ARTICLE IN PRESS

Engineering Fracture Mechanics xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Engineering Fracture Mechanics

journal homepage: www.elsevier.com/locate/engfracmech

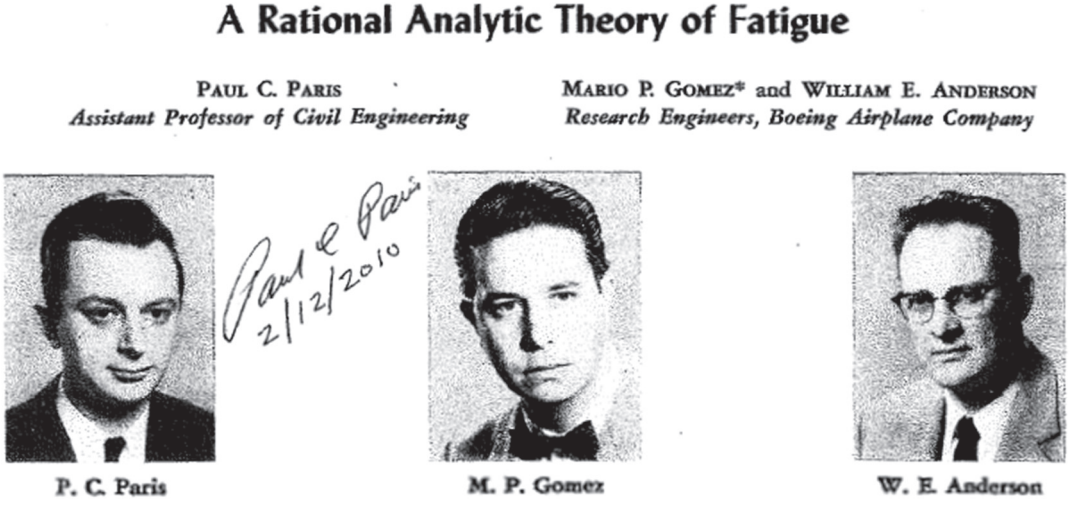
Dr. Paul Croce Paris August 7, 1930–January 15, 2017

A Eulogy

Dr. Paul Croce Paris, born August 7, 1930 in New York, New York, passed away at his home in Illinois on Sunday, January 15, 2017. Dr. Paris was Co-Founding Editor, with Dr. George Irwin, of *Engineering Fracture Mechanics*.

Dr. Paris received many awards for his contributions to fracture mechanics. In 2003, he was awarded the Crichlow Trust Prize (a medal and a $100,000 honorarium) by the American Institute of Aeronautics and Astronautics. In 2009, he was awarded the George Irwin Gold Medal by the International Conference on Fracture at Ottawa, Canada, the first gold medal ever issued by that conference. In 2016, the European Structural Integrity Society awarded him its Wöhler Medal.

His landmark 1961 paper, "A Rational Analytic Theory of Fatigue" has been cited over 1,600 times and is recognized as the foundational contribution to the understanding of fatigue crack growth. All told, his publications have been cited over 15,000 times.


A Rational Analytic Theory of Fatigue

PAUL C. PARIS
Assistant Professor of Civil Engineering

MARIO P. GOMEZ* and WILLIAM E. ANDERSON
Research Engineers, Boeing Airplane Company

Paul C Paris 2/12/2010

P. C. Paris M. P. Gomez W. E. Anderson

P.C. Paris, M.P. Gomez, and W.E. Anderson. *The Trend in Engineering*, 1961, **13**: p. 9-14.

This eulogy consists of heartfelt contributions from some of his closest professional colleagues. They recount technical and personal interactions which describe a once-in-a-lifetime relationship.

Subsequent editors of *Engineering Fracture Mechanics* have understood that their responsibility for the Journal derives from the lifelong dedication Drs. Paris and Irwin had for our field. The present editors offer their condolences to the Paris family, and re-dedicate the Journal to his memory.

Editors
Anthony Ingraffea, Meinhard Kuna

https://doi.org/10.1016/j.engfracmech.2017.10.001

Memories of Paul C. Paris

With the loss of Paul Paris, we lost a giant in our field, a good friend, and for many of us (certainly me included) a valued and dedicated mentor in our formative years.

I met Paul when, as a senior undergraduate in mechanics at Lehigh University, I had the opportunity to take what was, I suspect, the first academic course ever given under the name "fracture mechanics". That was organized during the 1961–1962 academic year by Paul and George Sih, while Paul himself was still officially a Lehigh graduate student.

Paul did much of the introductory lecturing, and George Sih also contributed to that as he was beginning his famous works on the stress analysis of cracks, with focus on crack tip singular fields. That had been pioneered by the great George Irwin and, I think it is fair to write, was shown to be unquestionably relevant to real-world problems of fatigue and fracture principally by Paul.

The late Fazil Erdogan was Paul's official PhD adviser at Lehigh, and Fazil likewise contributed famous works on crack stress analysis. Paul also worked separately at Lehigh with his senior colleague and mentor, the late Ferdinand Beer (then the department head for Mechanics, and my own PhD advisor) on the statistical properties of random loadings exerted on airplane structures, in flight through atmospheric turbulence with, of course, fatigue and fracture in mind. I became interested in that, too, and both Ferdinand and Paul advised me on that theme, which turned out to be the focus for my own PhD thesis.

From my point of view then, i.e., as a youngster looking for something interesting and hopefully important to do, I could not fail to be captured by Paul's dramatic accounts in his "fracture mechanics" lectures such as catastrophic cracking from Comet Airplane windows, of gas pipeline ruptures propagating for kilometer-scale distances, and of the Liberty ships of WWII cracking apart at sea.

It was an exciting time. Paul's formulation of fatigue crack growth, in terms of fluctuations in the Irwin stress intensity factor "K", was getting definitive experimental support, first in Paul's own work with collaborators at Boeing Airplane Company, and soon world-wide.

Also, with George Sih and Fazil Erdogan, Paul was quickly and greatly expanding the number of loading situations and crack configurations for which the Irwin intensity factors K were known. (Later in Paul's career that effort would emerge for the community at large as his "Stress Analysis of Cracks" handbook, compiled in collaboration with his postdoc collaborator M. Tada).

Subsequently, in work done principally with John Hutchinson of Harvard (who first met Paul when John, then a junior year undergrad at Lehigh, also spent a summer in research at Boeing), Paul advanced ways of applying approximate J-Integral methodology to characterize stable versus unstable crack growth under rising loads on tough semi-ductile metals, a topic important to such as reactor pressure-vessel safety issues.

We all, at least in my age range, know how dramatically the field of fracture mechanics has advanced, changed, and broadened. And many of us, fortunate to be influenced by Paul, can look back with pride at how much he shaped his era, and with gratitude for being able to join him in some small part that.

James R. Rice
Mallinckrodt Professor of Engineering Sciences and Geophysics, Harvard University, United States

A tribute to Paul C. Paris

Paul Paris, the quintessential engineer, scientist, and mentor had the broadest bandwidth in fracture research that I know off. His contributions span the breadth of stress analysis of cracks, fracture test methods, his famous "Paris-Law", the concept of fatigue crack growth threshold, effects of load ratios, stress corrosion cracking, elastic-plastic fracture mechanics and the list goes on. He was the first to propose the use of ΔK *to characterize fatigue crack growth behavior in structural materials and components. He was the first to also discover the concept of threshold stress intensity for fatigue crack growth used widely today in design across several industries*. These developments revolutionized the design and structural integrity assessment methods in the aerospace, power generation, biomedical, civil infrastructure, metals, and oil and gas industries. These concepts, even today, are finding new applications such as for studying the behavior of nanocrystalline and novel structural materials.

In the mid to late nineteen sixties, *Paris and co-workers produced stress intensity solutions for a variety of practical configurations*. These developments were the basis for application of fracture mechanics in testing materials. Several standards were produced by the American Society for Testing and Materials (ASTM) based on these developments. I would particularly note a paper entitled "Stress Analysis of Cracks" co-authored with Professor George Sih that appeared in an ASTM publication in the mid nineteen sixties that must have numerous citations (Editor's note: Over 8000 citations). *His "The Stress Analysis of Cracks Handbook", co-authored with George Irwin and Hiroshi Tada, must be a best seller in the field* (Editor's note: The Handbook is in its third edition). In addition, it is a testimonial for how deeply Prof. Paris cared about practical applications of his theories. You will find a copy of this book on the shelf of every practitioner of fracture mechanics.

The "*Hutchinson-Paris Theory for J-Controlled Crack Growth*" is acknowledged as the seminal work on which the theoretical under-pinning of J-Integral for predicting stable crack growth and fracture in metals is based. This work put on firm ground the theories proposed for tackling fracture under elastic-plastic and fully plastic conditions proposed earlier by none other than some of Prof. Paris' own students that included names such as Jim Rice, John Hutchinson, John Landes, Jim Begley, and Hugo Ernst. All these names are very recognizable names in the field of fracture and all have received the prestigious George Irwin Medal from ASTM and many other honors for their own pioneering contributions to the field. His other notable students include Richard W. Hertzberg and Robert C. Bucci who in their own rights contributed immensely to the field of fracture mechanics. Paul was a role model as a scientist, who had the knack of getting to the heart of a problem and if he did not have the time to work on it himself, he reached out to younger scientists and first inspired them to work on the problem and then supported them.

Professor Paris was also known for his controversial views; one that he held but modified later, was about lack of any connection between microstructure of metallic alloys and fatigue crack growth. This irked metallurgists and challenged them to do their best to prove that his view was not entirely right. Such controversies were important and played a significant role in early developments of fracture mechanics. Then, there was the argument of the time in 1970s, about the importance of fatigue crack initiation or formation versus fatigue crack growth. Back in the late 1970s, I had the privilege of being part of a small private gathering at the Westinghouse R&D Center in Pittsburgh where I spent my early career, about crack initiation versus propagation. On one side was Jo Dean Morrow, a very well respected and charismatic figure in the fatigue crack initiation community, and on the other side was Paul Paris. As a young scientist, it was a real treat to hear these giants of the times to discuss and debate their different views on fatigue with deep insights and strong arguments to support their points of views; they did that with utmost respect for each other!

Paul Paris awarding the first ICF Paul Paris Gold Medal to Prof. Y. Murakami of Kyushu University in Japan at ICF13 in June 2013.

Paul was deeply touched when ICF chose him as the winner of the inaugural George R. Irwin Gold Medal at ICF12 in 2009; I had the privilege of calling him and letting him know that he was chosen for the award and he greatly appreciated the honor. ICF then honored him once again by naming a gold medal in his name at ICF 13 in 2013, an honor that we all felt he really deserved. His winning of the Crichlow Award from the American Institute of Aeronautics and Astronautics was a major high point of his career. I was honored to have been asked to write a letter of support for the nomination package. Paul saw my letter after he received the award. The letter was as factual account of his accomplishments; in other words, no embellishments because it never even crossed my mind. Paul called me to express his genuine gratitude. It drew us closer to each other in the later years and that friendship has meant a great deal to me.

The world of fracture mechanics has greatly benefited from Paul Paris' unusual insight and problem-solving ability, coupled with his rigorous approach to mechanics and an appreciation for the importance of experiments, and teamwork in finding good solutions to important fracture and crack growth problems.

Ashok Saxena
Distinguished Professor
University of Arkansas, United States

A few recollections of Paul Paris and his contributions

I'll speak to the technical contributions of Paul Paris but first let me tell a little of our personal interactions. I first met Paul when I was a junior at Lehigh University in 1959, not at the university but in Seattle where Paul was on leave from his graduate studies from Lehigh working at Boeing and where I spent that summer working as an engineer in the aircraft division. The head of my department at Lehigh, Ferdinand Beer, who over the years was one of Pauls' closest friends, told me I could not visit Seattle without meeting Paul Paris. Beer provided me with Paul's phone number and Paul kindly invited me to his home. His home turned out to be a houseboat on Lake Washington. I well recall that reaching his houseboat, which was the farthest one from shore, required walking across at least five other houseboats, one of which was on the verge of sinking. In spite of wet feet, this was the beginning of a beautiful friendship. When I started working on aspects of fracture in the late 1960's, Paul took me under his wing. Paul was exceptionally kind to younger colleagues. He included both Jim Rice and me as lecturers in the short courses on fracture mechanics that he and George Irwin developed for the larger mechanic community (see more below). These interactions led to several research collaborations related to crack growth stability and, in the years that followed, to a number of industrial consulting jobs, including pairing with Paul to provide expert technical advice on several interesting, major legal cases.

Paul Paris is one of the major figures in the development of fracture mechanics. The "Paris Law" characterizing fatigue crack growth rates is used by every engineer concerned with fatigue cracking. More significant than the law itself was Paris's key insight in the late 1950s that the esoteric crack stress intensity factor with its strange dimensions is the relevant measure for correlating fatigue crack growth. To my knowledge, it was Paul and George Irwin, who later became Paul's close friend and colleague, who first appreciated the significance of the stress intensity factor for fracture characterization. In part, it was the early successes of the application of the fracture approach to fatigue crack growth that helped propel fracture mechanics. Paul shaped the early developments of the subject in many ways, and he was one of the leading practitioners in applying fracture mechanics to aerospace problems starting from the time of his employment at Boeing when I first met him. The famous Paris Law paper was written when he was a faculty fellow at Boeing, albeit while he was on leave as a graduate student from Lehigh. A few years later he worked with George Irwin to introduced approximate methods for dealing with plastic yielding, crack growth resistance and instability. Paul was responsible for devising many of the experimental techniques for measurement of fracture toughness and crack growth rates. Paul also made major contributions to the infrastructure of the field. He worked with Irwin, John Srawley and many others to develop the ASTM Standards for fracture toughness testing. Some of these standards have significant inputs from his early work. The Crack Analysis Handbook (with Hiroshi Tada and George Irwin), originally published by Paul's company, Del Research Corporation, and ultimately published by ASME, remains *the* source reference of the field. Paul and George Irwin, through Del Research, offered introductory and advanced courses on fracture mechanics which more than any other mechanism promulgated the subject to both industrial practitioners and university researchers in the US in the 1960s and 70s. Throughout the 70s and in the decades that followed, Paul was one of the most important consultants to the power industry on issues related to the integrity of pressure vessels and pipelines. As much as any other individual, Paul contributed and motivated the methods that were to provide criteria for reactor safety. When Paul returned to Lehigh University in the 1960s he was the individual behind the scenes motivating individuals there to work on the wide variety of fracture problems that brought Lehigh to the forefront of the field. Here, again, his leadership had a major effect on shaping what fracture mechanics was to become. In total, these contributions have made an enormous impact on our nation's economy, as well as to that of the rest of the world. One often hears astronomical estimates of the cost of material and structural fractures to our economy. Regardless of how inflated these estimates may be, there is no doubt that there are huge economic consequences due to the fact that engineers are now able to design against fractures of all kinds—Paul Paris was one of the major players who made this possible.

In addition to his remarkable ability to cut through to a simple, basic view of engineering problems, it is less well known that Paul was an extraordinarily dedicated teacher. Whether the subject was statics, dynamics or fracture, no one derived more pleasure at teaching mechanics to undergraduate engineering students than Paul. He continued teaching mechanics on a voluntary basis long after his formal retirement. To those who knew him well, it was no secret that Paul was a wine connoisseur who maintained a wine cellar well-stocked with wines collected from his much cherished trips to France. One of the luckiest days of my life was when Paul stopped by unannounced at Harvard to deliver a bottle of the finest sauterne to his good friend Bernie Budiansky. As luck would have it, Bernie was out of the country on sabbatical so Paul decided I might as well have the bottle instead. As a follow-up to this gesture, for almost every year afterward, I sent Paul a copy of the printed menu, complete with the wine listings, from an annual dinner held at Pembroke College in Cambridge signed by a small crowd of his friends in fracture including, among others, Mike Ashby, Tony Evans, Norman Fleck, Bob McMeeking and John Willis. I am told by Guy Genin, a close friend of Paul in St. Louis, that these signed menus were greatly appreciated by Paul and had the desired effect of making him wish he were with us.

John Hutchinson
Abbott and James Lawrence Research Professor of Engineering in the School of Engineering and Applied Sciences, Harvard University, United States

Remembering Paul Paris

Paul C. Paris has left a legacy of lasting and significant contributions to many individuals, universities, companies and government agencies. His stellar career in academia and industry as a researcher, engineer, innovator, educator and mentor has left an indelible mark. Paul's creative and innovative research led to a description of fatigue crack growth rate that is both founded in theory and applicable to practical engineering problems. He was an outstanding teacher and mentor and was accomplished at discussing his work with students in the classroom, engineers in industry, and academics in research. Yet he was personable, flamboyant, colorful, dramatic, insistent and sometimes controversial. When Paul and I co-chaired the 30th National Symposium on Fatigue and Fracture Mechanics at Washington University in St. Louis he wanted to make the symposium a memorable event. George Irwin was in failing health so we made special arrangements for George to attend the meeting. The symposium was held on campus with lectures in the Moot Courtroom of the School of Law and a banquet, catered by a French chef, in the century-old Holmes Lounge with music by the St. Louis Ragtimers. As an educator Paul was exceptional. He would go to great length to be an effective teacher. One semester he returned from a trip to Europe where he had fallen and broke both of his arms. To finish the semester Paul sat and lectured while Hiroshi Tada wrote notes and equations on the chalkboard.

Ken Jerina
The Earl E. and Myrtle E. Walker Professor of Engineering, Washington University in St. Louis, United States

A few recollections of Paul Paris on my acceptance of the 2017 Paris Gold Medal Award

I humbly accepted the 2017 Paris Gold Medal Award from the International Congress on Fracture. I sincerely appreciate this significant honor since I was Paul Paris' first graduate student. What I took away from Paul's lifetime of accomplishments, were three characteristics: his innovation, his perseverance, and his communication skills. As we all know, his application of fracture mechanics to fatigue crack propagation studies revolutionized our understanding of fatigue processes in structural materials. He demonstrated determination and perseverance in having his work accepted by the technical community, given his first paper's early rejection for it being "outside of the stream of current scientific thought". Paul then became the consummate communicator with the many short courses that he organized, his consulting, his classroom activities, and his organization of the national fracture mechanics symposia at Lehigh University. During one of those short courses, I became acquainted with an energetic course attendee, Dr. Stephen Antolovich, who would later become thesis advisor for Dr. Ashok Saxena, my fellow awardee. Indeed, the fatigue community is a small world.

For the past 53 years, I was first Paul's student, then fellow teacher and consultant, and long time friend. I participated in teaching many of his fracture mechanics short courses and then he took part in those offerings that I had organized.

At the conclusion of my four-hour initial interview with Paul, he showed me his log-log linear plot of FCP rate vs ΔK for various metal alloys with different crystal structures. He then asked with a hint of sarcasm "Why do we need a metallurgist for such studies?" After 53 years of investigations, more than 200 research papers and six textbooks, I can confidently state that, indeed, there are material variables that influence a material's fatigue response.

Richard W. Hertzberg
New Jersey Zinc Professor Emeritus, Lehigh University, United States

Recollections of my times with Paul Paris

I first met Paul Paris in the summer of 1967 at what was then called "The Rad Lab" in Livermore, California. The occasion was a short course on Fracture Mechanics, organized by him and his colleagues, George Irwin, Richard Hertzberg, John Srawley, and Bob Churchill. I was impressed by his intuitive grasp of the basic mechanics and by his ability to make the complex easily comprehensible. It was clear that he was a great teacher. I was drawn to the discipline and to his way of viewing things and had many "after hours" discussions with him about both the development of fracture mechanics and future directions. My assignment at the Rad Lab was to become the resident expert on Fracture Mechanics, a daunting task for a fresh Ph.D. from Berkeley whose main connection with mechanics was in Quantum Mechanics! After the course, I got in touch with Paul and he generously invited me to visit him and his colleagues at Lehigh (aka Fracture Mechanics University). He also set up visits for me with all the main players in the field at the time. The entrée that he provided to the field was nothing short of amazing and was a gift which showed his generosity and which gave me the confidence to really get involved in the field.

Shortly thereafter, as predicted by George Irwin, I was in academia and pursed Fracture Mechanics from a materials perspective, being motivated to go deeper into fatigue crack propagation by Paul's simple "damage mechanics" approach. Paul and I were in occasional contact and had useful discussions about recent developments and friendly disagreements about the role of crack initiation over the years.

More recently we connected through our mutual French colleague, Claude Bathias. Claude and Paul worked closely together on books and published a very well-known and influential paper addressing fatigue initiation and propagation issues in the gigacycle régime. During our "French Connection" times, Paul and I participated as members of a French student's Ph.D. committee. Again, I enjoyed Paul's insights and gentle guidance of the student. It was during those times that I received a delightful and unexpected letter from Professor Saxena informing me that I had been elected as Academician of ICF-WASI, an award made even more meaningful when I later learned that Paul was very influential in bringing this about.

A highlight of those times was dinner parties in Paris hosted by various friend's at their apartments. The food was great, the discussions delightful and good wine flowed rather freely. And at one notable soirée, our host produced a well-known book, written by a French wine connoisseur, in which Paul's opinion on several FRENCH (!) wines was cited as the highest authority.

My last contact with Paul was just before his passing. I was engaged in writing a paper on the history of fracture mechanics with colleagues Ashok Saxena and Bill Gerberich. Paul was, as usual, very encouraging and helpful. We had many telephone discussions and he shared several personal documents which were very useful in developing the "story behind the story", woven throughout the paper. My only regret about the paper is that Paul will not be able to see it in print and see the dedication to him and to George Irwin.

Teacher, scholar, mentor, friend and bon vivant; it has been a privilege to have known and worked with him. He will be sorely missed.

Stephen D. Antolovich
Professor
Department of Materials Science and Mechanical Engineering
Georgia Tech, United States
Washington State University, United States

Memories of Paul Paris

Not only was Paul Paris one of the fracture and fatigue greats but he was also a gentleman. I cannot remember when I first met him which was quite a while ago, but it was always a pleasure to meet him. At the European Conference on Fracture (ECF 21) last June which was sponsored by the European Structural Integrity Society, he was awarded the Wöhler Medal for his

Paul Paris at ECF 21, Catania, 2016.

seminal contributions to the field of fatigue crack propagation. The Paris Law continues to be quoted in an ever increasing list of publications. From crack propagation in metals, it has been extended to many materials including that of delaminations in composite laminates. At ECF 21, the young (and old) researchers gathered round him to hear his stories and take selfies with him. He was the hit of the conference. He so appreciated the recognition from the award. All of us who knew him, will miss him dearly.

Leslie Banks-Sills
Professor Emerita and President
European Structural Integrity Society, Tel Aviv University, Israel

Memories of Paul Paris

I was fortunate to have both Paul Paris and George Irwin teach me the fundamentals of Fracture Mechanics as an undergraduate at Lehigh University in 1971. Upon graduation, I accepted a position at Del Research with the stipulation that I take the summer off to teach sailing in Annapolis. Paul was a sailor too and enticed me to return in the fall with the added caveat that I learn how to use a DEC PDP-8e computer to enhance the application of fatigue crack growth through automation. I am forever grateful to Paul for that opportunity. His insight and understanding of complex problems and his ability to find an eloquent and uncomplicated solution was truly astounding. I will always admire that trait and no doubt generations have benefited from his insight. Over the years, we maintained a personal and professional relationship and I can't thank him enough for his mentoring during various research efforts. I was privileged to be included in many of his publications. At an International Fatigue Conference in Hyannis, MA, despite the flurry of technical activity, one day Paul encouraged me to join him on a sailing trip instead of attending the meetings. He had a flair for life that can't be forgotten as we remember his accomplishments. My last conversation with him last fall included thoughts of spending time in Annapolis in the near future. I will miss that opportunity.

J. Keith Donald
Fracture Technology Associates, Bethlehem, PA, United States

Memories of Paul Paris

Paul Paris came to Washington University from Brown in 1976 and immediately became a lynch pin of our applied mechanics program. But it was in 1983, when I became chair of Mechanical Engineering, that I first understood the impact that Paul was having on our department as well as on the field of fracture mechanics. He and I immediately became great friends, and that friendship endured for over 30 years.

In terms of teaching, Paul brought a sense of organization, rigor, and clarity to every class he taught. To him, analytic dynamics was not just another subject. It was the pinnacle of Western thought! His courses on plasticity and fracture mechanics were equally superb, and students clamored to be in his classes.

Of course, his research was superb, improving the state-of-the-art and also raising the reputation of our university. Every work he published was a new and wonderful adventure for him. I remember how excited he was when in 2005 he brought me a copy of his new book (with Claude Bathias), Gigacycle Fatigue in Mechanical Practice. He was as enthusiastic as if it had been his Ph.D. thesis!

Perhaps the biggest impact of Paul Paris on our department was in recruiting of new faculty. His connections around the world (including Harvard and Brown) brought us some excellent prospects and faculty members. He was a resource beyond value.

When I stepped down from being Chair in 2007, Paul gave my wife and I (along with any other couple we wanted to invite) a great meal at a local French restaurant; and he included special wines from his private wine cellar for every course (and he paid the corking fees, too)! It was the kind of generous and warm gesture that made him one of my best friends.

David A. Peters
The McDonnell Douglas Professor of Engineering, Washington University in St. Louis, United States

My collaboration and memories with Paul Paris

I had the great privilege of meeting Paul Paris for the first time in 2007 at the University of Paris X where he was invited by Claude Bathias. Paul worked with him on the propagation of cracks under cyclic loading at ultrasonic frequency (20–30

kHz). He had been demonstrated that most of the fatigue life of metals in the gigacyclic domain was governed by the crack initiation and not by the propagation.

This encounter was very important for me, as much on the scientific as on the human level. I discovered an open-minded colleague, very curious and above all modest despite his great international reputation and his prestigious contribution to fracture mechanics and fatigue. Our scientific discussions quickly focused on crack tip heating under fatigue loading. This opened a fruitful collaboration with Paul and another colleague, Nicolas Ranc (Arts et Métiers ParisTech, Paris campus). Paul visited me in Bordeaux several times between 2009 and 2012 as invited Professor. His various stays allowed us to publish articles on the effects of heat dissipation at the crack tips due to cyclic plasticity.

During these stays at Arts et Métiers, Paul also kindly agreed to give courses in fracture mechanics to engineering students. He always loved to teach. I could see how he interacted with students, who were very impressed to meet the father of the famous Paris' law. While Paul, always very modest, kept telling them that it was not a law but a relationship often used beyond its domain of validity. He emphasized also that a lot of things are still not understood in fatigue, especially in gigacycle regime.

Finally, I cannot finish these few lines to his memory without mentioning his love for Bordeaux wines. Paul Paris was a great lover of Bordeaux wines. He possessed a large wine culture and a great knowledge of the Châteaux of Bordeaux. He was also an "ambassadeur des vins de Bordeaux" world-wide. After 2012 we continued to correspond by email and phone. Paul remained very active in suggesting ideas for research and always asking new questions. I was very lucky to meet him, it was an immense honor to be able to work with him. We have lost a prestigious colleague. We will miss him.

Thierry Palin-Luc
Professor
Department of Mechanics and Mechanical Engineering
Arts et Metiers ParisTech, Bordeaux Campus, France

Paul Paris and I

This first: I was with Paul a few days before his passing. He had an eye operation in the second week of January. I helped him with a few trips to hospital leading to the operation on Thursday, January 12. After the operation, I sent him home and stayed with him until a helper arrived at night. When we said goodbye, Paul was in good spirits and even talked about watching the Super Bowl together with his better vision. I waited for a few days expecting good news from him. Instead I received sad news from his son, Anthony. Paul's death was so sudden and unexpected that nothing in my memory was as devastating to me as it. Already eight months have flown by since (I am writing this on 9/14/17). R.I.P., my dear friend.

I came to Lehigh University in 1967. It happened in an 'out of the blue' manner to me. My professor at University of Tokyo received a letter from Paul Paris who was looking for his research assistants, and 'ordered' me to go. I arrived with little preparation for anything, English conversation in particular. Inevitably I started out as a floundering student and was not much of an assistant to Paul. Nonetheless, Paul was kind and patient with me, and. very fortunately for me, George Irwin joined the Lehigh faculty soon afterward and became my thesis adviser. Although it took me longer than most, I eventually obtained my PhD degree in 1972. So I am the luckiest of all - I had both giants in Fracture Mechanics as my direct and close mentors.

I tabulated some solutions I obtained on the way in an appendix of my dissertation. It was Paul who came up with the idea to expand it to a handbook form. Thus, we embarked on our efforts on "The Stress Analysis of Cracks Handbook", which turned out to be a three decades long project. The 1st edition (1973, Del Research) and the 2nd edition (1985, Paris Productions/Del Research) were in a loose leaf bound form, and the eventual 3rd edition (2000, ASME) is hardbound.

Paul and I worked closely together on and off, certainly more on than off, for more than four decades. Even after I became a performer, we had casual meetings from time to time and enjoyed our friendship. Interestingly, my becoming a performer has a lot to do with Paul.

One day in the late '80s, when I stopped by his office, Paul was preparing the analysis of the motion of a top for his class. I casually told him that I could do many tricks with a top. A few years passed, and I finally brought my plain crude top with me to show him some of what I could do. He was totally stunned with what he saw, and he even asked the university's engineering machine shop to make more precise tops. I designed the tops and I occasionally use these tops very carefully at my shows.

Until I showed my top spinning to Paul, it never occured to me that it was such a big deal. Once I realized that it IS a big deal, I started thinking of becoming a performer for children after my academic career. I started practicing again in earnest. Now I am a world-class top spinning artist and a very popular performer. I owe Paul a great deal for my success with this as well.

I am eternally grateful to Paul for our lifelong friendship.

Hiroshi Tada
Top Spinning Artist (Performer)
Washington University in St. Louis, United States[1]

Memories of Paul Paris

Paul Paris was a major force in the development of Fracture Mechanics. We all know that George Irwin was the inventor of the term "Fracture Mechanics" and known as the father of fracture mechanics. However, Paul Paris was the person who saw that this new technology grew to become a mature methodology, accepted in academia and industry. He was a major innovator and promoter for this technology. Without his contribution, fracture mechanics would have been much slower to develop and be accepted.

Paul stated that he was introduced to this technology through a summer job. While he was a graduate student at Lehigh University in the late 1950s he had a summer job or internship with Boeing Aircraft. His assignment was to do something about failure of aircraft structures, especially due to fatigue. This was an area that he knew nothing about and he was eager to do a good job but concerned about his lack of knowledge in the area. He began studying the literature to see what papers he could find on the subject. Although there were several suggested and diverse approaches, he said that the only one that made sense to him was the work of George Irwin, a relatively unknown researcher at the Naval Research Labs in Washington, DC. He did more than study Irwin's work, he make a personal visit to him to discuss his ideas. This was his introduction to the technology that Irwin had recently labeled "Fracture Mechanics". This began his decades of work in the field, not only personally but in collaboration with many other workers.

One of the things that he first did was to encourage colleagues to work in this field. At Lehigh this included faculty members, George Sih, Fazil Erdogan, Robert Wei and students, Jim Rice and John Hutchinson. Lehigh became a center for fracture mechanics work. Later, after retiring from the Naval Research Labs, George Irwin came to Lehigh as a professor and encouraged many other faculty and students to begin working on fracture mechanics.

I first met Paul Paris while I was an undergraduate at Lehigh. A few students studying in a newly formed major called "Engineering Mechanics" and headed by Ferdinand Beer of textbook fame, were recruited to participate in an undergraduate research project in which we could work with a faculty member and conduct a small research project, mainly a small experiment that we would conceive, conduct the work and write a small paper, perhaps to publish, after a year-long project. Several faculty members had volunteered to work with the students, Paul being one of them. Of the about six student involved, I was the only one that chose Paul Paris as my mentor. He suggested a small project involving fatigue crack growth, an area that he had recently made a major discovery using the fracture mechanics parameter K to correlate the fatigue crack growth rate and a power law equation to describe the data trends. This has since been labeled the "Paris Law". Although initially, I was the only student working with Paul, by the end of the project time all of the other students were working with him. When it came to giving advice, especially involving experimental ideas Paul was a master. When a student presented him with a problem that they could not solve, he would typically sit and think for a few minutes and then respond with "why don't you try this, it might just work and be the solution that you are looking for". Most of the time it did work.

Paul Paris is known worldwide for his work on fatigue crack growth and the "Paris Law". However, his contributions to the field of fracture mechanics are quite numerous, both in the development of new ideas and also in the collaboration and suggestions to other workers in the field. His contributions are too many to list but they included the idea of a threshold fatigue ΔK value, the use on fracture mechanics parameters in describing environmentally enhanced cracking, called stress corrosion cracking. His work on nonlinear fracture was considerable and often not acknowledged. He suggested using the elastic slope; from a load versus displacement measured during a small unload to monitor crack length during a J test. He developed the idea of a tearing modulus, T, to predict instability for nonlinear fracture behavior.

While I was working at Westinghouse Research Center under the leadership of Ed Wessel, Paul Paris was one of our consultants. Ed believed in getting outside help when it came to developing and selling new research ideas. Paul Paris was a master at the presentation and promoting of new ideas. One of the things that Paul did best was the understanding of new and complex theoretical ideas and then the translation of these to practical things that the common engineer could understand and use. Ed Wessel liked to get the best technical advice from consultants. This often involved our Westinghouse research colleagues making a trip to Harvard University to talk to some of the best minds in the development of fracture technology. We would visit with Jim Rice and John Hutchinson, in the days that they were involved in fracture research, and Paul Paris would be with us. When the discussion of technology got beyond the comprehension of the Westinghouse group, we would turn to Paul to interpret. His mind operated both at the understanding of abstract technical concepts all of the way to the practical application of these.

One of Paul's hobbies was wine. You could label him as a connoisseur. When he would travel places where there were good wine stores, he often bought several cases to take home. These were usually not ready to drink and went into his wine cellar for aging and appreciation in value. He typically had in excess of 2000 bottles in his wine cellar. It was not unusual

[1] Formerly.

Paul Paris at ECF 21, Catania, 2016.

when technical meetings were held in his home area for Paul to invite people for wine tasting and appreciation. A bottle of wine purchased soon after bottling and then aged for many years would be worth a lot more. "You know I bought this wine for only $ and now it is worth $$$ a bottle", an increase in value of maybe a factor of 10 or more It is all in knowing what to buy, he usually did. He was partial to red wines and sauternes from France and often took trips to the wine areas of France.

When I heard of the passing of Paul, I was suddenly reminded of a personal touch. In our kitchen is an ornate bowl used to hold fresh fruit. This was a wedding gift from Paul back in the Lehigh days more than 50 years ago. My wife and I have used this bowl for our more that 50 years of marriage. It is both elegant and practical but most of all enduring. This is just like the work of Paul Paris, both elegant and practical but most of all enduring.

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