

PHYSICS AT WABASH

Welcome!

Summer is here so it is time to review what has been going in the Physics Department over the past year with this new issue of the Physics Department Newsletter. As you'll see, a lot has happened, and many changes are coming. Remember that you don't have to wait a year—follow us on Facebook to keep up to date. Also, please let us know of what you are doing so that we can include it in next year's newsletter.



Faculty and Staff Update



Jim Brown enjoyed working with our freshmen as he took over the second-semester introductory course this spring. Following Dennis Krause's lead, he used the electromagnetism volume of the *Six Ideas that Shaped Physics* text for part of the course. The focus on concepts, tactics, and problem solving worked well with this text.

Jim particularly enjoyed teaching two elective physics courses: a special topics course on astrophysics with very self-motivated and enjoyable students, and electronics which had students doing self-designed projects interfacing analog sensors to digital hardware and software on the Arduino microcontroller platform.

In his research, he continues to work on the nuclear structure of extremely neutron-rich nuclei. With the MoNA collaboration, Jim had one publication this year,

- "Neutron correlations in the decay of the first excited state of ^{11}Li ," J.K.Smith, T.Baumann, D.Bazin, J.Brown, P.A.DeYoung, N.Frank, M.D.Jones, Z.Kohley, B.Luther, B.Marks, A.Spyrou, S.L.Stephenson, M.Thoennessen, A.Volya, *Nuclear Physics A* **955**, 27 (2016)

He was also awarded an NSF grant to continue this collaboration for another three years. With students Tyler Mix ('18) and Cody Cochran ('18), Jim is preparing for another experimental run in July.



Dennis Krause taught the first semester introductory physics (PHY 111) during the fall semester, the first time in quite a few years. This time he decided to use Thomas Moore's *Six Ideas that Shaped Physics* textbook which reverses the traditional order of topics. Beginning with momentum, energy, and angular momentum, it then moves

on to forces and projectile motion. He also implemented Moore's novel homework procedure, where students submit initial work via smartphone scans and then correct their own homework by reviewing posted solutions. They then submit their homework with corrections for review. In this way, students receive instant feedback and can compare their work with correct solutions.

In addition to teaching our two sophomore-level courses (PHY 209 Thermal and Relativity Physics and PHY 210 Modern Physics), this past spring Dennis taught Enduring Questions for the first time with Jim Brown's freshman tutorial students. He enjoyed the readings and the stimulating discussions with the students.

Dennis continues to work with researchers at Purdue, IUPUI, and Indiana University on the search for new physics using force and radioactive decay experiments. He has gotten very interested in the search for dark matter as current experiments continue to find nothing. He's studying the mechanical forces that a dark matter "wind" should exert on objects as the earth moves

through the galactic dark matter halo. (There would be a similar effect due to motion through the relic neutrinos from the Big Bang.) This is analogous to an “ether” wind which Michelson and Morley failed to find. He has two summer interns working with him this summer, Joseph Bertaux ('19) and Quan Le Thien ('18).

Since the last newsletter, Dennis has had four publications:

- “Calculations of the dominant long-range, spin-independent contributions to the interaction energy between two nonrelativistic Dirac fermions from double-boson exchange of spin-0 and spin-1 bosons with spin-dependent couplings,” S. Aldaihan, D. E. Krause, J. C. Long, and W. M. Snow, *Physical Review D* **95**, 096005 (2017).
- “Relativistic coupling of internal and centre of mass dynamics in classical and simple bound quantum mechanical systems,” D. E. Krause and I. Lee ('16), *European Journal of Physics* **38**, 045401 (2017).
- “Constraining Exotic Weakly Coupled Long-Range Interactions with Pseudoscalar and Axial Couplings with Unpolarized Data,” S. Aldaihan, W. M. Snow, D. E. Krause, J. C. Long, and E. Fischbach, in *Proceedings of the Seventh Meeting on CPT and Lorentz Symmetry*, edited by V. Alan Kostelecky (World Scientific, Singapore, 2017), pp. 280–282.
- “Is There a Signal for Lorentz Noninvariance in Existing Radioactive Decay Data?” M. J. Mueterthies, D. E. Krause, A. Longman, V. E. Barnes, and E. Fischbach, in *Proceedings of the Seventh Meeting on CPT and Lorentz Symmetry*, edited by V. Alan Kostelecky (World Scientific, Singapore, 2017), pp. 197–200.



Martin Madsen pioneered a new physics track this year for our life science students. In recent years, the department has had a single introductory physics track that served everyone from physics students, pre-engineers, chemistry students, to the pre-med students and biology majors. We now split off the life science students in order to better serve their needs, which are slightly different than the needs of the incoming physics students. Martin taught two classes for this new track: Physics 109: Motion and Waves in the fall and Physics 110: Fluids and Fields in the spring. The classes were well received by the students, especially the biology and pre-med students.

Martin has also been pushing into a new direction for

research: working on making predictive models using machine learning on big data. He taught 24 students the techniques he was learning in a special topics course introducing machine learning in Python. Although the course had no prerequisites and drew in students from across the sciences and social sciences, the students were able to design and build useful projects from predicting the motion of the stock market to predicting the user ratings for video games.

Martin will be on leave for the next academic year as he continues to explore the application of machine learning in the business environment.



Danielle McDermott is moving to Forest Grove, OR where she accepted a tenure-track physics position at Pacific University. Without a doubt, her best memories from Wabash are of time spent with her physics colleagues: hauling around telescopes for observing sessions with Jim Brown; team teaching PHY111/112 with Martin Madsen and Dennis Krause in a trial by fire experience of flipping the classroom; and watching Wabash undergraduate researchers excel in new challenges. She thanks the entire Wabash community for helping her grow personally and professionally during her 3 years as a visiting professor at Wabash.

This year Danielle taught astronomy for the first time, along with Classical Mechanics and Electromagnetism. Danielle's research continued her work with physics majors Minh Quan Le Thien ('18) on superconducting vortices on hyperuniform surfaces, Yang Yang ('17) on granular materials on rough surfaces, and Aaron Wirthwein ('17) on the flocking dynamics of bacteria-like active matter systems. Danielle co-authored the following publications since the last newsletter:

- “Collective ratchet effects and reversals for active matter particles on quasi-one-dimensional asymmetric substrates,” D. McDermott, C.J. Olson Reichhardt, C. Reichhardt, *Soft Matter*, **12**, 8606-8615 (2016).
- “Structural Transitions and Hysteresis in Clump- and Stripe-Forming Systems Under Dynamic Compression,” D. McDermott, C.J. Olson Reichhardt, C. Reichhardt, *Soft Matter* **12**, 9549-9560 (2016).
- “The dynamics of active matter on ordered and disordered substrates,” C. M Reichardt, C.J. Olson Reichhardt, D. McDermott, *SPIE Proceedings* **9922**, Optical Trapping and Optical Micromanipulation XIII, 99221H (2016)
- “Dynamic Phases, Clustering, and Lane Formation

for Driven Disk Systems in the Presence of Quenched Disorder," Y. Yang ('17), D. McDermott, C.J. Olson Reichhardt, C. Reichhardt, *Physical Review E* **95**, 042902 (2017)

- "Enhanced Pinning For Vortices in Hyperuniform Substrates and Emergent Hyperuniform Vortex States," Q. Le Thien ('18), D. McDermott, C.J. Olson Reichhardt, C. Reichhardt, arXiv: 1611.01532. [Submitted to *Physical Review B*.]

We thank Danielle for her wonderful work and wish her our very best on her new position.



Matt Roark continues to guide Advanced Lab students in the safe and effective use of the Physics machine shop, seeing many senior projects take shape. He has also collaborated with the Biology Department to prototype controlled light exposure boxes for plant growing experiments.

Matt is often involved in the implementation of new class components or accompanying laboratory components. This past year he coordinated with Dr. Madsen's Big Data class to implement a machine learning software package based on Theano, Lasagne, and Nolearn that runs on the CUDA accelerated workstation in Dr. Feller's computing lab. Several students from the previous year's condensed matter class have also continued to utilize the high performance clusters in the lab.

Matt is working with chemistry interns are working in Dr. Feller's lab this summer doing computational chemistry. Connor Brooks ('19 is working on parameterization, a key component in molecular



Photo taken by Matt of sandstone natural arches that dot the landscape of Red River Gorge Geological Area in Kentucky.

dynamic simulations that modifies forces and therefore controls equilibrium states and preferred structure (e.g., protein folding). Rithy Heng '19 continues his work parameterizing several states of retinal, a form of vitamin A, and is using computing time at Hope College to accelerate calculations. Vision, and the signaling process associated with it, begins when retinal absorbs light and undergoes photoisomerization. This process and the return to "dark" steady state involve several transitional states.

Matt continues to find new trails to hike. An unusually warm winter forced Matt to take a break from snow camping and instead take a spring trip to the Adventure Hiking Trail deep in the woods of and Harrison-Crawford State Forest in Indiana. This 25-mile trail features steep, dry, and challenging terrain adjacent to the Ohio River. Sinkholes and karst topography, abundant wildlife, vistas, and pioneer remnants are found along the trail.



Nathan Tompkins will be joining the Department as a visiting assistant professor for 2017-18 to fill in for Martin Madsen. Nate received his B.A. degree from Reed College and M.S. and Ph.D degrees from Brandeis University. He will be coming from Brandeis where he has been a post-doc

working on the synchronization of nonlinear chemical oscillators with an interest in effective teaching pedagogy.



Linda Weaver has enjoyed working in Goodrich Hall for the past eighteen months. On July 1st, she will move to the Advancement Office and serve as Senior Administrative Assistant to Michele Janssen, Dean for College Advancement. She will miss working closely with our faculty and students,

but is looking forward to working with our alumni, parents, and friends of the College. The Department thanks her for everything she's done for us this past year.



Keep up-to-date on what's happening in the Physics Department through our Facebook page:

<https://www.facebook.com/WabashCollegePhysics>

Student News

Graduating Seniors

We had a large group finishing this year. Six majors (Andy Dong, Trevor Fitzpatrick, Cordell Lewis, Karl Prasher, Aaron Wirthwein, and Yang Yang) and four minors (Connor Brummert, Wesley Deutscher, Taner Kiral, and Andrew Roginski). Wirthwein and Yang are heading off to physics graduate school at the University of Southern California and the University of Minnesota, respectively. Andy Dong and Cordell Lewis are planning to study engineering at Purdue next fall, while Trevor Fitzpatrick is planning to study aerospace engineering at Arizona State University. Finally, Wesley Deutscher is entering the chemistry PhD program at the University of Illinois. Good luck to all and stay in touch.



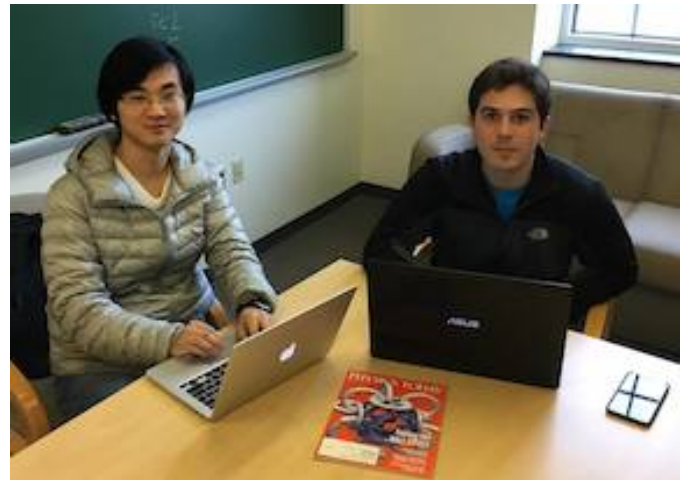
Most of this year's seniors on the steps of Goodrich after the graduation ceremony. Front (left to right): Cordell Lewis, Andrew Roginski, Karl Prasher, Aaron Wirthwein, Andy Dong, and Yang Yang. Back: Prof. Krause, Wes Deutscher, Prof. Brown, and Trevor Fitzpatrick.

Senior Trevor Fitzpatrick (left in red) and junior Dave Johnson (right in black) assist a team of prospective students with their Scarlet Celebration Challenge activity. The goal was to predict where a ball placed randomly on a tabletop ramp would hit the floor. The winning team was able to land their ball on a 1-centimeter-wide strip of paper they placed on the floor!

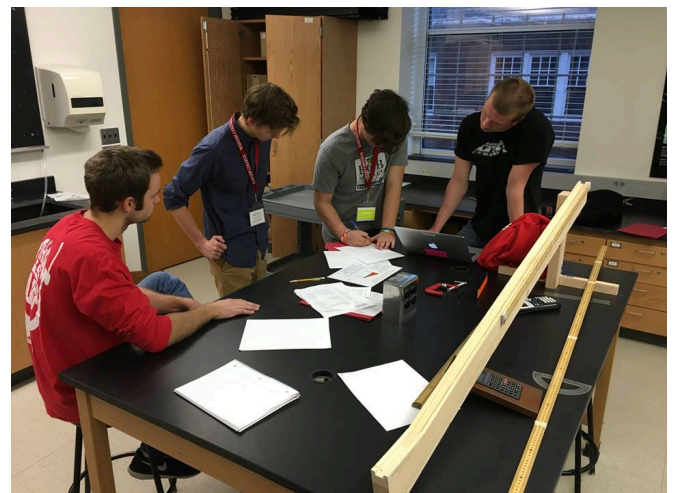
Awards Chapel Winners

Physics students were prominently featured at the annual end-of-year Awards Chapel. Seniors Aaron Wirthwein and Yang Yang were elected into Phi Beta Kappa. They also received Mackintosh fellowships for graduate school. In addition, Yang Yang was this year's winner of the Carscallen Prize in Mathematics.

Quan Le Thien ('18) was this year's recipient of the Fuller Prize for the most outstanding junior physics major. Quan also received the Lewis Salter Memorial Award "given to that member of the junior class who best exemplifies the characteristics of scholarship, character, leadership, and service."



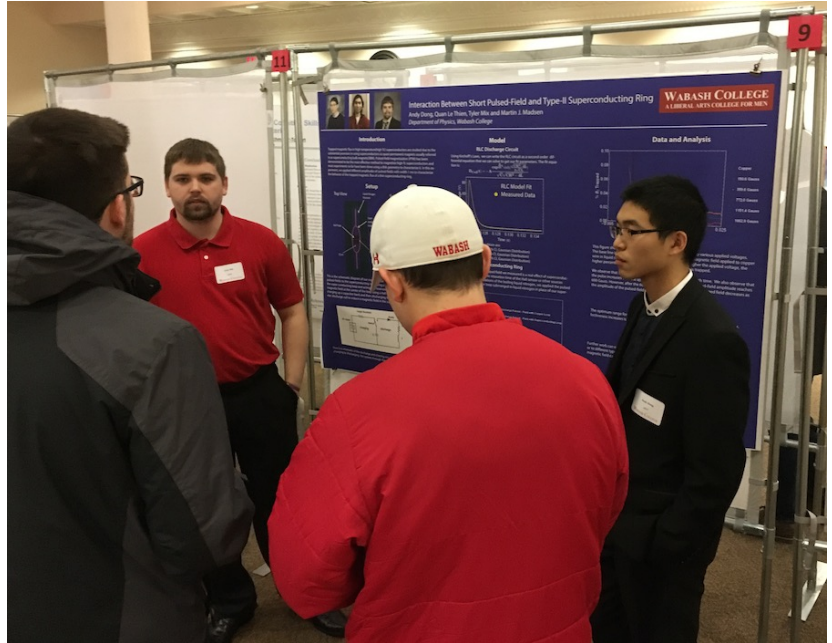
Seniors Yang Yang and Aaron Wirthwein both received distinction on their physics comprehensive exams and Mackintosh Fellowships for graduate school, and were elected into Phi Beta Kappa.



Celebration of Student Research

This year's Celebration of Student Research in January showcased the work our students did in the advanced lab and internships:

- Aaron Wirthwein ('17): "Dark States Enhance Photocell Power via Phononic Dissipation"
- Yang Yang ('17): "Flowing and Jamming of Granular Particles in a Disordered Landscape"
- Andy Dong ('17) and Tyler Mix ('18): "Interaction between Short Pulsed-Field and Type-II Superconducting Ring"
- Patrick Kenney ('18), Trevor Fitzpatrick ('17), and Timothy Riley ('18): "Four-Cycle Nitrogen Gas Engine"
- Aaron Wirthwein ('17) and Yang Yang ('17) "Measuring Acceleration via Laser Interferometry with Rolling Spherical Mirrors"



Tyler Mix ('18) and Andy Dong ('17) describe how they showed that the behavior of the trapped magnetic flux of their superconducting ring agreed with the result from a thin superconducting disk.



Patrick Kenny ('18), Trevor Fitzpatrick ('17), and Tim Riley ('18) explain their design of a four-cycle nitrogen gas engine. They used 3-D printing to build and test components.

Society of Physics Students (SPS) & College Mentors for Kids

College Mentors for Kids brought 40 elementary school students over to the Goodrich labs this afternoon where our SPS students demonstrated some optical physics.



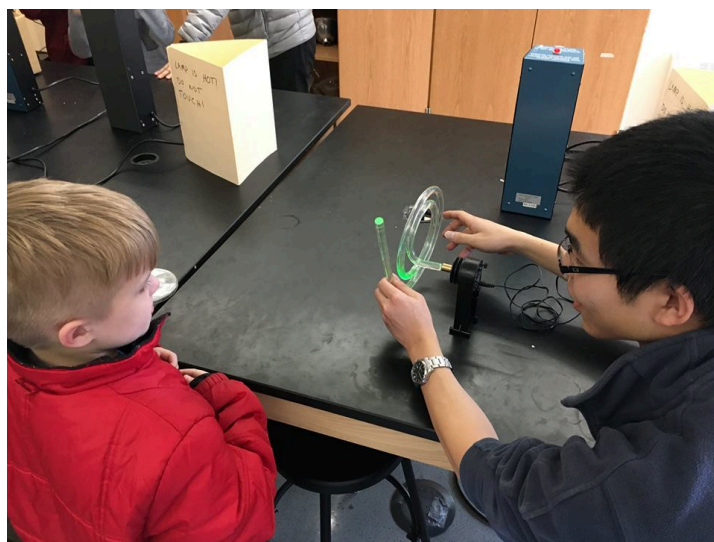
Cody Cochran ('18) points out the effects of polarization while Oscar Chavez ('18) on the right looks on.



Robert Reed ('19) (left) explains image formation with lenses.



Devin Atkins ('18) creates a real image of a light bulb with a spherical mirror.



Andy Dong ('17) demonstrates total internal reflection, the principle behind fiber optics.

Pi (π) Day

In March after Spring Break, Professor Brown led a large group of SPS students for the annual Pi Day physics demonstration show at the Crawfordsville Carnegie Museum. The photos indicate the kids had a great time!



Robert Reed showing off the amazing Euler's Disk.



Joseph Bertaux ('17) creating sand vibrational patterns with a Chladni plate.

Alumni News

Updates

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

- **Ernie Henninger ('55)** was very impressed with the work of our students and faculty. "My reaction is WOW! Physics at Wabash going gangbusters. The research and teaching of all your staff and students is remarkable. I'm sure this excellence is matched through-out the other departments at Wabash." Indeed it is.
- **Ken Loker ('59)** has been posting to <https://www.facebook.com/Spacetimemodels1/> as well as Phys.org blogs as Seeker2.
- **David Bohlin ('61)** was impressed by the advanced nature of some of the courses we're teaching and that sophomores are able to take them. "Dr. Salter taught my freshman and senior courses, but regrettably was on sabbatical my sophomore and junior years. My esteem for him bordered on reverence for his grasp of physics and ability to teach it in such a fluid and understandable way." Dave continues to enjoy retirement in 2004 after 28 years at NASA Headquarters in a variety of jobs administering research grants and the Level 1 management of the unmanned space science programs, finally achieving the job of Deputy Associate Administrator for Science in what was then the Space Science Directorate (one of those jobs with all of the responsibility and none of the authority). His NASA career was during a truly golden age of unmanned missions, though not to just the planets. He worked on the solar and solar-terrestrial programs for the first decade there, and then on policy and selection procedures for all unmanned programs. Every mission literally rewrote the textbooks in their respective fields. Today he keeps busy with travel and puttering in his woodworking hobby shop, working almost exclusively with recycled and otherwise scrap wood.
- **Jim Clynch ('67)** was impressed with the research our students were doing. He also sent us photos and physicist playing cards from the AIP History Center.
- **Dennis Henry ('67)** wasn't able to attend this year's Big Bash, but he sent us a wonderful photo of him with his father, long-time Wabash physics professor Bob Henry, taken at the 1989 AAPT meeting in San Francisco. Dennis has retired from a 30-year physics teaching career at Gustavus Adolphus College.
- **Jim Rushton (67)** says that "Bob Henry set my entire career in motion by offering a special course in Nuclear Physics; it was a one-on one opportunity to explore the basis of what would develop later into MS and PhD degrees in nuclear engineering at the University of Wisconsin. And those degrees led to a fascinating set of opportunities, first at Oak Ridge National Laboratory, then in the nuclear fuel cycle in the Department of Energy Uranium Enrichment Enterprise, and later back to ORNL for leadership roles in Nuclear Science and Technology. I retired in 2011 and have been consulting for the DOE Office of Science, ORNL, MIT, UCB, Georgia Tech, and Ohio State. Little did I know in 1967 that a liberal arts education with a science and math focus would yield such a fabulous career. Thank you Wabash and the Physics Department."
- **David Nisius ('87)** has been working in the same building for over 19 years, but for 3 different companies (Bio-Imaging Research, Inc. Varian Medical Systems and now Varex Imaging Corporation) and 9 different job titles. BIR was acquired by Varian in 2007 and this year Varian spun off Varex Imaging as an independent company. But his main focus through the years has not changed: making the highest fidelity x-ray images by developing detector hardware and image processing software. He says, "It has been an interesting career with customer visits all over the world, China, Japan, Saudi Arabia, UK, France, Italy, Canada and all over the US."
- **Jon Button ('05)** finished his Ph.D in experimental nuclear physics at Texas A&M, and has started a postdoc research fellowship sponsored by Oak Ridge Institute for Science and Education (ORISE) to do work at the CDC in Atlanta (Chamblee campus). The lab does radiological bioassay measurements, and he will eventually be responsible for the HPGe detectors used for identifying and quantifying gamma emitters in the samples. His project will be to write the method validation for identifying 4 different isotopes.
- **Jason Roberts ('05)** is in his 12th year teaching physics at Kenwood Academy, a Chicago Public School. "It's been a fun journey so far and I think each year I get a few students to consider pursuing physics which is always nice. I've been working on flipping the classroom and integrating combustion science into my AP course. I received a grant from the Central States Section of the Combustion Institute to provide student inquiry in the efficiency of Estes rocket engines."

- **Dan Brown ('10)** defended his Ph.D. in Material Science and Engineering in July 2016 at Florida State University. His dissertation, "Hard Magnetic Materials Without Rare Earth Elements," investigated rare earth free permanent magnets to replace the Nd-Fe-B magnets that currently dominate the market. He then accepted a job at the company X-Energy as a Process Engineer. For this position, he is working at Oak Ridge National Lab where he performs characterization on nuclear fuel for gas cooled, pebble bed reactors.
- **Micah Milliman ('10)** has been working at a Tier 1 Automotive Supplier for three years as a project engineer in their Advanced Planning Engineering Department. He's enjoying the work which has provided a lot of neat opportunities and experiences including a few international trips and some extended time in Mexico.
- **Rabin Paudel ('10)** received his Ph.D. in physics from the University of Colorado. His advisor, Deborah Jin, passed away last year, which was a terrible tragedy for Rabin and the whole physics community. Eric Cornell, 2001 physics Nobel laureate, supervised the final year of Rabin's research. Rabin is joining the Process Technology Development group at Intel Corporation in Portland Oregon.
- **Scott Pond ('10)**, who is now an engineer and business owner, returned to campus on Monon Bell weekend to show off his electric conversion car.
- **Jia Qi ('15)** says things are going smoothly during his second year of graduate school in astronomy at the University of Hawaii. He's now working on infrared observations of local galaxy mergers, while he recently submitted his first paper on analyzing a galaxy cluster collision. A second paper on galaxy merger simulations is also in the works. He reports he's "still enjoying the endless summer and sunshine here in Hawaii."
- **Cameron Dennis ('16)** enjoyed his first year of physics graduate school at the University of Oregon. "I was well-prepared for all [my courses] and the current course-load is lighter than I am used to at Wabash. (Don't tell your current students I said that--if anything, assign them more homework.)"
- **Tuan Le ('16)** reports that he is enjoying studying physics at Ball State University. This summer he's doing research on graphene and carbon nanotubes, and reports that his Wabash thermal physics course (PHY 230) has turned out to be very useful

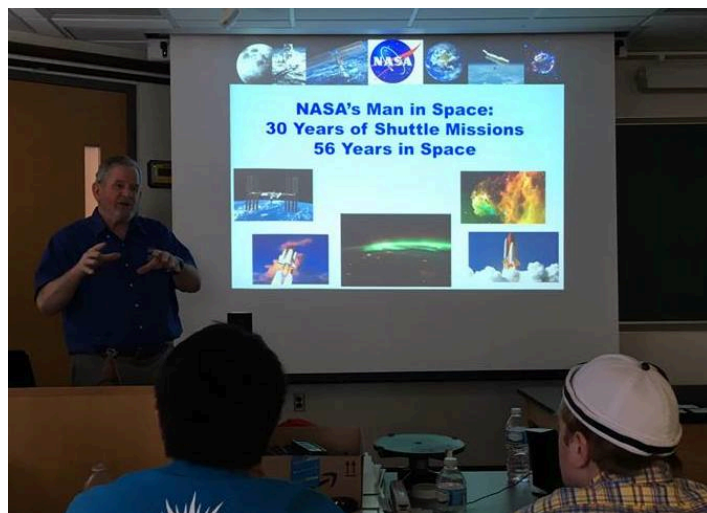
We apologize to anyone we missed, and for misspellings or other mistakes made while editing the material sent to us.

In future newsletters we happy to include your news and comments in an Alumni News section of the newsletter. Not only is it wonderful to hear from you, it is also very useful for us to know 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.

Alumni Colloquia

In February, Ken Crawford ('69) came back to campus to speak to a packed Goodrich 104 audience at lunch time on his work with the Space Shuttle Program: "NASA's Man in Space: 30 Years of Shuttle Missions, 56 Years in Space, Engineering Challenges in the Space Program."

While our speakers budget is limited, we would love to have alumni come back to campus to talk to our students about they've done. If you're interested, please let us know!



Big Bash Physics Department Open House

Quite a few alumni stopped by to chat and get a tour of Goodrich at this year's Physics Department Open House for Big Bash. **We invite all physics alumni to attend our Big Bash open house next year.** Please come share your stories of Wabash and experiences since you graduated. Check the schedule of events for the time and location.



Physics Fund

This summer we have four Wabash students working with us, with three of these students being supported by the College while gifts from our generous alumni are supporting the fourth student. We don't want to turn away any eligible student since internship experiences are nearly a necessity for graduate school or jobs. Also, our 2-semester advanced lab sequence involves real research projects which often require new equipment or supplies, but our budget is limited. In addition to your support of the Wabash Annual Fund, we hope you will consider a gift to the **Physics Fund** (or the **Physics Fund for Student-Faculty Research**) by making an online donation at:

<https://www.wabash.edu/egift>

or contacting the Advancement Office at giving@wabash.edu or 1-877-743-4545.

Thank you!!

We thank **Roger Alig** ('63), **Mike Gallagher** ('68), **Susan and Eric Need** ('16), **David Nisius** ('87), and **Harrison Smith** for their support to the Department over the past year. 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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