Joe's impact on black holes and phone service

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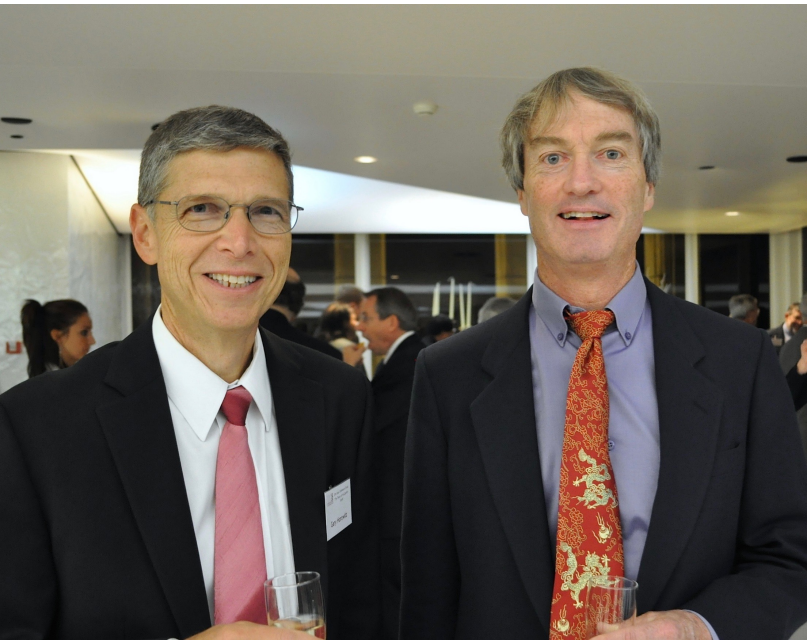
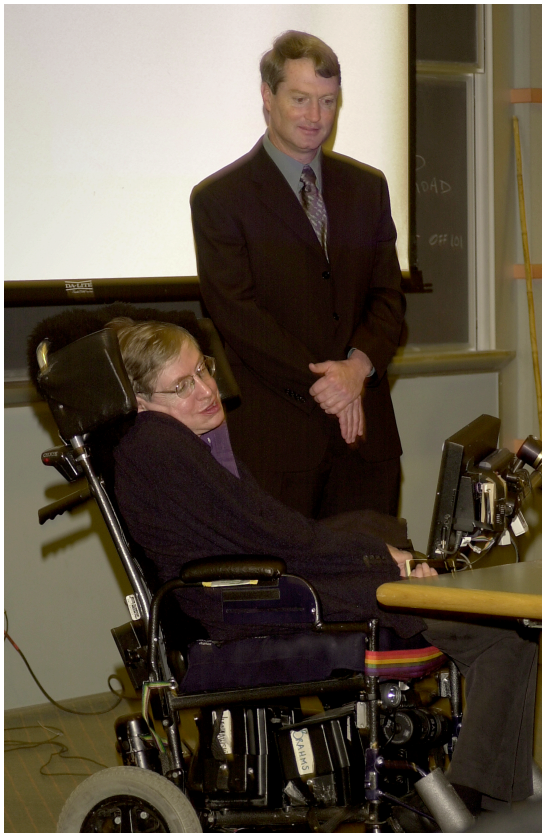




Joe's impact on black holes

- D-branes and counting of black hole microstates
- Correspondence principle
- Firewalls

D-branes and counting of black hole microstates

1970's: Bekenstein and Hawking show black holes have an enormous entropy: $S_{BH} = A/4$

1995: Joe shows that his D-branes are the weak coupling description of extremal black branes

1996: By combining D-branes, Strominger and Vafa count the microstates of a charged black hole for the first time and get precise agreement with $\exp(S_{BH})$

From my 1997 review, talking about events in 1996:

"In January, the first calculation showing precise agreement between the entropy of an extremal five dimensional black hole and the counting of string states was performed. In February, this was extended to near extremal black holes, and extreme rotating black holes (still in five dimensions). In March, the entropy of four dimensional black holes, both extremal and near extremal, was reproduced. In June, the rate of low energy radiation from a near extremal five dimensional black hole was shown to agree exactly with the rate from excited D-branes. In August, this was extended to four dimensions."

From my 1997 review, talking about events in 1996:

"In January, the first calculation showing precise agreement between the entropy of an extremal five dimensional black hole and the counting of string states was performed. In February, this was extended to near extremal black holes. Extreme rotating black holes (still in five dimensions). In March, the entropy of four dimensional black holes, both extremal and near extremal was reproduced. In June, the rate of low energy radiation from a near extremal five dimensional black hole was shown to agree exactly with the rate from excited D-branes. In August, this was extended to four dimensions."

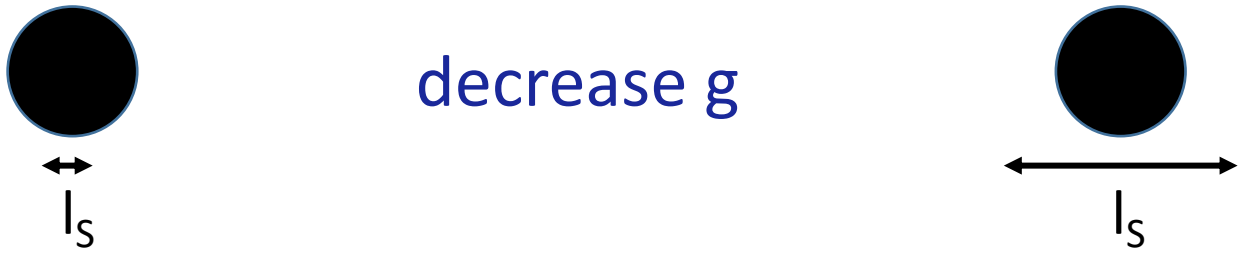
All of this was made possible by Joe's D-branes

Correspondence Principle

Susskind ’93: there might be a 1-1 connection between (4 dim, neutral) black hole states and fundamental string states.

But $S_{BH} \sim M^2$ and $S_{string} \sim M$

Polchinski and GH ‘96: More precisely, $S_{BH} \sim M^2 l_P^2$, $S_{string} \sim M l_s$ and $l_P \sim g\ l_s$ where g is the string coupling. Have to pick g to compare.



If you compare the entropies when the size of the black hole is the string scale $r_0 \sim l_s$:

$$S_{BH} \sim S_{string}$$

in all dimensions (and also for black holes with charge and angular momentum) since $S_{BH} \sim r_0 M$ in all dimensions.

Correspondence Principle: When the curvature at the horizon becomes of order the string scale, the typical black hole state becomes a typical state of strings and D-branes with the same mass, charge, and angular momentum.

Firewalls

Almheiri, Marolf, Sully, Polchinski (AMPS) 2012

They showed that three widely held beliefs about large evaporating black holes were inconsistent:

1) Someone falling into the black hole passes the horizon without noticing it
2) Black hole evaporation is unitary
3) Ordinary local QFT is a good approximation outside the horizon

They suggested that perhaps (1) failed and there was a “firewall” at the horizon.

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