The Photon: Spotlight

On Alumnus Michael Leung

Why consider a career in industry?

Department of Physics and Astronomy alumnus, Mike Leung (Ph.D. 1985) conducts a tour of his journey from graduate school to industry. Along the way, he offers lessons and some great career advice. Got any questions for Mike? He invites you to ask them! (Click here to ask, we'll pass your message along.)

by Dr. Michael Leung

Synopsis

I finished my Ph.D. in 1985, working with Dr. H. Dennis Drew. My research area was studying semiconductors under high-intensity far-infrared light and with an applied magnetic field. I then went to a post-doc at the Naval Research Lab under Dr. Ulrich Strom (also of UMCP). There my research area was studying the structural properties of glasses and semiconductors. The tool of choice was (again) pulsed far-infrared light. Some of this work used superconducting films as phonon detectors. About the time my post-doc was ending, the High Temperature Superconducting hoopla happened, and I was drawn into directly probing our superconducting films and HTS films with far-infrared radiation. From this, I was able to move back to Southern California and an industry job at TRW. The department I joined did superconducting electronics AND solid state lasers. Now I work on digital circuits and systems that use superconducting electronics and do a little project management, as the opportunities arise.

Physicists in Industry

Things to keep in mind once embarking on an industrial R&D career:

1. Keep sight of how your work fits in with the larger business picture of the

I think physicists are valued in industry because they bring the following set of skills: a strong base in the fundamentals (of physical science), the ability to design experiments, the ability to interpret data and the ability to develop models. Certainly, these are general characteristics of being able "to

The Photon: Spotlight

On The Study of Neutrinos

Physics Professor Rabindra Mohapatra Pursues the Exotic and the Novel

By David Bazell

One of the big mysteries surrounding the neutrino is why its mass is so minute. To decipher this puzzle, scientists must uncover what symmetries govern neutrino physics. This may help to establish superstring theory as the overarching theory of fundamental interactions in physics or bolster another theory.

One of the first persons to propose why neutrinos may have such a tiny mass was Maryland Physics **Professor Rabindra Mohapatra**. Dr. Mohapatra, a theoretical physicist with interests in neutrinos, supersymmetry, unified field theory, and cosmology, developed the idea of the "seesaw mechanism," which may explain small neutrino mass and may be connected to another mystery of nature, the mirror asymmetry of the weak force (the force responsible for nuclear beta decay).

In physics, something called the "Standard Model" describes the fundamental particles in nature and how they interact via the four fundamental forces: gravity, electromagnetism, the strong force and the weak force. But according to Dr. Mohapatra, "the weak force has always been the odd man out. Gravity, the strong and the electromagnetic forces describe processes that are mirror symmetric," while the weak force describes the ones that look different when viewed in a mirror.

Unlike the other forces (gravity, electromagnetism and the strong force), the weak force is "heavier" on one side, and is therefore, asymmetric. This one-sided "heaviness" creates a "seesaw" effect where the "heaviness" of one side is responsible for the "lightness" of the other. In other words, it is essentially responsible for the neutrino's minute mass.

Dr. Mohapatra's "seesaw mechanism," a depiction of the weak force's asymmetry. Click here to enlarge.

Exploration of the mirror symmetry in fundamental processes has led Mohapatra to explore a strange form of matter called mirror matter. Possible evidence for mirror matter comes from--you guessed it--neutrino experiments.

Super-Kamiokande (above), a large-scale neutrino experiment located one kilometer underground in Japan. Click here to enlarge.

Several experiments have shown that the three familiar types of neutrinos, the electron, muon and tau neutrinos, oscillate, or change form with each other and with a fourth, unknown type of neutrino. The Standard Model has no place for this fourth neutrino, but other theories do. Along with this fourth neutrino comes a whole family of mirror particles and mirror forces that can only interact with our familiar particles through the gravitational force. They will therefore not be directly visible to instruments that we employ to see stars and galaxies.

photo by R. Svoboda and K. Gordan (LSU)

Neutrinos are a byproduct nuclear fusion in the sun's core and are dispersed unhindered from the Sun because they barely interact with ordinary matter.

Present understanding of the structure of our universe is that there is more matter out there than we can see. One possibility advanced by Mohapatra and his colleagues, Z. Berezhiani of Italy and V. Teplitz of SMU, is that mirror matter may be the dark matter of the universe. We can detect it through its gravitational interaction with matter that we can see, such as stars, and through its gravitational effect on radiation. Mirror matter could form mirror stars that emit mirror photons that are invisible to us. The theory of mirror matter predicts that mirror stars have a typical mass of about one half the mass of the Sun. This corresponds well with the measured mass of recently detected **MA**ssive **C**ompact **H**alo **O**bjects (MACHOS)--a dark matter candidate.

To further explore this exciting frontier, Dr. Mohapatra, along with **Dr. David Caldwell** of the Stanford Linear Accelerator, recently organized a miniworkshop on neutrino physics in Seattle early last April. At this workshop about 20 of the world's top neutrino researchers discussed current developments in neutrino experiments and the theories that help elucidate these experimental results.

Dr. Mohapatra was recently named to the editorial board of the New Journal of Physics, a completely electronic journal that will cover all branches of physics. He was also named one of five 2001 Distinguished Scholar-Teachers by the University of Maryland for both his research and teaching.

A Maryland physics faculty member since 1983, Dr. Mohapatra considers neutrino physics one of several exciting areas of physics unfolding around the world. For him, the discovery of neutrino mass in 1998 was "the first sign of new physics in about 20 years."

do research," but let's consider why these are valuable to an industrial company.

Much, if not all, of engineering design is multi-disciplinary. For example, even though my primary function is circuit design, in order to assemble a working prototypical widget I must also consider the thermal/mechanical issues, RF/EMI issues, materials, etc., etc. I now also have to throw in three non-technical variables into the design equation, PERSONNEL, COST, and SCHEDULE. Unfortunately, most of our days spent slaving away in the UMCP laboratories didn't include training in dealing with these last three variables. But, that's part of life, so you'd better get learning.

As an aside, let me offer this: Sometimes in industry, having an engineering solution that is 90% right on time and within budget is better than being 100% right but past the deadline or over budget. Another aside, one model for industrial career growth is to work your way up the "system" chain. That is, if your starting job is working on widgets, try to work your way up to the next level of complexity to the component or module that uses the widgets. The strong fundamental background that physics majors have will make it easier to see the bigger picture. But if your dream is to work on better and better widgets, that's okay as long as you learn enough about the next level(s) above where your widgets are used. You'll need that to sell your widget technology and keep it growing.

company.

2. A good way to gradually insert your technology is to look for a "socket" where you can plug in your widget. This widget will have form, fit, and function of the older widget, but will give the end user some performance advantage, or some savings e.g. in power.

3. A more challenging approach is to assert a "breakthrough" or "disruptive" technology. Such an approach may have higher payoff but will require more work and money to get it going.

4. Figure out what supporting technologies you will need for a product; support them, get them involved, and pitch the "turn key" solution.

5. Learn what the competing technologies are, keep a close eye on them, and try to beat them to the punch.

Courtesy of TRW

Michael Leung (standing, 3rd from right) at the IR&D awards luncheon. Mike was honored with the Silver Award given for demonstrating components of a digital switch, including demonstrating (then) speed record for a 200 GHz static divider in superconducting electronics.

As the design team develops new widgets, we find we have to run a number of little experiments and simulations. This is where the research background you're getting comes in handy and probably doesn't need further expounding. Much of it is seemingly mundane (e.g., which solder works best?), but you have to eliminate all the "gotchas" that can kill a design or project. For our kind of work, there is a lot of what I call "device physics," wherein we study how our circuits are made and suggest how to make them so they work better for us. For example, we questioned why ground contacts for our circuits shouldn't be made closer to the active device, in order to reduce parasitic inductance (kills speed, not speed kills). Thus, we devised an experiment, tested it, and now this design change is an integral part of the process. By the way, don't bother trying to patent it; we already did.

Why a Career in Industry?

And why should one consider an industrial career? It presents an opportunity to work on a project with a scope too large for academic work. The work can still be very interesting, even though it's not "basic" research. You will likely produce something useful, possibly patentable, and maybe even marketable. You will not have to teach a class if you don't want to. You will be handsomely compensated.

Even theorists can find meaningful industry work. The lab may become a computer simulation, but everything else is the same.

Preparing for an Industrial Career

Are there specific classes to take to make oneself more marketable to industry? Should one take some engineering electives? Maybe. It's hard to predict what will be a growth industry when you're ready to graduate. I took elective classes in quantum electronics because that topic was related to my thesis work, I was interested in it, and I thought that may be a growth area in industry. As it turned out it was not a growth industry when I started working. It is now an area called photonics. Oh well.

So what technical disciplines are worth knowing? It might be nice to know a little programming (although you can do a lot with Excel and macros), beyond that, it would have to depend upon the field you enter. You had better have or develop excellent communication skills. You can still take courses to learn what you need, once you start work (e.g. extension courses at the local university or on-site courses).

Of my classmates that I still keep in touch with, the ones who have industrial jobs are not working in their thesis topic. See? That illustrates the flexibility of physicists that industry values.

One other note: My department manager asserts that a BS in physics, followed by a Ph.D. in EE is the way to go. I won't argue that, with him anyway.

Post-Docs, that first job for many Ph.D.s

A post-doc is an excellent opportunity to stretch your wings after getting kicked out of the graduate school nest. The National Research Council has a sweet deal with the Naval Research Lab, and the proximity to UMCP means you can hang with your friends for a couple more years. If you go the academic route, the NRC post-doc will give you a start-up stipend. In my case, Ulrich Strom wanted someone to set up a pulsed far-infrared laser facility. Since I had already done so, and Dennis Drew didn't speak too unkindly about me, Ulrich and I hooked up. Since I knew nothing about what he had in mind for the post-doc work, he gave me some reference papers to read, then suggested some experiments he liked. I worked this into the research proposal to the NRC, which then asked Ulrich to review it. So did I get my post-doc more on connections and less on merit? Yeah, so?

Let me help you get that glazed look in your eyes for a moment as I mention how my post-doc got me into superconductivity. We were interested in studying phonon propagation, so we would whack a sample with a light pulse (hitting an absorbing film on the sample surface), and look at the output on the other end with a superconducting thin film. The phonon pulse is a heat pulse that changes the resistance of the film (these detectors are called bolometers), and we could measure the change readily. These pulses occur on nanosecond time scales.

The bolometers were made in another department at NRL. We noted that these films were quite sensitive photon detectors too, when using the far-infrared radiation. This is considered sub-gap radiation so would not ordinarily be detectable by the film. However, the disorder in the film altered its spectral properties making it quite sensitive to this radiation. It is thought that the disorder in the film created a random network of nano-scale Josephson junctions. The tunneling is sensitive to sub-gap radiation, but not the bulk material.

So anyway, we published that and then also published similar stuff for HTS films. About the time I was finishing the government wanted to fund work in HTS, so it was this experience that got me to TRW. The department I joined had two others who passed through the NRL post-doc program. That helped me get my foot in the door. Connections again!

Return to Southern California

Many of you will have the "two-body problem," a spouse with their own career. It can be a tough problem but it's worth solving. One of you may have to make a significant change but a good career can still result. A large metropolitan area facilitates this. Also, I was returning to family, so here I am.

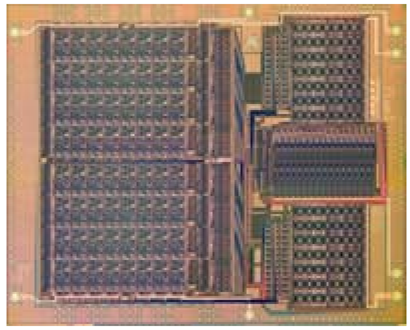
Superconducting Electronics

Now this is a very interesting technology. Many of our papers can be accessed at:

http://www.trw.com/innovations/main/0,1099,6_866_869_874^4^874^874,FF.html

The work here involves a logic and technology called "Single Flux Quantum

(SFQ)." The circuits we design perform logic using the flux quantum (h/2e), so the closest semiconductor analogy would be to create circuits using single-electron transistors. Since SFQ is not a transistor technology, but a Josephson junction technology, unusual new circuit architectures can be created to perform useful functions. This technology is capable of extremely fast digital circuits that operate with very low power. In comparing a digital divide by 2 (a flip flop) circuit between SFQ and indium phosphide (InP), which is the fastest semiconductor technology right now, SFQ is 3-4 times faster and consumes 1% of the power (this power figure includes the cooling power needed to cool the circuit to 5 K). Such a speed and power combination makes this technology attractive to a number of exciting applications, such as high performance (petaFLOP) computing, sensitive and fast analog-to-digital conversion, and digital routers that operate at photonic speeds.



Courtesy of ***TRW***

Superconducting, single flux quantum logic, digital processor chip. This is a prototype 8-bit integer microprocessor chip for a petaFLOP computing project. The dimension is about 1 x 1.3 cm2, and it contains 64,000 Josephson junctions (equivalent to ~5,000 gates).

It's Only the Rest of Your Life

Choosing a particular field or technology or career does not close the door on making changes. You should expect changes. Stick with what got you thus far but add the skills I've described, and you can not only weather changes, but you might even take control of your work. Okay, so Stockholm may not come calling, but you can still have fun with an industrial career.

Got any questions for Mike? He invites you to ask them! (Click here to ask, we'll pass your message along.)

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