Dr. Wyant: Educator, Expert, and Entrepreneur

Isaac Trumper[a] and Logan R. Graves[a]

[a]ELE Optics Inc., Tucson, AZ USA

ABSTRACT

Dr. James C. Wyant invited a young undergraduate to declare Optical Sciences as his major, claiming that optics offered innovation, impact, and challenges; backing that claim up with stories of his career of academic discoveries and entrepreneurial successes. Years later, the lasting contributions Dr. Wyant made to the field of metrology offered a new point for further exploration, both for the original student and another young optical scientist coming from the University of Rochester. These students, Dr. Graves and Dr. Trumper, joined the graduate optical sciences program at the University of Arizona to further explore the field of optical metrology and science that Dr. Wyant had been a pioneer of. With the generous support of the Friends of Tucson Optics (FoTO) Scholarship to support them early in their careers, and one of Dr. Wyant's prior students turned professor to advise them, Dr. Graves and Dr. Trumper learned the intricacies and needs of the field of optics and metrology, and how a commercial product needs to serve the customers. These experiences, and knowledge of Dr. Wyant's own entrepreneurial successes, provided the required motivation, knowledge, and community to create ELE Optics, a company providing software solutions to the optical science community. We are indebted to Dr. Wyant's generosity, kindness, and accomplishments and strive to show our appreciation for his vision.

Keywords: James C. Wyant, ELE Optics, Optical Software

1. INTRODUCTION

Dr. James C. Wyant, in the author's undergraduate years, was something of a living legend. He could be seen pacing the hallways at random times with a stern, focused look on his face and his hands clasped behind his back. Students were certain he was actively solving complex optical problems, wrestling with concepts far above the level of undergraduates. He was at the time the dean of the college, but his name was splashed throughout course lectures; it was tied to interferometric devices and equations, and even professors spoke of him with reverence. However, get up the nerve to approach this legend, and you were met with an incredibly kind, patient, and gentle human. This manuscript sets out to show through anecdote and concrete impact how Dr. Wyant has shaped the authors' careers in the field of optics from the moment they entered the college to now, and honor his immeasurable contributions.

2. EDUCATOR AND MENTOR

By the time the authors began their undergraduate degree, Dr. Wyant possessed a mountain of accolades, and most likely was at any given point in time confronted with a variety of challenges from optical research, thoughts of innovation, and the stresses of deanship. Yet, if you saw him and asked him a question he would immediately smile, pause, and proceed to offer a clear answer. Even more impressive, he would do this whether you were a familiar face or a new one. Logan Graves in his first year at the University of Arizona had determined that he should pursue biomedical engineering during his undergraduate career. During a tour of the optics building, Logan happened to encounter Dr. Wyant, who after learning of his decision to go the biomedical route, made a straight-forward, but compelling, case for pursuing optics as well. Dr. Wyant's honest passion for the field shone through, and, along with hearing about the innovations in optics he had delivered as well, Logan was convinced. Five years later he obtained his B.S. in Optical Sciences.

Further author information: (Send correspondence to I.T.)
I.T.: E-mail: itrumper@eleoptics.com
L.R.G.: E-mail: lrgraves@eleoptics.com

Tribute to James C. Wyant: The Extraordinaire in Optical Metrology and Optics Education,
edited by Virendra N. Mahajan, Daewook Kim, Proc. of SPIE Vol. 11813, 118130C
 · doi: 10.1117/12.2568973

At this point, not only for Logan but for a University of Rochester graduate named Isaac Trumper, the time came to pursue graduate school. Once again, Dr. Wyant provided inspiration, and direct support, which caused both students to select the University of Arizona for their graduate careers. For Logan, the field of metrology and how it could be applied to advanced optics was a driving motivator. At the time Dr. James Burge, along with Dr. Daewook Kim, were part of a team leading cutting edge research work for metrology of extremely large mirrors. These were the optical surfaces that would serve as the primary mirrors in the next generation of telescopes. Interestingly, these super large mirrors, ranging in size from the 4.2 meter Daniel K. Inouye Solar Telescope primary mirror to the 8.4 meter mirrors that will make up the Giant Magellan telescope, required metrology analysis methods and tools (including a 4D interferometer or two) that were directly influenced or created by Dr. Wyant. Projects like these caught the minds of Logan and Isaac and convinced them that this was the right area for their graduate work under Dr. Kim. Throughout their graduate career, these authors heard many stories from Dr. Kim as he taught and guided their research. Dr. Kim was heavily influenced by Dr. Wyant as he was the dean of the college when Dr. Kim was applying. The impact of Dr. Wyant's time as an educator and mentor is realized through the generations as his students become mentors and teachers and carry his energy forward.

Of course, one of the perks of choosing the University of Arizona and their optics program for graduate school wasn't just the research being done on these telescope mirrors; it was also the ability to spend the first year as a student judiciously exploring research labs of interest, gaining hands on experience, and making an informed decision of what lab best suited the student. It was a rare opportunity that was due to the Friends of Tucson Optics (FoTO) Scholarship, a scholarship that was created to provide a year of funding for up to 30 graduate students to explore and participate in research labs their first year. A large collection of generous donors contributed to the FoTO Scholarship fund; Dr. Wyant and his family generously provided a 10 million dollar gift, in celebration of the college's 50th anniversary. Due to Dr. Wyant's and others incredible donations, the FoTO scholarships provided funding for Logan and Isaac for their first year of graduate school. The scholarship continues to provide highly beneficial support to students today.

The impact of this gift cannot be over stated. As anyone who has gone through a graduate program can attest, a student's work becomes to some extent their life, and an ongoing defining contribution they make to the public realm of science. Similarly, the student's advisor becomes their wise mentor, or in other cases, their unmovable gate-keeper. Due to the nature of graduate work, like most good things, significant investment in time and energy is required before the payoff is seen. Traditionally, first year graduate students are expected to take a position at a lab that can last anywhere from 3 (for the extremely fast students) to 8 or more years with an advisor they barely know, working on a project they have only heard the description of, with lab peers they may have never met. Given the at times stressful nature of research work, having a supportive advisor who a student resonates with, strong lab group members, and a compelling personal interest in a research project makes all the difference. The FoTO scholarship still is one of the few offerings these authors have heard of that provides young students the support needed to take their time and select an ideal research group.

Given these support structures, and the influence, both directly and indirectly via his impact on the professors and courses at the optics college, Logan and Isaac, along with many others, chose to study optics at the University of Arizona. Dr. Wyant's gravity has pulled many young aspiring optical scientist into this field of study, and his support and guidance has propelled them to explore new areas and make their own innovations. For Logan and Isaac, that work focused on metrology, particularly as it applied to novel optical surfaces. The remainder of this manuscript defines the scope of metrology used, how Dr. Wyant shaped and influenced this area, how Dr. Graves and Dr. Trumper's work interfaced with the prior work, and how this research set the foundation for forming their own company to provide software solutions for the optics community, which was a result directly of the inspiration provided by Dr. Wyant.

3. METROLOGY EXPERT

Since the first optical systems were made, there are two essential questions that have been asked: What does an optic need to do, and is this optic good enough for that purpose? Early methods of answering this problem were straight-forward: could the user see through the surface to their object of interest well enough, and could they see an image of their desired object at the hoped for focal point, or even could someone polish the surface a little

better to improve the quality? As time advanced, so did the demand for better optics, and thus fabrication and metrology advanced hand in hand.

Optical systems began to expand into high-element count systems, which required precision manufacturing both of the optics themselves and of the assemblies holding them together. Surface shapes also became more complicated, with aspheric surfaces more commonly replacing standard spherical surfaces, and apertures became *extreme*, with customers requesting both very large and very small aperture optics. Not only were optical systems changing, but the science around optics also advanced; design went from hand written equations to being performed with powerful computer aided technology, metrology techniques rapidly evolved from an art to objective and quantitative tools, and fabrication changed from a hand polished art form to robot guided manufacturing methods.

Through all of these advancements, Dr. Wyant was a key guiding force in the optics community. His early graduate work, and later academic and commercial work in part, focused on a field of metrology known as interferometry. Interferometry is a method where by the wave nature of light is utilized to measure the difference in shape between an optical surface and some ideal surface shape. This also happens to be the field of study Dr. Wyant focused on early in his career as a student at the University of Rochester. Dr. Wyant's entire career has contributed to the field of interferometry, indeed, during his academic tenure he taught a course on optical testing and fabrication methods at the University of Arizona, and contributed, along with Dr. Katherine Creath, an essential manuscript *Basic Wavefront Aberration Theory for Optical Metrology.*

This manuscript is worth noting not only for it's superb quality, but also the impact it had on these authors. As an early student of optics young scientists are often taught that the core practical aspect of classic optics is to design an optic for some purpose. If they dig deeper, they may learn that there will be some faults along the way of getting their optic made, and thus tolerances for allowable errors are needed. Finally, if they go the route of taking an optic from design to reality, they will have to go through the process of metrology analysis, both for the bare optics and the final assembly, to determine if in fact the optic meets specifications, or if not, can compensations be made. Throughout this entire learning process they will hear whispers and then louder statements declaring that Zernike polynomials are the best route for stating mathematically the quality and shape of the optic they are measuring. There exists a wealth of excellent texts on Zernike polynomials, and it is a subject which the authors encourage readers to explore, but for brevity they can briefly be described as a polynomial set which well describes common shape errors in an optic (for classically made optical surfaces with circular apertures). While this is generally true, the aforementioned manuscript by Dr. Wyant and Dr. Creath was one of the early, and important texts, these authors encountered which laid out not only the value of using Zernike polynomials in metrology, but how they work, and most importantly, where and why they may fail to be a good solution. This information helped to open up the authors to the realm of advanced metrology, and optical surfaces which exceeded the realm of being readily described by Zernike polynomials.

This insight had lasting impacts on the author's academic and later professional career, as it introduced a fundamental realization into their world view. Namely, optics at the end of the day are real world objects, and accounting for their unique features, flaws, and capabilities in a practical and tangible sense is essential to delivering promised performance to the final users. Further, just because some method or technique is common or espoused, an optical scientist has a duty to understand any technique they utilize, and to decide whether it is an appropriate method for the task at hand. Chesterton's Fence is a useful rule of thumb, but when it comes to delivering a final optical product, an optical scientist must understand fully why a process was followed to assure themselves, the final user, and the community that the methodology was robust and well reasoned; something that Dr. Wyant consistently demonstrated academically.

4. BUSINESS LEADER

Throughout graduate school, the authors had heard of the local Tucson, AZ metrology company 4D that Dr. Wyant had started and its technical achievements. Additionally, they extensively relied on the interferometers produced by the company for a variety of optical measurements. The success of the company demonstrated in a concrete manner just how much of a positive impact a company can have on the world at large by successfully providing optical innovations in the commercial realm. The fact that a world-renowned metrology company had

been started by someone who had already strongly impacted the authors' graduate career served as inspiration that the dream of building a business could be made into a reality with the right mixture of technical innovation, insight into the needs of the community, and drive to bring a concept to fully formed product.

Dr. Wyant's stewardship has been a key guiding force for these authors in the creation of their own company. Through his career, Dr. Wyant demonstrated several essential business principles that the authors are determined to continue. Among these include the idea that the company serves the community. Dr. Wyant demonstrated with his own company that the tools and services a company provides must be for the community that uses them, to maximize their innovative and creative potential; the interferometers he and his companies created help to 'super power' many optical scientists in their careers. Another lesson is to be attentive and responsive to the feedback of the field. Dr. Wyant was deeply connected to the field of optical science and its scientists, and this allowed him to consistently hear what their needs and goals were and adapt his company to those inputs. Along these same lines, operating honestly and transparently was another key lesson. Dr. Wyant demonstrated a career that was reliably clear and straightforward regarding the products his companies provided, and how the companies operated; this provided a good feeling for the customers, knowing who they were purchasing from and what their business and personal values were. Finally, Dr. Wyant showed that a company should always be pushing the boundaries of the field. His companies delivered cutting edge innovations to the community, and the authors strive to continue this trend with their own company.

The authors formed ELE Optics immediately after graduating and have been pursuing the idea that optical software connected to metrology and manufacturing can serve the community delivering ever accelerating innovations in optical products and technologies. The authors' background in metrology from graduate school serves as the conceptual foundation to building software tools for the optical community. Dr. Wyant's contributions to the field of metrology and his commercial success continue to inspire our business. In this way, his impact is still propagating outwards, through the work that he has made possible by his technical and financial contributions. The authors hope to continue to honor Dr. Wyant's support by pursuing their own vision with a similar passion that he shared with these authors, and then in turn be able to give back to the next generation of optical scientists so that we reach ever higher places.

ACKNOWLEDGMENTS

The authors would like to express their gratitude for their graduate school advisor and peer, Dr. Daewook Kim for always being a source of inspiration and energy for innovation.