The Quark

The Quark - February 2018

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Upcoming Events

- SPS General Meeting #4: 03/05 - 6pm at SCI 234
- 1st Annual STEM Org Dodgeball Tournament hosted by SPS: 03/25 - 1pm at TTU Rec

Contact Us:

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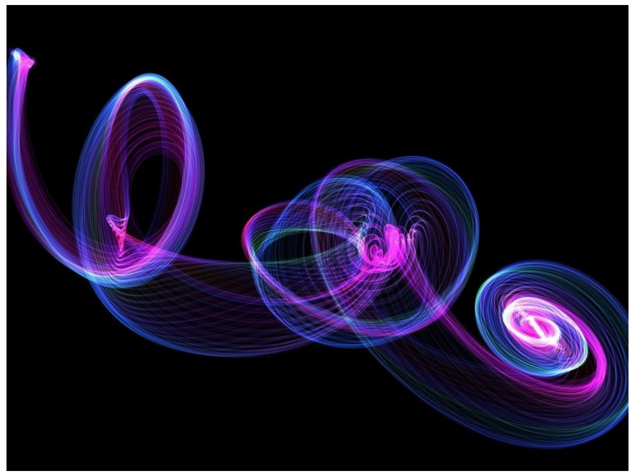
A New Form of Light



An abstract image of three individual photons[4]

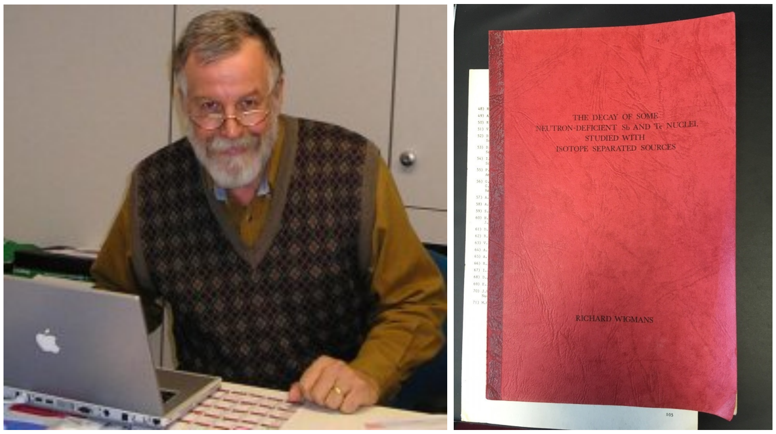
Photons usually do not interact with each other, however, new controlled systems have allowed this to be possible. In February 2018, a team at Massachusetts Institute of Technology (MIT)- Harvard Center for Ultracold Atoms, led by physics professors Vladan Vuletic from MIT and Mikhail Lukin from Harvard University, identified that three photons can interact and bond with each other to create a completely new form of photonic matter (light). Vuletic says that "the interaction of individual photons has been a very long dream for decades."[3] Previously in 2013, the researchers observed a new state of matter created when two photons interact and bond together.

The researchers shone a weak laser beam (only a few photons at a time) through "ultracold (a millionth of a degree above absolute zero) atomic gas(^{87}Rb) to search for a photonic trimer"[1], three photonic monomers. The ultracold atomic gas was used to "create ideal model systems for diluteness (absence of not-well-understood interactions), control, manipulation, and precise probe."[2]. The emerging hybrid photons, sometimes in pairs and sometimes in triplets, were found to have a speed much lower than that of a photon traveling in a vacuum (about 100,000 times slower) and also acquired a mass equivalent to a fraction of the mass of an electron.

To explain this observation, the researchers hypothesized that based on physical principles, "a single photon [moving] through the cloud of [immobilized] rubidium atoms, briefly lands on a nearby atom before skipping to another atom..."[3] The photon continues to do this until it reaches the other end. A polariton, a hybrid that is part photon and part atom, is thus created through this interaction and lasts for over one-millionth of a second. They continue to hypothesize that "if another photon is simultaneously traveling through the cloud, it can also spend some time on a rubidium atom, forming another polariton." The polaritons formed, interact with each other via their atomic component and exit combined leaving the atoms behind.

Future applications of these methods include improving quantum computing efficiency. Vuletic says "if photons can influence one another, then if you can entangle these photons, and we've done that, you can use them to distribute quantum information in an interesting and useful way."[3]

Professor Spotlight: Dr. Richard Wigmans



Dr. Wigman and his Ph.D. Thesis: *The Decay of Some Neutron-Deficient Sb and Te Nuclei, Studied with Isotope Separated Sources*

Dr. Richard Wigmans is a J.F. Bucy Chair Professor at Texas Tech University. He first became interested in physics at a young age because he found it to be the most difficult subject in high school. Thanks to an inspiring teacher from his youth, he decided to pursue physics as an undergraduate student. In 1968, Dr. Wigmans obtained his B.S. in Physics, Mathematics, and Astronomy at Vrije Universiteit Amsterdam in the Netherlands. Shortly after, while still an undergrad, he published his first research paper in 1970. The research, under the leadership of a graduate student, allowed Dr. Wigmans and his fellow undergraduate students to work with a cyclotron.

At the age of 27, Dr. Wigmans obtained his Ph.D. in physics at Vrije Universiteit Amsterdam. He was, at the time, the youngest person to obtain such a degree in the Netherlands. Pictured above is a copy of his Ph.D. thesis. He was responsible for the discovery of three new isotopes: tellurium 112, an isometric state of 115, and an antimony isotope.

Dr. Wigmans recalls having to type out his thesis using an assigned typewriter. As the deadline quickly approached, he spent all day and night attempting to finish his work. During the New Year's Eve of 1974, he worked on his thesis until 10pm, left his office to attend a party, then came back at 2am to continue working on his thesis. Nowadays, Dr. Wigmans often "looks through the table of nuclides to see if anybody has improved upon [his] [previous] research."

Dr. Wigmans worked at CERN for fifteen years. During his time at CERN, he made various advancements in the field of calorimetry and is now considered to be the world's leading expert in that field.

Dr. Wigmans recalls making "detectors out of depleted uranium." Incidentally, this was around the same time a Swiss bank found out that several of its gold bars were actually (gold-plated) depleted uranium. Being that depleted uranium and gold have the same density and that in Switzerland you can anonymously trade a bar of gold for cash, someone could have easily exchanged a block of depleted uranium for cash. Thus, the Swiss equivalent of the FBI interrogated Dr. Wigmans's research team for any missing uranium.

Introducing: Women in Physics

The Women in Physics (WiP) group at Texas Tech University was recently founded in January 2018. Their purpose is to improve the recruitment and retention of women in physics by providing opportunities for professional development through community building, networking, and mentoring. Membership is open to all currently enrolled students at Texas Tech University. Join WiP at the following upcoming events:

- 03/08 - WiP Meeting #2 and LaTeX Basics Workshop:
  5:30pm in SCI 234
  6pm in Library Lab 150
- 04/05 - WiP Meeting #3:
  6pm in SCI 234
- 05/03 - WiP Meeting #4 with Dr. Jingyu Lin:
  6pm in SCI 234

Free LaTeX Basics Workshop

Want to learn LaTeX for FREE? Join WiP on Thursday, March 8th at 6pm in Library Lab 150 for a LaTeX workshop hosted by Ian Barbra. Registration is required at https://www.ttuwip.com/. Registration closes on 03/06.

"It doesn't matter if you are a woman or a man. The important thing is your ability, your intelligence, and your determination.'
–Milka Duno

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LinkedIn's Most Popular Behavioral Interview Questions[9]

1. Tell me about a time when you were asked to do something you had never done before. How did you react? What did you learn?
2. What are the three things that are most important to you in a job?
3. Give an example of when you had to work with someone who was difficult to get along with. How did you handle interactions with that person?
4. Tell me about the last time something significant didn't go according to plan at work. What was your role? What was the outcome?
5. Recall a time when your manager was unavailable when a problem arose. How did you handle the situation? With whom did you consult?
6. Tell me about a time when you had to juggle several projects at the same time. How did you organize your time? What was the result?

Be prepared to ask questions of your own, such as:

1. What's the biggest opportunity for this role? What's the most challenging element about this role?
2. What does success look like in this position?
3. If you could describe your team in 3 words, what would they be and why?
4. What type of person works well with this team?
5. How did the company determine its mission?
6. Why do people say ___ about your company?

https://www.linkedin.com/

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No culprit was found. Dr. Wigmans described it as being the "perfect crime."

Dr. Wigmans left his permanent position at CERN in 1992 because he wanted to be in close vicinity of the Superconducting Super Collider (SSC), which was to be built near the Dallas/Fort Worth area. He believed the future of his field was in Texas and thus accepted Texas Tech University's offer to have him as endowed chair in the Department of Physics. There, Dr. Wigmans founded the High Energy group. As it turns out, however, the SCC was unfortunately never built due to budget issues.

Around this same time, Dr. Wigmans started to write his book, "Calorimetry: Energy Measurement in Particle Physics." He tasked himself with writing one page per day in order to complete his book, nicknamed "The Bible of Calorimetry," which summarizes over 1000 scientific research papers. The book is pictured on the previous page.

Currently, Dr. Wigmans teaches stellar astronomy and nuclear and particle physics. During his leisure time, he likes to listen to music, particularly jazz and classical music. His favorite composers are Bach, Vivaldi, and Beethoven. He also enjoys reading. His most recent read was a book about the history of the Manhattan project.

SPS, Sandia National Laboratories, and more!

For the spring 2018 semester trip, SPS embarked on the drive to Albuquerque, New Mexico to tour one of three National Nuclear Security Administration research and development laboratories – Sandia National Laboratories.

Under the gracious chaperoning from Texas Tech alumnus, Dr. George Laity, SPS was able to tour two accelerator facilities – the High-Energy Radiation Megavolt Electron Source (HERMES), "the world's most powerful gamma simulator", and the Radiographic Integrated Test Stand (RITS), "designed to demonstrate voltage enhancement technology for advanced water influenced radiography."[11] [12]

SPS visited Sandia's Z Pulsed Power Facility to see "the world's most powerful and efficient laboratory radiation source", national solar thermal test facility, which is home to a heliostat field of 218 individual heliostats, and the 61m tall solar tower.[13]

During a lunch discussion with distinguished APS Fellow and Sandian physicist, Jim Bailey, SPS members learned about current research regarding improvement of the standard solar model and received advice about pursuing a career in the industry. Following the discussion, SPS visited the MESA Complex which "integrates the numerous scientific disciplines necessary to produce functional, robust, integrated microsystems and represents the center of Sandia's investment in microsystems research, development, and prototyping activities".[14]

Finally, on the last day of visiting New Mexico, SPS went to the New Mexico Museum of Natural History and Science and the National Museum of Nuclear Science and History. Following the museums, all SPS members returned safely back to Lubbock.

SPS would like to thank the following people who made our semester trip a success: Debra Boyce, Dr. George Laity, Jim Bailey, and Sandia National Laboratories.

Student Spotlight: Diane N. Ha

Diane Ha is a senior studying professional physics at Texas Tech University. She is the current president of the Society of Physics Students (SPS) and Women in Physics (WiP). She was born in Ho Chi Minh City, Vietnam and came to America when she was just two years old. She graduated from the Engineering Academy at Hightower High School of Missouri City, Texas in 2013. Her expected graduation date at Texas Tech is December 2018.

In 2013, Diane did an internship in the Department of Automotive Infotainment at Texas Instruments in Stafford, TX. This department made microchips that go into the head units of cars. One of her assignments was analyzing technical documents and creating a spreadsheet to compare the peripherals of various microchips to market in Japan. In 2016 and 2017, she conducted undergraduate research with the iGEM Raiders in the International Genetically Engineered Machine (iGEM) competition. Her positions were wiki developer, dry lab member, and later, dry lab manager. Her other activities at Tech include two years of robotics and academic mentoring at Estacado High School and a year of robotics mentoring at Bennett Elementary School.

Diane joined SPS in 2014, and now as the president, strives to make the organization a place of professional growth for its members. Recently, at a Conference for Undergraduate Women In Physics (CUWiP) held at Arizona State University, she had “a life-changing experience” where she met a group of “inspiration women who also study physics”. It was during that conference that she realized that such a community is missing in our own physics department and so she created Women In Physics (WiP), an organization at Tech to provide women opportunities to pursue academic, skill, and professional development.

When asked what made her choose physics as her major she said, “I found high school physics challenging so I wanted to continue challenging myself going into college. I also love the experimental side of the subject.” The best tip she would give to her peers is to figure out which study method works best for them such as studying with others or working on their own. She also recommends students talk to their professors to clarify any doubts they may have.

Currently, she teaches three Lego NXT robotics courses to students of ages 6 to 14 using LabView programming at the Maxey Community Center. She was also recently hired as a new operator for the local Moody Planetarium as well. In her free time, she enjoys to read, paint, and play with her dog, Beau. In the future, she hopes to do research in particle physics or work for NASA in their robotics laboratory.

8th Annual University Physics Competition

On a November 2017 weekend, SPS members Colin Brown, Safwan Hasan, and Charlie Neuendorff, under the advisory of Dr. David Lamp, made their mark on the 8th Annual University Physics Competition – an international contest for undergraduate students from various universities to "[analyze] an applied scenario using the principles of physics, and [write] a formal paper describing their work." [10]

Among 72 teams around the world, the Texas Tech group earned the rank of silver medal winner for Problem B, Ion Thrusters, described below.

Ion thrusters can be an effective means for propelling space probes through our solar system. Gridded electrostatic ion thrusters begin by ionizing their propellant, accelerating the positively charged ions using a potential difference between two or more grids, and then neutralizing the exhaust by firing a beam of electrons into it. A research team is working on a prototype Xenon ion thruster, 35 cm in diameter, with a specific impulse of 5,100 seconds and a thrust of 350 millinewtons. However they find that ions exit the final grid at a wide range of angles. A member of the team proposes that you could generate a magnetic field that would affect the trajectories of ions out of the final grid, before the ions are neutralized, to direct their velocities into a more uniform exit direction. Evaluate this proposal. Would it be practical to generate such a magnetic field, and if so, how?

https://www.uphysicsc.com/

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Problem: Refraction and Fermat's Principle[5]

When a ray of light strikes an interface between two mediums, we expect one of two things to occur: the light is either reflected off of the surface, according to the law of reflection(1), or it passes through and is refracted according to Snell's Law(2) based on the medium's indices of refraction n (3).

$$\theta_1 = \theta_2 \tag{1}$$

$$\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1} \tag{2}$$

$$v = \frac{c}{n} \tag{3}$$

Another well known property of rays of light is that they follow Fermat's Prinicple, The Principle of Least Time. Fermat's Principle states that a ray of light will always take the path between two points that takes the least amount of time.

A ray of light should follow Fermat's Principle even when being reflected or refracted. Show that Snell's Law can be derived from Fermat's Principle.

Begin by using the following diagram to define a formula for time, and then minimize this formula.

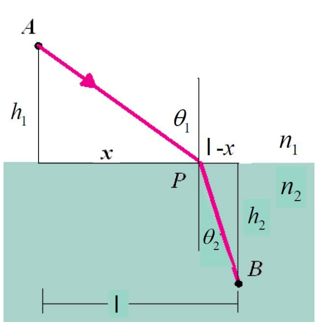

Figure 1. Diagram and worked solution here.

The Brachistochrone Problem[6]

"I hope to gain the gratitude of the whole scientific community by placing before the finest mathematicians of our time a problem which will test their methods and the strength of their intellect. If someone communicates to me the solution of the proposed problem, I shall publicly declare him worthy of praise." –Johann Bernoulli[6]

Snell's Law and Fermat's Principle are laws that describe only the motion of rays of light. These laws were, nevertheless, a key part of Johann Bernoulli's solution to a problem in mechanics. The Brachistochrone Problem:

"Given two points A and B in a vertical plane, what is the curve traced out by a point acted on only by gravity, which starts at A and reaches B in the shortest time. "[6]

The more traditional method of solving this problem, as well as the method Isaac Newton used when shown the problem, is the use of Calculus of Variations.[7] The problem can also be solved however, by considering the very similar motion of light through slabs of mediums of decreasing indices of refraction. The ray's velocity should increase and, by Fermat's Principle, the light should follow the path that takes the least time. This is how Johann Bernoulli found the solution.

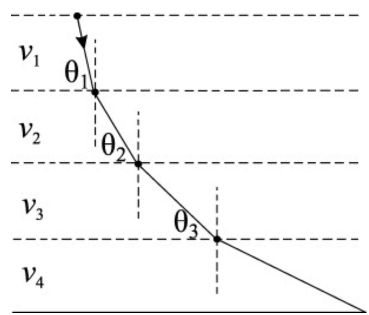

Figure 2. Visualisation of Bernoulli's Method found here.

Taking the limit as the thickness of each slab approaches zero results in a medium with an index of refraction that varies smoothly as a function of y: its vertical distance.

A solution can be determined by first defining how n, and thus the velocity, vary as a function of y such that they match an object under the force of gravity. Snell's Law can then be used to derive a differential equation that describes the motion of the light, which is of the same form as the equation describing The Brachistochrone. The solution takes the shape of the figure below.[8]

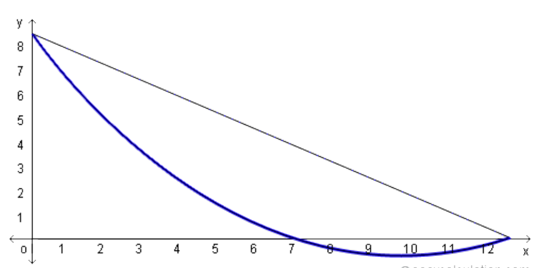

Figure 3. The Brachistochrone Curve

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