Paths of Partial Coherence: Jim Wyant's influence on my profession career

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ABSTRACT

Since 1978 my professional career has been in partial coherence with James C. Wyant. Sometimes strongly and other times weakly. Sometimes in phase and other times out of phase.

Keywords: History

INTRODUCTION

Writing a tribute paper is fraught with peril. While it is supposed to be about the other's impact upon your life, in really it cannot help but be all about the author. Back in 2012, after my initial reluctance, the paper I wrote for the Bill Wolfe tribute [1] was so cathartic, that I had to write one for Jim Wyant – to add a chapter to my story, to explain how a path of successes and failures have lead me to the present, and in the process to exorcise more ghosts from my subconscious.

While our relationship is complicated, it has always been respectful. In many regards, Jim Wyant may be one of the most important people helping me reach my potential. I am NOT 'A' Wyant Student. I am 'a' Wyant student. I took three classes from Jim: Interference and Diffraction, Holography and Optical Testing. As a result of those classes, I found something that I loved, something at which I was good, something that became a part of me – I found my technical bliss. And beyond the classroom, my professional career has been inescapably connected with Jim Wyant.

VIGNETTES

Jim Wyant had a minor role in my coming to Arizona for graduate school. A co-worker at Wright-Patterson AFB by the name of Bill Martin strongly encouraged me to apply to Arizona. He had taken classes at the Optical Sciences Center. And, he believed that OSC would be good for me. So, I applied. Unfortunately, Arizona rejected my application. I don't know if Bill had anything to do with it, but then Arizona accepted me into the MS program. So, what is the Wyant connection? Bill had been a roommate of Jim Wyant.

Personally, I always felt a kinship with Jim – we were both 2 farm kids from Ohio. And, maybe he too felt that bond, he once called me the 2nd best optical metrologist he knows from Ohio. And, maybe it was that kinship that motivated him and Louise to give Karen and I a baby stroller for our son Michael.

INTERFERENCE AND DIFFRACTION

My first official connection with Jim Wyant came in spring 1980 when I took his interference and diffraction class. As an undergraduate, Waves was the class in which I did the best. I have always been an 'ok' student. But in Wyant's interference and diffraction class I found an academic subject that was absolutely intuitive to me – not only the theoretical academic part but also the practical laboratory part – for which John Hayes was the instructor.

The favorite thing about which I learned was the Van Cittert Zernike Theorem. That taking the Fourier transform of the spatial irradiance distribution of the source give the spatial visibility of the interference pattern. And, that taking the Fourier transform of the source's spectral distribution gives the interference pattern's localization.

1981 TO 1983

I have previously written in detail about my early days at OSC in my Wolfe tribute paper. But, the years of 1981 to 1983 were a pivotal period in my life with many momentous events and accomplishments which impacted all that has followed. Therefore, they require some revisitation. Professionally, it is during this period that I transitioned from infrared radiometry to optical metrology. And, it was a period of profound personal change.

The transition starts in the fall of 1981 when I took Jim Wyant's Optical Testing course. I loved it. I was good at it – particularly the hands-on laboratories. I had finally found my technical bliss.

Three major events occurred in the spring of 1982: Dick Babish introduced me to Dave Markel; I met Robert Greenler; and I was admitted into the PhD program.

Dick had been recruiting me over several years to join Perkin-Elmer. During the Spring 1982 Industrial Affiliate meeting, he introduced me to Dave Markel. And Dave Markel gave me an internship during the Summer of 1982 in Building 50 Danbury Rd with Fritz Zernike – that summer changed the entire trajectory of my professional career and eventually brought me back to 100 Wooster Heights from 1993 to 1999. Fritz gave me my own lab with a Tropel 70 phase-measuring system and told me to figure out a method to measure the wafer height – I was a kid in a candy store. I spend my summer making and using phase-measuring interferometers. Also, I met Abe Offner and Don Hewett.

I first met Dick at the 1980 Industrial Affiliates reception. He invited me and my wife Karen to join him for dinner at the Tack Room restaurant. He continued the practice every time he came to Tucson. And every now and then he would tell Karen that she was an ideal 'Perkin-Elmer' girl. Dick continued these meals when we would meet at an SPIE conference and while I worked in 100 Wooster Heights. During these dinners he would regale us with wonderful stories of his exciting adventures. I have lost the details over the years, but I'll do my best to hit some of the highlights. He met Rita Hayworth while working in Hollywood on various cinema camera lens projects. He had lunch in the Egyptian desert next to the pyramids. He was flying to somewhere in the Middle East on a military plane and they landed in the desert to refuel. Next to the runway a tent was setup where they disembarked and had a meal before continuing their trip. The memo that Rommel authored after inspecting a PE tank sight regarding its engineering simplicity and robustness of the design. The business areas that 'got away' when PE decided not to pursue the HeNe laser and high-speed computers. And, he told me about how at the encouragement of a young engineer, he performed an after-hours 'flash-light' test of the Hubble mirror that convinced him that there was a spherical aberration problem.

Robert Greenler visited OSC on 21/22 April 1982 to give lectures on Meteorological Optic Effects. After his first talk, I introduced myself and told him about my MS thesis ammonia crystal scattering research. The next day he visited with me for 2 hours asking questions and just discussing. I have never forgotten the validation I got that that such an important person spent that much time with me. It motivates me to spend as much time as possible with students during my travels for SPIE or OSA. As a result of that interaction, Robert Greenler invited me to give two – back to back – papers in his conference at the OSA 1982 Annual Meeting in Tucson and another paper at his 1983 Topical Meeting on Meteorological Optics in Lake Tahoe. While the Lake Tahoe trip was a great experience, my OSA talks directly resulted in a job with Breault Research.

Bob Breault had been in the OSA audience and based on my talks (and a subsequent interview) hired me to do straylight analysis. I started working for Breault Research Organization on Tues 31 May 1983 (which required me to buy my first computer, and IBM PC with 256K memory). For the rest of my student career I supplemented my graduate assistantship doing stray-light analysis on that computer. And, I used it to write my dissertation with my son Michael on my lap.

In the Spring of 1982, I was admitted into the PhD program. And, by the end of the year I had passed the written and oral preliminary exams.

I completed my transition to optical metrology when on 10 Jan 1983 I was hired by Bob Shannon to design and build an infrared phase-measuring interferometer for in-situ metrology of ground surfaces produced by Bob Park's swing-arm off-axis grinder.

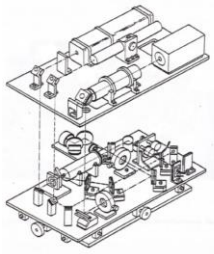
Additionally, I made a small step towards my future when, on 11 Jan 1983, I became a faculty member at Pima Community College to teach an algebra-based introductory physics class. I loved having students and this experience would motivate me to seek and accept a faculty position with Rose-Hulman in 1990.

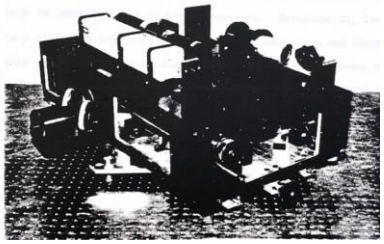
Personally, this period started with the graduation of Karen with her BS in 1981 and ended with receiving my MS degree in 1983. Between these bookends, I earned my BSA Woodbadge beads in Dec 1982. Since coming to Tucson in fall of 1979, I had been a Scoutmaster – holding weekly meetings, organizing monthly campouts and hikes in the desert and mountains, and going to summer camp. While my Scouting activities probably slowed me down, I would not change anything. As a lifelong Scouter, I believe in its program of Character development. I was a youth scout as were my two sons, Michael and Mark. And, Mark and I represented SPIE as Engineering Merit Badge Counselors at the 2010 and 2013 National Jamborees. But most importantly, on 4 March 1983, our first child – H. Michael – was born.

PHD

After I passed the Prelim Exam, Bill Wolfe suggested that my MS research on Scattering Phase Function and Linear Degree of Polarization of Ammonia Ice Crystals was sufficient for a PhD. But, I was hooked on optical testing and I wanted to learn about phase-measuring interferometry.

I would have loved to become 'A' Wyant Student, but he was not accepting new students. So, I signed on with a new professor – one of Jim's former students. And on 10 Jan 1983 I got the perfect dissertation project which combined my infrared experience with my interest in phase-measuring interferometry. Bob Shannon hired me to design and build an infrared phase-measuring interferometer for in-situ metrology of ground surfaces produced by Bob Park's swing-arm off-axis grinder. While Shannon had eviscerated me during the Prelim Oral, I enjoyed working for him and I think he approved of my work. He said that my instrument design contained more science than most such designs. The project was funded by the Rapid Optical Fabrication program. The first year was spent designing and building the interferometer itself. One fond memory of that time was briefing my Rome Air Development Center sponsors about my design while holding Michael in a belly bag sucking on my little finger to keep him quiet. The next 6 months were spent getting the interferometer to talk with my advisor's electronics and phase-shifting software. I had so much trouble with it that I wrote my own IBM PC code – and so did Bernard Bell.





Beyond being my 'research grandfather', Jim was critically important to my PhD. My research topic on phase-shifting infrared interferometer was a direct extension of his own research and the research of his student Osuk Kwon. He provided me with technical mentoring into the craft of phase measuring interferometry and how to write my software. He provided encouragement when times were difficult. And, while I don't know what happens behind closed doors, I believe that Jim protected me during my dissertation defense.

For the first 6 to 9 months, things with my advisor went fairly well – or as well as things can go between two strong personalities. My advisor even kept talking about starting a company together to sell IR interferometers to compete with Jim and John Hayes. During the 1984 Industrial Affiliates meeting, my advisor brought a parade of companies to the lab for demonstrations, and some said they wanted to buy one. It was so obvious that John asked me at the Affiliate's reception how many interferometers I had sold that day. John and I always had a friendly rivalry. I patterned my dissertation after his and would use his research in my future work. John incorporated some of my ideas into his own IR interferometer (which he showed om on Tue 12 June 1984).

The venture with my advisor never happened. Instead he joined with Jim and John in forming Wyko. So, my adviser and I drifted apart. At times the relationship was so toxic that we didn't speak – at the worse he told me that I was stupid, a nobody, my future was at his mercy and I would never ever be a part of Wyko. Fortunately Bob Parks and Achim Leistner filled the void. Bernard Bell and I commiserated our respective experiences of being verbally berated and taken advantage. I had a long conversation with Jim on Wed 18 July 84 about the situation. He tried to explain my advisor's behavior (and offered a pseudo-apology). Finally, it was Jim who told me that I knew more about my topic than anyone else in the world and that I should write it up. During the last few months, I thought that I had reconciled the relationship with my advisor. But, after my dissertation defense, he came to my celebration party, told me that he had voted against me then left. While I doubt he has changed his opinion, I hope time has proven him wrong.

For the record, I've always been envious of my peers who have benefited from relationships with their advisors. It is much easier to sail the winds and waves when you have a support system. And, maybe my experience as a grad student is why I needed my RHIT students, why I have had so many NASA undergraduate and graduate research assistants and fellows, and what drives my desired to be collegial with my team and SPIE family. It is also why I'm grateful for the support I got regarding SPIE from Bob Fischer, Sue Davis, Kevin Harding, Terry Montoya and Marylin Gorsuch.

Some would tell me that I could have completed my PhD quicker had I not been working part time at BRO. But, I could not have supported my family without the income I got from working for BRO. And, that income allowed me to stay in Tucson and work on my research instead of taking summer jobs out of state. It was during the summer of 1984 that I worked out the theory for phase-modulated infrared interferogram detection via a pyroelectric vidicon. Using that theory, I made predictions and experimentally verified the theory by test. In my mind, designing and building an interferometer was not worthy of a PhD – it was just engineering. But, developing and validating a detection theory was worthy.

Apparently, Wyko also thought that my research was worthy. John Hayes asked permission to use a graphic from my dissertation in a paper he was writing. I agreed as long as he cited me, which he did – which I appreciated. What I did not appreciate was that all subsequent Wyko papers or sales literature, they only cited John's paper. Unfortunately, I find self-citation to be a common practice in publishing. Also, my advisor thought enough of my engineering work to submit a patent disclosure without including me or telling me. After I filed a grievance with the University of Arizona Graduate College to have my name added to the disclosure, it was withdrawn. This is the reason that I have filed patents with my NASA research fellows. But, I have learned, that patents are no guarantee either. If someone is so motivated, they will knowingly infringe on a patent and avoid paying a license royalty.

Anyway, in May 1985 I graduated with my PhD and Karen with her MS.

BREAULT RESEARCH ORGANIZATION

Some may think that I joined Breault Research Organization after my graduation to compete with Jim and WYKO. And, yes – I am strongly motivated by competition and establishing my own identity. But truthfully, I was really competing with my family. I come from a long line of entrepreneurs - farmers, businessmen, etc. In particular, I was competing with my Great-Grandfather who in the early 1900s, as owner of the Ohio Cultivator Company, was a successful industrialist manufacturing farm implements. And, an interferometer was not the first product which I developed for BRO – it was a scatterometer. Additionally, we took contracts to provide engineering support to the SDI program.

In my five years at BRO, I developed a dozen different hardware and software products: two different scatterometers, IR phase-measuring interferometer, visible phase-measuring interferometer, Zygo phase-measuring adapter, interferogram analysis code and phase-measuring code. The interferogram code was based on the FRINGE code which BRO purchased from OSC. The phase-measuring code was based on my PhD code and code BRO purchased from Bernard Bell. At the recommendation of my lawyer, I also paid Bernard for the same code. In addition to my IR and Visible interferometers, I used this code to demonstrate phase-measuring interferometry in the Mid-IR with a Schottky CCD, a scanning IR camera, a micro-bolometer, a Newport HoloCAM and a Newport speckle system.

I am most proud of using this code with a high-speed interferometer system I developed to test the Keck mirror segments at ITEK. [2] For several years I had been thinking about the challenges of atmospheric turbulence identified in John Hayes' dissertation – which I had read many times. My solution was to use a 340-Hz CCD to freeze the turbulence. ITEK invited me in to see if I could figure out how to test the Keck Telescope primary mirror segments. Because of their focal length and optical prescription, the total optical test air-path for each segment was 40 meters. And required 5 reflective bounces. I solve the problem by remembering a test setup I saw in Norm Cole's optical shop. I rotated ITEK's LUPI reference flat 45 degrees and sent the reference beam along the same path as the test beam. In the process I discovered another issue that would be critical for when I needed to absolutely characterize the LIGO reference flats – laser frequency drift introduced a phase shift error from the start of the frame readout to the end.

So, what is the Wyant connection? In the ITEK cafeteria after the interferometer system and software I wrote was working routinely. Jerry Nelson told me that there had been a lot of skepticism about inviting me in. But since neither Zygo nor Wyant had been able to offer a solution, they figured that they had nothing to lose by giving me a try.

I was raised to believe that all one needed to be a successfully entrepreneur was to develop a better mouse trap and sell it at a fair price. Well, real life is more complicated. While I'm pretty good at solving problems and developing products, I am terrible at making money from those solutions or products. The reasons are multiple. I try to do too much by myself. I'm a terrible salesman. I'm not ruthless enough. I didn't set my prices high enough. I'm idealistic and naïve. I could not compete with Jim Wyant's network. My software was not user friendly and pretty. I solved the software problem by hiring Raymond Castonguay – which may have worked out better for him than it did for me. And, I solved a similar problem for my hardware by hiring Jay Tome – and I suspect that things have also worked out well for him.

But, I must admit that on the whole I too benefited. I gained enormous insight into how phase-measuring interferometer hardware and software work that I could never have gotten in grad school OR by just operating someone else's commercial interferometer. This knowledge served me well both at Danbury and with NASA. And, if I had actually been a successful entrepreneur, I probably would have never left Tucson and my life would be entirely different.

After 5 years at BRO, it was time to move on. But, my decision had nothing to do with Jim Wyant – other than my product line never making any money. The real reasons I left are that I had stopped progressing professionally; I sensed that Bob Breault had lost confidence in me; I saw no future for myself in the company; and, Karen's Dad, Tom Hunt,

had suffered a massive heart attack and we wanted to live closer to Ohio so that our sons Michael and Mark, and soon to be daughter Sarah, could get to know their Grandfather.

ROSE-HULMAN INSTITUTE OF TECHNOLOGY

I had always wanted to be a teacher. My original undergraduate plan was to be a high school physics teacher. I scratched that itch a bit by teaching an algebra based physics class (for pre-meds) at Pima Community College. And, I had observed how Jim Wyant had leveraged his student network. Thus, when the opportunity to join RHIT as an assistant professor of Physics and Applied Optics presented itself, I took it. Leaving Tucson and all of its personalities, egos, politics, etc. was like a breath of fresh air – I could breath – at least for a while. I had no idea that the political infighting at a small college could be so intense.

I have two Wyant connections during this time. First, I used my Wyant class notes (light blue binders) as the source material for my undergraduate Physical Optics course notes (red binders) and my graduate Optical Testing notes (dark blue binders). And, during this time I decided to brand myself.

In 1988 I decided that I needed an MBA to continue my development. So, I applied to the Eller School of Entrepreneurship. Initially they denied me saying that a PhD is a terminal degree. Then they admitted me. While I left Tucson before completing the MBA, the communication class changed the way I write and the marketing class got me thinking about how to present myself.

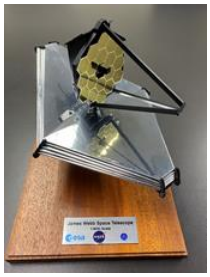
Based on what I learned in the marketing class, I needed to establish a unique identity for myself. Previously I had taught SPIE short courses on phase-measuring interferometer. But Jim was already the PMI and optical testing person, and he was passing the PMI brand on to Kathy Creath. So, I decided to brand myself with Testing Aspheric Components. In addition to creating a new SPIE short course, I also wrote a series of 'From the Test Bench' articles for Laser's and Optronics. [3-8] While not peer reviewed, with a circulation of 60,000 engineers, I got more feedback and recognition from those 'marketing' pieces than any previous journal paper.

I loved having students. It was intoxicating – addictive. It filled a need in my soul. I loved organizing information and teaching it to my students. I loved the interaction with really bright and inquisitive students. I loved collaborating on my research with students (graduate and undergraduate). Having students changed me. But, being a professor was not to be. RHIT was fundamentally an undergraduate teaching institution and I am more of a researcher and a mentor. And, when RHIT went co-ed, I was told that for the next several years they were only going to hire and tenue female professors. So, now my attempt at an academic career was at an end – time to try industry.

100 WOOSTER HEIGHTS

From July 1993 to Oct 1999 I worked as a Senior Staff Engineer at 100 Wooster Heights Road first as Hughes Danbury then as Raytheon Optical Systems. It was here that I got to make real optics by applying all of my academic study and knowledge about how interferometers work. I also got to develop a UV phase-measuring interferometer under contract to Silicon Valley Group and a wafer contouring instrument (based on an HDOS patent) that HDOS spun off into Advanced Technology Materials Inc. The closest potential Wyant connection was that after HDOS purchased ITEK, Victor Bennett became my supervisor. Another connection is that I applied the insight I had gained from working on the Keck segments at ITEK (which Jim indirectly made possible) about how laser frequency shift introduces an error into a temporal phase-shift measurement to solve a problem related to the absolutely characterize the LIGO reference flats.

NASA



In November 1999 I joined NASA to develop the technology needed to enable the primary mirror for what would become the Webb Space Telescope. NASA recruited me specifically because of my direct relevant experience in refurbishing, aligning and operating the 4-meter 7-segment actively controlled LAMP mirror; And, for my experience testing the Keck mirror segments and making the beryllium secondary mirror for the Spitzer Space Telescope. One Wyant connection is that Jim served as an independent outside reviewer of the technology development efforts. Another connection is the PhaseCAM.

4D PHASECAM

For the entire time I worked at RHIT and 100 Wooster Heights, I was consulting with NASA on the Space Shuttle microgravity Surface Tension Driven Convection Experiment and continuing to develop my phase-measuring and fringe analysis software packages. Once I accepted a position with NASA in 1999, I tried to find someone who might be interested in my IP. One company with whom I talked and visited was MetroLaser. While they were not interested in my code, I saw something that interested me.

NASA recruited and hired me because I had figured out how to test the Keck mirrors. NASA had a problem that they didn't know how to solve. My job was to figure out how to test the mirrors for what would become the Webb Space Telescope. The mirror segments had a 15-m radius of curvature and had to be tested at 30K. Thus, they were located inside of a cryo-vacuum chamber while the interferometer was outside. The problem is that the mirror and interferometer were moving relative to each other by micrometers. Thus, a traditional phase-shifting approach would not work.

At MetroLaser, on a table in a back lab I saw a breadboard setup that was producing a phase-map of a flame plume. I immediately saw its potential. The first thing I did when I got to NASA was to get Bernie Seery to fund a risk reduction experiment on my hunch. I specified what I wanted and gave a $60K order to newly incorporated 4D Vision Technology. They delivered the first ever PhaseCAM in just 6 months and it worked great. Its resolution was 1.2 nm and its repeatability was 1/300 waves RMS. And, over a 20-meter air path, its measurement uncertainty was 5 nm RMS. We started using it immediately. And, we could not have made JWST without the 4D PhaseCAMs.

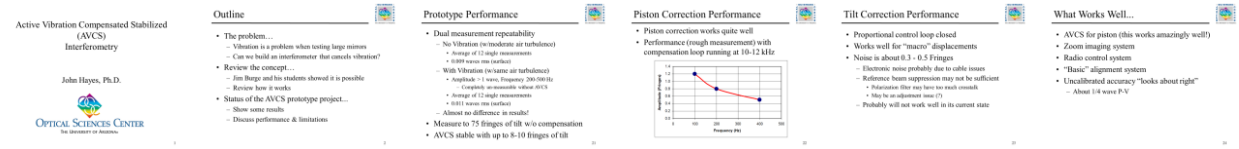
As an SBIR Sub-Topic Manager, I made an additional investment in 4D's technology development for the NanoCam instrument (Contract 10-1-S2.05-9256). Several other US Government Agencies also made investments in 4D Technology, including National Science Foundation, Navy and National Institutes of Health. On the whole, we in the SBIR program consider 4D Technologies to be one of our success stories. A company that might not existed without Government investment.

So, how did James Wyant become involved in 4D Technologies – well that is the rest of the story and involved Mirror Technology Days in the Government.

In 2000, I created Mirror Technology Days in the Government. The purpose of Tech Days is to annually provide a public peer review of the progress made by Government funded mirror technology related development efforts and to provide a networking opportunity for potential users and providers. Well the first Tech Days was a great success. We had 44 presentations and an attendance of over 100. Two of those presentations were from 4D Technologies about their PhaseCAM and from University of Arizona.

8:40	4D Vision PhaseCAM	James Millerd
9:00	University of Arizona Anti-Vibration Compensated System White Light Scatter Plate PMI	John Hayes
9:30	COFFEE BREAK	

As I previously stated, the 4D investment was a JWST risk reduction. Bernie Seery had already funded a large contract to Jim Wyant and John Hayes to develop a high-speed interferometer. Their concept based on some work of Jim Burge and his students was to provide a servo loop that sensed the relative vibration between the interferometer and test article and imposed a compensating signal on to the phase-shifting PZT. John's presentation reported that the AVCS system was stable with up to 8 to 10 fringes of tilt and worked quite well for piston and for 1.2 fringes of piston, but that its noise was about 0.3 to 0.5 fringes with an accuracy of about 1/4 wave PV.



Maybe I am naïve, I had personally paid the NASA cafeteria vendor $1500 for the meeting refreshments and asked everyone to donate. Well, very few people donated. So before every coffee break, I was reminding people to donate. John Hayes started giving me some 'good-natured crap' about constantly asking for money. So, I gave his some 'good-natured crap' back about the success of the 4D PhaseCAM. Well John and Jim got the last laugh they bought 4D and

doubled the PhaseCAM's price – which is exactly why I funded the development of the PhaseCAM – not for Jim and John to buy it – but for it to be a commercial success and for NASA to use it to make JWST.

As a postscript, because of my $900 personal financial lost in hosting the first Tech Days, I made the registration fee mandatory. And as of 2020, surpluses from this meeting – which are held by the Huntsville Electro-Optics Society - have allowed the donation of $47K to local SPIE/OSA Chapters, $25K for the North Alabama Optics Apprenticeship Program and $10K in Student Optics Project Science Fair Awards.

SPIE FELLOW AND OSA FELLOW

Jim Wyant is partially responsible for my being named both an SPIE Fellow and an OSA Fellow. For SPIE citation, Jim Bilbro cited my work on developing the high-speed interferometry test setup that was used to make the Keck Telescope primary mirror segments [2]. If Jim had been able to solve the Keck problem, then I would not gotten the opportunity to be involved in Keck. And, for my OSA Fellow nomination submitted by Vasudevan Lakshminarayanan, I was told by both Vengu and Elizabeth Rogan that Jim Wyant and Steve Fantone wrote a very nice letters of recommendation.

SPIE

I have two primary SPIE connections with Jim Wyant. The first is that we are both Past-Presidents. The second is that I got to spend some of his Wyko/4D money by presenting SPIE's contribution to his Scholarship Program. And, I will always cherish when he told me that that I was doing a good job as President.

CONCLUSIONS

Since 1978 my career has been inescapably connected with James C. Wyant. Sometimes strongly, sometimes weakly. Sometimes in phase, sometimes out of phase. Jim Wyant is possibly the one person most responsible for my professional career – by helping me fulfill my potential. He introduced me to my technical bliss. I benefited from his support during my PhD research. I was given the opportunity to demonstrate my capabilities by solving the Keck problem which he could not – resulting in being named an SPIE Fellow. Competing against Wyko allowed me to gain a deep understanding of phase-measuring interferometer software and hardware – which I used to test the Spitzer secondary mirror, the LIGO test mass and ensure that the Webb Telescope mirrors met their specifications. I used his class notes as a professor and discovered my love of mentoring students. He supported me for OSA Fellow. And, by buying 4D he validated my technical judgement in funding the first PhaseCAM interferometer creation – of which he also benefited.

So, I tip my metaphorical hat to the best optical metrologist from Ohio whom I have had the privilege of knowing.

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