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After dinner speech at Gravity and Black Holes conference dinner

Trinity College, Cambridge, July 3, 2017

It is a pleasure and an honour to be here to help celebrate Stephen's 75th birthday and to share with you some thoughts about Stephen and his work.

Last year I taught a course on Black Holes based very much on the course taught to me by Malcolm Perry here at Cambridge. It was wonderful to teach, not least because the LIGO announcement of the detection of gravitatational waves was made in the middle of it so I was able to bounce into class the next day and tell everyone, right lets read this paper and check that the black hole merger obeys Hawking's area theorem. Anyway, at the beginning of the course I told the students that over my career the quantum and classical physics of black holes, pioneered by Stephen and his collaborators, has become a central part of theoretical physics from something that only the relativity community was interested in to something that is now ubiquitous in a huge range of areas from string theory to high temperature superconductors.

This is because great scientific advances do not *end* a particular line of questioning they open doors to *new* questions that could not have been conceived of before. Stephen's work with Roger Penrose on the singularity theorems told us that we must seek a theory of quantum gravity to understand the universe. His discovery of black hole radiation unified quantum theory, gravitational physics and thermodynamics and revealed the new and fundamental question of the origin of black hole entropy.

When I joined the Relativity Group in 1987, Stephen was developing the Euclidean Quantum Gravity programme to address these new questions in cosmology and black hole physics and he had just written a paper, Quantum coherence down the wormhole, in which he proposed that if topology change is allowed in the gravitational path integral then the branching off of small baby universes will cause pure states to evolve to mixed states in the parent universe. This was the beginning of his investigations into the effect of spacetime wormholes.

Stephen was a most generous supervisor, involving his students fully in his current interests. I think he had some initial doubts about me when I turned up to the department in my first week having had all my hair shaved off. I could tell Stephen was shocked because he has the most expressive eyebrows in all of physics and they nearly shot off the top of his head. However, all he said was "I see you had a fight with a lawnmower... and lost". Anyway, Stephen immediately set me to work out the effect of the branching off of baby universes on the propagation of the electromagnetic field. The jury is out on the final significance of wormholes since we do not know enough about quantum gravity yet to be able to decide if there is a regime in which they are relevant, but I ascribe my enduring belief that topology change will be a crucial part of quantum gravity to Stephen's influence.

Stephen's office in the old DAMTP building was off the tea room which was the centre of our world where you could get a cup of well-stewed tea from an enormous metal teapot

for 2p. Stephen would regularly join the group of students gathered there for lunch. It was fun and lively. Our lives were made even more exciting after Stephen published A Brief History of Time in 1988. Its enormous success added a new frisson to our lives: TV crews and celebrities would sometimes appear to visit Stephen. Our Relativity Group Christmas Lunch one year was graced by the actress Shirley McClaine who flounced in an hour late in furs and a leopardskin outfit to find us sitting round looking nerdy wearing the paper hats from our Christmas Crackers. A surreal scene ensued with Shirley bending Stephen's ear about her New Age theories. She argued that since Stephen talked about energy and since she knew the world ran on love energy, they must be talking about the same thing. Occasionally there would be a pause and Stephen would say No and Wrong, though this didnt seem to dampen her enthusiasm at all.

One thrilling opportunity I had as Stephen's student was to go with him to a workshop at the ITP in Santa Barbara in 1988. The group at Santa Barbara - Jim Hartle, Gary Horowitz and Andy Strominger - were instrumental in propagating advances in relativity into the wider community of cosmology, string theory and high energy physics. I have a golden memory of that time: the Californian sun was shining, wormholes were hot, and Stephen was at the heart of everything.

One characteristic of Stephen is his irrepressible intellectual confidence - there's none of this shilly-shallying "on the one hand this and on the other hand that" with Stephen. This confidence is something that shines through in his academic writing as well, from the very earliest papers he wrote as a young scientist. Id like to draw attention to one of these: his Adams prize essay of 1966. This has just recently been published by European Journal of Physics together with an excellent commentary by George Ellis. There's a result in that essay I want to draw attention to. Stephen proves that if one knows the local null geodesics in a spacetime and the topology of the spacetime, one knows the differentiable structure after which it is a matter of half a page of calculation in Hawking and Ellis to show this determines the metric up to a conformal factor. This result completes the UR-theorem of the approach to quantum gravity that I work on, "causal set theory": the causal structure of spacetime determines the topology, differentiable structure and 9/10 of the metric.

So in some sense the thread of my own research is a time reverse of Stephen's: I started out working on Euclidean wormholes, I now believe that it is the causal structure of spacetime that is most fundamental. And Stephens early work - that Adams prize work - is at the very foundation of this belief. So Stephen, very cleverly, turns out to have all the bases covered: Euclidean or Lorentzian spacetime, whatever turns out to be more fundamental, his work is at the foundation of both.

I'll end by telling you about the first time I heard about Stephen. I was a teenager and my family was staying in Cambridge in the summer of 1979 while my father Stuart Dowker - who many of you know works on quantum field theory in curved spacetime - attended a workshop here. One day Dad said, we have to go out and see "Hawking's Ramp". No more explanation - my dad is a man of few words. So I imagined this to be a mighty earthwork on the scale of Offa's Dyke or perhaps an ancient monument like Hadrian's Wall. Instead, Hawking's Ramp turned out to be a tatty wooden construction tacked onto the back of the

old DAMTP building - the access for Stephens wheelchair - and I remember being distinctly underwhelmed by the sight of it. Little did I know then what significance it would hold for me. Being Stephen's student and having the opportunity to learn from him has been one of the great blessings of my life. I think that the esteem in which he is held all over the world, as a great scholar pursuing pure knowledge, would fully justify the raising of Hawking's Ramp to the status of a National Monument.

Thank you for listening.