

Summer/Fall 2016



OTTERBEIN  
UNIVERSITY

# Schrödinger's Otter

## Department of Physics

### About Otterbein Physics

Visit the Department on line at: <http://www.otterbein.edu/physics>

Otterbein University is a private, co-educational four-year university in Westerville, OH (a suburb of Columbus). The Physics Department offers the **BA and BS in Physics**, a **BS in Engineering Physics**, a **BA in physics with secondary teaching licensure**, and a **3+2 dual-degree program in engineering**, in partnership with Case Western Reserve University and Washington University in St. Louis. We have four full-time faculty members with expertise in theoretical and experimental particle physics and experimental atomic physics. All are active in research and students have the opportunity to work on neutrino experiments at the Fermi National Accelerator lab, ultra-cold atoms and quantum computing in the Otterbein Atomic Physics lab, or theoretical and computational problems related to ongoing experiments at the Large Hadron Collider and the study of strongly-interacting quantum systems. Students have also recently participated in research programs at CERN in Geneva, the Lawrence Berkeley National Lab, the University of California, UNLV, and Fermilab.

In addition, Otterbein is excited to offer a new program in **Systems Engineering**, which started in the fall of 2015. This is a multi-disciplinary engineering curriculum, combining fundamentals of mechanical, electrical, and industrial engineering. When coupled with the liberal arts background that is at the core of the Otterbein educational experience, we hope to produce an engineer for the 21<sup>st</sup> century: literate, broadly skilled, able to work across multi-disciplinary teams, and with a commitment to ethics. We have established relationships with leading industrial partners including Honda, Worthington Industries, and Xigent, involving internships and other support.

The 3+2 dual-degree program allows students to pursue a more traditional area of engineering such as mechanical, civil, or chemical, in partnership with Case Western Reserve University and Washington University in St. Louis. The program in Engineering Physics is a mixture of physics and engineering courses, and can be tailored to each student's particular interests. It is attractive to students wishing to pursue applied science.

Special scholarship support is available through the Cardinal Science Scholars program (open to students in any physics or engineering program) and the Arthur A. Wiese scholarship (open to students interested in engineering). See <http://www.otterbein.edu/public/FutureStudents/FinancialAidAndScholarships.aspx> for further details.

Nathaniel Tagg, Chair



### Physics Department Hosts Nobel Laureate

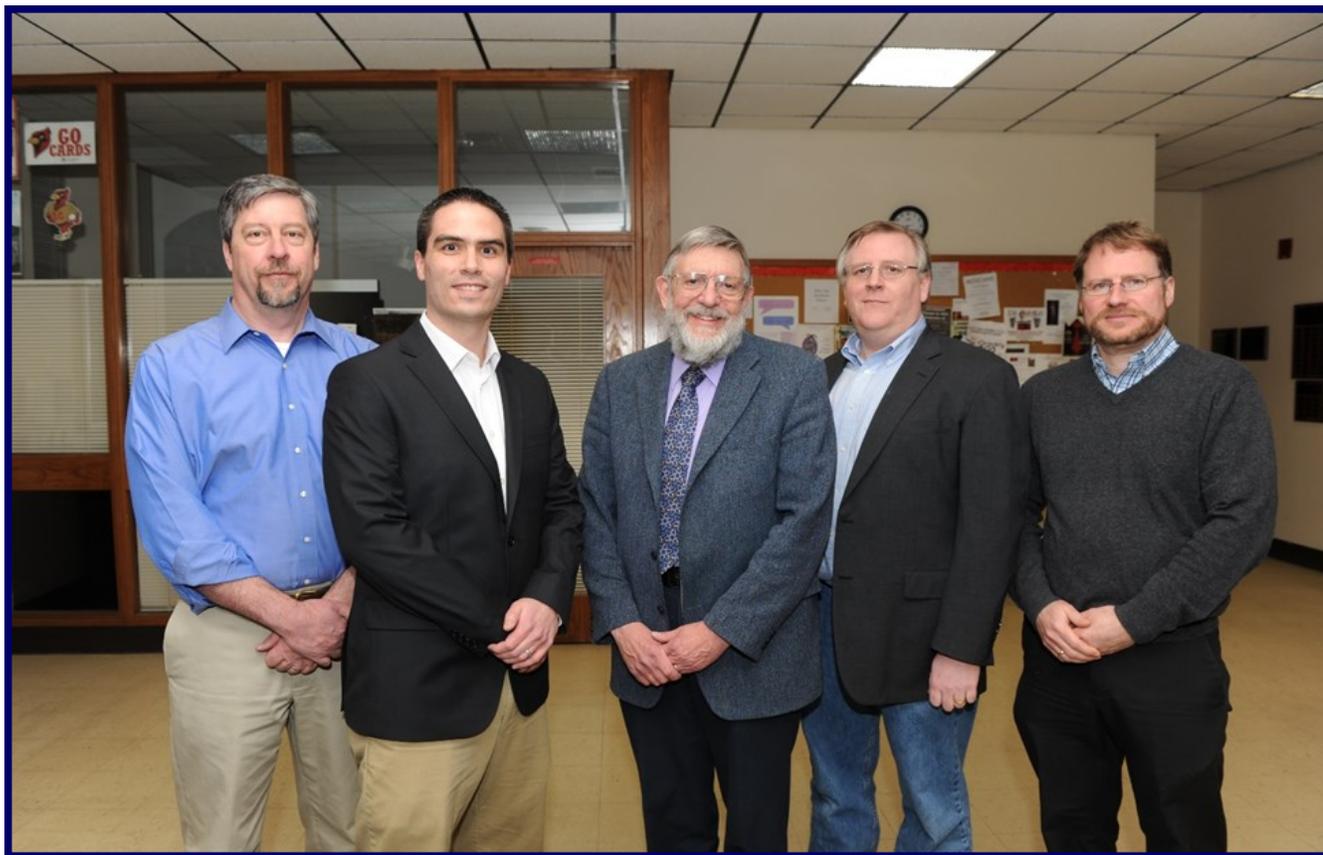
On February 18-19, 2016 the Otterbein physics department hosted Dr. William D. Phillips as the 2016 Science Lecture Series speaker. Dr. Phillips is a fellow of the National Institute of Standards and Technology (NIST) and a co-recipient of the 1997 Nobel Prize in physics "for the development of methods to cool and trap atoms with laser light." Dr. Phillips pioneered the techniques used to cool atoms down to temperatures just a tiny fraction of a degree above absolute zero, and his group was the first to observe "sub-Doppler cooling" in which he was able to cool atoms to temperatures much lower than theory suggested was possible.

During his visit Dr. Phillips delivered two lectures and met with students and faculty. His public lecture, titled "Time, Einstein, and the Coolest Stuff in the Universe" was delivered to

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an overflow crowd in Riley Auditorium and featured live demonstrations using liquid nitrogen. The talk focused on the basic ideas of low temperature physics and laser cooling. His public lecture, titled "The Coming Revolution in the Metric System," was presented to a group of science students and faculty. He described how, in about 2018, the SI system of units will undergo its most radical revolution since the French revolution established the metric system. Specifically, the base units will be defined by fixing the values of a number of fundamental constants of nature.



Otterbein Physics Department together with Bill Phillips (L to R: Robertson, Reinhard, Phillips, Tagg, Trittmann).

### **Dr. Reinhard Receives NSF CAREER Award**

On May 1, 2016, Dr. Aaron Reinhard was awarded a National Science Foundation Early Career Development Grant (or CAREER grant): "CAREER: The Effect of State-Mixing Interactions on the Rydberg Excitation Blockade." The NSF's description reads:

The program offers the National Science Foundation's most prestigious awards in support of junior faculty who exemplify the role of teacher-scholars through outstanding research, excellent education and the integration of education and research within the context of the mission of their organizations. Such activities should build a firm foundation for a lifetime of leadership in integrating education and research.

Dr. Reinhard will study the interactions among ultracold, highly excited atoms (or Rydberg atoms). These interactions might have application in neutral atom quantum computers. Dr. Reinhard will focus on quantifying those processes which might compromise the ability of ultracold Rydberg atoms to be usefully deployed in quantum computers. He will also develop educational modules on laser cooling and trapping, which are appropriate for students in classes from general education to upper level physics courses. Finally, he will perform a study of the impact of metacognitive exercises on problem solving outcomes in the introductory physics classroom. The \$400,000 grant will last through spring of 2021 and will include support for student research on experimental atomic physics.



## Otterbein AMO Lab: The Coldest Place in Westerville

At the end of July, 2015 Dr. Reinhard and his students, Michael Highman and Tyler Thompson, detected ultracold rubidium atoms in a magneto-optical trap for the first time. The atoms, seen below with an infrared sensitive camera, have a temperature of about 100 micro Kelvin, or about a million times colder than room temperature. For reference, the surface of the sun is only about 20 times hotter than room temperature. Next up, Dr. Reinhard and his students will excite these ultracold atoms to high energy internal states to study their interactions.

## Neutrinos Win Prizes

The **2015 Nobel Prize** was given jointly to two great experimentalists: Art McDonald, representing the **Sudbury Neutrino Experiment (SNO)** and Takaaki Kajita for the **Super-Kamiokande Experiment (SK)**. These experiments produced important results between about 1996 and 2008, providing arguably the biggest surprise in particle physics for the last fifty years: neutrinos have mass, and they oscillate.

What does that mean? Neutrinos are fundamental particles (they are not made up of smaller things) which were thought for many years to be massless. They rarely interact with matter: right this second there are billions of neutrinos streaming through your body, but you may never have one interact with a single atom.

The discoveries made by SNO and SK show that these very neutrinos, made by the sun and by cosmic rays, change from one type ("flavor") to another. The fact that they change over time means that neutrinos experience time, and therefore cannot be massless. The changing is consistent with a model called 'oscillation', in which the neutrinos flip from one flavor to another and eventually back again.

(In physics parlance: there are believed to be three mass states of neutrino, and three flavor states - electron, muon, and tau - but these eigenstates are mixtures of each other, with mixing angles that are large compared to those in the quark sector.)

This Nobel is particularly meaningful for Dr. Nathaniel Tagg at Otterbein, who worked under Art MacDonald as a graduate student on the Sudbury Neutrino Observatory in the late 90s. This honor was then extended when the **2015 Breakthrough Prize in Fundamental Physics** was awarded to multiple neutrino experiments: SNO, SK, and well as KamLAND, Daya Bay, and K2K. Dr. Tagg, as one of the living 262 original authors of the SNO result received a small fraction of the Breakthrough Prize award.



*Dr. Tagg's Breakthrough Prize came through!  
Alas, what it came through was the Otterbein mail...*

## OSAPS Meetings 2016-17

There are two meetings of the Ohio-Region Section of the American Physical Society (OSAPS) scheduled this year. The fall conference will be at Bowling Green State University on October 7-8, 2016, and the spring meeting will be at Eastern Michigan University on May 5-6, 2017.

Both conferences will be Friday afternoon/Saturday morning events, and are free for students. Although there is a set of plenary talks on the main theme of the meeting, many more short talks with topics from all areas of physics are scheduled in the parallel sessions.

The OSAPS conferences are a wonderful opportunity for undergrads to get their feet wet and visit a first professional conference!

## Operation Physics Funded for 2016-17

The Ohio Department of Higher Education has approved funding (about \$110,000) for a seventh year of *OP2: Operation Physics for Middle Grades Science Teachers*. This program brings to Otterbein a group of 30 (mainly) middle school physical science teachers for an intensive course in basic physics principles, with lots of hands-on activities. The teachers also take home lots of gear for teaching science.



OP2 teachers study force and motion

Static electricity supermodel Philip Kellogg '15 demonstrates the Van de Graaff generator during OP2.



### Department Faculty:

- σ Aaron Reinhard (PhD, University of Michigan), experimental atomic physics
- σ David Robertson (PhD, University of California), theoretical particle physics
- σ Nathaniel Tagg (PhD, University of Guelph), experimental particle physics
- σ Uwe Trittman (Dr. rer. nat., University of Heidelberg), theoretical particle physics



#### Department of Physics

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### SCHEDULED EVENTS

#### Starry Mondays

##### Astronomy Lecture Series

1st Monday of each month, during the term, excluding holidays  
Everyone is welcome.