Graduate School

I know, I know, thinking about continuing your education beyond your B.S. degree is often hard to think about, especially after slogging through all of your undergraduate courses over a number of years. That continuation is graduate school, either master's (M.S.) degree or doctorate (Ph.D.). The M.S. degree typically adds one to two years in your academic journey, while the Ph.D. is typically four to seven years (5.25 years is the average in Optical Sciences). Why graduate school? Consider your B.S. to be your introduction to the field you have chosen, the M.S. is making you advanced in your chosen field, and the Ph.D. is making you an expert, especially due to the individual research you will be doing. A number of employers are looking for individuals to lead projects, and graduate degrees often can lead to such right after graduation. Let me take some time to explain a little more about each of these degrees, especially as they relate to the Wyant College of Optical Sciences.

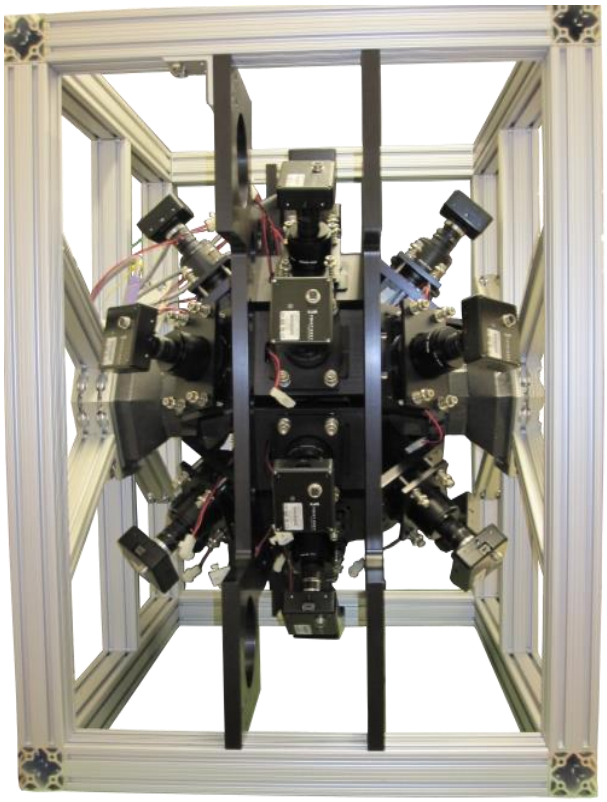

Figure 1. Gamma ray imaging: FastSPECT III developed in Prof. Furenlid's laboratory. Gamma ray cameras simultaneously acquire multiple 2-D projections from multiple angles. A computer performs a tomographic reconstruction to yield 3-D images, including thin slices along any chosen axis similar to images from MRI, CT, etc.

M.S. Degree

The M.S. degree is analogous to a professional degree, much like a business, law, or medical degree. You are spending typically one to two additional years to learn more about the nuances of your chosen field of study, options to assist in teaching undergraduates or to conduct research, and dramatically increase the earning power of your degrees. In Optical

Sciences there are two types of M.S. degrees: thesis and non-thesis. For a thesis you will be conducting novel research in an area that you agree upon with a faculty member (i.e., your research advisor). You will have eight units of thesis (OPTI 910), which amounts to around a total of 360 hours of work during your studies. For the non-thesis M.S., there are two options: three units of M.S. report (OPTI 909) or three units of technical writing (OPTI 597B). For the report you will study in depth a subject that you choose with your advisor (e.g., zoom lenses, ultrafast lasers, x-ray optics, or so forth). In the M.S. thesis and report options you will be writing a document that you will present at your M.S. defense. For the thesis this document will be comprised of around 75% novel work and 25% of a review of the literature, while for the report this document will be comprised of around 75% of a review of the literature and 25% of design (novel) work to show you can develop novel "technology." For the non-thesis technical writing option, you will also have a M.S. defense, but you will be asked about your courses that you took for your master's studies.

What courses do you have to take? For the standard master's degree, you will take 24 units (thesis) or 32 units (non-thesis) of additional coursework. Along with the report, technical writing, and thesis units, this will typically mean about two years of additional study. Fortunately, there are no required courses, but you will select those that assist you in your report or thesis demands, especially those suggested by your advisor. There is one way to speed up this process – the Accelerate Master's Program (AMP).

Figure 2. Ultra-compact femtosecond fiber laser developed in Prof. Khanh Kieu's laboratory. This handheld laser emits pulses of light on the order of 100 femtoseconds (10^{-15} seconds).

Accelerated M.S. Program

The process to get admitted into the AMP starts in your junior year. First you must do an interview with the Associate Dean for Undergraduate Affairs (me!) to gauge your background and interests in additional studies. The deadline for such an interview is 15 May, and upon completion of such and agreement that you are a candidate for the AMP, you will have till 15 June to apply. What else is required to apply to the AMP? A 3.5 GPA in your core curriculum and 3.5 GPA overall in your undergraduate courses. Upon joining the AMP, you can use up to 12 units of 500-level courses that can be used for both of your B.S. and M.S. degree requirements while you will be pursuing the M.S. report option. Of course you can still do a thesis and you can still transition to the Ph.D. This "double dipping" of 12 units means you can complete your M.S. studies in one additional year. The typical 12 units are: OPTI 530 Optical Communications, OPTI 521 Introductory Optomechanical Engineering, OPTI 513R Optical Metrology, and one 500-level elective. How difficult are graduate courses? They are more demanding, typically 25%+ more work and increased classroom speed.

Ph.D. Degree

The Ph.D. is the culmination of one's education in the United States. While there are increased demands in coursework (54 units of courses and 18 units of dissertation (OPTI 920)), the primary focus is independent research. You will work with your dissertation advisor to work on a detailed project that will go over one-plus years. As like the M.S. thesis, you will do around 75% novel research and 25% literature review. Along the way you will take a preliminary exam at the end of the first year to ascertain your knowledge in four distinct areas of optics, you will conduct extensive research, present your research at conferences, write papers that are published in journals, and write and orally defend your dissertation. As you can see the Ph.D. is decidedly more demanding than the M.S. In your first couple of years you will be spending a fair bit of time in the classroom, but increasingly you will be working in labs, modeling on computers, and reviewing the extensive literature. Upon graduation with your doctorate, you will command a higher salary compared to those with the B.S. or M.S. hires at the same institution. Note that the Ph.D. is highly competitive to be accepted into the program – there are only so many spots in a given year, unlike the M.S. degree.

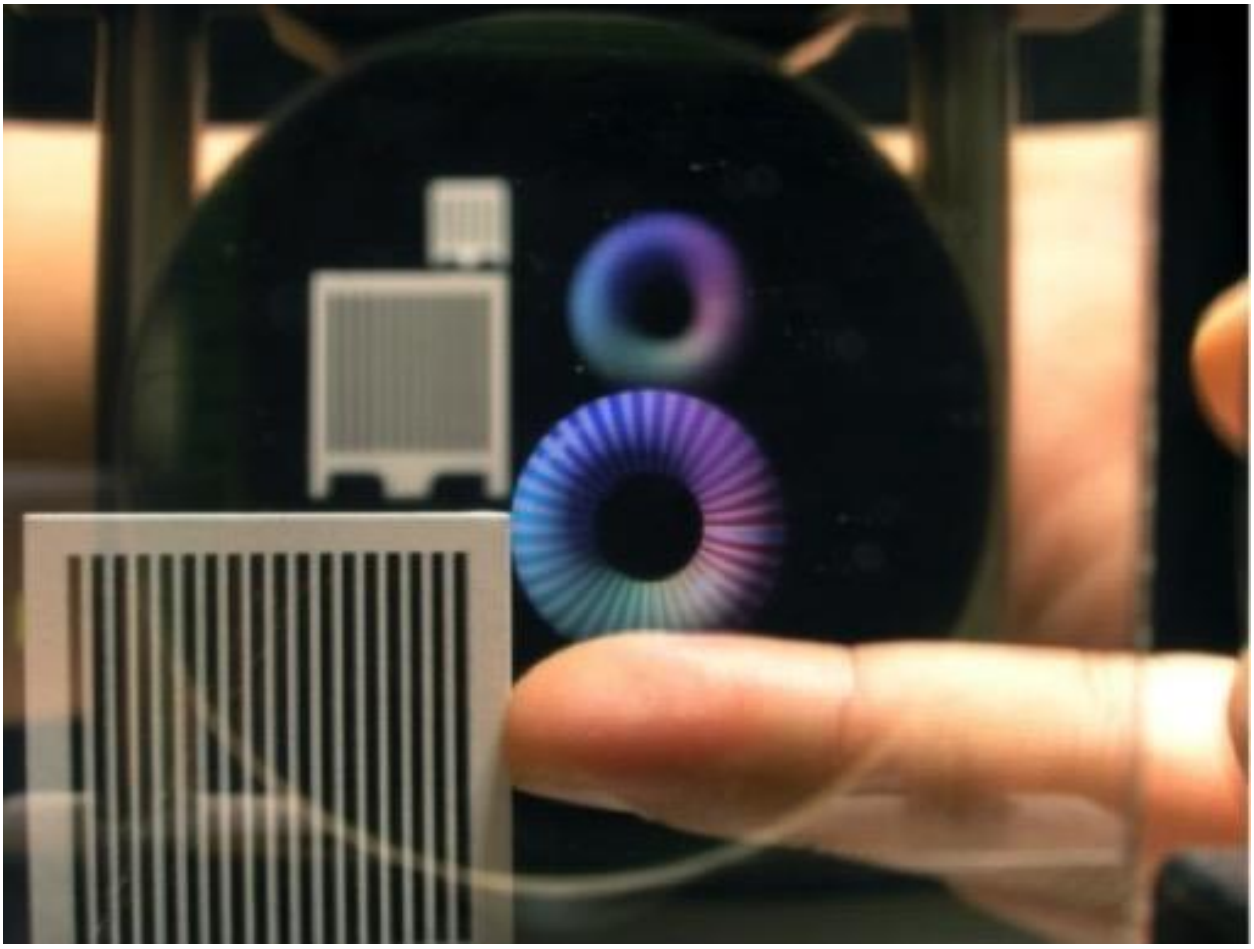

Figure 3. 3D display augmented reality technology developed in Prof. Hong Hua's laboratory. Proper perception is integrated into this technology so that vergence and depth of field is accurate. Such provides the cues so that your brain can correctly interpret while alleviating physiologic mismatch.

How does one pay for this?

As stated the M.S. degree is analogous to a professional degree, so at first blush you are expected to pay for it. Fortunately, you can be hired as a research assistant (RA), especially for those doing a thesis, or a teaching assistant (TA). Ph.D. students are typically hired as RAs, but also TAs if research funding is tight or coming in soon for your given project. Simply, doctoral students are virtually guaranteed 0.5 FTE status, but one must maintain satisfactory academic progress. You are hired either at a rate of 0.25 or 0.5 full-time equivalent (FTE). For 0.25 FTE, this pays for half of your tuition while giving you a semester stipend, and the remaining tuition is at the in-state rate. For the 0.5 FTE, all of your tuition is covered and your semester stipend is doubled. Students from our B.S. program have immediate options to be a TA for the undergraduate courses.

In conclusion, though graduate school will add more time to you academic studies, it will open a lot of additional opportunities and a higher salary. In closing note that you do not need to pursue optics for your graduate studies – you have the knowledge and skills to pursue other options which meet your desires. Additionally there are graduate institutions all over the

globe. The Academic Programs office remains open all the time to answer your questions about graduate school. We are here to help make your dreams a reality.

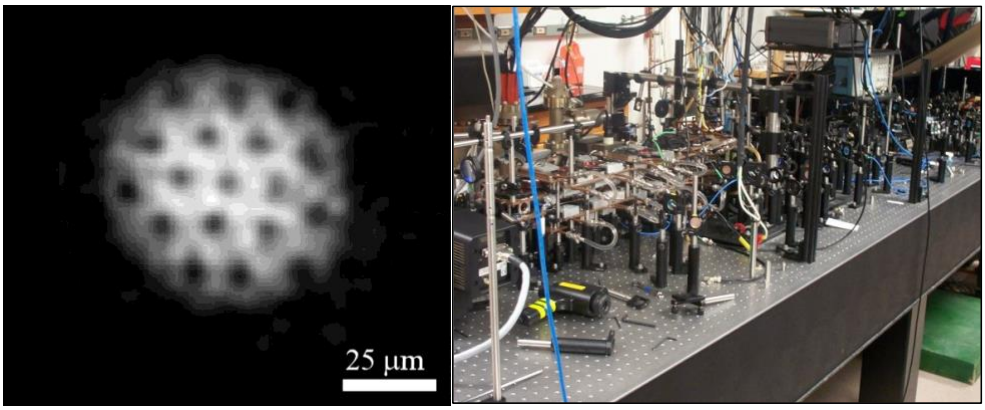

Figure 4. A rotating Bose-Einstein condensate (BEC) cloud developed in Prof. Brian Anderson's Laboratory. A BEC is when matters behaves like light – it constructively and destructively interferes. It produces producing many quantum vortices that can stabilize into a *vortex lattice.* Vortices are like little quantum hurricanes.

Photon Snacks is a column for Light Bytes written by John Koshel, Associate Dean for Undergraduate Affairs in the Wyant College of Optical Sciences. You can find the previously written articles at . Additionally, make suggestions for articles by emailing jkoshel@optics.arizona.edu.