Physics at Wabash

Welcome!

Welcome to the 20th edition of our annual newsletter! It is hard to believe we've been doing this for 20 years.

This has been a difficult year, but we managed. An unfortunate consequence of the pandemic is the absence in this newsletter of a lot of activities with students on which we normally report, but we're optimistic that the coming year will let us resume better than ever. You can follow our progress on Facebook, and please let us know how you are doing so that we can include it in next year's newsletter.

Faculty Update

Jim Brown continues as our department chair. He spent the year doing many of the usual things in new ways and suspects that that our readers did too. He is indebted to his colleagues Thomas Baumann, Paul Geuye, and others at MSU for setting up and running an experiment to measure the fraction of ^{13}Be, which immediately decays to ^{12}Be and a neutron, that leaves the resulting ^{12}Be nucleus in its isomeric state. This research was also aided by the efforts of Will Lillis ('22) and Andrew Rippy ('22). Participating remotely via Zoom as the lab was under strict CoVID protocols was a new experience!

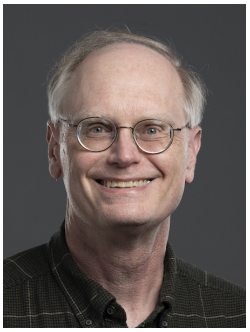
Jim also greatly enjoyed teaching Electronics again and was impressed by the creativity and careful execution of the student projects, which ranged from a small digital oscilloscope and experiment controls to self-balancing stand-up toys and magnetically levitating rods. Wabash physics majors continue to be a delight when asked to do creative things, and they don't step back from a challenge.

On the AdLab front, sophomore Elijah Scurlock ('23) was able to use Software Defined Radio technology to detect the neutral atomic hydrogen in the plane of the Milky Way using its distinctive 21 cm radio emissions. The measurement was made from the lawn of the new housing district using another Adlab project, the radio telescope built by Hamza Moudden ('21) with less than $300 worth of equipment.

After a long year of remote, hybrid, and in-person instruction, Jim spent many weeks this summer in northern Michigan at his family's cottage enjoying the sun, the water, and the company of his parents, siblings, and children.

Jill Keller continues to be our Academic Administrative Coordinator for the Physics Department. She is going on her third year here at Wabash and she loves working with the Physics Department and everyone else on campus. It was a quiet year at Wabash and Jill missed the Physics Cookout and the in-person colloquia, with the pizza aroma wafting through the halls. She is hoping that it will all be back this year.

In the spring, Jill watched her son graduate from Southmont High School and start planning his college career. Over the summer, Jill and her family had a small vacation, watched her youngest start Driver's Ed, and moved her oldest into his new home for the next four years.



Dennis Krause taught both semesters of introductory calculus-based physics (PHY 111/112) again this year. He met the class virtually on Zoom, but was able to meet the lab *almost* normally. Students worked in pairs separated by plexiglass, sharing their computer screens using Zoom. The biggest challenge came near the

end of the fall semester, when students teamed up to create their own experiments. Unfortunately, a number of students were forced into COVID quarantine so Dennis had to come up with experiments they could perform in their rooms. Fortunately, earlier in the semester they had been introduced to the phone app phyphox, which turns their phones into data collection instruments. Using phyphox to extract data from the phone's gyroscope and specs found on the web needed to calculate the phone's moment of inertia, students were able to test conservation of energy as the phone rotated from an upright position downward onto a soft horizontal surface.

During the past year, much of Dennis's research time was devoted to working with colleagues at Purdue re-examining two older tests of the weak equivalence principle (WEP)—all objects fall with the same acceleration. A review of the history of WEP experiments revealed that most experiments prior to the 1930s, including those by Newton and Galileo, used a variety of test bodies, while experiments since then only used one or two pairs of test bodies. An argument calling for new tests of the WEP using a significant number of samples was made in the paper Dennis and his colleagues published earlier this year:

- "Significance of composition-dependent effects in fifth-force searches," E. Fischbach, J. T. Gruenwald, D. E. Krause, M. H. McDuffie, M. J. Mueterthies, C. Y. Scarlett, *Physics Letters A* **399**, 127300 (2021).

This work led to the examination of data from a pendulum test of the WEP conducted by Potter in the early 1920s. With the help of Wabash librarians, Dennis was able to obtain from the Royal Society of London a copy of the original manuscript by Potter, containing many details omitted in the published paper. (Incidentally, the paper was reviewed by Nobel laureate J. J. Thomson; the report can be found on the web.) These data revealed a dependence of acceleration on the sample's baryon number similar to what was found by Fischbach et al., in their reanalysis of the WEP by Eötvös. This result is causing a lot of head scratching since the Potter experiment was much less precise than the Eötvös experiment, so no effect would be expected in the former experiment even if one appeared in the latter experiment. A preprint of this work can be found on arXiv.org: https://arxiv.org/abs/2105.03501.

This summer has been very busy for Dennis even though he doesn't have any research interns. He's teaching a freshman tutorial on "time" in the fall, so he advised 14 freshmen over Zoom as they registered for classes in late July. He's also been meeting regularly on Zoom with colleagues at Indiana University [including Quan Le Thien ('19)] as he's carrying out the most complicated calculation he has ever undertaken, to find the potential energy arising from two fermions exchanging two virtual axions. He's been battling this problem for years!

Matt Roark happily finished a healthy year with the Physics Department. Flexibility and quick turnaround times for labs, along with creative instruction from the professors, were critical components to successful lab experiences. He is looking forward to next year's instruction that will look more normal. "It was a good feeling to rearrange the spaces in Goodrich this summer to their pre-pandemic status."

Additionally, Matt continued to help with the final phase of Prof. James Makubuya's MUS 202. This was once again a virtual instruction, an unfortunate reality, but it was filled with practicality and critical thinking. Matt has used time in nature to recharge with several backpacking trips, including a trip to complete the Knobstone Trail, Indiana's longest hiking trail.

Gaylon Ross is continuing his joint appointment as Visiting Associate Professor in the departments of Physics and Chemistry after successfully completing a third-year review. The 2020-21 academic year allowed him to keep refining PHY-101 Astronomy so that it could meet the needs of students attending in-person and also those who, for various reasons (e.g. COVID quarantining), were required to attend remotely. The vast majority of the labs for the course underwent significant rewrites so that students in either situation could have a beneficial hands-on experience, and in the spring semester students alternated in-person attendance, with their lab partners participating remotely via Zoom; surprisingly, this worked very well since students had to communicate clearly with their partners throughout the lab period.

During the Spring 2021 semester, Gaylon taught components of four different courses, two of them for the first time. In addition to astronomy lab and PHY-314 Electromagnetic Theory for junior physics majors which he had taught previously, he directed the lab section for PHY-210 Introduction to Quantum Theory, a course taken by sophomore physics majors and minors. He also taught FRC-101 Enduring Questions, a requirement of all second-semester freshmen that uses classic literature and modern writings to explore such topics as what it means to be a man in today's society, expectations of members of a community, and gender, class, race, and other social issues. Gaylon was

pleased to participate in a true "liberal arts" class that is discussion-based and requires students to engage with the material differently than in science courses, and he has requested that he teach it next spring.

In the upcoming year, Gaylon will again be teaching lots of astronomy classes and labs as well as PHY-315 Quantum Mechanics in the fall. He also plans to mentor one of our senior physics majors who completed a summer internship in nuclear astrophysics with Gaylon's former research group at Notre Dame, assisting in independent study and perhaps experimental analysis in preparation for future graduate study.

Nathan Tompkins finished his fourth year as a member of the Physics Department and is looking forward to in-person physics classes again this fall. This past year he taught the Physics I/II – Algebra sequence entirely online. He also taught a section of Freshman Tutorial entitled "Why trust science? – What do we know, and how do we know it?" in the fall continuing with Enduring Questions in the spring. Both Freshman Tutorial and Enduring Questions were taught primarily in person, but with significant online portions.

Within the past year Nate published a paper with Theodore Lupinski ('20),

- "An Arduino-based constant pressure fluid pump," T. Lupinski, M. Ludwig, S. Fraden, and N. Tompkins, *European Physical Journal E* **44**, 14 (2021),

and another with Tyler Richmond ('21),

- "3D Microfluidics in PDMS – Manufacturing with 3D Molding," T. Richmond and N. Tompkins, *Microfluidics and Nanofluidics* **25**, 76 (2021).

He also has another paper accepted for publication with psychology Professor Karen Gunther, "Color Vision Deficiency and Teaching Electromagnetism," which will appear in *The Physics Teacher*.

This summer Nate worked with Caleb Powell ('22) and Fardin Hoque ('24) on numerical simulations of brinicle formation. Caleb and Fardin worked in Python to create a point-model simulation to recreate the ice stalactite formations found under arctic and antarctic sea ice. Their work will appear as a poster at the next Celebration of Student Research on campus.

Nate intends to continue working on pattern formation in the laboratory and continue to upgrade the microfluidic fabrication facilities within the Physics Department. A combination CNC micro mill and laser cutter is currently being installed in Goodrich. The Pattern Lab already includes two 3D printers, rate controlled fluid injectors, pressure controlled fluid injectors, a planetary mixer for PDMS casting, and a plasma bonder for surface treatment and device bonding.

This upcoming year Nate is looking forward to teaching Nonlinear Dynamics & Chaos as an elective course for the physics department. Nate will also be teaching the life sciences focused algebra-based introductory physics sequence again, this time utilizing an open source (free!) textbook.

Matt had perfect weather at his favorite Midwest destination, Red River Gorge, KY.

The radio telescope built in AdLab by Hamza Moudden ('21) and used by Elijah Scurlock ('23) to detect the Milky Way.

Student News

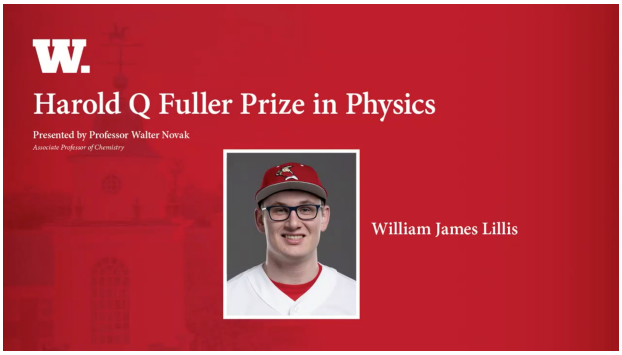
Graduating Seniors

We had three physics majors (Hamza Moudden, Tyler Richmond, and Chad Wunderlich) finishing this year. We also had one minor, Fanxiang "Jack" Su, wrapping up a year early to attend Columbia University in the fall as a 3-2 engineering student. This summer Hamza participated in a virtual internship at the Los Alamos National Laboratory in applied math and physics. Hamza and Chad will be attending Washington University St. Louis as part of the dual degree engineering program.

We are also thrilled that several seniors from last year (Michael Reising, Teddy Lupinski, Zach Ostrowski, Quan Chau) were able to return for the joint 2020/2021 graduation ceremony. (Last year's graduation was virtual due to the pandemic.) We wish everyone our best wishes and hope they will keep in touch.

(Virtual) Awards Chapel

The Awards Chapel was held online again this year. The 2021 winner of the Fuller Prize, which goes to the most outstanding junior physics major, is Will Lillis ('22):



His prizes were the *Feynman Lectures on Physics* and, appropriately, *The Physics of Baseball* by Robert Adair.

We also congratulate Andrew Rippy ('22) who was inducted into Phi Beta Kappa as a junior.

Students and faculty on the steps of Goodrich after the joint 2020/2021 graduation. Top row (left to right): Prof. Tompkins, Prof. Ross, Prof. Brown, Prof. Krause. Bottom row: Michael Reising ('20), Teddy Lupinski ('20), Zach Ostrowski ('20), Quan Chau ('20), and Chad Wunderlich ('21).

April Celebration of Student Research Poster Session

For the first time in many months students and faculty were able to attend talks and posters exhibiting the work of students at the 21st annual Celebration of Student Research, Scholarship, and Creative Work. Normally this event is held at the end of January, but it was decided to move it later in the year so that it could be held in-person. Students gave talks indoors while the posters were presented outside. This year's students and topics were:

- Chad Wunderlich ('21): "New Limits on Dark Matter Wind Force"
- Tyler Richmond ('21): "Innovative PDMS Manufacturing"
- Will Lillis ('22) and Andrew Rippy ('22): "Numerical Simulation of Ion Optical Flight Paths through a Sweeper Magnet"

Congratulations to them all for their great work!

Juniors Andrew Rippy ('22) (left) and Will Lillis ('22) (right) presenting their summer research work with Prof. Brown.

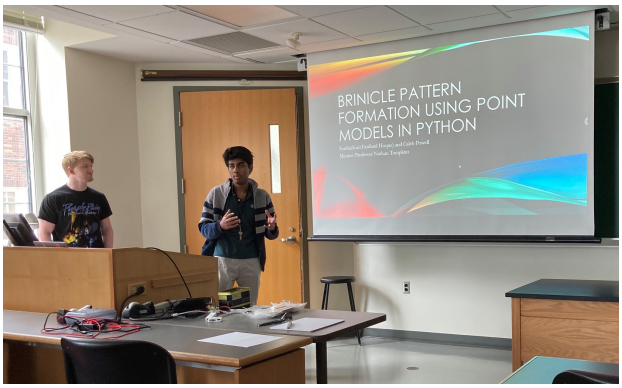
Tyler Richmond ('21) discusses his poster describing the work he conducted with Prof. Tompkins.

Chad Wunderlich ('21) spoke on his research last summer with Prof. Krause

Summer Research

It was a quieter than normal in Goodrich this summer. Professor Tompkins had two interns, Caleb Powell ('22) and Fardin Hoque ('24), developing numerical simulations of brinicle formation. In addition:

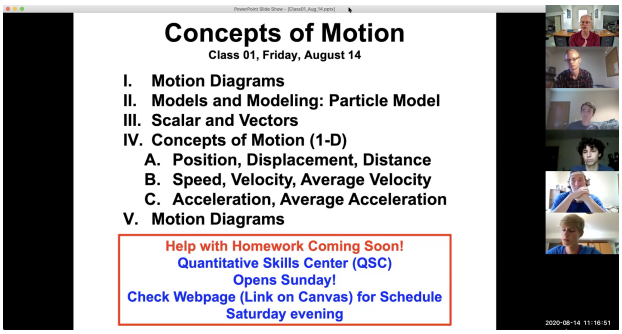
- Joey Forchetti ('22) participated in an NSF REU program at Notre Dame, working with Michael Wiescher's Nuclear Astrophysics group.
- Will Lillis ('23) worked with Prof. Zachary Gates in the mathematics/computer science department on combinatorial game theory.
- Andrew Rippy ('22) worked on cybersecurity algorithms at an NSF REU program at Montana State University.
- Elijah Scurlock ('23) participated in a quantum computing internship at Fermilab.



Here Caleb Powell ('22) (left) and Fardin Hoque ('24) (right) present the results of their research at the end-of-summer colloquium with the mathematics interns.

Teaching During a Pandemic

Some Classes Met Online



Most of our larger introductory classes, like PHY 109 (left) and PHY 111 (right), were taught online via Zoom.

Some Classes Met In-Person

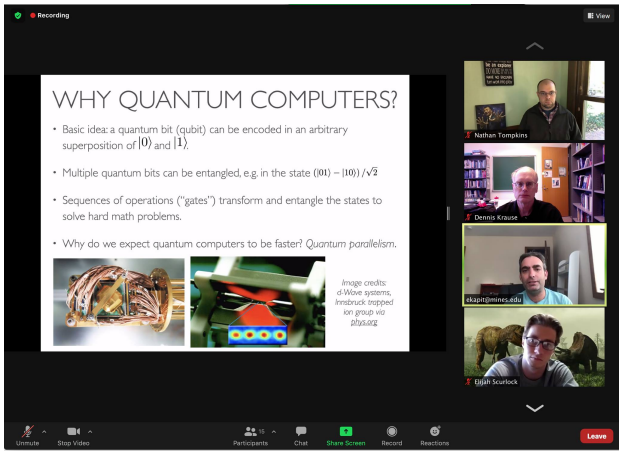
But many of our smaller classes, like PHY 209 (left) and PHY 315 (right), could be taught in-person, with masks and socially-distanced.

While Labs Met In-Person

Labs, like PHY 209 (left) and PHY 111 (right), could be taught in-person, with masks and plexiglass partitions (made by Matt Roark) separating students. Lab capacity was cut in half, and tables moved to allow sufficient social distance.

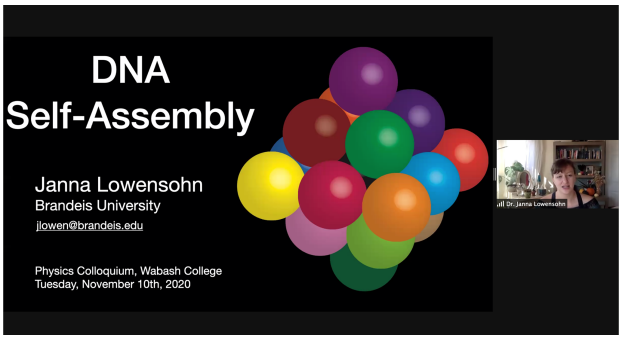
(Virtual) Physics Colloquia

Dr. Jackie McDermott, Assistant Director of Graduate Recruitment and Retention for the Purdue College of Engineering, started off a busy month of October by talking with our students about engineering graduate school.



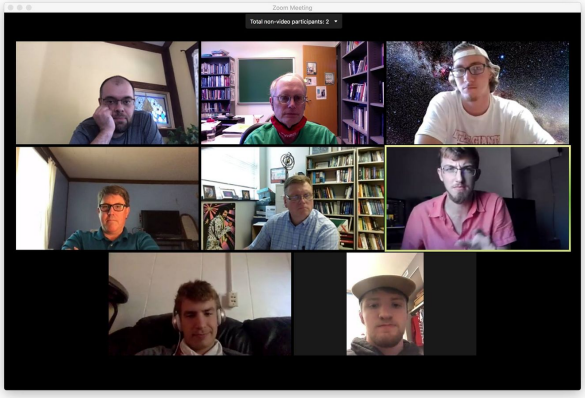
On October 13th, Professor Eliot Kapit from the Colorado School of Mines presented a colloquium on quantum computing.

At the end of October, Chris Ramsey, Assistant Dean and Director of Academic Success of the McKelvey School of Engineering at Washington University in St. Louis, spoke to our students about their dual degree engineering program. He was joined by Wabash student Will Li ('20) who is currently studying systems engineering at Wash. U.



In November, Dr. Janna Lowensohn from Brandeis University gave a colloquium on her work on "DNA Self-Assembly."

Co-Curricular Activities



(Virtual) Thursday Cookies at 4:00

(Virtual) Physics Journal Club discussion.

Alumni News

Updates

Since our last newsletter, we've heard from...

- **Dave Bohlin ('61)** is no longer professionally active, but he presented three "life-profession" talks at his retirement village in Denver that were well received. They have a "science club" consisting of about two dozen members, about half from the biological sciences and half from the physical. Several of them worked on NASA programs and knew of him from his position at NASA HQ.
- **Jim Nichols ('61)**[1] filled in some details of the kinds of work he did for the Navy during his 35 years at China Lake:
  When I graduated, a BA in Physics with a minor in Math with $\phi\beta\kappa$ simply meant I was probably a little ingenious, inventive, studious, and maybe a glutton for punishment. The Navy, with a Cold War, big budget, and bushel of technical problems needed just such a person. I was very lucky.
  We started kludging new approaches from the very start:
  - *how to measure the ignition delays in an array of rocket motors propelling a supersonic sled to estimate better the thrust curve and the resulting velocity trajectory (high speed camera and frame by frame analysis);*
  - *later how to solve the nonlinear equations of motion (with increasingly small time intervals) on a primitive computer with 32K of memory and friction and aerodynamics the principal resisting forces;*
  - *how to simulate the 6 degree of freedom trajectory of TV guided missiles Walleye and Condor (with 6 interconnected analog computers using 900 op amps, 60 multiplying servos and innumerable pots);*
  - *how to recover film from the nose of a missile impacting lava at Mach 3 (found it can't be done, so we invented the first crude rf telemetry system);*
  - *find what are the vibrational modes (flutter) of a missile wing and what are the maximum dynamic stresses (electromagnet plus salt);*
  - *what are the control stick forces required of the "pilot" to steer manually a 50 kt underwater manned vehicle;*
  - *and how do you design and test a non-propulsive device to attach to the thrusting end of a Sidewinder missile to keep it motionless if it accidentally fires off aboard ship.*

  And this was just the first year! Before competent digital computers!
  But I found that Drs Salter and Henry had put us through enough practical problems that we were prepared to start making a contribution from the start. And it just got better from there for 35 years. Maybe not technically physics, but proof that a budding physicist is ready for anything!
- **Dave Livengood, ('64)** was sad to learn of Vern Easterling's passing. "He had huge influence on my academic and professional direction by getting me excited about atomic and nuclear physics, which led to a career in nuclear and environmental engineering."
- **Stephen Covey ('71)** officially retired from his last paying job as Director of Research & Development for Deep Space Industries Inc. in 2018. (DSI was subsequently purchased by a European company.) At DSI, he had most recently led their Florida team to winning and completing several NASA contracts, including delivering 5 Mg of various carbonaceous chondrite asteroid regolith simulants to KSC.
  I spent the first 18 months after retirement traveling around the USA in my RV largely to visit friends and family from Florida to Indiana to Nevada, and I did little of interest to anyone but myself and my wife, and those family members and friends.
  Before my retirement, I did deliver multiple presentations and papers at various space conferences, most recently one that only slightly involved physics: I built a chamber to measure the energy requirements and productivity of farming in space, where I assumed 100% artificial lighting plus energy for air and water flows. It was somewhat controversial, as my own models only agreed within a factor of two, and the worst performer was (rather illogically) the most fundamental one, the number of photons (and their energy) required for chlorophyll to reduce CO_2 and produce a mole of glucose. Naturally, I would have thought that the most fundamental model would be the one you would strive to approach, but no such luck. It was rather odd to deliver a presentation with such an obvious flaw, and I pointed it out along with the assumptions upon which each of the models was based.
  I've been a space settlement enthusiast for decades, including being one of the editors for the National Space Society's "Space Settlement Journal", and I'm currently working on modeling orbital settlements for equatorial low-Earth orbit (low-radiation orbits that should not require radiation shielding for lifelong residents). Hopefully a paper will result.
  Did I mention that "retirement" is a euphemism for "career change"?
- **J. Marc Overhage ('79)** enjoyed catching up on the Department with our newsletter, but was sad to read of the passing of Vern Easterling.
- **Omar Hayat ('91)** was "saddened to hear of Prof.

[1] We apologize for referring to Jim as "Jeff" in the first edition of the 2020 newsletter.

Easterling's passing away. He was my mentor and advisor. He will be missed tremendously."

- **Jia (Alex) Qi ('15)** sent us an update as he continues his Ph.D. astronomy graduate research on galaxy formation and evolution at the University of Florida. The pandemic prevented him from going to Harvard to work with his collaborators, but his computational work on cosmological simulations can be conducted at home.
- **Tim Riley ('18)** accepted the physics teacher position at Scecina Memorial High School in Indianapolis.
- **Spencer Shank ('20)** is enjoying his work as a software engineer in the aircraft simulation division of FAAC, Inc., in Ann Arbor, MI.

We apologize to anyone we missed, and for mispellinggs or other mistakkes made while editing the material sent to us.

In the future, we would be happy to include your news and comments in our newsletter. Not only is it wonderful to hear from you, it is also very useful for us to learn what our alumni are doing and how they got to where they are. Our students wonder what one can do with a physics degree and it is great to have alumni stories to share with them.

Zach Rohrbach ('12) was November's WISH-TV Golden Apple winner: https://www.wishtv.com/.../avon-physics-teacher-uses.../ He's been teaching physics at Avon High School since graduating from Wabash.

Congratulations, Zach! (Photo from WISH-TV)

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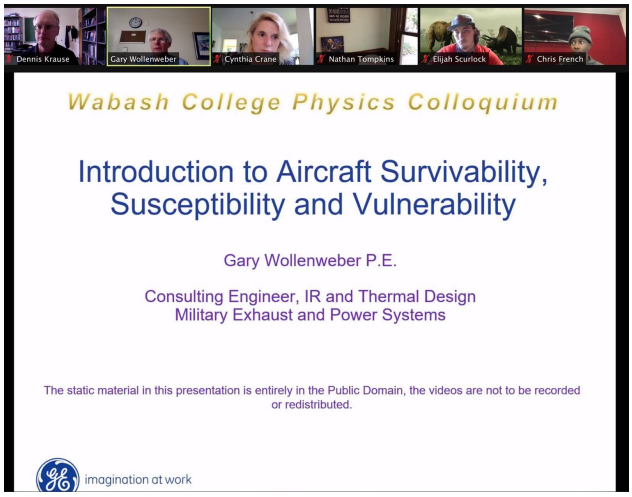
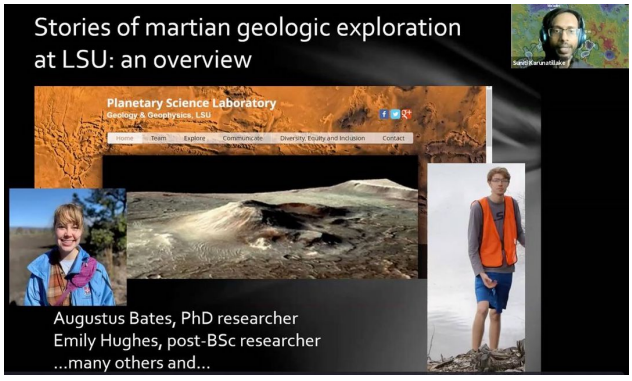
Keep up-to-date on what's happening in the Physics Department through our Facebook page: https://www.facebook.com/WabashCollegePhysics

(Virtual) Alumni Colloquia



Gary Wollenweber ('74) gave our first virtual physics colloquium of the year in September. He discussed his work on aircraft survivability, including modeling the effects of missile strikes on a jet engine. Gary is Consulting Engineer for GE Aviation's Inlet and Exhaust Systems Engineering Department in Cincinnati, OH.

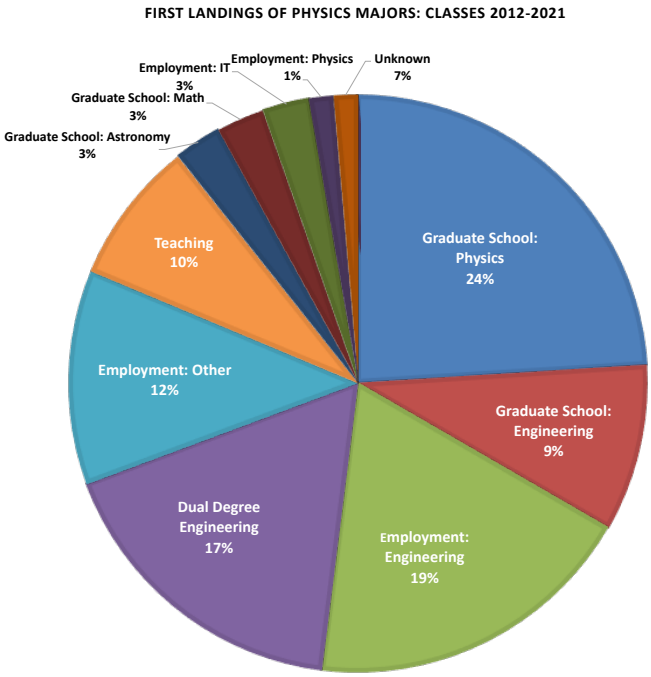


For our last physics colloquium of the year, we had the pleasure of being joined Prof. Suniti Karunatillake ('01), and his colleagues Gus Bates and Emmy Hughes to share their research on Mars. Suniti is the leader of Louisiana State University's Planetary Science Laboratory. Gus spoke on "Evidence for Supervolcanic Resurfacing in Arabia Terra, Mars," while Emmy discussed "The Global Regolith Mineralogy of Mars in Geologic and Geochemical Context."

What can you do with a physics degree from Wabash?

Some Graduate Schools and Companies Accepting/Hiring Recent Majors

Stanford University	Apparatus
University of Colorado	Axiom
Purdue University	First Gear
Indiana University	ELANCO
New York University	Apparatus
U. of Oregon	Epic
U. of Minnesota	Trans-United
U. of Notre Dame	Rolls-Royce
U. of Michigan	Backstop Solutions
Michigan State U.	Peerless AV
U. of Cal., Santa Barbara	J.P. Morgan Chase
U. of Southern California	FAAC, Inc.
U. of Hawaii	F. A. Wilhelm
Ball State University	Quest Global
Stony Brook University	Ontario Systems
Florida State U.	RQAW



Thank you for your support!!!

The Physics Fund is a special fund established specifically to support physics student-faculty research at Wabash. In the past, we have used this fund to purchase laboratory equipment and provide summer internships—we never want to turn away an eager student!

We thank all donors, with special mention to Roger Alig ('63), Dennis Henry ('67), David Nisius ('87), Harrison Smith, and J. Marc Overhage ('79) for their support of the Department over the past year. We also thank Jim Clynch ('67) for establishing the Haenisch-Salter Student Research Fund to support off-campus student research in the physical sciences. The Physics Fund and other funds set up by our alumni and friends have supported internships, student travel, departmental prizes, library book purchases, and senior dinners.

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