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Joseph Gerard Polchinski Jr

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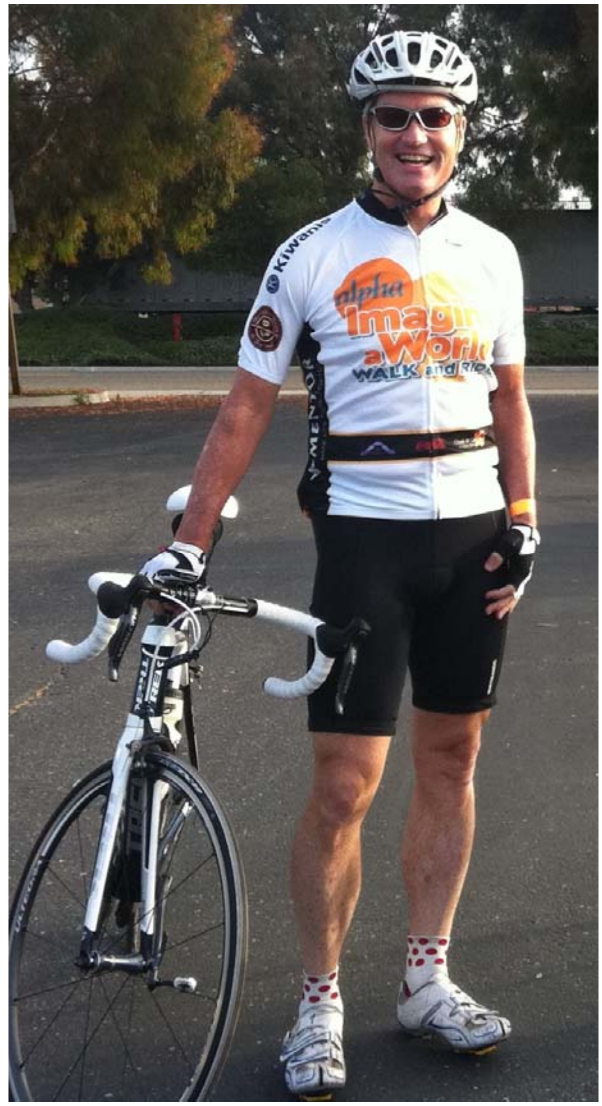

Physicists around the world mourned the death of Joseph Gerard Polchinski Jr. He died on 2 February 2018 in Santa Barbara, California, after having battled brain cancer since late 2015.

Joe is widely regarded as one of the leading theorists of recent decades. His contributions ranged from an exact prescription for the renormalization group to the discovery of central ingredients in string theory. Along the way he offered major insights into condensed-matter physics, the cosmological constant, and the quantum physics of black holes.

Joe is fondly remembered for his good-natured, informal style and his support of new generations of physicists. His mischievous grin and ready laugh lit up his surroundings.. He recalled a desire to name one of his most famous papers “Fun with duality,” only to have it vetoed by his supposedly much more serious graduate-student coauthor. Readers can learn about his perspective on physics and beyond in his recent memoir (https://arxiv.org/abs/1708.09093), in which he recalls the people and circumstances surrounding many of his results.

Born in White Plains, New York, on 16 May 1954, Joe developed his focus on physics at Caltech, where he obtained his BS in 1975. He earned his 1980 PhD from the University of California, Berkeley, with a dissertation, "Vortex operators in gauge field theories," supervised by Stanley Mandelstam. He then moved to a two-year postdoc at SLAC.

Joe's work began to have real significance to the physics community during his second postdoc, at Harvard University. There, starting from an insight of Kenneth Wilson that the couplings in quantum field theories depend on the scale at which they are probed, he proceeded to give an exact prescription for calculating the dependence. In that work and in his 1992 lectures on effective field theory and the Fermi surface, Joe gave a two-line argument that theories with a perturbation expansion are renormalizable—that is, their apparent infinities can be canceled with a finite number of parameters. Although that result was known, Joe's treatment displayed the conceptual power of path integrals and effective Lagrangian techniques.

The most far-reaching conceptual shift Joe brought forth stemmed from his 1989 discovery, with PhD students Robert Leigh and Jin Dai, of nonperturbative objects, known as D-branes, in string theory. Previously, the theory was formulated with extended one-dimensional objects called fundamental strings that smooth out the short-distance behavior of the theory. But Joe and his collaborators argued that consistency required new ingredients—D-branes—that could be extended in any number of spatial dimensions p. For example, the $p = 1$ D1-branes were another kind of string, the $p = 0$ D0-branes were particle-like, and so on. In 1995 Joe explained the significance of the D-branes as the carriers of charges known to play an essential role in unifying a zoo of seemingly different string theories into a single coherent structure.

Known as the "second superstring revolution," this unification involved dualities showing that two theories formulated in terms of different degrees of freedom could in fact describe the same physics. Indeed, D-branes became the tool of choice for understanding dualities, probing short-distance structures in spacetime, deriving nonperturbative features of both string theory and field theory, building new brane-localized models of particle physics and cosmology, and computing black hole entropy within string theory. That final direction led to the discovery of the anti–de Sitter/conformal field theory correspondence: the idea that quantum gravity with a negative cosmological constant is equivalent to a lower-dimensional nongravitating theory on a fixed spacetime background. During that period, Joe also completed the two-volume textbook *String Theory*, which carefully laid out the theory's foundations.

Joe's work also impinged on the theoretical interpretation of the small positive cosmological constant, discovered observationally in the late 1990s. As one example, he and Raphael Bousso anticipated that string theory might generate a large set of solutions with different values of the cosmological constant, fitting well with the anthropic explanation that only a small cosmological constant is compatible with our existence. They showed how the structure of generalized electromagnetic fluxes could help lead to diverse solutions that consistently generate entropy in the universe. Joe's extensive contributions also permeate string theory's cosmological models, including mechanisms for stabilization and inflation.

Returning to black hole physics, in 2012 Joe and collaborators, including one of us (Marolf), sharpened the information problem and reinvigorated its study. Many questions remain about its resolution, and Joe himself remained largely agnostic to what that might be while pushing on several fronts. Regardless, the newly clarified understanding of the puzzle stressed the relations between gravity and quantum information and helped advance, among other things, studies in quantum chaos and the dynamics of string theory.

As we look forward, Joe and his work will continue to inspire us far into the future. But we will miss his insights, his laugh, and his overwhelmingly positive influence on the community.

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