The Dilated Times

The Newsletter of the Drew University Society of Physics Students

Spring 2019 Volume 29 Number 2 Editor: Katelynn Fleming

New Options for the Physics Degree

By Dr. Minjoon Kouh

The Physics Department is excited to announce that, starting with the incoming class of 2020, there will be three different tracks for a bachelor's degree in physics at Drew: Bachelor of Science (B.S.) or Bachelor of Arts (B.A.) in Physics, or Bachelor of Science (B.S.) in Engineering Physics. This expansion of degree options reflects the diverse goals and interests of physics students. American Institute of Physics (aip.org) reports that, upon graduation, many physics students enter the workforce, carrying such job titles as engineer, data or business analyst, programmer, consultant, project manager, teacher, etc. Other physics students enroll in graduate studies not only in physics and astronomy, but also in engineering, social sciences, law, medicine, etc.

Sophomores Camila López Pérez and Matt Gronert view options for the new physics degrees.

All three tracks include a common set of foundation courses in physics and math, consisting of classical mechanics, electricity and magnetism, modern physics, introductory and advanced laboratories, and advanced mechanics. One might summarize the three tracks as follows:

B.S. in Physics: Most focused in the discipline of physics and recommended for students interested in careers in research and development in diverse areas of physics. Students in this track are recommended to study well-established topics in physics, such as electrodynamics, quantum mechanics, and thermodynamics, along with advanced math methods and a course on computer programming.

B.A. in Physics: Most flexible to provide opportunities to explore physics broadly. This track is recommended for students interested in careers in business, finance, medicine, law, education, science policy/ communication, etc. In addition to the common core, students can take a wider range of courses, such as astronomy, energy and the environment, etc.

...Continued on Page 9

Conference for Undergrad Women in Physics

By Shanjida Khan '20 and Camila López Pérez '21

"I feel like within the department it's often a competition- who's got the best lab group, highest GPA, the most awards, etc. This is especially true among women in our program because there's almost a vibe of 'only one of us can make it.' I really liked that CUWiP was pretty much only about the love of physics and supporting other women."
- Morgan Caswell, physics major at Temple University.

Shanjida and Camila at the CUWiP Conference

Although it was Morgan's second time attending the American Physical Society's Conference for Undergraduate Women in Physics (APS CUWiP), her reaction still captured how we (and most likely many other students) felt in our first time attending the conference. CUWiP is a three-day conference held annually in various universities simultaneously across the United States and Canada. This year, the conference was held from January 18th to 20th with a total of 12 sites, and an attendance of about 1800, which is approximately the number of women graduating with a degree in physics every year in the US.

The location we attended, the College of New Jersey, had an exciting schedule full of workshops, panel sessions, students' presentations and poster sessions, and networking events relevant to empowering women in physics, and providing us with tools for future physics careers. We were lucky to attend the Princeton Plasma Physics Laboratory (PPPL) tour. Some of the workshops we attended at the conference were: "Setting Yourself Up for Success: A Journey from College to Industry", "Mental Health and Awareness", and "Optical Engineering."

There were two plenary speakers: Dr. Jami Valentine Miller, the first African American woman to earn a PhD in Physics from Johns Hopkins, who described how she decided to work for the US Patent Office, and Dr. Emily Rice, an associate professor in the Department of Physics and Astronomy at the College of Staten Island of the City of New York, whose talk focused on the significance of understanding that each of us is truly a scientist. The keynote speaker Dr. Fabiola Gianotti, Director-General at CERN, the European Organization for Nuclear Research, discussed her beginnings in the field of physics and how she got there.

A panel discussion was led by the Senior Program Associate Shannon Greco of the PPPL, with three women in diverse careers: Dr. Emily Conover a physics reporter from Science News; Nicole Callen a research technician from Exxon Mobil; and Dr. Katie Shirey program officer of Knowles Academy, a nonprofit organization that offers leadership courses and development for mathematics and science teachers. Listening to how these women studied physics throughout college and graduate school was really inspiring. A message delivered

...Continued on Page 8

Famous Physicist: Georges LeMaître

The Belgian Physicist-Priest, Father of the Big Bang Theory and "Hubble's" Law

By Jean-Philippe Suter '95

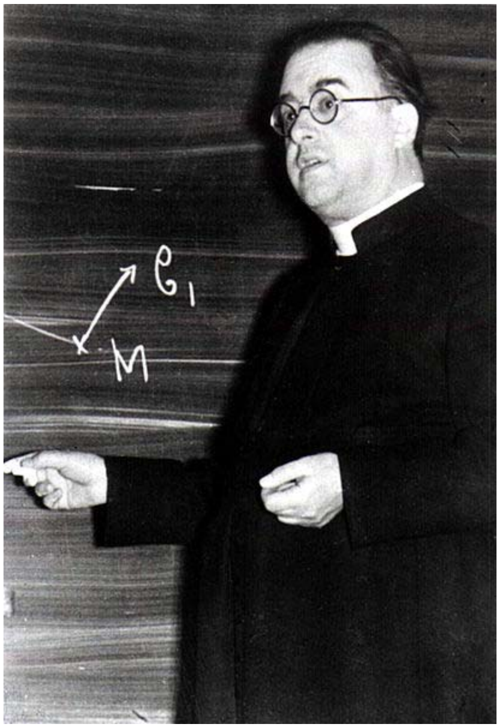


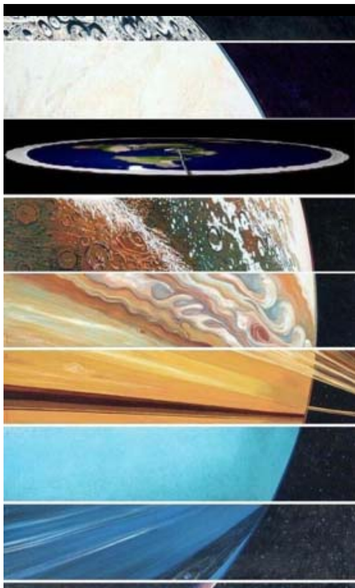
Photo credit: Astronomy.com

Georges LeMaître was highly-educated. He earned two Ph.D.'s, achieved priesthood, and joined the order of the Jesuits. After fighting with distinction for Belgium in the trenches of World War I, he earned his first Ph.D in mathematics at a renowned Belgian university in 1920. He later travelled to Cambridge University in London to deepen his understanding of the new theory of general relativity under the tutelage of astrophysicist Arthur Eddington, who described LeMaître as "exceptionally brilliant." A year later LeMaître travelled to MIT in the USA where he earned his second Ph.D, this time in physics, by applying the equations of general relativity to the universe as a whole.

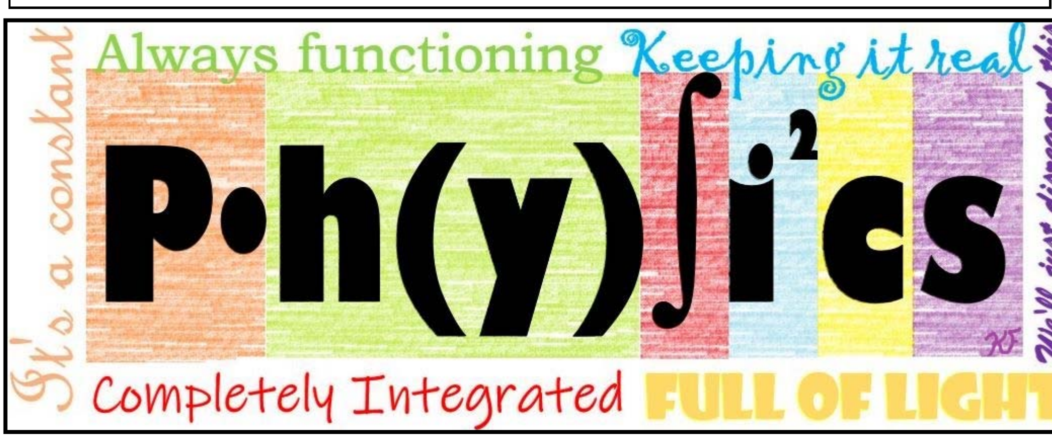
From Einstein's equations LeMaître obtained a solution which suggested an expanding universe. LeMaître managed to corner Einstein at the 1927 Solvay Conference in Belgium (Dr. Supplee has a famous photo of the participants outside his office). Einstein refuted LeMaître's work, telling him "Your calculations are correct, but your physical insight is abominable." Einstein still clung to his belief that the universe must exist in a steady state, neither expanding nor contracting. History vindicated LeMaître over Einstein.

Despite being dissed by Einstein, LeMaître persisted. From LeMaître's own solution of the general relativity field equations, he predicted a linear relationship between the recessional velocity of a galaxy and its distance from an observer. He showed that the recent observational data of these quantities indeed obeyed a linear relationship, and moreover estimated the proportionality constant from the data. LeMaître published his results in French in a Belgian journal in 1927, but between the language and the obscurity of the journal, no one noticed it.

...Continued on Page 11



Physics Humor



...More Physics Humor on Page 10

Notes From the Outside: How I Got Here

By Melissa Hoffman '13

Three days ago I was walking up a dusty desert path slightly out of breath, marching steadily towards a lone radio antenna when I thought, *I probably really need to stop and breathe.* Despite the very mild incline, the thinner atmosphere at higher altitudes was making even small jaunts upstairs a challenge. I was heading towards the control room of the ALMA telescopes – the Atacama Large Millimeter and submillimeter Array – which is at a formidable altitude of 2900 m. And that's not even as high as the array itself, perched upon a plateau in the Atacama desert at 5000 m. As I paused , cursing myself for my lack of cardio and acclimation to the friendlier ≤200 m altitude of the East Coast, I turned around in an attempt to save face and make it seem like I was taking in the view rather than struggling for breath; I looked out over hundreds of miles of desert, mountains and volcanoes peppering the landscape so far away that the snow-capped tops could be clouds. In the other direction, the volcanos Licancabur and Juriques command the horizon, and just next to them is a dirt path for industrial vehicles, leading off to the ALMA telescope, another mile up from where I stood now.

Just like the Talking Heads, I thought to myself, *well, how did I get here?*

Of course, to get *here,* the ALMA Operation Support Facility, I took an Uber then a plane, then a taxi, and another plane... But in a larger sense, I took some unexpected life turns that led me to work as an Astronomer on Duty at the ALMA telescope.

The first unexpected turn was actually at Drew – I knew I wanted to do physics, but I didn't expect to get so hands on with a telescope so early in my career. Having the opportunity to work at the telescope, do research using the telescope, and almost break the telescope (just kidding, Dr. F.): those experiences gave me a vector towards a life in astronomy. At times I resisted; I did some non-astronomy research with Dr. M. in undergrad, applied to Physics *and* Astronomy grad programs so I had the option to do one or the other, but I always ended up coming back to the stars.

...Continued on Page 5

ALUM…Continued from Page 4

I assumed my path would be very linear after college – undergraduate degree in physics then on to grad school, PhD in 5-7 years, postdoc number one, postdoc number two, and then if I'm lucky and some university thinks I've got the right combination of research ambition and competence in teaching, I start my long- term career in academia.

But that's not how things went at all. I started doing work in radio astronomy with my first advisor in grad school but he had a year long sabbatical abroad coming up, and I had yet to finish classes and pass my comprehensive exams, so that path didn't work out. I ended up in a computational astronomy group, where I pursued interesting research completely out of my comfort zone. However after having a rough time with comprehensive exams, and struggling with how I quantify my worth as a scientist and person, I left with my masters degree. For a while I was miserable. The plan had gone to hell and I had no idea what I would, or could do next. Luckily, not too long after graduating, a job as a Data Analyst at the National Radio Astronomy Observatory opened up. I had always thought my brief time in radio astronomy was temporary, that I would never use it again, and that I didn't have enough relevant experience to qualify for this job. It was a job that I thought I only had a slim chance at getting because I didn't exactly fit the description, a job that I wouldn't necessarily have thought of had I stayed on the academic path. And a job that, two years later, put me on a plane and trusted me to work at one of the most powerful telescopes in the world.

If I've learned anything, it's to embrace those times when your plans go to hell, because it means something new and unexpected is on the horizon. It may be hard to see at the time, but a failure isn't a failure; it's a period of experience and learning that eventually informs another part of your life. I still struggle when things don't go exactly how I want them to, but I'm learning that some of the best parts of my life blossom from a little bit of unplanned chaos.

Most days, I don't get to stand next to state-of-the-art facilities while I peer out over the highest and driest desert in the world. Most days I work at a computer in Charlottesville, Virginia. Some days are normal and a little slow; some days are challenging days and someone else reminds me I have to stop for a lunch break. And while that moment looking over the horizon of the desert towards volcanoes and telescopes and ongoing sky was a breathtaking moment, even on those normal boring days I am so grateful that my very non-linear, unplanned life path has turned out the way it did.

Optics and Energy Production: Solar PV

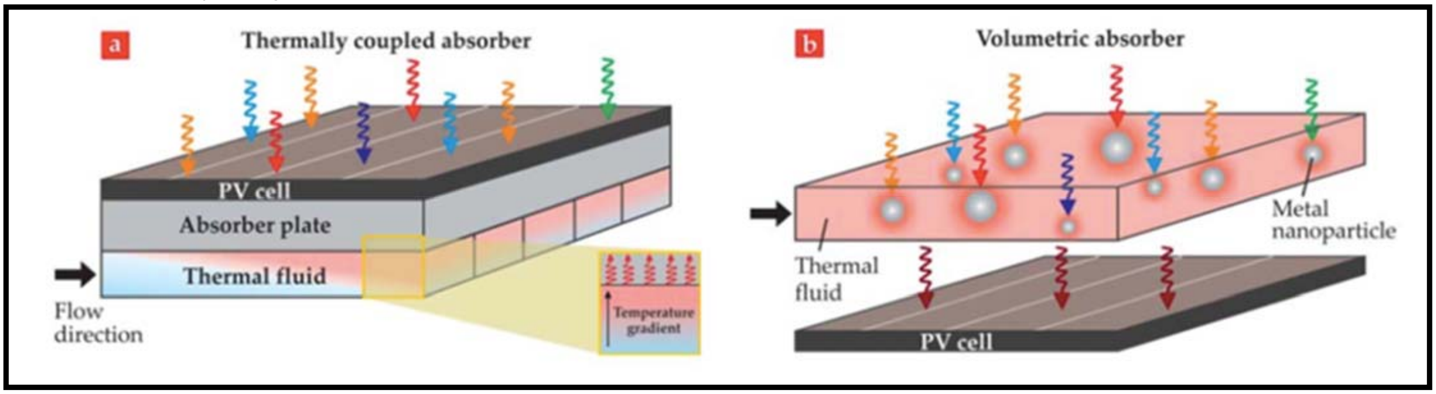
By Camila López Pérez '21

In 2017, the global capacity of solar photovoltaics (PV) increased more than any other energy technology. Nevertheless, the solar industry needs to improve efficiencies in order to keep up with the fast-growing market.

A promising approach is combining PV and thermal collection technologies in order to generate electricity and heat. Typically, PV cells can operate efficiently using only a small portion of the light spectrum; therefore a thermal (T) collector could use the remainder to generate heat. Hybrid PVT collectors are not a new idea, but getting them to work efficiently has been challenging. A PV cell operates ideally at 25°C (77°F) and anything above that diminishes its efficiency. On the other hand, thermal collectors need to be at temperatures between 60°C and 70°C (140°F - 158°F). Putting thermal collectors and PVT cells together would either make the PV suffer because of overheating or require external electricity to increase the temperature of the water that's being heated. However, if the PV and thermal components are decoupled, the benefits from both can be simultaneously achieved. This can be done using a spectrally selective mirror, which transmits effective sunlight to the PV cell and deflects everything else to the thermal collector. However, these

...Continued on Page 6

SOLAR PV…Continued from Page 5



Boosting solar energy conversion with nanofluids, Natasha E. Hjerrild, and Robert A. Taylor.

mirrors are really expensive. A cheaper alternative is to swap the conventional heat collecting fluid for an optical nanofluid. In these fluids, a phenomenon called plasmon resonance happens: when a photon comes across a nanoparticle, the electromagnetic field of the photon causes a cloud of electrons (plasmon) to oscillate back and forth along the nanoparticle's surface. By changing the nanoparticle's geometry, one can adjust the plasmons to resonate in specific bands, ranging from the UV to the IR.

When used in PVT collectors, optical nanofluids combine the thermal and absorber fluid. Because the fluid can be tailored to absorb only wavelengths that aren't efficiently converted in the PV cell, it can be positioned above the PV cell, where the light would enter. As long as the fluid is not touching the PV cell, this lets the thermal collector operate at high temperatures while the PV cell absorbs the most efficient wavelengths.

This technology can be used in households both generating electricity and heating, and even in industry to generate steam.

A Journey Through the Supply Room

By Kayla Rockhill '21

Curiosities found in the supply room: A Van der Graaff generator, a table drill, and computer circuitry.

One of the biggest parts of a physics student's academic career is the laboratory work that must be completed. But how often do we think about the effort that is put into designing and setting up the labs? For each lab class, there is a binder in the supply room describing the individual parts of the lab and the materials needed to complete them. Each item is listed with pictures and its location in the supply room for easy recognition and retrieval.

Some of the lab materials must be altered before they are used in lab, so they are

…..Continued on Page 7

Why I Study Physics

By Rutendo Jaachira '20

Throughout my physics career I've learned the value of challenges and the growth they bring. I started studying physics when I was fourteen. At the time I was attending high school in Zimbabwe and with the way the curriculum was set up, physics was a compulsory subject. I should probably add that I failed my first physics exam. I got fifty-six percent. That I will never forget. Two years later we were given the chance to drop the subject. I was strongly advised not to take Physics (under the Cambridge International Examinations) by my father. He had taken the subject at this level himself and recalled the experience being quite the ordeal. Understandably he didn't want the same for me. I initially dropped physics and continued on with mathematics, chemistry and biology. I had let people's perception of my ability dictate my choices.

I couldn't ignore the lingering cloud of dread that followed me. I was good at biology but I didn't enjoy it. No matter how many series of Grey's Anatomy I binged-watched, I didn't see myself as a biology student, not to mention the medical school student my parents so badly wanted. I had made a mistake. I went to my curriculum advisor at the time and told her of my feelings. "Are you sure you can handle physics?" she asked as I confirmed I would be dropping biology and picking up physics.

I went on to be awarded the 'Top Physics Student' award in my senior year. This was a pinnacle moment as I had brought to naught the doubts that had hung above my head. It was confirmation that I could do anything I put my mind to.

Studying physics hasn't always been a walk in the park. Physics has taught me the importance of passion, patience and perseverance. It's made me appreciate the fact that valleys are paramount to peaks. I've learned that there is no such thing as failure; we either win or learn. I look at each homework set I'm presented with as a new opportunity for growth. I'm not sure what the future holds. All I can say is, I have a strong feeling that I'm heading in the right direction.

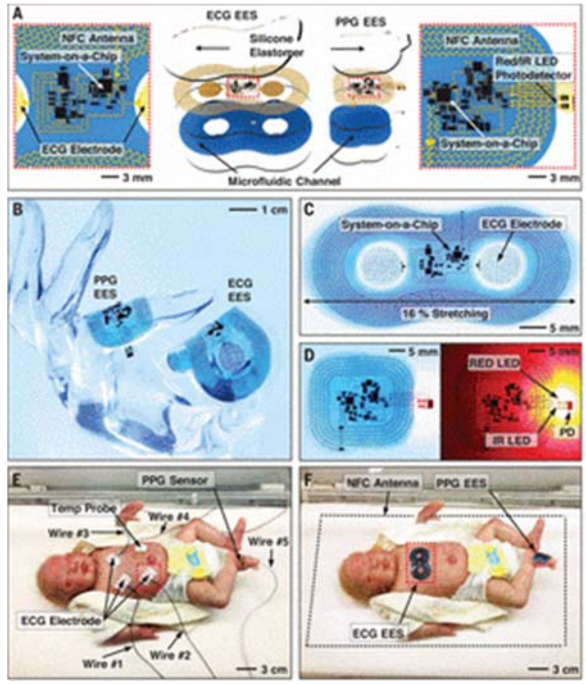
JOURNEY…Continued from Page 6 more student friendly and reliable. This must be done with enough time before the lab to complete the alterations and test the materials to make sure they are working properly. There are also tools for fixing materials that may break, and replacement parts for things that can't be fixed. When it comes to designing the curriculum of the labs that accompany each class, members of the physics department meet before each academic year to discuss any changes they want to make to previous years' labs. Individual labs can be added or removed, or changes can be made to specific labs. Any changes must be recorded in the binders and updated in the lab notebooks distributed to the students at the beginning of each semester.

As with almost everything in life, there is much more that goes into our lab classes than we often realize, and it's important to appreciate those who put in this effort so we can further our education. So many thanks to Howard and all the physics faculty.

Breakthroughs in Physics: Wireless, Batteryless Vitals Monitors

By Matheus Macena de Carvalho '21

In the United States there are approximately 300,000 newborns, or neonates, admitted to neonatal intensive care units (NICUs). Due to their fragility, these neonates are subject to a monitoring system that requires multiple electrode/sensors and multiple hard-wired connections which may stand-alone separately for heart rate, respiratory rate, temperature, blood pressure, and blood oxygenation. This hardware interferes with medical clinical interventions, radiological studies, impedes therapeutic skin-to-skin contact and even the most basic bedside tasks, such as turning a neonate from prone to supine. For these reasons, Ha Uk Chung developed a fully wireless alternative that represents a substantial advance over the existing neonatal standard of care.



A-D shows structure of new monitors, E-F compares traditional to new monitors. Image credit: Ha Uk Chung et. al

The new technology consists of a binodal pair of ultrathin, low-modulus measurement modules which adheres to the body with water in a wireless, battery-free system. The system operates with a sensor on the chest to record electrocardiograms and one on the base of the foot to record photoplethysmograms, which measure the changes in volume of the organs from fluctuations in the amount of blood. This new system eliminates the radio-opaque wires, by improving evaluation of x-ray imaging with a computer x-ray system which exhibits improved radiolucency in comparison to standard ECG electrodes and wires. The sensors are composed of an electronic layer of a thin, narrow serpentine copper traces only five micrometers thick, a microfluidic chamber of a liquid which provides mechanical isolation, and a thin film of silicone. The silicone makes the system capable of transferring information via a single radio frequency, even when completely immersed in water. This research was tested, the results showed preliminary feasibility, and the technology is currently undergoing further trials before the widespread use of the new monitoring system in NICUs.

CONFERENCE…Continued from Page 2

by Dr. Shirey really stuck with us: "Apply to everything you find...and then show up, and try!"

There were many great takeaways from the conference that we both resonated with. We particularly noted how every panelist in the conference mentioned how they were (and still are) affected by the imposter syndrome. The imposter syndrome, according to the Ted Talk "What is imposter syndrome and how can you combat it?" by Elizabeth Cox, is the feeling of being a fraud or feeling like everyone else is just as good or better than yourself. The first time the imposter syndrome was mentioned was during the mental health workshop. Robbin Loonan, staff therapist at TCNJ, cited one of her clients: "I feel like if everyone really knew me, they'd find out I'm not as intelligent, competent or good as they think." She mentioned how the imposter syndrome is especially common in STEM careers given the expectations and culture in STEM. In response to the question, "What are some expectations that people pursuing a physics major have?" students answered by saying, "Be the best at all times." and "Because we're in physics, we're gonna get it immediately." Everyone in the room agreed with these.

Dr. Rice further addressed this by showing some statistics on how retention rates for women in STEM are related to the imposter syndrome, and how they are influenced by factors like

…Continued on Page 9

CONFERENCE. Continued from Page 8...

identity, belonging, and self-efficacy. For instance she explained how according to a recent study, undergraduate women have much less self-efficacy than undergraduate men. It was shocking for us to see so many successful women in physics feeling out of place or not competent enough. They all explained how this feeling started when they were undergraduates. For example Dr. Conover said in a panel, “When I was an undergraduate I didn’t want to ask questions because I wanted to look smart.” This shows how the imposter syndrome is not only feeling out of place but also having the constant fear of people thinking less of you as a scientist.

All in all CUWiP and CUWiP+ were amazing opportunities to grow as a student and as a scientist. It was a pleasant surprise that we could relate to 300 other women who were present at the conference with the same goals and aspirations as we have. The conference gave us tools to prepare and plan our careers, informed us via different workshops and networking, and brought in women scientists to share their experiences and advice. We hope to attend CUWiP again next year and recommend everyone, especially women, to attend at least once during their time in college!

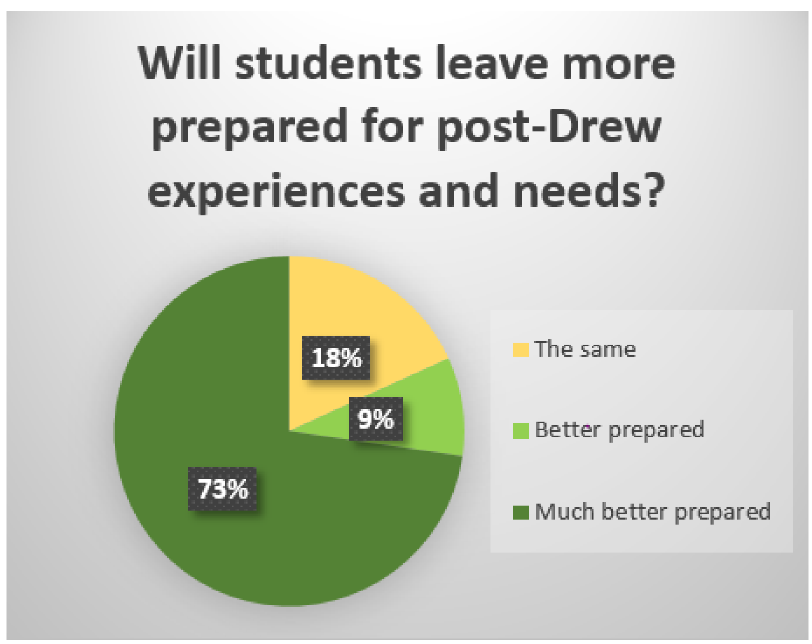
NEW DEGREES. Continued from Page 1...

B.S. in Engineering Physics: Recommended for students pursuing engineering and other technical fields. Students in this track take courses in advanced math methods and in computer programming. An introductory course in Chemistry, and other upper-level courses in physics, math, or chem are allowed. An introductory engineering course and related electives will be offered in the coming years.

Regardless of these differences, all three tracks embody what physics education represents: learning how nature works and learning how to solve complex problems analytically and quantitatively. Students are encouraged to be in continuous conversation with their advisors, so that they can choose the best option aligned with their interests and career plans.

How Do Current Physics Students Feel about these Changes?

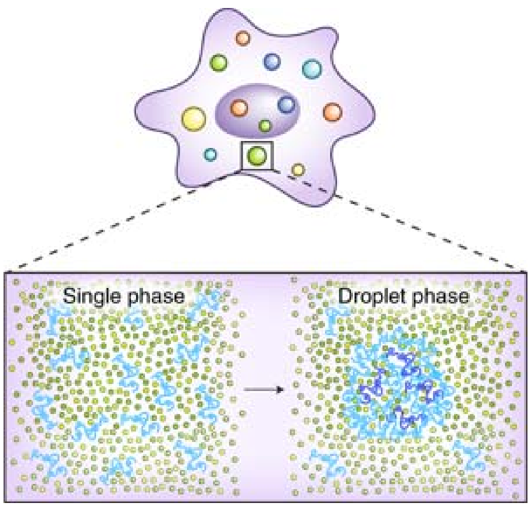
A poll by the DT found a positive response from the student body. All respondents replied that they would have strongly considered or definitely chosen one of the new tracks. Some of their reasons include: it makes it easier to go into engineering, either right from Drew or through Columbia, that they like the diversity of the physics program with these options, and that they feel the BS would improve their chances when applying to grad school.



They also feel these changes will strengthen the physics department and that students will leave more prepared. Matt Gronert C’21 commented, “I hope this will encourage a greater variety of students to get involved in physics, especially those who are not interested in doing research in the field or becoming engineers.”

Interdisciplinary Connection

By David Van Dongen '19



Compartmentalization of cellular contents is a vital aspect of the functionality of a cell, because it controls how intracellular proteins interact. Typically in biology, we consider this compartmentalization in reference to membrane-bound organelles, such as the nucleus or the "powerhouse of the cell", mitochondria. These organelles are formed by lipid bilayers, which exclude materials that are unable to passively diffuse or lack transport proteins to promote their flux into the organelle. Recently however, membrane-less organelles have garnered a large amount of attention due to the unique methods by which they are able to form and exclude undesired material. Many of these organelles are induced by liquid-liquid phase separations, which allow certain molecules to form organelle droplets within the cytoplasm. These separations are similar to how oil and water separate when mixed together. Though the two liquids are in physical contact with one another, they remain separate and distinct entities.

This is where the physics comes in: the entropic and enthalpic forces that drive the formation of these droplets are derived from our understanding of thermodynamics and atomic interactions. The stabilization of molecules from ionic and dispersion forces is able to overcome the entropic barrier associated with the "demixing" process. Understanding this phase separation that occurs regularly in nature is crucial to understanding the protein dynamics and interactions that control all of us on a microscopic level.

PHYSICS Humor…Continued from Page 3 By Melissa Hoffman '13

SPS Event

Dr. James Mandala on Mental Health

By Matt Gronert '21

SPS hosted an event where the director of the counseling center, Dr. James Mandala, talked about managing stress in a healthy way, and dealing with imposter syndrome. There were several activities which allowed staff, students, and faculty to share their strategies for managing stress and positively responding to challenges.

A main takeaway was that if we can put the challenges before us into perspective and realize that our success or failure is not our be-all and end-all, then we can attack any situation with optimism and clarity of thought. Oh, and don't wait until the last minute to do your homework.

PHYSICIST…Continued from Page 3

Two years later, Edwin Hubble published the linear relationship between the distance to galaxies and their apparent recessional velocity, based on the same data used by LeMaître together with more recent data. As no one was aware of LeMaître's paper, the relationship became known as Hubble's Law. Though there is some dispute, many believe that Hubble actually discussed the apparent expansion of the universe with LeMaître in between their two papers, which of course raises the question of whether Hubble dishonestly failed to cite the contribution of LeMaître. Surprisingly, it turns out that Hubble never believed that redshifted galaxies were truly moving away from each other; to the end of his life he maintained that the "apparent" recessional velocities were due to some other phenomenon. Even LeMaître's former mentor, Eddington, never believed that the universe was truly expanding.

Einstein and Lemaitre meet. Image credit: findagrave.com

During an astronomy conference in 1930, Eddington voiced his concern that no theory existed to explain the apparent expansion of the universe. Upon learning of this, LeMaître wrote to remind Eddington of LeMaître's 1927 paper which had done just that. Henceforth, Eddington did what he could to make the research community aware of LeMaître's foundational work, but by then the terms Hubble's Law and Hubble constant were widespread.

Later, LeMaître conceived of another idea. By thinking of cosmic expansion backward through time, LeMaître proposed that in the distant past the universe must have existed as a "unique quantum," from which the universe has been expanding ever since. This epiphany formed the basis for the Big Bang theory. Here his role as a Catholic priest put him at a disadvantage in science, as many felt that a priest's theory of the universe beginning in an explosion from a mote of energy smacked too strongly of the Biblical account of creation. To make matters worse, the current Pope seized on the finding as scientific proof for the Bible's story of creation. LeMaître disagreed with the Pope, believing that science and faith can and should coexist without interfering with each other, as parallel and equally valid approaches to contemplating the cosmos. Eventually he convinced the Pope to leave the science to the scientists.

LeMaître proved prescient again in 1931, when he was the first scientist to propose that the expansion of the universe was actually accelerating. After observational confirmation finally came in the 1990's, it led to the 2011 Nobel Prize in physics.

In 1966, LeMaître lay ill in hospital when a colleague told him news of the discovery of the cosmic microwave background, radiation left over from the Big Bang which provided potent evidence for the theory LeMaître had predicted so long ago. Georges LeMaître, "the father of the Big Bang," died two days later.

Fast-forward to this past October, when the International Astronomical Society recommended by vote that the Hubble Law be henceforth known as the Hubble-LeMaître Law. The very idea of correcting accepted history was controversial, but for some it opens the way to recognizing other scientists whose contributions have been ignored or misnamed, for example women scientists. I, for one, plan to use the term Hubble-LeMaître Law.

Send The Physics Department Your Business Card!

We're very proud of our alums and want to share your paths with current students. Let us know what you are up to and where you are working. Send us your business card for our display. Please send your card or cards to:

Dr. Minjoon Kouh

Department of Physics

Drew University

Madison, NJ 07940.

Remember:

The observatory is open to the public on clear Friday nights!

Visit the physics department website at:

http://www.drew.edu/phys/

The Dilated Times

Drew University
Department of Physics
Madison, NJ 07940

Address Correction Requested

Inside...

New Physics Degree Options, Conference for Undergraduate Women in Physics, Famous Physicist, Notes from Outside, Solar PV, Physics Supply Room, Why I Study Physics, Physics Breakthroughs

Contributors...

Dr. Minjoon Kouh, Shanjida Khan, Camila López Pérez, Jean-Philippe Suter, Katelynn Fleming, Melissa Hoffman, Kayla Rockhill, Rutendo Jakachira, Matheus Macena de Carvalho, Matt Gronert, David Van Dongen