Winter 2012

www.otterbein.edu/physics

Otterbein University
Department of Physics

Schrödinger's Otter

Otterbein Students at Fermilab

The Neutrino Research Group at Otterbein continued its studies at Fermilab last June, with a month-long visit to work on experiments in the Fermi neutrino beam. Prof. Tagg, and students Molly Clairemont, and Matthew Jamieson were invited to stay and contribute to the MINERvA experiment, which aims to perform high-precision measurements of interactions of high-energy neutrinos with matter.

Neutrinos, which have very little mass and no charge, are very difficult to detect. The NUMI neutrino beam produces a pulse of about 10^{14} neutrinos every two seconds. But even with a 200 ton detector, only about one of these neutrinos interacts in the body of the detector each pulse. Each neutrino interaction is measured by observing the decay products of the interaction, typically a muon, a hadron, and sometimes one or more pions. The fine details of these interactions are of great interest to the neutrino physics community, both for probing nuclear structure and for analyzing next-generation neutrino oscillation results.

At Fermilab, students had a crash course in the experimental design, and sat in on almost daily meetings on experimental issues, as well as attending many talks on particle physics. Matthew spent the majority of his free time studying the fine details of the detector reconstruction software, carefully looking for small changes in how the computers interpreted data when given different rules for pattern recognition in an attempt to improve detector acceptance of muon tracks. Molly continued her work from the previous summer, using the reconstruction output to find stopped muon tracks in the detector and finding Michel electrons from the muon decay. These electrons are valuable to MINERvA in that they provide a 'standard candle' of energy which which one can calibrate the detector's calorimetric response. Prof. Tagg continued his work on the MINERvA offline software framework, as well as making upgrades to the Arachne event viewer, a web-based application that allows scientists to visualize neutrino events and watch live data from the experiment. (You can see this for yourself at http://minerva05.fnal.gov/Arachne/live.)

This work was funded in part by direct support from the MINERvA experiment, and in part by the group's NSF research grant. This work will continue this summer: interested students should contact Prof. Tagg about doing (paid) research work the coming summer.

Science Lecture Series

For 2011-12 the Science Lecture Series, in partnership with the Vernon L. Pack Distinguished Lecture Series, will welcome distinguished Harvard psychologist Steven Pinker, who will give a talk entitled "The History of Violence" at 3 p.m. on Wednesday, Feb. 22, 2012 in Cowan Hall. The lecture is free and open to the public, although tickets must be reserved in advance by calling the Box Office at (614) 823-1109.

Pinker is the Johnstone Family Professor of Psychology at Harvard University, a best-selling author, Pulitzer Prize finalist and a frequent guest on The Colbert Report. He has been listed on TIME magazine's "100 Most Influential People in The World," as well as on Foreign Policy's list of "The World's Top 100 Public Intellectuals." He has received awards and honors from the National Academy of Sciences, the Cognitive Neuroscience Society, and the American Psychological Association.

Nobel Prize in Physics

This year's Nobel prize was awarded to three observational astronomers. Half of the prize goes to Saul Perlmutter of Berkeley, the other half of Brian Schmidt (Australian National University) and Adam Riess (Johns Hopkins University). The prize was awarded for their surprising discovery in 1998 that the expansion rate of the universe is accelerating. For decades, physicists had believed that there are only three possibilities for the form of the expansion of the universe after its birth in a *big bang*: either it expands forever, or it slows down to a halt eventually, or the expansion reverses at some point and everything falls back together in a *big crunch*.

This fate of the universe is determined by a single number, the mass density of the universe. If there is a critical amount of mass in the universe, the expansion will get slower until it stops. If there is less mass it keeps expanding, and if there is more it will re-collapse. The problem is that the amount of mass in the universe is very hard to measure, since most mass is not in the form of bright stars, and is therefore hard to detect. So the two competing groups did measure something else, namely the rate of expansion of the universe. Ideally, all one has to do is measure the distances of a number of bright objects that are very far away. You can predict how far away these objects should be given the (mass) content of the universe. Turning the argument around, you can measure the distance and compute the mass of the universe. The trouble is that you need very bright objects indeed to be able to see them from a few billion light-years away, and on top of that, you need to know how bright these objects are intrinsically. If you know the latter, then by comparing how bright they *appear*, you can deduce the distance to the object. There are only two kinds of objects bright enough: galaxies and supernovae. The latter are massive stars exploding at the end of their lives that can become as bright as a whole galaxy (roughly 100 billion stars), if only for a short time. A type of supernova (Type Ia) turns out to be very predictable, and this *standard candle* was used to do the measurements.

Photo: Roy Kaltschmidt, Courtesy: Lawrence Berkeley National Laboratory

Saul Perlmutter

Photo: Belinda Pratten, Australian National University

Brian P. Schmidt

Photo: Homewood Photography

Adam G. Riess

Both groups found that the supernovae where dimmer than they should be in a "normal" universe. Seeing that they are more distant than expected, the groups concluded that there has to be something in the universe that makes it expand faster. It cannot be any form of mass, since that slows down the expansion. So it was called it *dark energy*, because we have not been able to observe it. In fact, we don't know what it is at all – we just know what it does: accelerate the expansion of the universe. Surprisingly, it is possible to calculate how much of the universe is dark energy, which turns out to be most of it – about three quarters. That means that we have no idea what most of the universe actually *is*. Incidentally, it is worse than that; the remaining quarter is mostly made up of stuff that we have never seen in the lab, so-called *dark matter*. The upshot is that all we know something about (atoms, elementary particles, etc.) makes up only 4% of the universe. The rest is unknown – how exciting!

Chris Porter Joins Department

Dr. Christopher Porter is a visiting professor of Physics, specializing in condensed matter theory. Dr. Porter received his Ph. D. from the Ohio State University, and received undergraduate degrees from both the Ohio State University and Universität Leipzig, in Leipzig Germany. His research interests lie primarily in granular superconductors and disordered magnetic systems; his recent papers have focused on tuning the properties of graphene via ferromagnetic adatoms. Dr. Porter is the recipient of numerous teaching awards including the Hazel Brown teaching award and the Ohio State University's Graduate Associate Teaching Award. Dr. Porter spends his free time writing and enjoying the city's many playgrounds with his daughter.

OSAPS

Two meetings of the Ohio-Region Section of the American Physical Society (OSAPS) are scheduled for this academic year. The autumn conference at Ball State University takes place October 14 & 15, 2011 and has the theme "Applied Physics".

The spring meeting will be at Ohio State University on April 13 & 14, 2012 and will focus on biophysics.

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 and non-threatening opportunity for undergrads to get their feet wet and visit a first professional conference!

Student Research at UNLV

This past summer senior Jack Brangham conducted research at The University of Nevada, Las Vegas, as part of the National Science Foundation's Research Experience for Undergraduates program. Jack worked with Prof. Michael Pravica's group, studying the novel high explosive 1,1-diamino-2,2-dinitroethylene (Fox-7). Fox-7 is of interest due to its stability and resistance to accidental detonation while maintaining a very high explosive yield. The study investigated how Fox-7 responded to extreme pressures using Raman spectroscopy. This type of study is important as these materials will be under pressure when packed into military shells, in the vicinity of other explosions and during their own detonation. Understanding how Fox- 7 reacts to pressures is needed to ensure the material is safe to handle during and after being pressurized.

The material was studied while pressurizing to 20 gigapascals (GPa) in 1-2 GPa intervals. This data was used to identify phase changes within the material throughout the pressure increase. The results indicated that the material is 100% reversible when increased to extreme pressures and showed no signs of hysteresis. This means that the material returns to the original phase and crystalline structure after being pressurized and depressurized to ambient conditions.

Jack is planning to pursue a PhD in physics after graduating from Otterbein, focusing on either condensed matter or AMO (atomic, molecular, optical) physics.

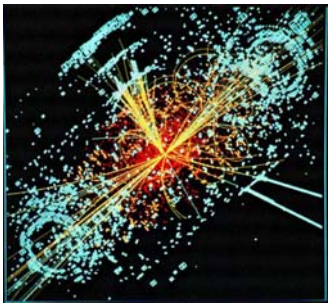
First Wiese Engineering Scholar Welcomed

Beginning this year Otterbein has created an endowed scholarship for students with an interest in engineering. This scholarship is funded by a gift from the estate of Arthur A. Wiese, a Columbus engineer, which provides full-tuition scholarships for up to four years to one or two new students each year. Qualifying students must either participate in the 3+2 dual-degree engineering program or pursue a major in physics or chemistry.

This year we are very happy to welcome Philip Kellogg as the inaugural Wiese scholar. Philip is an exceptional student from Yellow Springs, OH, with diverse interests including philosophy, creative writing and the visual arts. He is currently pursuing the dual-degree engineering program.

For more information about engineering at Otterbein, visit the Physics Department website at http://www.otterbein.edu/physics.

Large Hadron Collider Update



The Large Hadron Collider in Geneva, Switzerland, has been running beautifully at half its design energy (3.5 TeV per beam) and has by now supplied 5 fb^{-1} of data to the two main experiments, Atlas and CMS. (An "inverse femtobarn" is a measure of the number of collisions that have been produced; 5 fb^{-1} represents exceptionally good performance this early in the life of the LHC.) An astonishing amount of analysis has been carried out on this data, including searches for the Higgs boson and new physics such as supersymmetry. On December 13, 2011, the Atlas and CMS collaborations both reported a small Higgs boson signal at about the same location. Individually the significance of the results is relatively weak, but taken together they most likely indicate that the Higgs boson has been discovered, with a mass of around 125 GeV/c^2. Official claim of a discovery will await more data confirming these hints, however. It is expected that this should be possible by the end of 2012.

Beyond this there have been no clear signals of new physics. So far the results suggest that the simplest implementations of the supersymmetry idea, in particular, are probably not realized in nature. Significant limits have also been placed on other popular proposals for new physics, for example models with large extra dimensions and "technicolor."

The LHC is currently shut down for maintenance and will resume operations in March 2012. At the end of 2012 it will be shut down to prepare for running at higher energy starting in 2014.

Prof. Dave Robertson is continuing to develop computational tools for high-precision calculations of particle masses in supersymmetric extensions of the Standard Model of particle physics. This work is being carried out in collaboration with Prof. Steve Martin of Northern Illinois University and the Fermi National Accelerator Laboratory.

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Otterbein Chapter
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SCHEDULED EVENTS 2011/12

Physics Coffee Hour

Wednesdays, 3:00pm, Science Center Room 205

Starry Mondays
Astronomy Lecture Series

October 3, 2011	7:00 – 8:00pm
November 7, 2011	7:00 – 8:00pm
December 5, 2011	7:00 – 8:00pm
February 6, 2012	7:00 – 8:00pm
March 5, 2012	7:00 - 8:00pm
April 2, 2012	8:00 – 9:00pm
May 7, 2012	8:00 – 9:00pm

Night Sky Observing

Prairie Oaks Metro Park

Friday, April 13, 8pm