Robert G. Bedford, PhD

Senior Electronics Engineer

Sensors Directorate, Air Force Research Laboratory

Work Address: 2241 Avionics Circle

Wright-Patterson Air Force Base, OH 45433

937-528-8853

robert.bedford@wpafb.af.mil

Education:

1998-2003	Optical Sciences Center, University of Arizona
	(2003) PhD: “Finite Aperture Tapered Unstable Resonators”
	(2000) MS
1994-1998	Physics Department, Stetson University
	(1998) BS (Physics), Minor (Info. Tech.)

Professional Organizations:

(2000-present) IEEE Member

(1999-present) OSA Member

Select Publications:

M. Fallahi, and R. Bedford (2012) *High power diode lasers*. In *Semiconductor Lasers- Fundamentals and Applications* (Alexei Baranov and Eric Tournie, Ed.)

R. Bedford, G. Triplett, D. Tomich, S. Koch, J. Moloney, and J. Hader, “Reduced auger recombination in mid-infrared semiconductor lasers,” J. of App. Phys., Vol 110, pp 073108-1, 2011.

C. Hessenius, N. Terry, M. Fallahi, J. Moloney, and R. Bedford, “Gain coupling of class A semiconductor lasers,” Opt. Lett., Vol 35, pp 3060-2, 2010.

M. Walton, N. Terry, J. Hader, J. Moloney, and R. Bedford, “Extraction of semiconductor microchip differential gain by use of optically pumped semiconductor laser,” App. Phys. Lett., Vol 95, pp 111101, 2009.

OPEN LETTER TO PHYSICS MAJORS:

I am not sure what I really have to contribute to present students’ futures, but here is my story in which something may be gleaned. First, a little about me: I grew up in central Florida, was reasonably good at high school math, although was more interested in music. I chose Stetson not only because of its beauty, but also because the school offers an excellent program wherein the family of faculty and staff are provided a tuition scholarship, and my mother was on the computer programming .When I entered Stetson I had no clear career goals and had no distinct aspirations for my future.

While coming to the conclusion that a business degree would be “suitably vague”, I had the good fortune to stumble into Professor Riggs' “Science of Music” course. Because I had studied piano for 14 years and percussion for seven, and this was a perfect combination of math and music. Quickly, I realized that physics rang true to me – the propensity of physicists to wonder and test not only how things work, but also *why* they work. This may have been the most pivotal stroke of luck in my life and career.

Figure 1 Mid-IR optoelectronics research group at Sensors Directorate, AFRL, 2012 (left to right Sarah Dooley, Robert Bedford, Tuoc Dang, Igor Anisimov, Saima Husaini. Not pictured: Afusat Dirisu)

I took the typical undergraduate courses and had a rewarding senior research program working with Professor Riggs on vibrational holography. As graduation approached, I realized I still didn't know what I really wanted to do and graduate school offered a good way to put off “real life”. With my experience in vibrational holography and not much else, I found that however ill-defined, “lasers” and “optics” seemed like a good idea. In 1998, there were two universities that had dedicated optics programs, The University of Rochester and The University of Arizona, with a host of other engineering and physics departments that had strong optics research. I applied and was accepted to the PhD program at the Optical Sciences Center (now “College of Optical Sciences”) at The University of Arizona in Tucson.

At a new student social at UA, shortly after arriving, I met a professor who asked what my interests were. My response was (paraphrasing) “anything except semiconductors”. I cannot say why I had this bias, but as fate would have it, I ended up in the semiconductor laser community under the guidance of Professor Mahmoud Fallahi, and have never regretted the decision. While working with more senior graduate students to whom I am eternally grateful, I was exposed to various types of advanced semiconductor lasers. These included diffraction-grating coupled lasers (both “distributed Bragg reflector” and “distributed feedback” lasers) stable vs. unstable-semiconductor lasers, as well as lasers and materials of varied wavelengths (from visible through the near-infrared regimes).

This foray into an area which I previously (and irrationally) deemed “uninteresting” has changed my life. Like many groups at the time, the research group I joined was motivated in large part by telecommunications, which was enjoying a boom at the time, and I almost got wrapped up in it. Shortly after I passed my comprehensive exams (2-years in), I took a semester off to work with a Nortel Networks company outside of Boston on broadly tunable vertical cavity surface-emitting semiconductor lasers. While this was a brief three month experience, I saw firsthand what a strong team of motivated people could accomplish in a short time.

Another graduate student and I created a new class of semiconductor laser termed a “finite aperture tapered unstable resonator”, which ultimately became my dissertation topic. This type of laser is a

Figure 2 Robert and Patty, on their wedding day, 2004.

small modification to an existing tapered unstable resonator which opened up the area to a different thinking of semiconductor lasers, spawning research as far as Germany!

Upon graduation, I entertained several opportunities, including both government laboratories and private industry. In early 2004 I accepted a position onto the technical staff of the Sensors Directorate of the Air Force Research Laboratory (AFRL) in Dayton, Ohio. I have spent an amazing eight years with AFRL.

We have a great deal of freedom to collaborate with the academic and commercial communities, fund others' research, as well as continue with our unique research. I can't speak for the organization at large, but from a researcher's perspective, we have critical goals designed to create technology that results in better performing, smaller, and more agile sensing capabilities. The hope is that these improved capabilities make our military's job a little easier and safer. Additionally, I have been involved in significant components of basic research where a military system does not have to be explicitly defined. I am fortunate to be able to learn new things every day - whether I like it or not. I have given invited talks from California to Italy, have collaborated with Universities of California (LA), New Mexico, Missouri, and Massachusetts, to name a few, small and large companies, and have had many great experiences. In 2008, I was given an Adjunct Professor position at University of Arizona, and have had the opportunity to lecture several classes there as well.

While at Stetson, I met Patricia McCabe, and we finally married on New Year's Eve 2004 in Ohio. Together we raise Golden Retrievers and compete in AKC conformation and performance events. A few years ago, we discovered the joy of hunting with our dogs (they are "retrievers", after all) and rarely spend an idle weekend at home. We've been across the country several times for dog shows, which for some reason seem to also consume our vacations! We've met and formed great friendships both in and around Ohio, and try to spend as much time with friends and together as possible.

Figure 3 Robert and "Buck" at a national dog show, 2011.

We were able to find a beautiful piece of wooded property in Beavercreek, a Dayton suburb in 2004 (we were actually married on this land in

the snow!). The following year we began construction of our home. I can't say *we* built it, because there was a contractor and team of subcontractors that actually assembled it. However, I can say that both Patty and I took a significant role in the difficult process, therefore we take a great deal of credit for it. Having said that, we are presently going through and addressing rookie mistakes (five years later), hopefully from a more educated point of view. It is another outstanding learning experience for us, and we treasure it, complications and all!

Coming back to education, and Stetson in particular, I found my fundamentals and experiences within the Stetson Physics Department to be second-to-none. The nature of the department, opportunities to work with other students and the tight-knit group was one of the lucky accidents I happened into.

I would like to close with a few choice lessons that I have learned, or am in the process of learning:

1. *If you are not completely confused by quantum mechanics, you do not understand it.*

   - John Wheeler

   This quote by Prof. Wheeler (Princeton) is perhaps the most direct of a host of quotes by famous people like him (e.g. Feynman, Bohr). I feel it should be applied more liberally. Virtually everything (in science, career, life) seems to become more convoluted and complicated the more one considers it. As such, it seems important remember that the pursuit of knowledge (of anything) is a process, and not a route to an end.

2. *You have to pretend you're 100 percent sure. You have to take action; you can't hesitate or hedge your bets. Anything less will condemn your efforts to failure."*

   - Andrew Grove

   I constantly must remind myself of this quote from the co-founder of Intel. As much as any of us know what we don't know (a corollary of (1), we have an obligation to pick a direction and attempt to proceed in that direction with gusto. This seems to be the most satisfying way to live life for me.

3. *What kind of mind-boggling technology might emerge from graphene? Before we proffer an answer, imagine you are on a boat trip watching a school of dolphins. Everyone is mesmerized by the magnificent animals until someone spoils the moment by voicing the unromantic question, 'But can we eat them?'*

   - Andrey Geim [Phys. Today, "Graphene: Exploring carbon flatland" (Aug, 2007)]

   This quote comes from a great review article on a single layer of carbon atoms which assemble into hexagonal structures ("graphene", which is nomenclature for a single atomic layer of graphite). Sometimes the goals are the goals, sometimes it is the pursuit. Physics, engineering, and science can be beautiful in general, and we must always remember to appreciate its beauty. Perhaps this is the science equivalent to the old adage "stop and smell the roses".