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ALUMNI SPOTLIGHT

Challenges During College Become Learning Experiences for Alumnus Bob Goldberg

Alumnus, Bob Goldberg, had a lifelong interest in understanding how things work, in large part due to his father, a physicist. After growing up in Silver Spring, MD, his decision to come to UMD came from the department's honors program, proximity, courses and faculty. Unfortunately, like many students, his confidence was challenged his freshman year after enrolling in PHYS 181.

"In my first semester, and later also, I worked very hard to solve all the assigned Physics homework problems," said Goldberg. " Sometimes, I would have to spend hours to work out a solution to one or two of the more difficult problems, and I felt that I must not have been very good at Physics, and not intelligent enough in general."

At an *end of semester*
party, Goldberg was approached by the class TA, who revealed that his homework was used as the key for the entire class. To his great surprise, the TA praised his understanding of some of the most difficult problems. Needless to say, this taught him a lesson. It would not be the only time his confidence was tested.

Goldberg graduated from the Physics honors undergraduate program in 1981 and then attended Rutgers University to obtain his MS and Ph.D. in Computer Science. After years of working for both large and small companies, he has recently started a software company, RD3 Software Corporation. The company's mission is to develop technology related to a new computer language (DASL), which Goldberg, along with colleagues from Sun Microsystems Laboratories, helped to create.

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RESEARCH SPOTLIGHT

Double Beta Decay Search Continues Maryland's Tradition of Excellence in Neutrino Physics

By: Carter Hall

Neutrinos are the most mysterious and elusive of the fundamental particles known to physics. Their existence was first proposed in 1930 by Wolfgang Pauli, who was concerned that the radioactive beta decay of the atomic nucleus appeared to violate the principle of conservation of energy. In beta decay, one of the neutrons in a nucleus turns into a proton, while emitting an electron to conserve electric charge. Pauli suggested that the decay must also emit a ghostly un-observed neutral particle which would carry away the missing energy. A few years later, Enrico Fermi developed a theoretical description of beta decay which incorporated the neutrino as a cousin of the electron. Fermi quickly realized that this new particle was either massless, or else very light compared to the electron.

Pauli's ghost was eventually seen in 1956 by Fred Reines are Clyde Cowan, and by 1962 experimentalists had shown that there are actually several types of neutrinos. Meanwhile, theorists generalized Fermi's ideas about neutrinos and beta decay into what we now call the standard model of particle physics. The standard model seemed to work best if the neutrino was completely massless, but it did not rule out the possibility of a small mass.

Soon experimentalists began to see evidence for non-zero neutrino mass. Beginning in the late 1960's, University of Maryland alumnus Ray Davis carried out a heroic experiment to detect for the first time the neutrinos being produced by the nuclear fusion reactions in the center of the sun. Davis observed about one-third the number of neutrinos that were expected based on solar models. Other experiments found that there also seemed to be too few neutrinos produced by cosmic rays in the earth's atmosphere. Finally, in 1998, an experiment in Japan known as Super-Kamiokande showed beyond any reasonable doubt that the effect was real. The University of Maryland's Greg Sullivan and Jordan Goodman played a key role in this landmark experiment, and many subsequent experiments have concurred with this result.

Fig. 2: The Super-Kamiokande detector is a tank holding 50,000 tons of water and surrounded by over 11,000 photomultiplier tubes (PMTs). When a neutrino interacts in the water, a cone of light is seen by the PMTs. In this picture workers are cleaning the PMTs as the tank slowly fills with water. The University of Maryland played a leading role in the experiment, which offered the first conclusive evidence for neutrino mass.

Fig. 1: University of Maryland alumnus and Nobel Prize winner Ray Davis with his Homestake mine experiment. Davis was the first person to observe neutrinos from the sun, and he discovered what came to be known as the solar neutrino deficit. The effect was later understood to be due to neutrino mass.

Today, there is general agreement that the phenomenon of the missing neutrinos implies that neutrinos must have a small non-zero mass. In fact, many theorists, including Maryland's Rabi Mohapatra, had long since proposed that neutrinos should have a tiny mass, and that this would be an indication that all the forces known to particle physics were unified into one force in the first moments after the big bang. These ideas lead to a clear prediction: that the neutrino should be its own anti-particle.

To determine if this is the case, I collaborate with other scientists on an experiment which is searching for a new type of radioactive decay known as neutrinoless double beta decay. In this process, Fermi's familiar beta decay occurs twice, but with a twist: the two neutrinos interact with each other inside the nucleus and annihilate before having a chance to escape. This can only occur if the neutrino is indeed its own anti-particle, and an observation of this effect would give great support to Mohapatra's ideas.

Our experiment, which is known as EXO (Enriched Xenon Observatory), is searching for the double beta decay of the xenon nucleus. Xenon is a noble gas at room temperature, but we cool it down to -110 C, where it condenses into a liquid with a density about three times that of water. This allows us to fit many more xenon nuclei into our experimental apparatus, giving us much more sensitivity to find this previously un-observed process.

Fig. 3: The EXO double beta decay experiment under construction. The copper cryostat seen the picture will cool xenon gas down to -110 C, where it becomes a dense liquid. If the neutrino and anti-neutrino are the same particle, as predicted by some theories, the experiment may

We are currently constructing and testing the experiment in California, but in May of this year we will move it to a salt mine in New Mexico near Carlsbad Caverns National Park. We must put the experiment underground to get away from the cosmic radiation that is always present on the surface of the earth. Double beta decay, if it exists, would be the rarest type of radioactivity ever observed, and all other types of radioactivity must first be eliminated in order to see it.

see the very rare decay of the xenon nucleus.

And so the story of the neutrino comes full circle from beta decay to double beta decay, and the University of Maryland continues to play an active role in this exciting field of physics. Stay tuned for further developments!

Dr. Hall is an Assistant Professor at the University of Maryland Department of Physics. He is a member of the Nuclear Physics Group. For any questions or comments, please contact him at crhall@umd.edu.

Although he doesn't use Physics in his work, his background has greatly influenced his approach to computer science. The study of physics has given him insight into understanding large computer software programs, including how to model them by simplifying some of the details, as well as how to design them so that their behavior is predictable and easy to understand.

"Physicists often create abstractions to help understand and simplify complex systems, such as the notion of gravity acting on a point mass," said Goldberg. "That ability to find higher level and/or simplified abstractions, to help understand and simplify abstractions that accurately predict how things work, turns out to be one of the key differences between simply writing computer programs vs. designing effective computer systems and languages."

The current position requires Goldberg to participate in several different activities. As co- founder, he has the responsibility of figuring out how to make the company successful. Additionally, he is responsible for teaching and conveying the capabilities of the [DASL] language to others, both inside and outside of RD3, as well as, leading the software development of RD3.

"I have always managed to find ways to make my jobs interesting and creative," said Goldman. "By looking for positions that were 'off the beaten path,' I have been fortunate to find positions that allowed me to invent new ways of doing things, which satisfies my creative nature. I've also made the choice, early on, to choose jobs that contributed in some way to make the world a better place, at least in some modest way."

These positions along with Goldberg's journey have provided excellent learning experiences. His advice to current undergraduate students is to find a summer job or part-time job to gain real world experience. After graduation, he recommends finding a position that offers flexibility. These positions enable you to contribute by being creative. Additionally, he strongly encourages networking and using friends, teachers, family, peers and colleagues to find a good starting position. In fact, all of his jobs were found by networking.

"The study of Physics is challenging," he recalls. "It takes a lot of work, but it is worth it if you persevere.

The biggest blow to my confidence occurred at my undergraduate oral exams for the honors program, my senior year. A very arrogant young professor, whom I had never met before, succeeded in intimidating me by openly judging my performance as 'disappointing.' Unfortunately, the professors who knew me didn't arrive until later, at which point I felt devastated. I limped through the rest of the oral. It took me a long time to recover from that experience. Unfortunately, there are some arrogant smart people in the world. After many years, I have learned that when someone is arrogant and critical of me, it isn't about me at all…this turned out to be a learning experience, though I didn't realize that it was part of my education at the time!"