colorado College (1)	Lancaster University (1)
Emory University (4)	Grinnell College (2)	London School of Economics (3)
Georgetown University (2)	Harvey Mudd College (1)	McGill University (2)
Harvard University (3)	Haverford College (1)	Queen Mary University of London (1)
Johns Hopkins University (3)	Macalester College (1)	University College London (5)
New York University (13), Stern (2)	Oberlin College (4)	University of British Columbia (2)
Northwestern University (3)	Pomona College (2)	University of Cambridge (2)
Princeton University (1)	Smith College (2)	University of Edinburgh (2)
Rice University (3)	Swarthmore College (1)	University of Manchester (1)
Rose-Hulman Institute of Technology (3)	Vassar College (3)	University of Oxford (1)
University of California - Berkeley (14)	Washington and Lee University (2)	University of Sheffield (1)
University of California - Los Angeles (15)	Wellesley College (2)	University of Sydney (1)
University of Chicago (3)	Wesleyan University (3)	University of Toronto (3)
University of Pennsylvania (3), Wharton (1)	Williams College (1)	Warwick University (1)
University of Southern California (4)		Yale - NUS College (1)
University of Virginia (12)		
Vanderbilt University (4)		
Washington University in St. Louis (4)		
Yale University (2)		

Did you know?

The Rio Olympics marks the first time the Summer Games are hosted in a country during the winter season. Winter in Brazil lasts from June to the end of August. The Sydney 2000 Summer Games were hosted at the tail end of the Australian winter, as the Games kicked off on September 15.

According to a study by the University of Oxford, jobs that are most likely to be replaced by robots in the future include accountants, drivers, retail workers, salespeople, bank tellers, carpenters, cashiers, telemarketers, butchers, bakers, servers and cooks. These professions are at high risk of being automated.



Google, Twitter, Dropbox and Facebook have employee a capella groups that perform every year together. They call themselves Googlapella, The Songbirds, Syncopation and The Vocal Network.

The sentence "The quick brown fox jumps over the lazy dog." uses every letter in the English alphabet. This kind of sentence is known as a pangram or holoalphabetic sentence. Pangrams have been used to display typefaces, test equipment, and develop skills in handwriting, calligraphy, and keyboarding.

This fluffy bunny named Tona from Japan became a Twitter celebrity because she enjoys sleeping in piles of stuffed animals where nobody can find her.