Joe Polchinski:

Memories of a life in physics

1954 - 2018

In the beginning…

Born in White Plains, New York in 1954 (sister Cindy, shown here, arrived three years later), Joe Polchinski notes that his interest in science appeared early:

'When I was six, my passion was the How and Why Wonder Books of Science. This was a series of several dozen books, each centering on a subject such as Dinosaurs, Atomic Energy, Chemistry, and Rocks and Mineral…I waited eagerly for each new issue. Once I misbehaved rather badly, playing with an ember from a campfire, and the new issue was taken away from me for a few days; it was an effective punishment. A few years later, Isaac Asimov's books in math and science drove me. So also did science fiction, by Asimov, Clarke, and many others, giving an inspiring if unrealistic picture of what science might do. Unfortunately, the science books and teachers through high school made little impression. At that level the subject was too purely descriptive. I remember asking my physics teacher, what is the speed of gravity?... from an early age I was drawn to the basic principles of physics.'

“Whenever I am asked where I am from,

I always want to answer `Caltech.’”

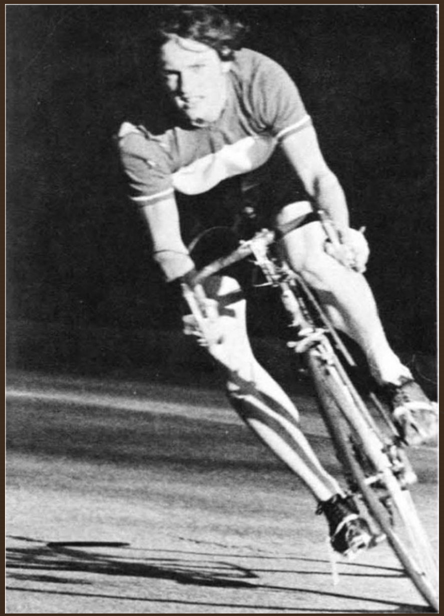
- Joe Polchinski, Memories of a Theoretical Physicist, 2017

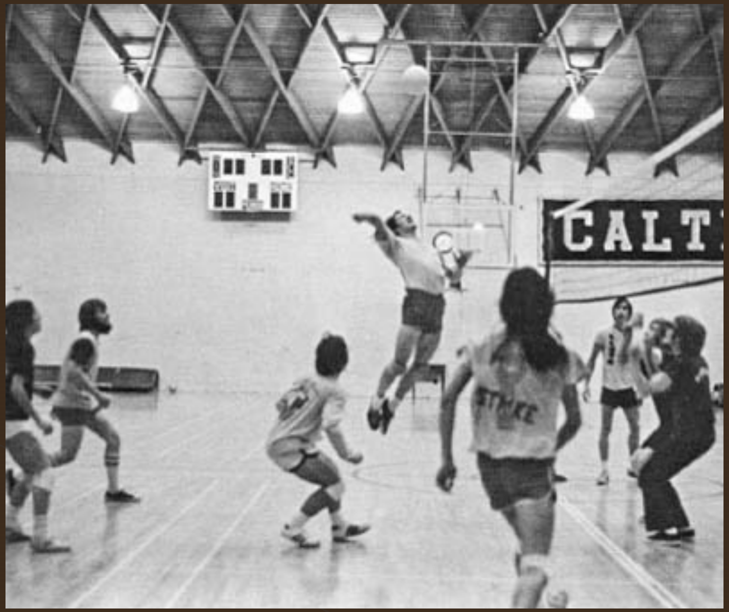
Joe was drawn to Caltech by the prospect of experiencing ‘pranks and top faculty’ and arrived as a freshman in 1971

Joe settled in alongside his classmates as a lively member of Blacker House.

Joe formed a particularly strong friendship with Bill Zajc which was to last the rest of his life:

‘During my first week on campus, I met three remarkable people: Richard Feynman, Kip Thorne, and William (Bill) Zajc…For four years Bill and I took most of the same classes, working together as we learned physics. But as much as the physics, I remember the ways that Bill, our other friends, and I blew off steam in between. These included drives for Tommy's burgers and various sports. A group of us became avid cyclists, riding to the beach at Santa Monica and exploring LA on rides as long as a century (100 miles). Our special challenge was the ride to the top of Mount Wilson.’





Joe and Bill’s shared interest in sports – including cycling and volleyball – continued throughout and after their time at Caltech.

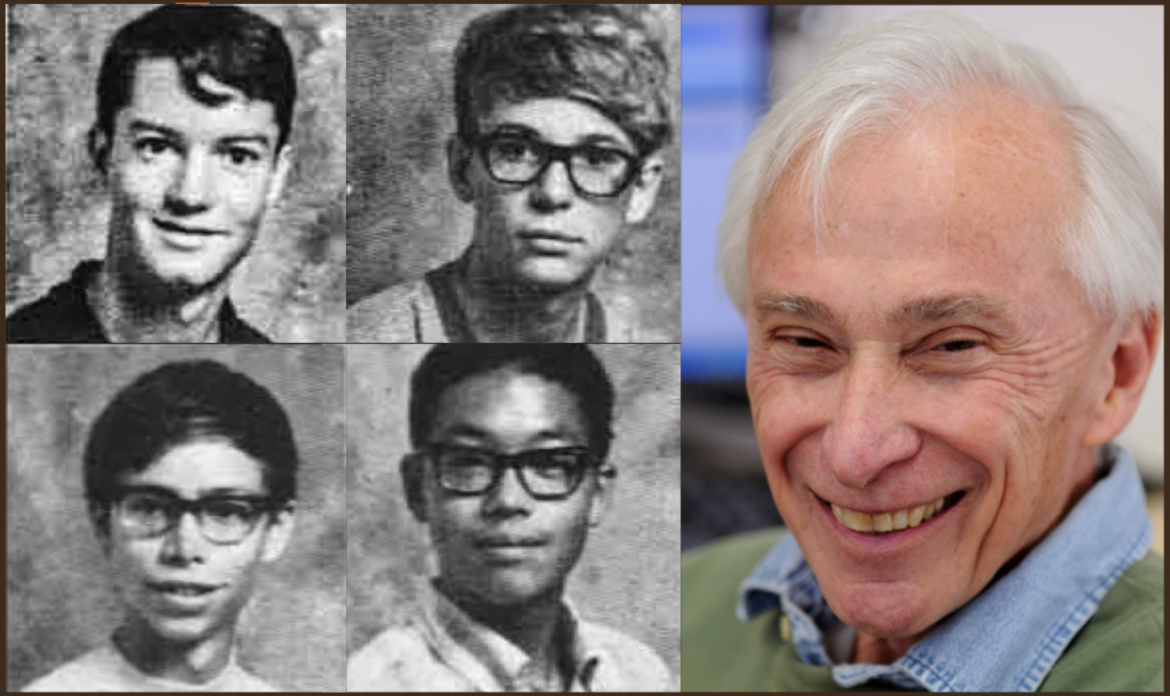
‘Although he had only a modest interest in sports as a child, he was a natural athlete. Joe was the star hitter on our ragged team of scientists, engineers and mathematicians (“old but slow”) that won the Cal intramural championships in 1978.’

- Bill Zajc

Like other Techers, Joe, Bill and their fellow classmates participated in various pranks, including stealing the door from the top of Millikan Library.

'We removed the door from its hinges, and a dozen of us carried it down to the library basement and then through the underground steam tunnels to the Caltech security office. The lock-pick experts opened the office and we left the door, but only after the group of us, including Zajc and me, signed it. This might seem to be a foolish thing, but we knew that Security understood Techers and was easy on us; in fact, there ended up being no penalty at all (Warning: things are different now. Do not attempt.).'

- Joe Polchinski, Memories of a Theoretical Physicist

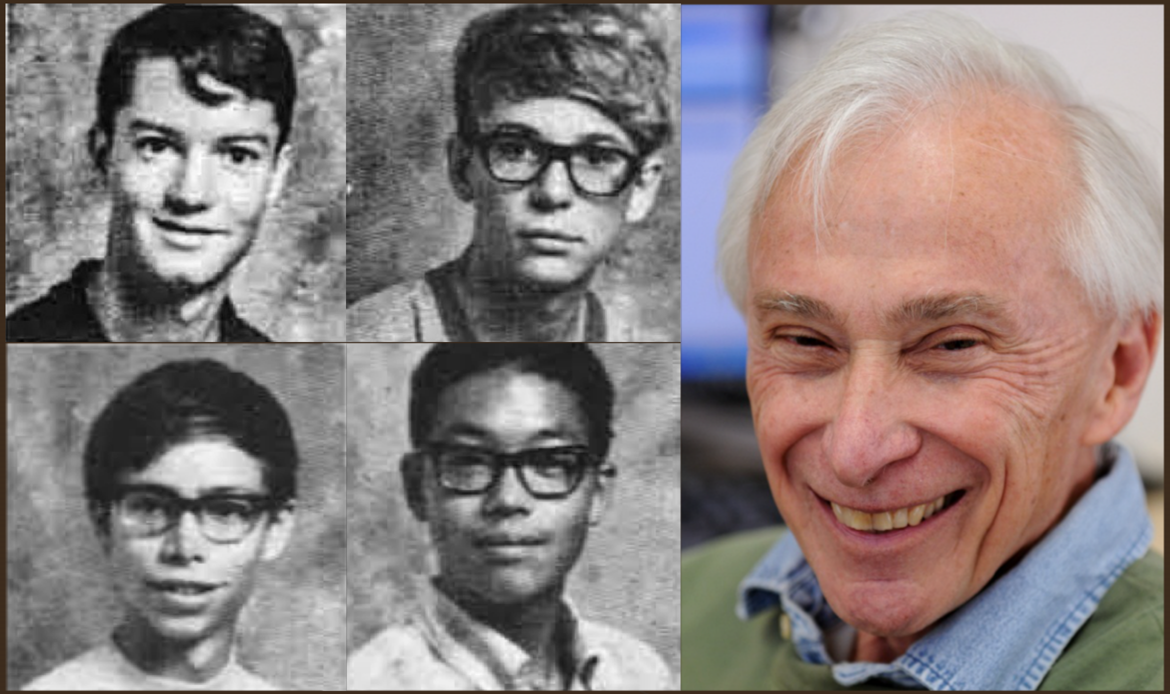


Clockwise from top: Joe Polchinski, Bill Zajc, Tom Tombrello, Roland Lee, Ken Jancaitis

Joe and Bill also became part of a quartet of ”extraordinary” students discovered as freshmen and mentored by Prof. Tom Tombrello.

‘A series of really great students came through. There was one named Joe Polchinski [BS 1975], who is now one of the shining lights in string theory. Very interesting kid. Another kid, Bill Zajc [BS 1975], is now the chairman of physics at Columbia—does high-energy nuclear physics. -

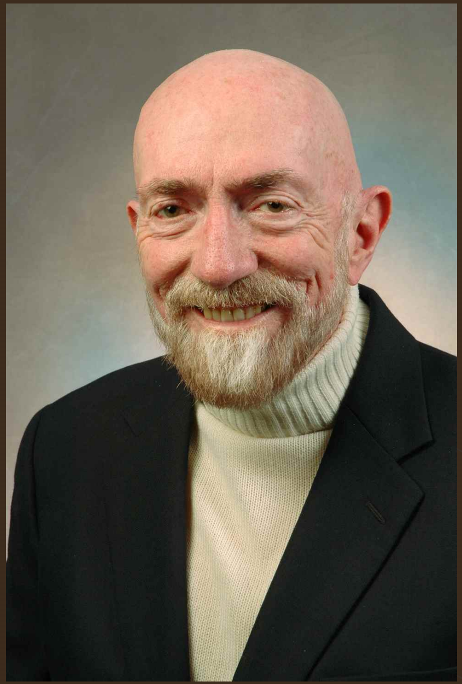
Tom Tombrello interview, Caltech Oral History Project, 2010



‘Tombrello was a remarkable people person. When he saw that four of the top physics students (Bill, me, Roland Lee, and Ken Jancaitis) were looking for research projects, he took all of us on!

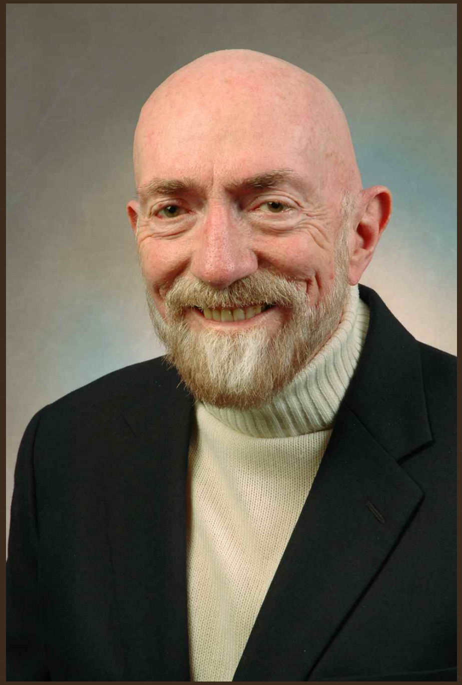
This was heaven: four of us sharing a basement office in Bridge, with a modest stipend, talking physics all day and unwinding at night.

- Joe Polchinski, *Memories of a Theoretical Physicist, 2017*



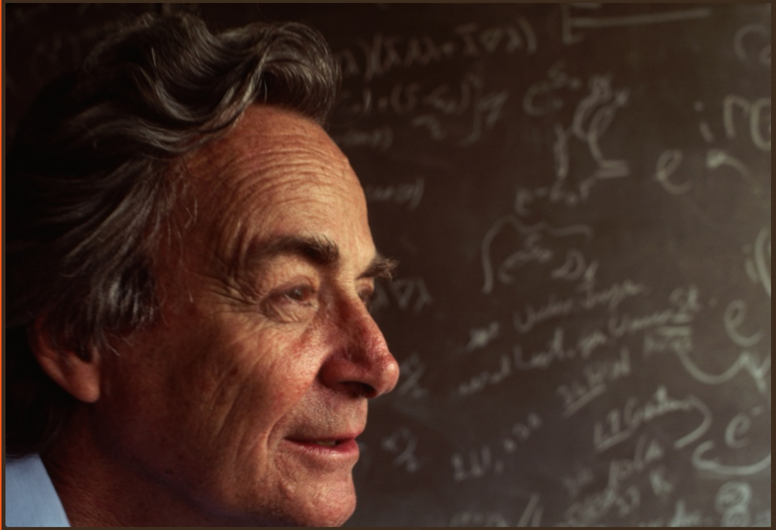
Joe ‘s initial contact with Prof. Kip Thorne, who was his freshman adviser, was cursory:

‘Kip Thorne was my designated freshman advisor, so we met every quarter...I did not have much interaction with Thorne as a student, aside from auditing his general relativity class. The research was too advanced for an undergrad. I did have an interesting science/sci-fi interaction with him several years later, which I will get to...’



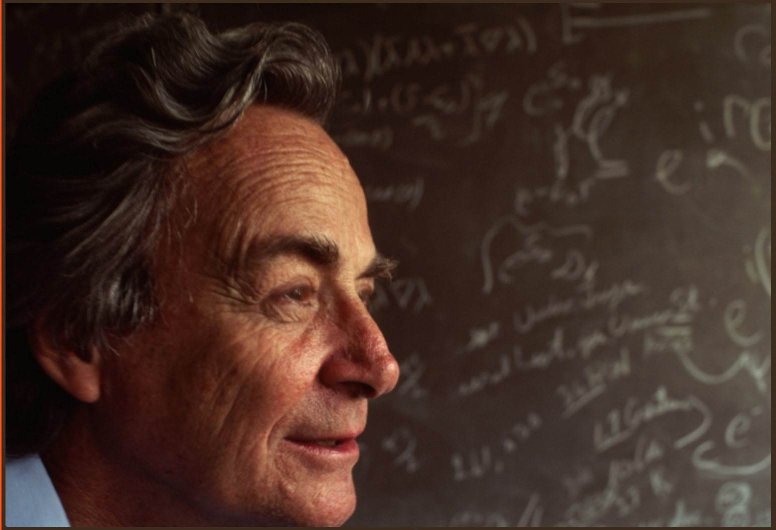
However, this connection came to life again many years later, culminating in ‘Polchinski’s Paradox’ in 1994:

‘As a veteran reader of science fiction, I was well aware of the grandfather paradox, and I was sure that Thorne was as well. The observer could go far into the past and then kill his grandfather before he himself had been conceived…But I realized that one could easily do away with that. You can just replace the observer with a billiard ball, aimed so that it travels from the past through the future wormhole, and then leaves the past wormhole in just such a way as to intersect its previous path and knock it o course. Then it will never be there to pass through the wormhole…I sent Thorne a message with this, and he got excited. His next paper was about motion in wormhole spaces. He had a possible solution to the conflict. If the ball was deflected just a little bit, then after passing through the wormhole it could meet its former past at just the right place to make it all consistent. He acknowledged me prominently for my note, which felt very good. So an idea for which I wrote no papers, seems to be my claim to fame.’



Joe's encounters with Richard Feynman while an undergraduate also echoed through his own subsequent work:

'I first met Feynman as an idol, not a person. In the courtyard of Dabney house, next to Blacker, a large bas-relief depicting the great scientists of history had been built many years before...I got a chance to meet the man himself before too long. Once a week, Feynman led Physics X, where freshman and sophomores could ask their questions about physics, or if we ran out of questions he would talk about some of his ideas...In addition to his powerful calculational ability and his outsized personality, Feynman's ability to think far outside the box was awesome…'



‘…I was too shy to take more advantage of the time with Feynman, though I saw him often on that small campus…

Most exciting, when we were seniors, Zajc and I, along with two other seniors, were asked to grade Feynman's junior quantum mechanics homework...I did get over my shyness one time, to ask him about the infinities that appear in quantum field theory (QFT): do they have a physical interpretation? Feynman said `no.' In retrospect, he must have known more, from the work of Wilson, Weinberg, and others. But perhaps it did not satisfy him, since he had not derived it himself. But this question tugged on me for the next eight years, and was my first deep result. [Zajc reminds me of another interaction we had with him, asking about whether rotating bodies produce gravitational radiation, something we were puzzling over.].’

UC Berkeley 1975-1980

New challenges in graduate school

At Berkeley, Joe worked for Prof. Stanley Mandelstam, with mixed results:

‘Students are generally started off with a warmup problem. This is for the student to get oriented to the advisor's research, and for the advisor to gauge the student. But as Mandelstam only worked on the hardest problems, he naturally gave the same to his students. My warmup was to find a QFT that had both electrically and magnetically charged particles. This is an contrast to the known theory of QED, which has only electric charges. I was unable to solve this problem, and I gave Mandelstam an argument why it was impossible… So I met with Mandelstam to discuss this about once a week for a year. Mandelstam was always generous with his time. But he was a difficult advisor, because his thinking was deep, but his explanations were often oracular. So I was never sure if I was making progress. I have always thought that my project was unsuccessful. But on reviewing it for the first time in a very long while, I realized that I had basically solved the problem.’


However, Joe benefited from the wisdom of other faculty members:

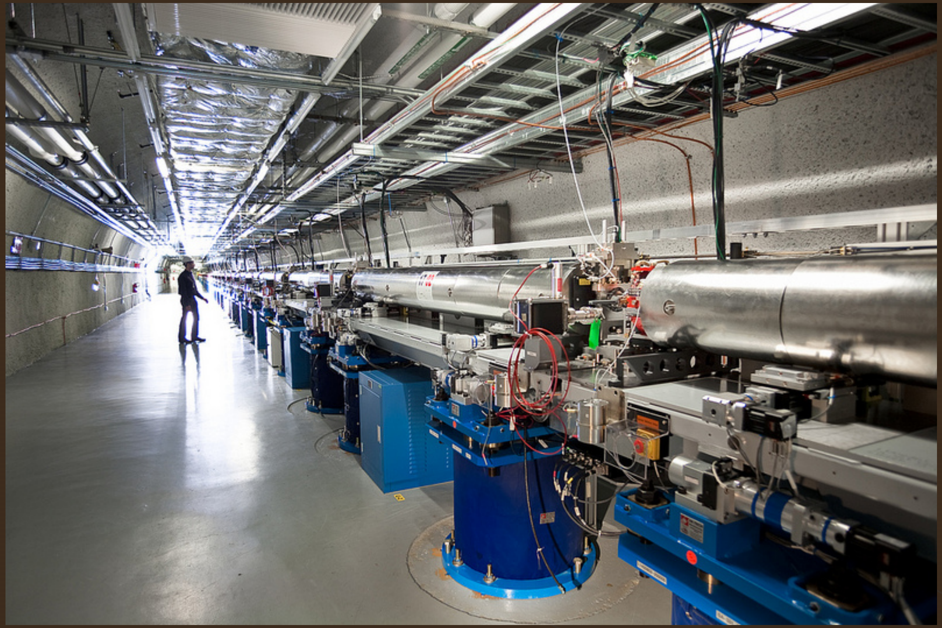
‘Two other professors I recall mostly for their advice: my strongest memory of David Jackson, was that "It is not enough to be smart, you have to work hard." It was good advice, and much-needed given my lack of common sense. The other was Robert Cahn, a new professor at LBL, the lab affiliated with Berkeley. He also helped to fill the gaps in my common sense, especially when it came to finding my next job.’

Dorothy

At Berkeley Joe met Dorothy Chun – who was connected to Caltech via a brother and former boyfriend – and they married in 1980. Specializing in German linguistics, she pursued her academic career in parallel with Joe's, joining the UCSB faculty as a professor alongside Joe in 1992.

'Tom Tombrello, whenever we met, would remind me what a good choice I had made in Dorothy. Although I had learned a few social skills at Caltech, I still had many rough edges. Having Dorothy straightened many of these out. I was always afraid of her asking me why I loved her, because the first answer that came to mind was always that she was the sanest person I knew. It seemed not so romantic, though she had many other wonderful features. But having been around for a while now, I think that in making a list of qualities in a spouse, being the sanest person you know should be near the top.'

Postdoc days: Stanford/SLAC 1980-1982



Navigating a new universe

'My postdoctoral appointment was actually at the Stanford Linear Accelerator Center, SLAC, about two miles from the physics building. Although this was an experimental lab, at the time most of the theorists were housed there as well…

The postdoc years are a chance to learn new things. One should generally not just continue working on their dissertation problem. So of course, this is just what I did, for a while. I believed that I could prove what Mandelstam wanted to show, that quarks were confined with infinite strength…I did get one little paper out of this… it would take me a while to realize ***that it is important not just to write papers but to give talks about them - not only to get attention, but to be forced to clarify your work, think it through, and get valuable feedback.'***

While at Stanford/SLAC, Joe's encounters with Leonard Susskind and his team were to have a profound impact on him:

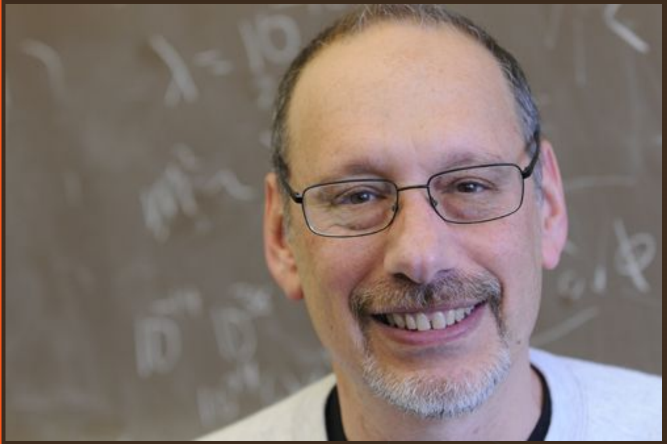
'About once a week, a whirlwind would settle on SLAC. Lenny Susskind and his group of visitors and senior postdocs…Where I was the extreme introvert, Susskind was the extreme extrovert. Even when I learned how to collaborate, my style was still to talk, perhaps for an hour, and then go away for a few days to think about things. Susskind, on the other hand, seemed to be able to work by talking, without a break, and to make progress in this way. In the many years that I have known him, he has almost always been surrounded by young people, talking through his current puzzle.

*Although our personalities were very different, our interest in physics was much the same: we wanted to understand the basic principles. Neither of us were drawn to mathematics for its own sake: we used only enough to solve the problem at hand. Of course **my own approach was still developing, and was surely influenced by Susskind.'***

What Susskind and his friends were excited about when I got there was supersymmetry...Both the strong and the weak nuclear forces had been understood around the time I got to Caltech. Together with QED, these three forces (or four, if you count the Higgs field as a force) seemed to account for all of particle physics, a theory known as the `standard model.'...The similarity of these forces suggested some more unified origin. Georgi and Glashow, in 1974, noted that the three forces t nicely into a 5 x 5 matrix, so called Grand Unification (GUTs)...Supersymmetry (SUSY) was another idea, which nicely complemented GUTs...

*So Susskind and friends hung out in his office thinking about how to calculate the quantum corrections to the D-term. They were happy to have a newcomer listening in. I had taught myself how to do some of the main calculations in SUSY, it was clearly an exciting direction. And after a bit I was able to go from skulking to making suggestions. Before long we had solved the problem, and I had made substantial contributions...**It was my first real contribution to theoretical physics, and my first exposure to doing science collaboratively.***

Postdoc days (2): Harvard, 1982-1984



Mark B. Wise
John A. McCone
Professor of High Energy
Physics, Caltech

Learning to do physics

*What was amazing about Harvard was the tremendous of number of really outstanding young people...The faculty would have their families, and there was a formal family and a phenomenological family. Still it was an environment where you talked about everything...**Mark [Wise – now at Caltech] was a key figure in my education. This was the first place where I was around people who were interested in data**. While I was at Harvard supersymmetry was discovered...It was great, because when there was a rumor — there were more rumors then — you immediately learned about it, figured out what it might be, and wrote a paper. It was a much different style from Mandelstam's style of thinking about impossible questions. It was great to be exposed to the style of really reacting quickly to new developments...**Harvard was where I finally learned how to do physics in how you identify your project and write a paper**... I didn't understand how you pick out an interesting problem to work on, and finally at Harvard I learned that from the milieu of young people and a bit of Howard [Georgi]'s influence. Howard had this dictum of "No more than one half of an idea per paper." Which was a good contract to what I had come in with. Mark Wise was good because he actually mentored me a bit.*
– Interview with Dean Rickles, American Institute of Physics, 2009

Austin, 1984-1988

Dorothy and Joe

Solving the 'two-body problem'

It had been a great two years on the East Coast. I had learned a lot of new physics, and new ways to do physics, and had written a couple of significant papers. I had met a large number of excellent scientists, both at Harvard and on various visits around the East, many of whom I still interact with to this day. Now it was time for the next step, a faculty position…

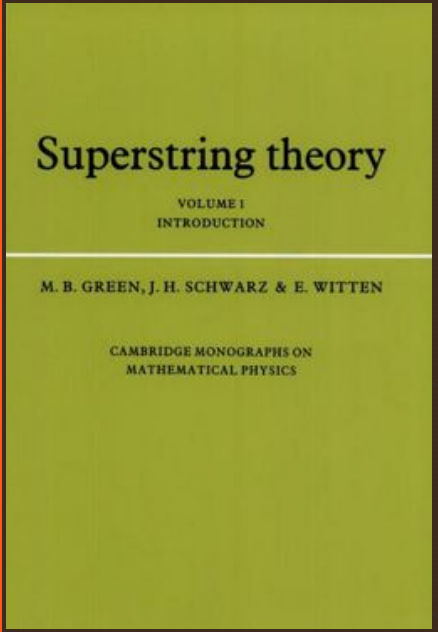
I had a two-body problem. Dorothy's MIT position was over, and the next position she found was at Urbana-Champaign. So I wanted time free to visit her. We had our two-body problem again, so we each looked at the jobs that were advertised in our field, and there was very little overlap…Fortunately, Texas came to the rescue, with a position for me in Weinberg's group, and a lecturer's position in German with the promise of a later tenure track job. This was neither of our first choices, and not one that we had expected, but it was an excellent compromise.

Steven Weinberg
Josey Regental Chair in Science, University of Texas at Austin
Nobel Laureate, 1979

The next chapter: Weinberg and (really) learning string theory

‘I had studied Weinberg's relativity book and papers at length, and heard some talks, but did not interact with him until Austin...Weinberg's focus on his physics was famous. When he needed to learn something that I might know, he would question me in detail. But when my knowledge was exhausted, and I changed the subject, his eyes would visibly glaze over, and I knew that the meeting had ended. But I held nothing against him for this: this is what made him great. Even with his public interactions and other distractions that came with the 1979 Nobel, he continued to be creative... ***over time I had ample opportunity to interact with him, as did all the group members and most notably the students…***

Weinberg was trying to learn string theory much as I was, looking for simple calculations to do. ***I do not know why we did not work together, I guess neither of us played well with others (though I improved with time). But I did find his work interesting.’***

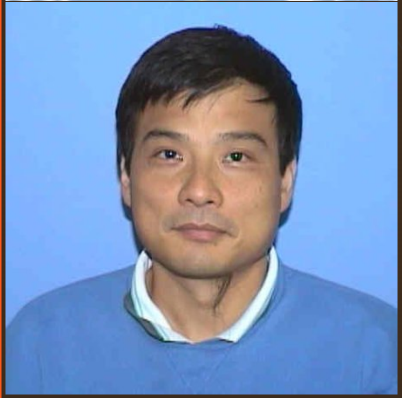


Green, M., John H. Schwarz, and E. Witten. Superstring Theory. Vol. 1, Introduction. Cambridge Monographs on Mathematical Physics. Cambridge, UK: Cambridge University Press, 1988.

The superstring revolution

Just as I was getting settled in Austin, the first superstring revolution struck. I had known very little about string theory before...it all came to a head in the fall of 1984, when Green and Schwarz found a new anomaly cancelation mechanism, Gross, Harvey, Martinec, and Rohm found the heterotic string, and Candelas, Horowitz, Strominger, and Witten found the Calabi-Yau solutions. Together, these gave a close connection between string theory and the standard model. I had spent the last several years on unification. My work was focused on supersymmetry, but I also informed myself about GUTs and Kaluza-Klein theory. Together they implied unification between fermions and bosons, between different gauge groups, and between gauge fields and gravity, while constraining the spectrum of particles. Moreover these three ideas were nicely compatible with one another, and it was plausible that they were all part of some larger structure. But there was one thing missing, even when all were taken together. Each had a lot of arbitrariness, in choice of gauge field, matter spectrum, masses, and coupling constants. A unified theory should have a uniqueness, and it was hard to see how this could come out of these frameworks. But string theory apparently did this.

Jun Liu
Professor of Finance and Accounting
Rady School of Management



Yunhai Cai
Head of Beam Physics Department at SLAC National Accelerator Laboratory

New responsibilities

'I had remained a postdoc for as long as possible, but now I had responsibilities. ***Supervising graduate students turned out to be a great thing.*** *The common pattern with a student was that I would suggest an idea and we would meet weekly. Usually the idea turned out to be too hard for the student, so we would end up working together. I am pleased that with almost all of my students I ended up writing one or or more significant papers. So the students got a great research experience, and many times* ***I got to work out good ideas that I otherwise might have let slide.*** *My first three students were Jim Hughes, Jun Liu, and Yunhai Cai…Each had their own projects, but they often ended up collaborating… Jim, Jun, and Yunhai each did a few postdocs and then moved on to other things. Jim is at Microsoft, Jun got a second Ph.D. in finance and is now a professor in this field at UCLA, and Yunhai became a magnet designer at SLAC. Even after the first superstring revolution, there were no jobs for string theorists.'*

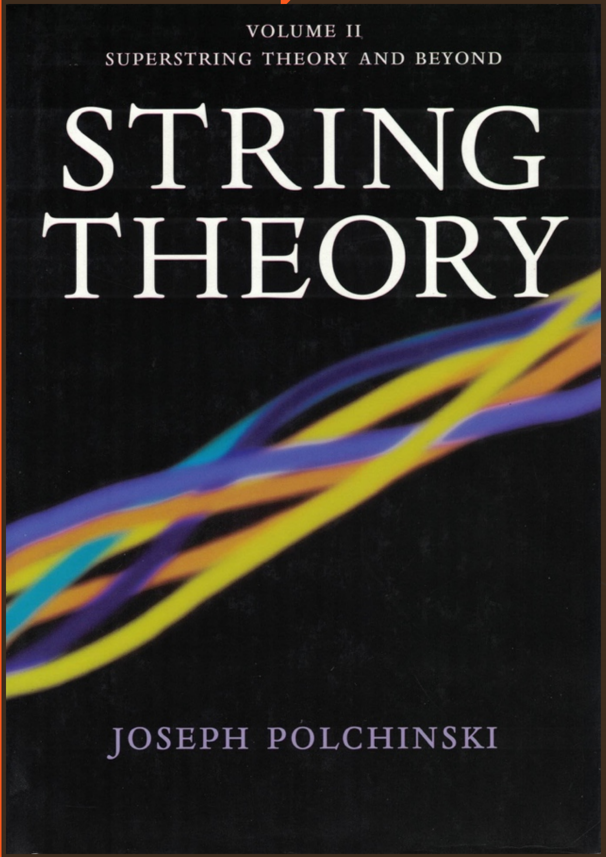
Austin part 2, 1988-1992

Edward Witten
Professor
School of Natural Sciences
The Institute for Advanced Study,
Princeton University

The book: a nine-year odyssey

So in the summer of 1988, having realized that I would never be a great scientist, I decided to write a book...I did not have a feeling that I was moving science forward. The great excitement of the day was connecting the heterotic string to the observed standard model, and I did not seem to have the particular tools for this. In fact, when I look back, I seemed to have worked almost entirely on what looked like oddities as compared to the real problem. Meanwhile, many others were making what looked like major progress.

Certainly, the most notable of these was Edward Witten. For nearly ten years he had driven high energy theory forward with new ideas, the way that Feynman, Gell-Mann, Weinberg, Polyakov, and 't Hooft had done earlier. I recall the pleasure, even before string theory came along, of reading each new paper by Witten and learning unexpected new aspects of quantum field theory. But at the same time, it was overwhelming...each new paper from him gave me the joy of reading, and the question, "why am I needed?" On a smaller scale, I must have had some of this effect on my classmates at Caltech. But science is large, and they found their own directions…



Joe's Big Book of String

…The reason for my book was that I had just taught a one-year string course based on the Polyakov path integral. Green, Schwarz, and Witten (GSW) had just written a two-volume book on string theory but it did not include the Polyakov path integral, using mainly the older light-cone methods. I thought that in a year I could transcribe my course notes, avoiding too much repetition with GSW. **People seemed to enjoy my writing, and I enjoyed it, though I did not account for how the effort would scale between a paper and a book. And I kept wanting to improve things, and string theory kept moving, and it ended up taking nine years…**

The overall title, simply `String Theory,' had been in place for a long time. Initially I had used `A Modern Introduction to String Theory,' signifying the use of the Polyakov description, but I realized how quickly such a title could look dated. Though if I were to write it today, it is not obvious how else to start. I also started using `Joe's Big Book of String' as an informal title very early; I should have fought harder to make this the official title.'

D-branes and Orientifolds 1992-1995

Kavli Institute for Theoretical Physics

University of California, Santa Barbara

Back to California: UCSB/Institute of Theoretical Physics

'The University of California at Santa Barbara had one of the leading string theory groups in the world, In 1978, the High Energy program director at the National Science Foundation, Boris Kayser, saw a need to enhance collaboration between physicists at different institutions and in different fields, and also to support postdocs who were leaving physics for lack of support. He persuaded his superiors to fund this, to the tune of around a million dollars per year...UCSB's gang of four [Jim Hartle (relativity), Ray Sawyer (particle physics), Doug Scalapino (numerical condensed matter), and Bob Sugar (lattice gauge theory)] had a unique idea, to use the funds to bring scientists from around the world to interact for as long as six months, rather than the typical week-long conference. There would be time to conceive new projects and carry out the collaboration there…But they had to convince their new chancellor, Robert Huttenback, to back them. Huttenback, just arrived from Caltech, knew about the competition because Murray Gell-Mann had boasted to him that Caltech's proposal would dominate UCSB's. So Huttenback gave the gang what they asked for [4 faculty positions], and ***UCSB got the Institute for Theoretical Physics (ITP), and the gang of four became the Founders. And so my position exists because of Murray's boast.'***

In string theory, D-branes are a class of extended objects upon which open strings can end with Dirichlet boundary conditions, after which they are named. D-branes were discovered by Dai, Leigh and Polchinski, and independently by Hořava in 1989. In 1995, Polchinski identified D-branes with black p-brane solutions of supergravity, a discovery that triggered the Second Superstring Revolution and led to both holographic and M-theory dualities. – Wikipedia, 'D-branes'

D-branes

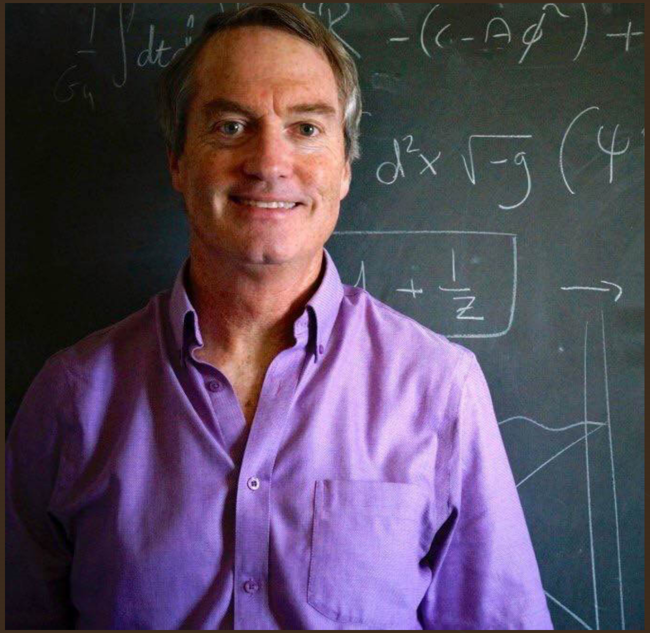
'For most of my career I've thought of myself as very smart but not especially creative. So I had done a lot of work, mainly by trying to unravel various puzzles and paradoxes, but nothing really groundbreaking. Then about four years ago, by looking at such a puzzle, ***I found that string theory was incomplete --- it had to contain these other objects, which I named D-branes. Although I didn't realize that it was going to happen, this started a revolution.*** *As others followed up on my work, it became evident that these things were perhaps more fundamental than strings, that strings were in a sense made of D-branes. This changed the entire direction of the field ---every talk that I go to now is essentially about D-branes, or other ideas that these have led to. It's really a singular experience, to have such an impact. Now I want to do it again. Incidentally,* ***I was 41 when I did that work (though it built on things I had done beginning when I was 28) so it goes against the idea that one's greatest impact comes when one is young.'***

- Private email message from Joe Polchinski to Melody McLaren, 4 November 1999.

Family time

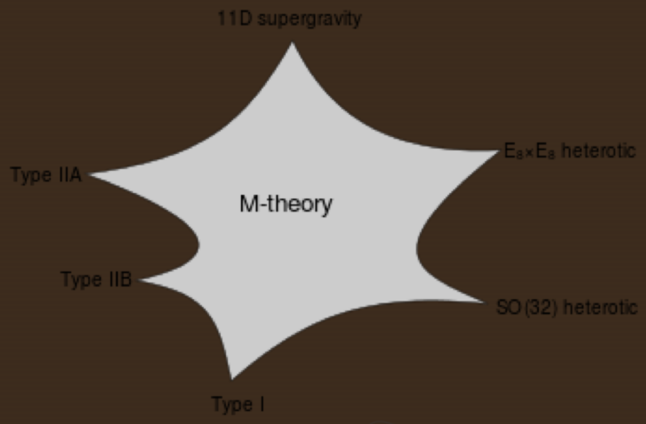
Steven and Joe Polchinski

'Just as my physics career was taking this spectacular jump, most of my mental energy was actually being spent on coaching Steven and Daniel's roller hockey team. Both Dorothy and I were mostly unathletic before college, her from going to Catholic schools and me from general nerdiness. But in college we both enjoyed sports, and we met playing volleyball in our first graduate year. When our first son, Steven, came along this accelerated. From the age of one or so he wanted me to be throwing or kicking a ball to him all the time. Daniel seemed more easygoing, but he also joined in, and so life for us largely centered on sports…Steven started playing roller hockey when he was six, and after a few years I was asked to coach. This did not come naturally to me. Even teaching physics had always made me anxious, and here I had no expertise. I took it on, and so spent the quarter mostly figuring that out. But ***this was the exact same time D-branes came along: somehow it all worked out.'***



‘The best part of my job is learning new things --- there are so many beautiful ideas. It’s still just like freshman physics at Caltech --- hearing about something neat and then getting to understand the details…Of course there is pressure of various sorts --- other responsibilities, and the fact that one has to work pretty hard to keep up with everything else. But now I have had this very lucky success I am trying to relax a bit and to simply enjoy what I am doing.’

- Email to Melody McLaren, 4 November 1999

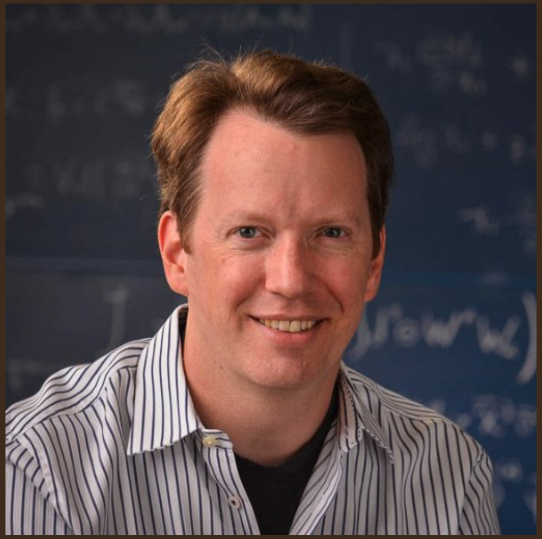


The second superstring revolution

'I see the second superstring revolution as five waves in succession: the first four were Witten's Strings talk (and the preceding Hull-Townsend paper), D-branes, the SV black hole counting, and the BFSS matrix model. AdS/CFT would be the fifth and crowning glory. Each built on the ones before it, and each greatly expanded our understanding of string theory.'

M-theory is a theory in physics that unifies all consistent versions of superstring theory. The existence of such a theory was first conjectured by Edward Witten at a string theory conference at the University of Southern California in the spring of 1995. Witten's announcement initiated a flurry of research activity known as the second superstring revolution. – Wikipedia, 'M-theory'

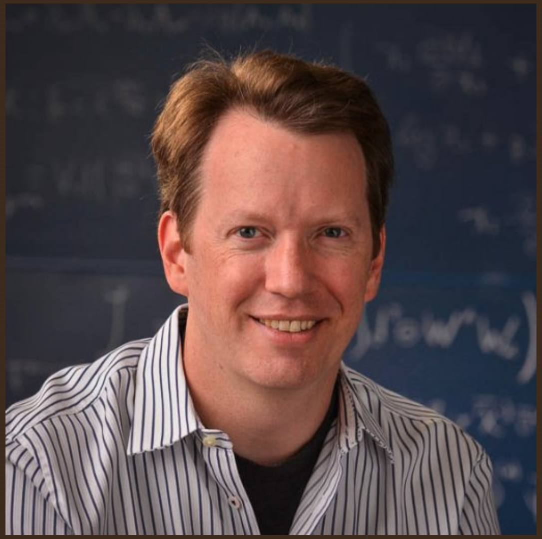
The CC and the discretuum, 1996-2000



Sean M. Carroll
Research Professor of Physics
Caltech

The cosmological constant (CC)

Joe Polchinski: *'In 1998, strong evidence was found for a cosmological constant, surprising almost every theorist. One might have expected string theorists to drop everything and think about this, but there was little reaction. Certainly a large part of this was that AdS/CFT had just been found, transforming fundamental theory. We needed to understand the theory better before applying it. My own reaction was different, from my interactions with Weinberg. I had half-expected the CC, and had feared it. Indeed, when the evidence started to come in, I told our postdoc, Sean Carroll, that if the CC turned out to be there, he could have my office. It would mean that the anthropic principle was here, and I would have to give up physics. I make a lot of comments like this that I do not remember - unfortunate, otherwise this memoir would be funnier. But Sean remembered, and as he introduced me at a meeting two years later, he asked when he was going to get the office…'Having told Carroll that I would give up physics if a cosmological constant were found, how could I go on? Well, I had just taken on three new grad students after finishing my book, and I had to take care of them. And, we still needed to see if all those de Sitter vacua were there. And there were all these cool things about AdS/CFT to look at. So life went on, and Carroll did not get the office.'*



Sean M. Carroll
Research Professor of Physics
Caltech

The cosmological constant

Sean Carroll: *'I once asked him what his favorite explanation would be if astronomers were to discovery a nonzero cosmological constant (the energy of empty space itself). In his always-quotable way, Joe immediately replied that this would be a disaster, as the only plausible answer would be the anthropic principle. That would be sad, as it would represent a failure of physics to make a unique prediction for a physically important quantity; he would probably have to quite doing physics under such conditions, he mused, and if that happened, he promised that I could have his office. In 1998, of course, astronomers did indeed discover that the universe is accelerating, a sign of a nonzero cosmological constant. I reminded Joe of his promise, but instead of retiring he decided to continue doing interesting physics, and he kept his office. That's okay, he put it to better use than I would have.'*

- Sean Carroll, 'In Memoriam: Joe Polchinski, 1954–2018, Scientific American, 8 February 2018

- *After the end of physics, 2001-2007*

NATIONAL ACADEMY OF SCIENCES

Election to the National Academy of Sciences, 2005

'Joseph G. Polchinski, professor of physics at at the University of California at Santa Barbara (UCSB) and a permanent member of the Kavli Institute for Theoretical Physics (KITP), has been elected a member of the National Academy of Sciences. He was cited as one of the "leading field and string theorists of his generation, contributing many significant ideas to both quantum field theory and to string theory." Polchinski's discovery of D-branes and their properties is, according to the Academy citation, "one of the most important insights in 30 years of work on string theory." String theory affords the best approach to date to a grand theory that encompasses gravity and the other three forces described by the Standard Model of particle physics (the electromagnetic, weak and strong forces). Strings and branes are the essential structures in string theory.

Instead of being only one-dimensional like strings, branes can have any dimensionality, including one. One-dimensional branes are called "D1 branes or D strings." So there are essentially two types of strings--the heterotic string or "F" (for "fundamental") string, which physicists knew about prior to Polchinski's 1995 discovery, and the "D string," or one-dimensional brane.'

‘Polchinski Elected Member Of National Academy of Sciences’,
Kavli Institute for Theoretical Physics, 2 May 2005

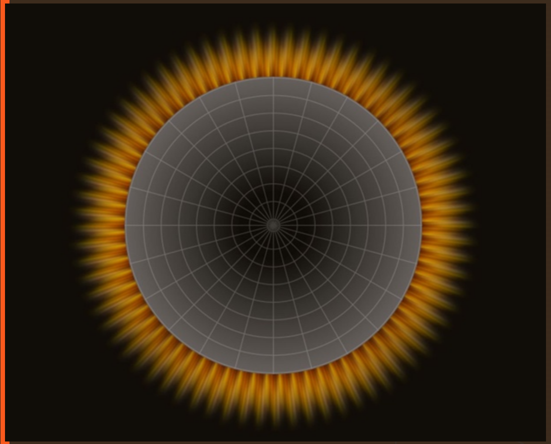
Before the firewall, 2007-2011

Quantum gravity: wormholes, black hole models, bubbles of nothing, loops

‘Having spent most of the last few years on cosmic strings, AdS/QCD, integrability, and other odds and ends, I wanted to focus more on the fundamental question, `what is quantum gravity.' Even with the anthropic principle looming, the problem of finding the theory of quantum gravity remained one that needed to be solved. Solving this might lead to any number of wonders. Moreover, it was the kind of problem that might be solved by theoretical reasoning alone…

According to INSPIRE, it was at this point more than ten years since I had written a paper on black holes and the information problem. Like many of those who had worked on this, I regarded it as essentially solved by gauge/gravity duality, in the BFSS matrix form and in the AdS/CFT form. Of the three options | information loss, information emission, and remnants |only emission was consistent with duality to gauge theory. There remained the question, how does the information escape? But this seemed to t nicely with the principle of black hole complementarity, enunciated by Susskind, Preskill, and 't Hooft: the information could be both inside the black hole and outside, as long as no single observer could see both copies. And various thought experiments supported this. Still, our understanding seemed to be incomplete.’

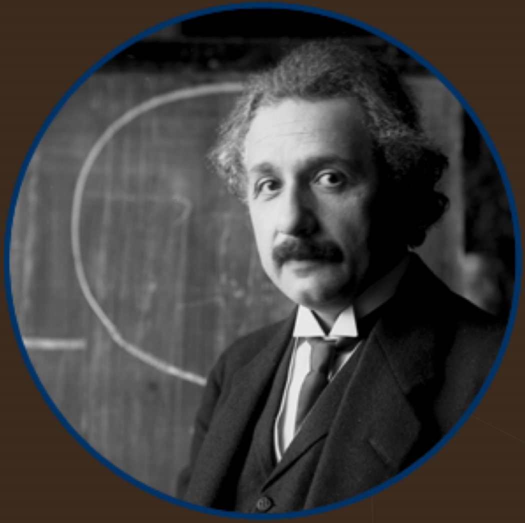
Firewall days, 2012-2015



The black hole firewall

'A black hole firewall is a hypothetical phenomenon where an observer falling into a black hole encounters high-energy quanta at (or near) the event horizon. The "firewall" phenomenon was proposed in 2012 by Ahmed Almheiri, Donald Marolf, Joseph Polchinski, and James Sully as a possible solution to an apparent inconsistency in black hole complementarity. The proposal is sometimes referred to as the AMPS firewall, an acronym for the names of the authors of the 2012 paper. The use of a firewall to resolve this inconsistency remains controversial, with high-energy physicists divided as to the solution to the paradox. 2016 LIGO observations provided tentative evidence of a firewall, or of some other phenomenon violating general relativity.'

Wikipedia, 'Firewall (physics)'



All change

‘On Nov. 30, 2015 I gave a talk "General Relativity and Strings" at the meeting to celebrate the 100th anniversary of GR [General Relativity]. It was held at Harnack House in Berlin, where Einstein often worked and spoke. I was scheduled to speak also the following week in Munich, at a rather different meeting. This was to address whether such theories as strings and inflation were in fact theories. I was looking forward to it, I felt that there were important points that were long overdue to be put forward. My paper, `String Theory to the Rescue,' presented the case that string theory, though often criticized, was in fact a great success.

Unfortunately I never gave the second talk, because three days after my talk at Harnack House I suffered a seizure that sent me to the hospital. I was found to have brain cancer. After many months of surgery, treatment, and recovery, I can write, as you see, but I still do not know whether I will be able to do physics again.’

Four generations of physicists at Kavli Institute of Theoretical Physics, 2014, including Joe Polchinski: Makoto Natsuume, James Sully, Tom Tombrello, Eric Gimon, Ahmed Almheiri, Rob Leigh, Stanley Mandelstam, Stanley Mandelstam, Nelia Mann, Iosif Bena, Andrew R Frey, Idse Heemskerk, Mariana Graña, Simeon Hellerman, Jorge Rocha, Eric Mintun, Andrea Puhm and Ben Michel.

Epilogue

‘It is interesting to go through one's life like this. It has taken a rather linear path, from the How and Why Wonder Books to today, with few deviations. I have not achieved my early science fiction goals, nor explained why there is something rather than nothing, but I have had an impact on the most fundamental questions of science. But it was a close thing: at the age of 40 you could say that I had not lived up to my potential. And if someone else had stepped in during the six or more years between my finding D-branes and figuring out what they were good for, that might still be true.

How far are we from finding the fundamental theory of physics, and what will we learn from it? Again, I am an agnostic, and not good at predicting things. I only follow my nose. Happily my nose is very busy, with the firewall, chaos, entanglement, and quantum information. So we may be close, or we may still have big steps ahead. I hope to help figure this out.’

Joseph Polchinski Wins 2017 Breakthrough Prize

‘Awarded for his transformative advances in quantum field theory, string theory and quantum gravity, distinguished UC Santa Barbara physicist Joseph Polchinski has won the prestigious 2017 Breakthrough Prize in Fundamental Physics, which recognizes major insights into the deepest questions of the universe. Polchinksi, a permanent member of UCSB’s Kavli Institute for Theoretical Physics and the Pat and Joe Yzurdiaga Professor of Theoretical Physics, shares the award and $3 million prize with Harvard physicists Andrew Strominger and Cumrun Vafa. They and other recipients of the 2017 Breakthrough Prizes were honored during a gala ceremony with prize founders Sergey Brin and Anne Wojcicki, Yuri and Julia Milner, and Mark Zuckerberg and Priscilla Chan.’

- UCSB press release, December 5, 2016

A peaceful entry into ... a parallel universe?
CaringBridge Journal entry by Dorothy Chun — 2/2/2018

‘I am utterly heartbroken to say the Joe left us this morning, yet it was entirely peaceful and without fanfare, just the way he was. He was surrounded by loved ones whose main goal was to keep him comfortable and ready for the next adventure. We hope he is having a grand time, discovering the secrets of the universe that have been eluding him all these years. Some possible scenarios of what he might be saying: (1) I knew it! I was right (e.g., about the firewall)! (2) Duh, so that's how it works. (3) No, that's wrong, and here's why ... Please feel free to add your own conjectures   At the moment no formal service is planned, though we may want to have celebrations of his life at some point in the future. In lieu of flowers or gifts, we would welcome any thoughts or memories you wish to share, either on this CaringBridge site or by email (or even snail mail). If you would like to make a contribution to the Joseph and Dorothy Polchinski Graduate Student Fellowship in Physics at UCSB, please click here; Joe would be honored.’

'Joe was my oldest - in the sense of longest duration - friend in physics. We met in our first few days at Caltech in September 1971. Joe recounted some of those memories in his wonderful autobiographical arXiv post…I can't recall our first bike ride together, but as Joe recounts in his "Memories…" there were many. I will never forget our last ride together, with Dorothy accompanying Joe on their tandem, in October 2016. It hurts so much to write "last", but all the same this is a treasured memory.'

Excerpt from tribute to Joe Polchinski by Bill Zajc, February 5, 2018

'We do not get to decide how predictive the laws of nature are, how much is random or environmental and how much is fixed. It is something that we have to discover. Of course, if the answer is that we live in a less predictable universe, it will be much harder to know that this is right. But we can figure it out.'

Joseph Polchinski, 'String theory to the rescue', December 2015