

# Physics Bets, and Conversations with John

## Kip

Whereas Stephen W. Hawking firmly believes that naked singularities are an anathema and should be prohibited by the laws of classical physics,

And whereas John Preskill and Kip Thorne regard naked singularities as quantum gravitational objects that might exist unclothed by horizons, for all the Universe to see,

Therefore Hawking offers, and Preskill/Thorne accept, a wager with odds of 100 pounds sterling to 50 pounds sterling, that when any form of classical matter or field that is incapable of becoming singular in flat spacetime is coupled to general relativity via the classical Einstein equations, the result can never be a naked singularity.

The loser will reward the winner with clothing to cover the winner's nakedness. The clothing is to be embroidered with a suitable concessionary message.



*John P. Preskill Kip S. Thorne*

Stephen W. Hawking John P. Preskill & Kip S. Thorne  
Pasadena, California, 24 September 1991



Whereas Stephen W. Hawking (having lost a previous bet on this subject by not demanding genericity) still firmly believes that naked singularities are an anathema and should be prohibited by the laws of classical physics,

And whereas John Preskill and Kip Thorne (having won the previous bet) still regard naked singularities as quantum gravitational objects that might exist, unclothed by horizons, for all the Universe to see,

Therefore Hawking offers, and Preskill/Thorne accept, a wager that

*When any form of classical matter or field that is incapable of becoming singular in flat spacetime is coupled to general relativity via the classical Einstein equations, then*

**A dynamical evolution from generic initial conditions (i.e., from an open set of initial data) can never produce a naked singularity (a past-incomplete null geodesic from  $\mathcal{I}_+$ ).**

The loser will reward the winner with clothing to cover the winner's nakedness. The clothing is to be embroidered with a suitable, truly concessionary message.



*John P. Preskill Kip S. Thorne*

Stephen W. Hawking John P. Preskill & Kip S. Thorne

Pasadena, California, 5 February 1997

Preskill Fest  
Caltech, 15 March 2013

"All the News  
That's Fit to Print"

# The New York Times

Late Edition

New York: Today, ample clouds, afternoon flurries. High 39. Tonight, partly cloudy. Low 26. Tomorrow, mostly sunny, brisk. High 35. Yesterday, high 39, low 27. Details, page D20.

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NEW YORK, WEDNESDAY, FEBRUARY 12, 1997

\$1 beyond the greater New York metropolitan area.

60 CENTS

## New York City Removes Staff at Women's Shelter

### Sex Abuse and Drug Use Cited at Bronx Center

By NINA BERNSTEIN

The entire staff of the only shelter for battered women run directly by New York City was replaced yesterday after investigators found that workers there had sex with the women, used drugs and alcohol on the job and allowed abusive husbands and boyfriends into the shelter at night.

Edward J. Kuriansky, Commissioner of the city's Department of Investigation, said that both supervisors and staff members had been implicated in the investigation at the New Day shelter in the Bronx, along with guards supplied by a private security company.

"In addition to the disclosure of improper sexual activity," Mr. Kuriansky said, "the investigation found a shocking lack of supervision and accountability that led directly to the theft of facility property and substantial overtime abuse — including staffers who doubled and even tripled their pay while sleeping on the job."

Although city officials removed the entire 44-member staff, most were transferred to other assignments; but 11 members, including the director, were suspended without pay pending disciplinary action. City officials would not disclose their names. Nor would they disclose the identity of the private security company replaced in yesterday's action.

Officials were reluctant to release specific information about the women's allegations for fear of identifying them, or of interfering with the investigation. The exact location of the shelter was also not being revealed to protect the women. The officials said the women described a shelter that was out of control and frightening, where even gifts of food and clothing brought to residents by family members were not safe from theft by staff members, and where children wandering the halls were in danger.

A detailed account of the problems at the New Day shelter emerged last month at the close of a daylong pub-

lic hearing held in the Bronx by the Governor's Commission on Domestic Violence, according to Brian Wing, the Commissioner of the State Department of Social Services, and his deputy, Rose Pandozy.

They said a woman who had testified about her dream of the perfect shelter returned to the audience and began talking privately with two other women about the grim reality they all knew. Ms. Pandozy overheard them, and asked them to tell Mr. Wing, a member of the commission, about their grievances in confidence.

"They started telling me all these terrible things," Mr. Wing recalled in a telephone interview. "It was a mix of allegations, and a lot of it sounded criminal to me, which makes it so shocking. This is supposed to be a safe haven for women."

One woman grew very emotional as she talked, Mr. Wing said. "She was clearly frightened, confused and fearful," he said, "but one was very matter-of-fact."

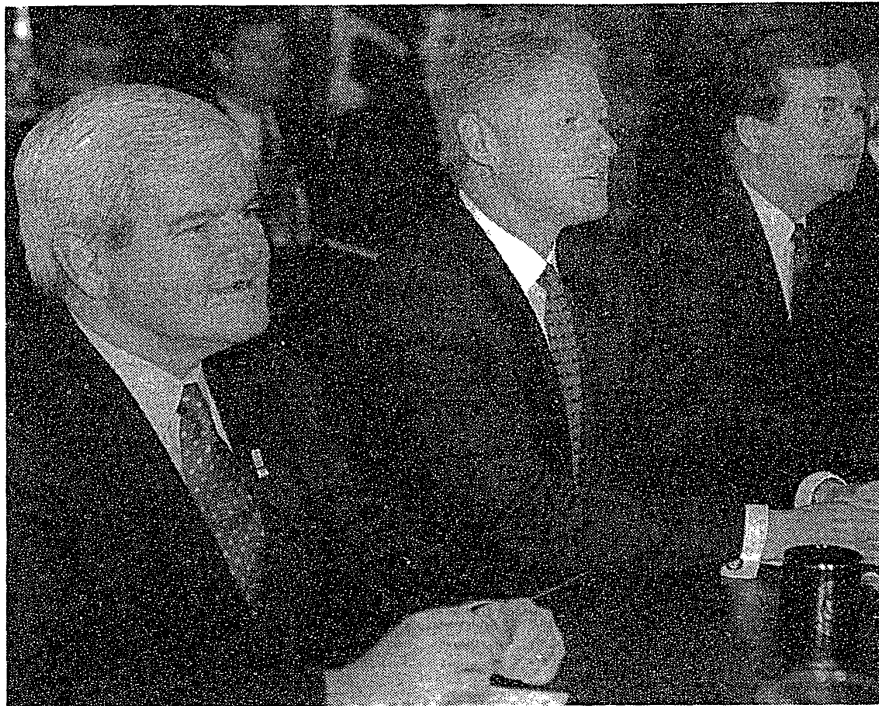
All three detailed rampant wrongdoing, including allegations that staff members coerced sex and stole clients' property and that security was so lax that guards allowed some of the residents' batterers into the shelter. They also told of witnessing child abuse and reporting it to the administrator, who did nothing.

"They had gone for a place looking for safety and they hadn't found it for themselves or their children," Ms. Pandozy said. "And basically, they asked us for help."

"The facility was allowing batterers back in to the facility at night, and that was very disturbing to me that they would allow that to happen," Ms. Pandozy said. On the other hand, residents trying to get back into the shelter after nightfall were sometimes locked out on the street, she said, and were unable to rouse the security staff that was supposed

Continued on Page B3, Column 1

## Clinton and Republican Leaders Agree on Five Goals



Pool Photograph by Joe Marquette

President Clinton on Capitol Hill with Speaker Newt Gingrich, left, and Trent Lott, the Senate majority leader.

### Advisers Say Dinkins Won't Run for Mayor

Two weeks ago, David N. Dinkins roiled the mayoral campaign in New York City by suggesting that he might enter the race to unseat Mayor Rudolph W. Giuliani. But associates of Mr. Dinkins now say that while the former Mayor has enjoyed shaking up what some feel had become a desultory race, he has decided not to run, and would instead lend his support to one of the Democrats who have already declared their interest in running for mayor.

The associates said that Mr. Dinkins had decided that he had already

## Campaign Finance Changes Lose Urgency in Both Parties

By R. W. APPLE Jr.

WASHINGTON, Feb. 11 — Reform of the campaign finance laws, described as a major priority by both Republicans and Democrats after charges of widespread abuses last year, is losing its urgency on Capitol Hill.

Senator John McCain of Arizona, the Republican co-sponsor of the reform bill endorsed by President Clinton, has so far lined up the support of only one other Republican in the Sen-

strong calls for action from the news media and from nonpartisan organizations that study campaign finance.

Only a few days after President Clinton challenged Congress to take early action, legislative leaders of both parties appeared to be stalling. The McCain bill, co-sponsored by Senator Russell Feingold of Wisconsin, a Democrat, would erode the advantage that current law gives to incumbents, and the incumbents,

## Education Help and Tax Cuts Are on List

By ADAM CLYMER

WASHINGTON, Feb. 11 — President Clinton and Congressional leaders agreed today on a five-item list of issues, from the quite specific to the very general, where they hope to work out agreements.

The list comprised a tax credit for employers who hire people off welfare, education, tax cuts for individuals, juvenile crime and justice and using the District of Columbia as a laboratory to test new ideas for education, employment and economic growth.

But just as pointedly, it did not include three issues where the participants were far apart.

The Republicans paid little attention to Mr. Clinton's suggestion that they include legislation to revise the way campaigns are financed.

Vice President Al Gore poked holes in the suggestion of Senator Trent Lott of Mississippi, the majority leader, that legislation dealing with the Superfund program to clean up toxic waste disposal be given a priority.

And Republicans did not agree to include measures to expand health insurance for children, the suggestion of Senator Tom Daschle of South Dakota, the minority leader.

After the meeting, leaders from both parties said it had been a resounding success, at least atmospherically.

"The tone was really uniformly excellent," Mr. Gore said. And Senator Lott said, "It was an overall good session, and the atmosphere was the best I've seen it in quite some time."

The comparison was plainly to the time, barely more than a year ago, when Mr. Clinton and Republican leaders met again and again at the White House, arguing about shut-downs of the Government and how to balance the budget. Today's meeting, which took as a given the idea that all sides wanted a balanced budget, was never contentious.

But for all their approval of the tone of the meeting, held among the Turkish-style drapes of the Presi-

## In Zaire's Unconventional War,

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## In Zaire's Unconventional War, Serbs Train Refugees for Combat

By HOWARD W. FRENCH

KISANGANI, Zaire, Feb. 11 — Every morning, from an airport at the edge of this crumbling city, Yugoslav jets with Ukrainian pilots take off with a scream, headed east toward a huge, shifting war zone, bombing anything that moves in the impenetrable forest below.

On the ground at the airport, Serbian trainers with tattoos and shaved heads drill members of an elite Zairian unit, showing them how to break down and clean the new mounted machine guns and shoulder-fired rockets that the Serbs have supplied to Zaire in defiance of an international arms embargo.

Zairian rebels supported by neighboring Rwanda and Uganda have declared this city, Zaire's third-largest, as their next strategic target. In an effort to blunt the rebel advance, Zairian Government forces with little appetite for battle have distributed assault rifles and mortar charges by the plane to Hutu refugees from neighboring Rwanda.

Some of the Hutu are militia members who organized mass killings of members of their home country's Tutsi minority in 1994, while others are former members of the Rwandan Army, which was defeated by the Tutsi-led forces now in power in Rwanda.

The Rwandan Hutu and a few hundred mercenaries recruited in haste from a handful of European and African countries form the backbone of the Zairian Government fighting force in what by any standard has to be one of Africa's least conventional wars.

Zaire's own soldiers, after blazing a trail of looting, rape and death from the Rwandan border zone, which they fled in November when the rebellion against President Mobutu Sese Seko began, remain twitchy and virtually useless in combat and are mostly left to guard this city.

Because Kisangani has been sacked by unpaid Zairian Army troops twice already in this decade, the population is wary. Given this mistrust, few soldiers dare circulate in town alone, despite the assault rifles they wear slung over their shoulders.

"You've got a bit of everything here," said one international aid worker with long experience in Zaire. "Hutu who have participated

Continued on Page A6, Column 3

## Court Halts Ouster Of Adelphi Trustees

A day after the State Board of Regents dismissed 18 of Adelphi University's 19 trustees, the trustees won a temporary court order blocking their removal. But the Regents said they would appeal, and insisted that the trustees they had appointed on Monday were still in charge of the Long Island university. For their part, the lawyer for the 18 ousted trustees said they were in charge.

The Regents voted on Monday to remove the 18 trustees on the ground that they had failed to protect the university's interests by, among other things, paying the university's president, Dr. Peter Diamantopoulos, too much. With the state courts closed today for Lincoln's Birthday, the legal dispute will not be untangled before tomorrow, at the earliest.

Article, page B1.

of Mr. Dinkins now say that while the former Mayor has enjoyed shaking up what some feel had become a desultory race, he has decided not to run, and would instead lend his support to one of the Democrats who have already declared their interest in running for mayor.

The associates said that Mr. Dinkins had decided that he had already succeeded in focusing public attention on the mayoral race, and particularly on what he saw as Mr. Giuliani's shortcomings.

Some Democrats, however, said they believed that Mr. Dinkins had only diminished the other candidates seeking to unseat Mr. Giuliani.

Mr. Dinkins said he would announce his decision on his radio show, on WLII-AM, at noon today — possibly leaving himself a crack in the door should he change his mind.

Article, page B1.

## A Bet on a Cosmic Scale, And a Concession, Sort Of

By MALCOLM W. BROWNE

Dr. Stephen W. Hawking of Cambridge University in England — the brilliant theorist regarded as one of Albert Einstein's intellectual successors — has conceded defeat in a famous bet he made six years ago on a matter of cosmic significance.

The bet he made with two professors at the California Institute of Technology was that naked singularities could not exist, and now, it seems, they could — maybe.

During a visit to Caltech last week, Dr. Hawking, the author of "A Brief History of Time," a book that delves into the origins of the universe, conceded defeat "on a technicality" to Dr. John P. Preskill and Dr. Kip S. Thorne. The stake was for £100, plus clothing "embroidered with a suitable concessionary message."

A singularity is a mathematical point at which space and time are infinitely distorted, where matter is infinitely dense, and where the rules of relativistic physics and quantum mechanics break down. Singularities are believed to lurk at the hearts of black holes, which conceal their existence from the outer world. A naked singularity would be a singularity bereft of a

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Stephen W. Hawking John P. Preskill & Kip S. Thorne Pasadena, California, 24 September 1991



Stephen Shames/Matrix

Bettor, and, below, the bet.

concealing black-hole shell, and therefore visible, in principle, to outside observers.

Although neither light nor any other kind of signal can escape from them, a half-dozen or so black holes have been revealed by their gravitational effects on nearby stars. Black holes have also betrayed their presence by sucking in matter from nearby space. As it spirals toward the hole, the matter is heated to incandescence and the emission of

Continued on Page A22, Column 1

zoned that study campaign. Finally a few days after President Clinton challenged Congress to take early action, legislative leaders of both parties appeared to be stalling. The McCain bill, co-sponsored by Senator Russell Feingold of Wisconsin, a Democrat, would erode the advantage that current law gives to incumbents, and the incumbents, whatever their party and whatever their seniority, are resisting.

Nor has bipartisan harmony been achieved on the terms of the Senate investigation into the alleged abuses in the 1996 campaign. And every day that goes by, Mr. McCain said, "represents another day when the subpoenas don't go out, the evidence is not gathered, and there is more time, for people to cover their tracks."

Senate aides said today that the Senate Governmental Affairs Committee, which is to conduct the inquiry, had prepared more than 40 subpoenas for, among others, the Democratic National Committee and the Commerce Department, where John Huang, later a top party fund-raiser, once held a senior position.

A subpoena has also been readied for the Republican National Committee.

Mr. Thompson, who is to head the investigation, has asked for \$6.5 million and a staff of 80 to carry it out, a figure that Senator Tom Daschle of South Dakota, the leader of the Democratic minority, described as "outrageous." Mr. Thompson has also resisted setting a deadline for con-

Continued on Page A20, Column 1

leaders' met again and again at the White House, arguing about shut-downs of the Government and how to balance the budget. Today's meeting, which took as a given the idea that all sides wanted a balanced budget, was never contentious.

But for all their approval of the tone of the meeting, held among the Turkish-style drapes of the President's Room, just off the Senate chamber, they were cautious about predicting the results to be achieved on an undetermined schedule by task forces whose composition they have not yet figured out.

Speaker Newt Gingrich said at a news conference, "There is a possibility here that we could actually begin a bipartisan process that would be helpful to the national capital, that would be helpful to helping people get off welfare and go to work, that would help young people get educated better, that would be useful in small business being able to hire more people."

Mr. Gingrich added: "That's not a small step, but that's the most we want to say for today. And if we go beyond that, we could end up starting an argument over how we're cooperating. So I think we're better off just to sort of relax. This is a nice step for one day, and we'll come back another day."

Senator Daschle said, "This is a very productive beginning. But it's only that; it's the beginning. It's an opportunity for us to compare priorities, to address those areas of com-

Continued on Page A20, Column 1

## White House Memo

# Clinton Seems to Keep Running Though the Race Is Run and Won

By ALISON MITCHELL

WASHINGTON, Feb. 11 — Last year, President Clinton waged a campaign that looked like government, announcing initiatives at his political rallies and virtually never mentioning his opponent. Now, with his last election behind him, Mr. Clinton is running the White House in a manner that looks like a campaign.

Some of the President's recent national appearances to highlight his education proposals have been indistinguishable from the re-election rallies of 1996. When he traveled to the northern suburbs of Chicago last month to call for testing to assess education standards, Mr. Clinton dropped into a classroom briefly, just as he did before campaign rallies, then delivered a speech in a gymnasium bedecked with a giant American flag.

Even the music is sometimes the same. When Mr. Clinton made a similar appearance at a college in Georgia last week, the school band struck up one of his campaign theme songs, Fleetwood Mac's, "Don't Stop (Thinking About Tomorrow)." Although Mr. Clinton will not run

for office again, he is still using his campaign polling firm of Penn & Schoen Associates to gauge public opinion and help him test and craft language for his speeches. On Monday, in fact, officials of the Democratic National Committee met with Mark Penn to discuss payment terms and a plan for polling in 1997 for both the White House and the Democratic Party.

The weekly evening meeting in the White House residence, where Mr. Clinton once gathered his aides and strategists to plot his campaign, is run by Erskine B. Bowles, the White House chief of staff. Along with other White House officials, the pollsters and the campaign media team of Robert Squier and Bill Knapp, of Squier Knapp Ochs Communica-

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### Trade Shift by China Is Seen

China is willing to drop trade barriers in return for membership in the World Trade Organization, Administration officials say. Page D1.

### Action Delayed on Nominees

Sensors delayed votes on Anthony Lake as head of the C.I.A. and Federico F. Peña as Energy Secretary. Pages A19 and A20.

### Oscar Bids to Independents

Independent films — "The English Patient," "Fargo" and "Shine" — led Academy Award nominations, beating big-studio movies. Page C9.

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Stephen Shames/Matrix

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Stephen W. Hawking John P. Preskill & Kip S. Thorne  
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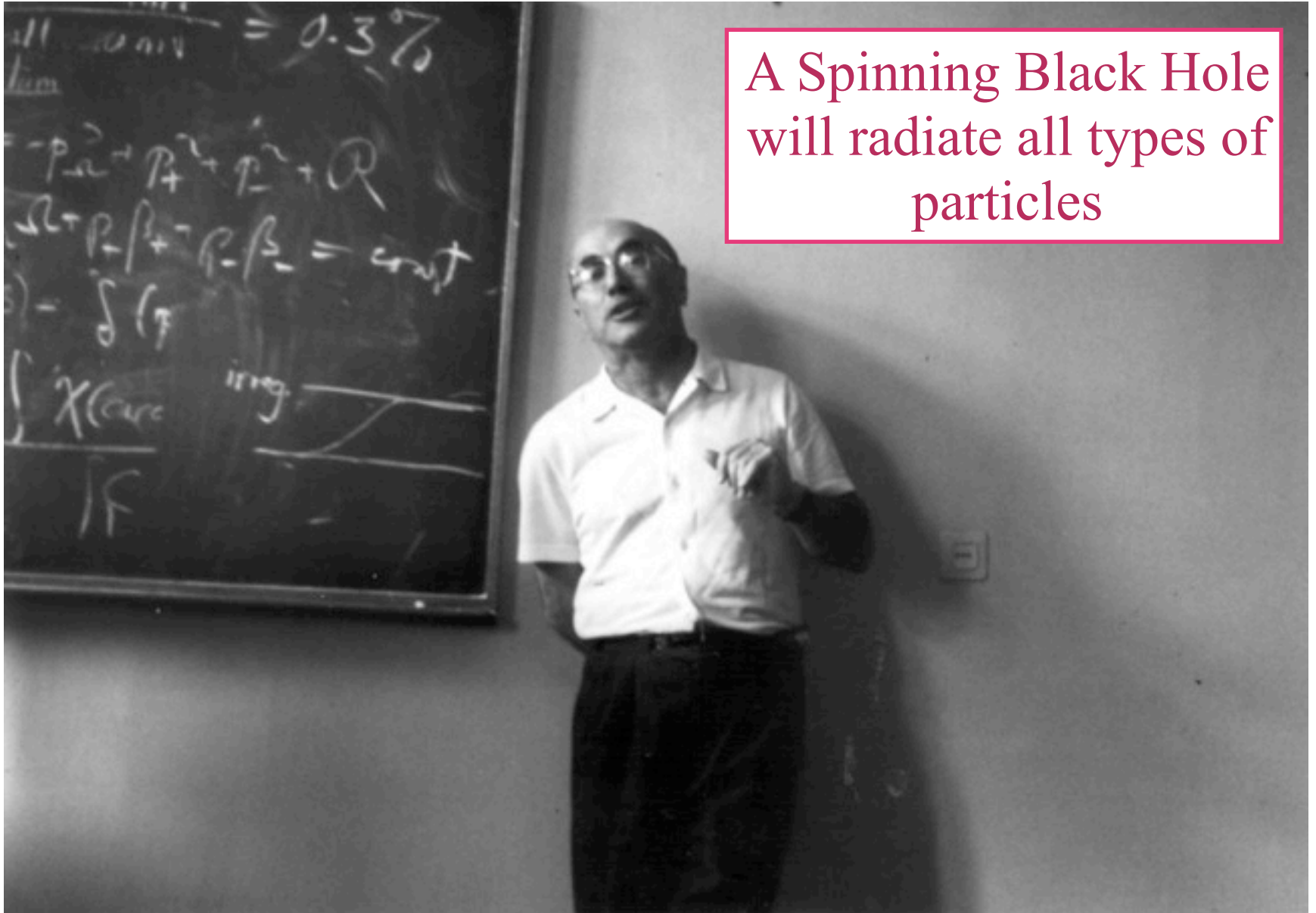
for office again, campaign posters, Schoen Associates' opinion and his language for day, in fact, cratic National Mark Penn terms and a for both the Democratic F

The weekly White House Clinton once strategists to run by Erskine House chief of White House and the campaign Robert Squier Squier Knapp

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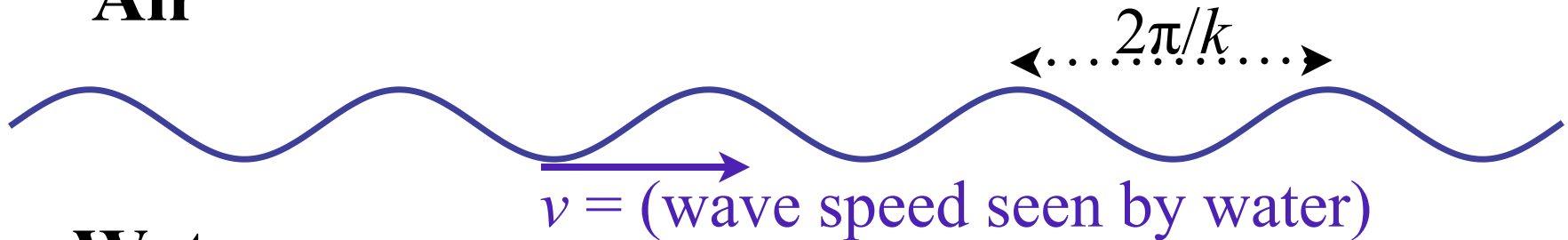


# 1971 Bet : Yakov Borisovich Zel'dovich



# What Zel'dovich Knew That I Did Not

**Air**

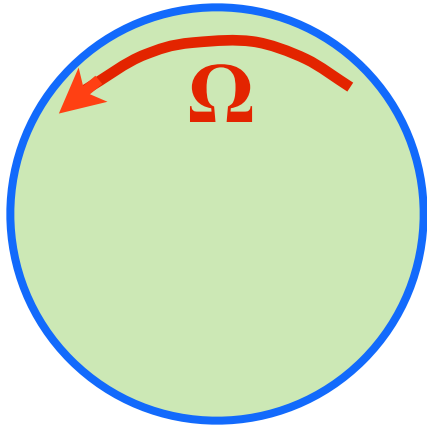


**Water**

$V =$  (water speed seen by air)

- In water's frame,  $\xi \sim \exp[ik(x - vt)]$
- Air's (primed) frame,  $x = x' + Vt$  so  $\xi \sim \exp[ik(x' - (v - V)t)]$
- If  $V > v$ , then
  - \* wave is dragged upstream by water
  - \* wave frequency has opposite sign in water frame and air frame
  - \* wave energy is positive in water frame, negative in air frame
  - \* sound waves in air: radiation reaction amplifies waves
  - \* incoming sound waves drive water waves, which amplify sound waves

# Rotating, electrically conducting sphere



- Incoming EM waves with  $E \sim \exp[i(m\phi - \omega t)]$
- In sphere's (primed) frame  $\phi = \phi' + \Omega t$  so  
 $E \sim \exp[im\phi - i(\omega - m\Omega)t]$
- If  $m\Omega > \omega$ , then

- \* wave frequency has opposite sign in sphere's and inertial frames
- \* energy of sphere's currents  $> 0$  as seen by sphere,  $< 0$  in inertial frame
- \* incoming waves are amplified by sphere

# Zel'dovich's Two Big Leaps

- Similarly, a spinning black hole must amplify incoming classical waves ... and also incoming Fermion fields
- **Incoming vacuum fluctuations will get amplified, producing real particles - a spinning black hole will spontaneously radiate**

*JETP Letters*, **14**, 180 (1971)



# Our Bet

- ◆ Earnest Hemingway's White Horse Scotch
- ◆ The Best Georgian Cognac



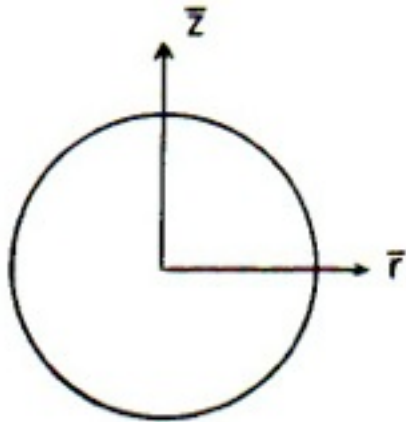
# 1973 - Hawking & I to Moscow

- Zel'dovich showed Stephen his argument
- Stephen went home and thought
- 1974: Stephen demonstrated that all black holes, rotating or nonrotating, must radiate all types of particles - Hawking Radiation
- I conceded my bet to Zel'dovich

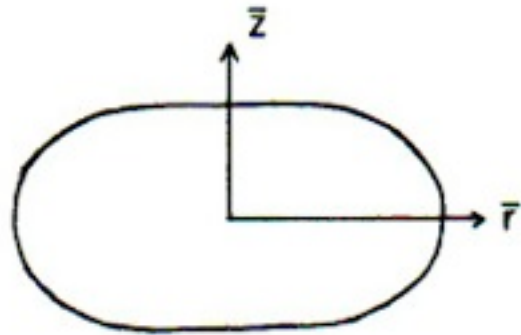
# Bet with Chandrasekhar: Black-Hole Stability



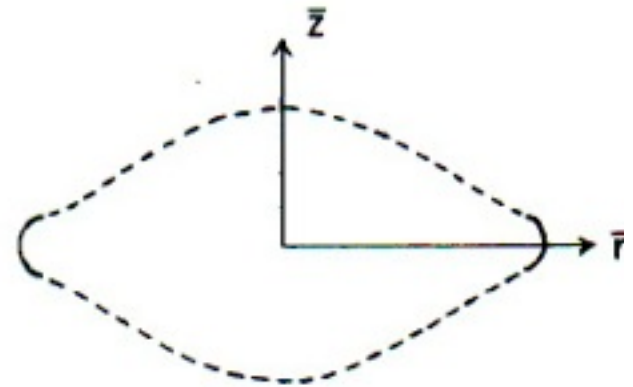
Larry Smarr, 1971:  
Embedding Diagram for Horizon of a Kerr Black Hole



(a)  $\frac{a}{M} = 0$



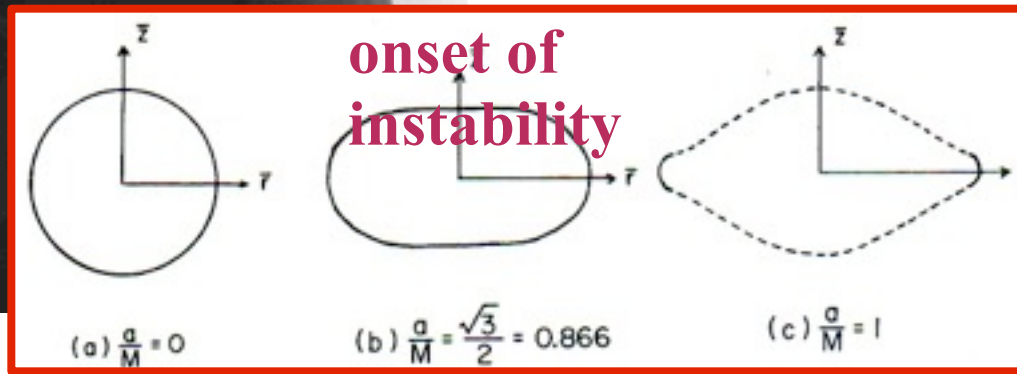
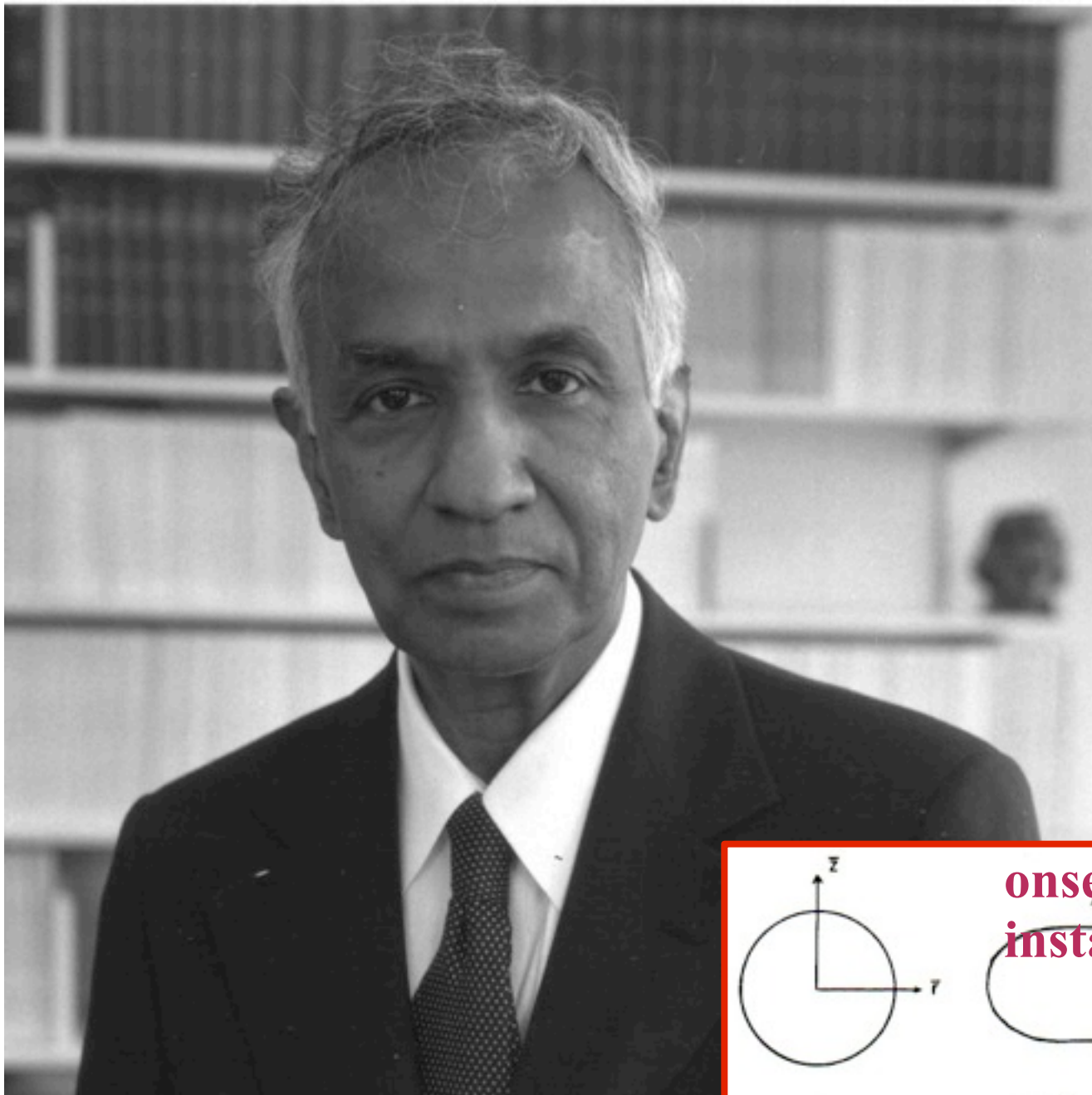
(b)  $\frac{a}{M} = \frac{\sqrt{3}}{2} = 0.866$



(c)  $\frac{a}{M} = 1$

# Chandrasekhar visiting Caltech





Whereas S. Chandrasekhar believes that the Establishment is falsely overconfident of its mastery of black-hole physics, and

Whereas Kip S. Thorne, Defender of the Establishment, has great confidence in the Establishment's 1971 view of black-hole physics,

Therefore let it be known that a wager is hereby accepted at odds of one 1-year subscription to Playboy Magazine (from S.C. to K.S.T.), versus one 1-year subscription to The Listener (from K.S.T. to S.C.):

S.C. wagers that there exists a critical value,  $a_0 < M$ , such that, for  $a > a_0$  the Kerr Metric is unstable against first-order perturbations. K.S.T. wagers that the Kerr Metric is stable or neutrally stable for all  $a \leq M$ .

S. Chandrasekhar

Witnesses:

John A. Wheeler, lawyer

William Press

Paul Teukolsky

Kip S. Thorne

Pasadena, California

29 November 1971

- 1973: Bill Press and Saul Teukolsky
  - » numerical computation of eigenfrequencies of quasinormal modes for  $l=2$ ,  $l=3$  and all  $m$ .
  - » No sign of instability



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K.S.J. to S.C.):

S.C. wagers that there exists a critical value,  
 $a_0 < M$ , such that, for  $a > a_0$  the Kerr Metric is  
unstable against first-order perturbations. K.S.J. wagers  
that the Kerr Metric is stable or neutrally stable for  
all  $a \leq M$ .

S. Chandrasekhar

Witnesses:

John A. Wheeler, lawyer

William Press

Saul Teukolsky

Kip S. Thorne

Pasadena, California

29 November 1971

I hereby accept, instead of a Playboy  
Subscription, a Subscription to The Listener - K.S.J.

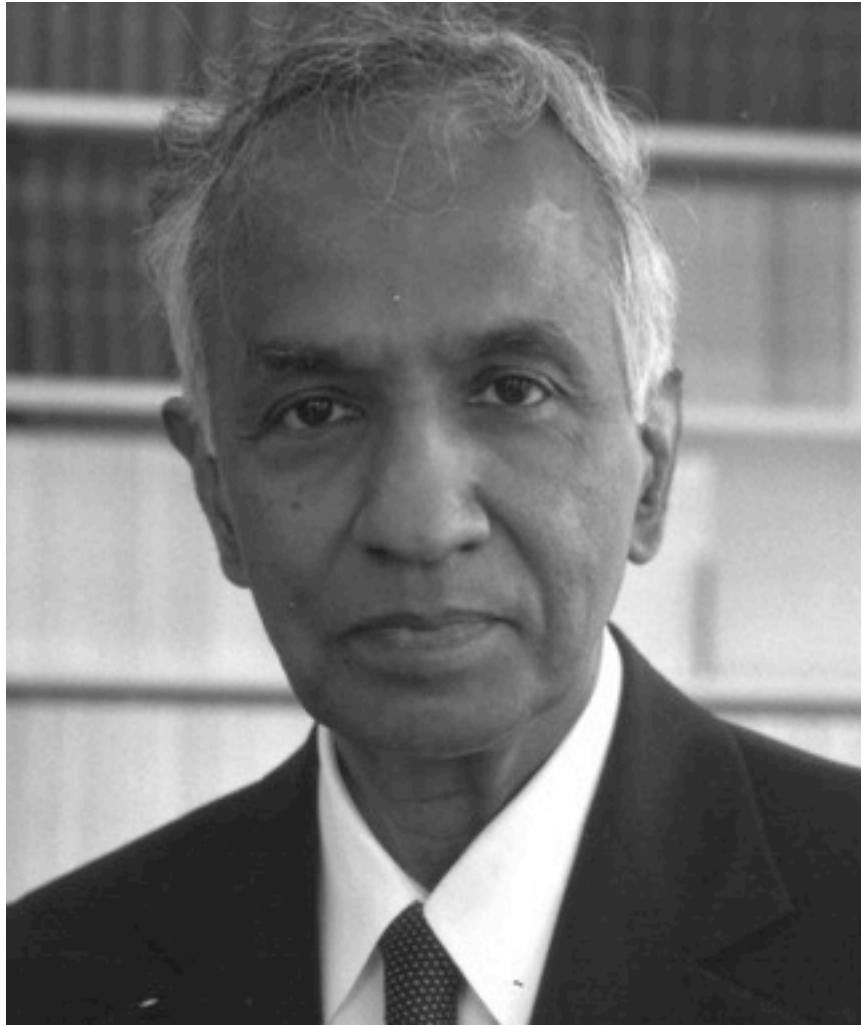
I concede that I was wrong

S. Chandrasekhar, July 8, 88

1988



# How Physicists' Minds Work

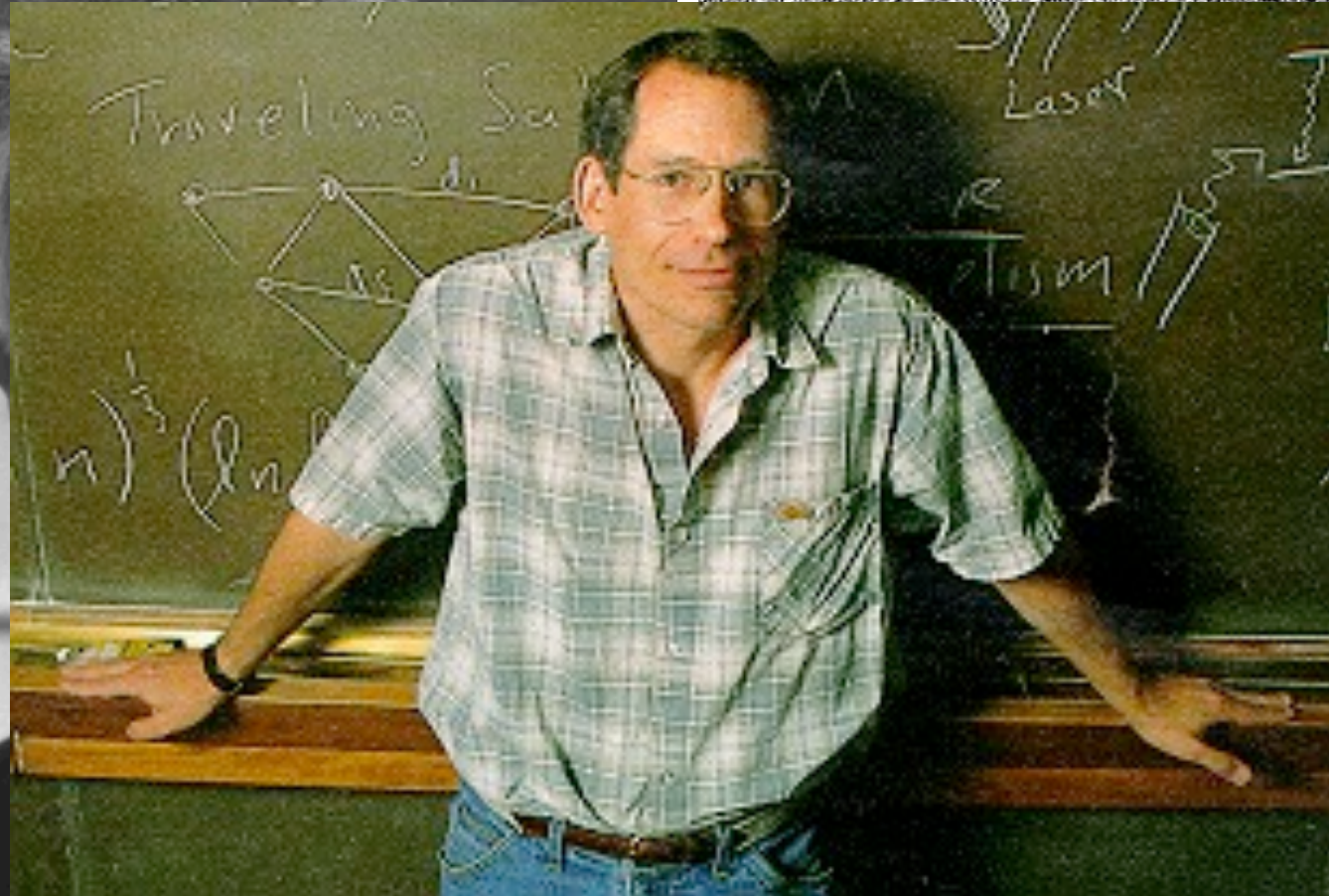


Chandrasekhar

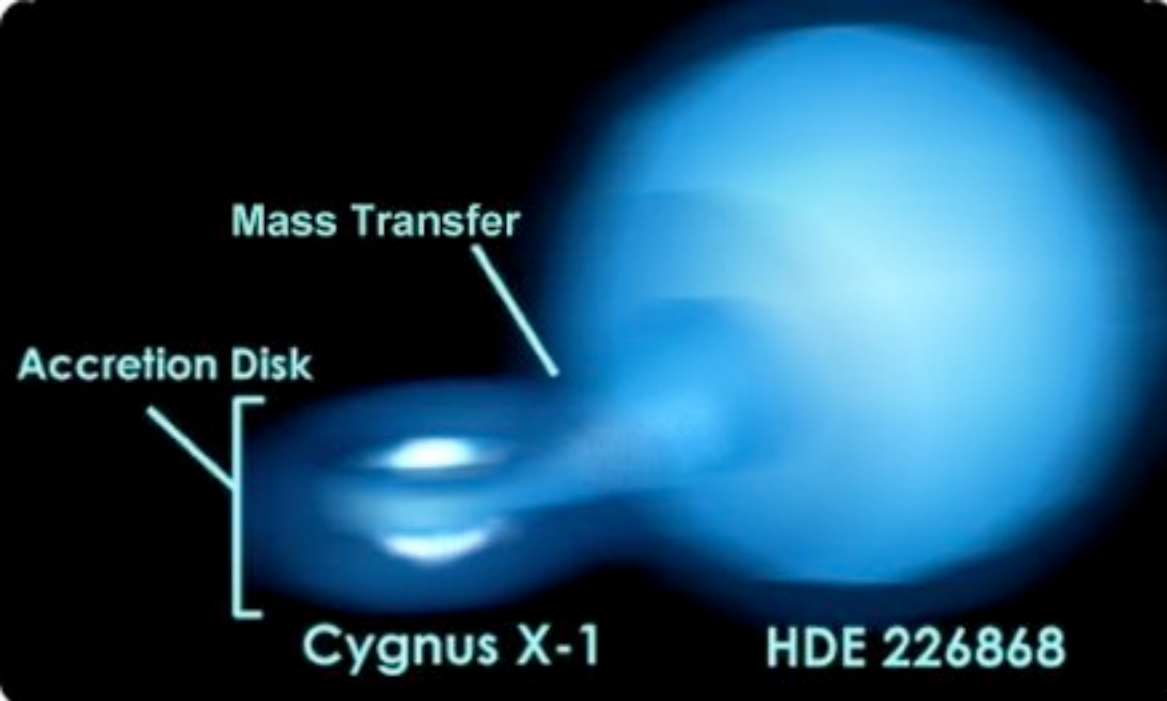
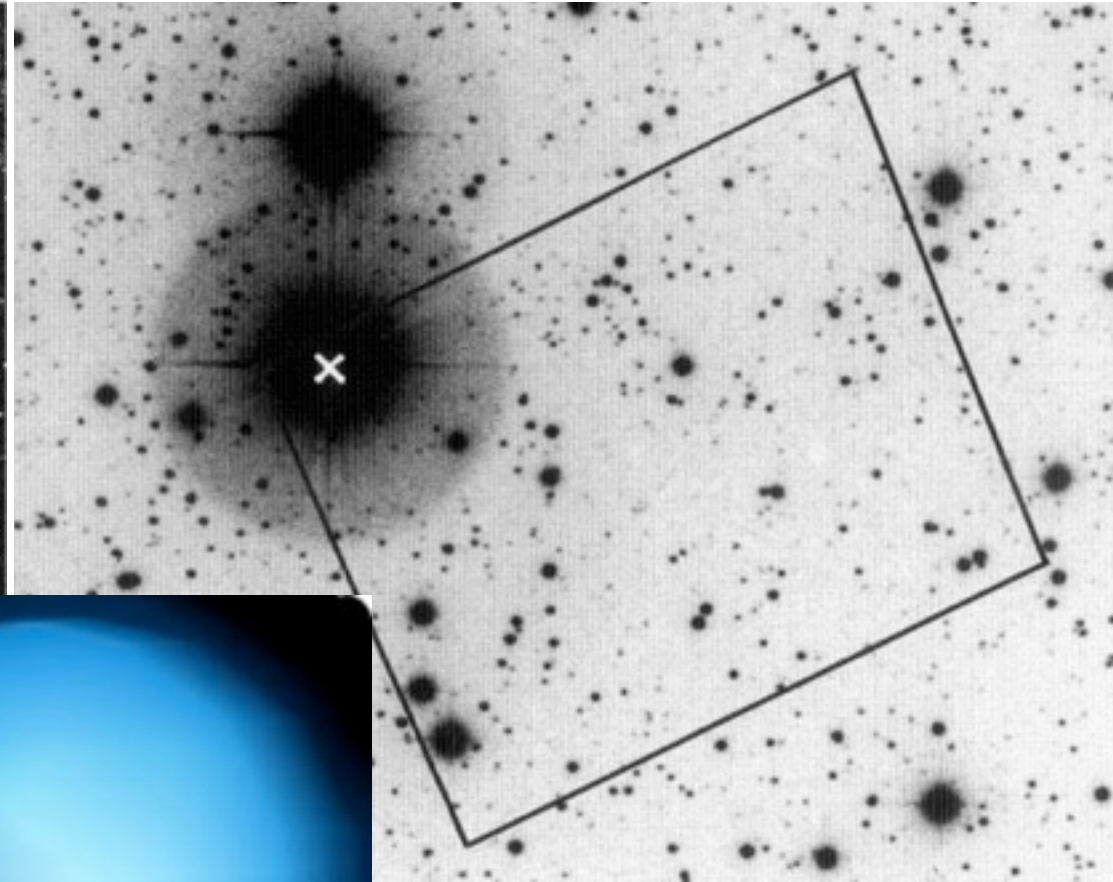


Zel'dovich

# How Physicists' Minds Work



# Bet with Hawking: Is Cygnus X-1 a Black Hole?



# 1974-75 Stephen at Caltech



Whereas Stephen Hawking has such a large investment in General Relativity and Black Holes and desires an insurance policy, and whereas Kip Thorne likes to live dangerously without an insurance policy,

Therefore be it resolved that Stephen Hawking bets 1 year's subscription to "Penthouse" as against Kip Thorne's wager of a 4-year subscription to "Private Eye", that Cygnus X 1 does not contain a black hole of mass above the Chandrasekhar limit

*Stephen Hawking*

*Kip S. Thorne*



Witnessed this tenth  
day of December 1974  
Frankman Amazyllus Werner J.

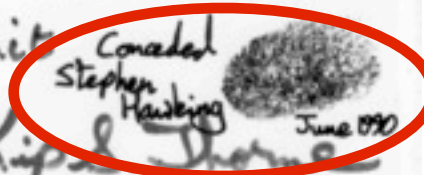


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*Stephen Hawking*

*Kip Thorne*



1990



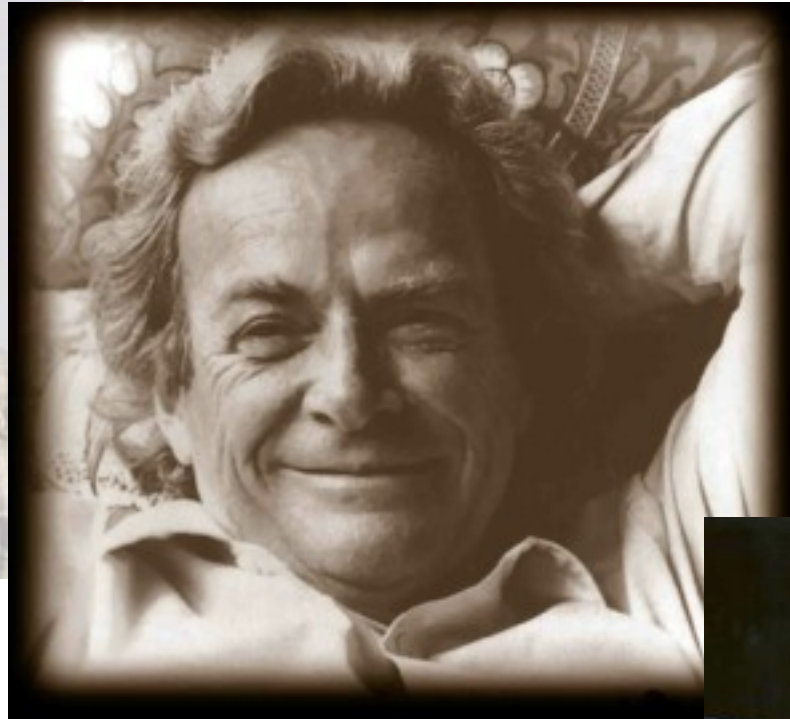
Witnessed this tenth day of December 1974  
Frankman Amazythas Werner J





*1983: John  
moved to Caltech*

*1988: Feynman Died*



*1990: Mike Scott*



*April 8-11, 1991*  
*Trying to Recruit Stephen for Feynman Professorship*



**September/October 1991 - Stephen's first visit**



# Bet: Cosmic Censorship



*Whereas Stephen W. Hawking firmly believes that naked singularities are an anathema and should be prohibited by the laws of classical physics,*

*And whereas John Preskill and Kip Thorne regard naked singularities as quantum gravitational objects that might exist unclothed by horizons, for all the Universe to see,*

*Therefore Hawking offers, and Preskill/Thorne accept, a wager with odds of 100 pounds sterling to 50 pounds sterling, that when any form of classical matter or field that is incapable of becoming singular in flat spacetime is coupled to general relativity via the classical Einstein equations, the result can never be a naked singularity.*

*The loser will reward the winner with clothing to cover the winner's nakedness. The clothing is to be embroidered with a suitable concessionary message.*

**September 24, 1991**



*John P. Preskill Kip S. Thorne*

Stephen W. Hawking    John P. Preskill & Kip S. Thorne  
Pasadena, California, 24 September 1991

# Six years later: 1997



*The loser will reward the winner with clothing to cover the winner's nakedness. The clothing is to be embroidered with a suitable concessionary message.*



*John P. Preskill Kip Thorne*

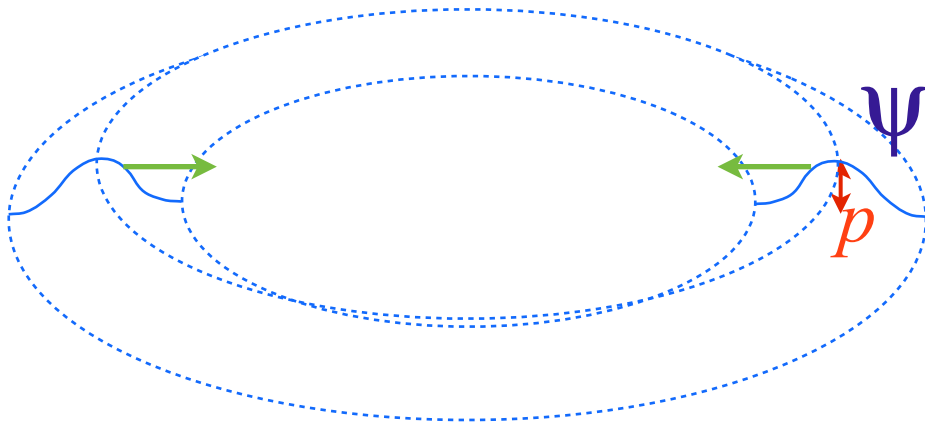
Stephen W. Hawking    John P. Preskill & Kip S. Thorne  
Pasadena, California, 24 September 1991

*Conceded on a  
Technicality  
5 Feb. 1997:*



*Stephen W. Hawking*

# Matt Choptuik: Scalar-Wave Implosion



scalar wave's energy generates spacetime curvature, then wave interacts with the curvature

$p = p_*$  : Discretely self-similar

***NAKED SINGULARITY***

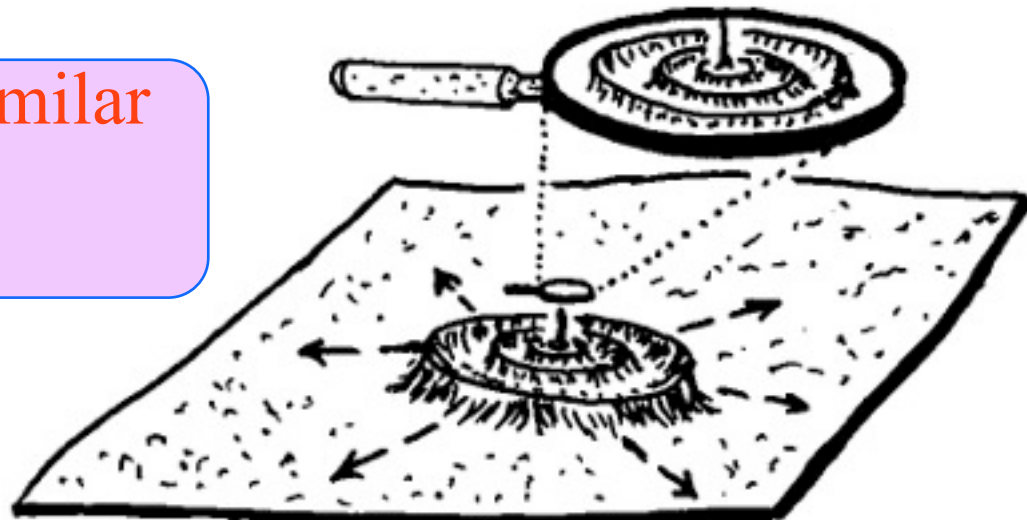
$p > p_*$  : Black hole forms

$$M_{BH} \propto (p - p_*)^\beta, \quad \beta \simeq 0.374$$

$p < p_*$  : Wave disperses

$$\left( R_{\alpha\beta\gamma\delta} R^{\alpha\beta\gamma\delta} \right)_{\max}^{-1/4} \propto (p - p_*)^\beta$$

***Organized Frothing***



# A Bet on a Cosmic Scale, And a Concession, Sort Of

By MALCOLM W. BROWNE

Dr. Stephen W. Hawking of Cambridge University in England — the brilliant theorist regarded as one of Albert Einstein's intellectual successors — has conceded defeat in a famous bet he made six years ago on a matter of cosmic significance.

The bet he made with two professors at the California Institute of Technology was that naked singularities could not exist, and now, it seems, they could — may-



Stephen Shames/Matrix

Bettor, and, below, the bet.

During a visit to Caltech last week, Dr. Hawking, the author of "A Brief History of Time," a book that delves into the origins of the universe, conceded defeat "on a technicality" to Dr. John P. Preskill and Dr. Kip S. Thorne. The stake was for £100, plus clothing "embroidered with a suitable concessionary message."

point at which space and time are infinitely distorted, where matter is infinitely dense, and where the rules of relativistic physics and quantum mechanics break down. Singularities are believed to lurk at the hearts of black holes, which conceal their existence from the outer world. A naked singularity would be a singularity bereft of a

concealing black-hole shell, and therefore visible, in principle, to outside observers.

Although neither light nor any other kind of signal can escape from them, a half-dozen or so black holes have been revealed by their gravitational effects on nearby stars. Black holes have also betrayed their presence by sucking in matter from nearby space. As it spirals toward the hole, the matter is heated to incandescence and the emission of

*Continued on Page A22, Column 1*

***The loser will reward the winner with clothing to cover the winner's nakedness. The clothing is to be embroidered with a suitable concessionary message.***



*John P. Preskill Kip S. Thorne*

Stephen W. Hawking John P. Preskill & Kip S. Thorne  
Pasadena, California, 24 September 1991

## *The value of science bets*

# Renewed Bet

Whereas Stephen W. Hawking (having lost a previous bet on this subject by not demanding genericity) still firmly believes that naked singularities are an anathema and should be prohibited by the laws of classical physics,

And whereas John Preskill and Kip Thorne (having won the previous bet) still regard naked singularities as quantum gravitational objects that might exist, unclothed by horizons, for all the Universe to see,

Therefore Hawking offers, and Preskill/Thorne accept, a wager that

*When any form of classical matter or field that is incapable of becoming singular in flat spacetime is coupled to general relativity via the classical Einstein equations, then*

**A dynamical evolution from generic initial conditions** (i.e., from an open set of initial data) **can never produce a naked singularity** (a past-incomplete null geodesic from  $\mathcal{I}_+$ ).

The loser will reward the winner with clothing to cover the winner's nakedness. The clothing is to be embroidered with a suitable, truly concessionary message.



Stephen W. Hawking

John P. Preskill      Kip S. Thorne

John P. Preskill & Kip S. Thorne

Pasadena, California, 5 February 1997

# Black-Hole Information Loss

- 1974-75: Hawking at Caltech



Vladimir  
Braginsky

Kip

Don  
Page

Sandor  
Kovacs

Carlton  
Caves

Steve  
Slutz

Stephen

David Lee

# Black-Hole Information Loss

- 1974-75: Hawking at Caltech

- \*Retooling - to work on quantum gravity
- \*Trying to understand implications of Hawking radiation
- \*Information Loss!!  
Pure state evolves to mixed state

**Great trouble getting his paper through the referees!**



# 1975 - 1997

- Two communities; two different views -
  - » **Particle theory roots:** Hamiltonian-based QM sacred; requires unitary evolution; no information loss
  - » **Relativity roots** [my version]: Why worry? Feynman path integral formulation can handle non-unitary evolution (Hartle Gell-Mann)
    - if include histories with CTCs in path integral, it will have to be nonunitary.



# 1997

(the day after our renewed cosmic censorship bet)

Whereas Stephen Hawking and Kip Thorne firmly believe that information swallowed by a black hole is forever hidden from the outside universe, and can never be revealed even as the black hole evaporates and completely disappears,

And whereas John Preskill firmly believes that a mechanism for the information to be released by the evaporating black hole must and will be found in the correct theory of quantum gravity,

Therefore Preskill offers, and Hawking/Thorne accept, a wager that:

When an initial pure quantum state undergoes gravitational collapse to form a black hole, the final state at the end of black hole evaporation will always be a pure quantum state.

The loser(s) will reward the winner(s) with an encyclopedia of the winner's choice, from which information can be recovered at will.



Stephen W. Hawking & Kip S. Thorne



John P. Preskill

Pasadena, California, 6 February 1997

# Seven Years Later

- Stephen caved in
  - » Motivated largely (I think) by Maldacena work
- In some (very few) histories, black hole does not form
  - » information gets out via those histories

**GRG Conference in Dublin, Ireland: 21 July 2004  
combined lecture, press conference, & bet signoff**



Kip S. Thorne


Stephen W. Hawking & Kip S. Thorne

John P. Preskill

John P. Preskill

Pasadena, California, 6 February 1997

I concede, now I have  
seen inside black holes  
- 21 July 2004  
Stephen W. Hawking



## The New York Times

July 22, 2004

### About Those Fearsome Black Holes? Never Mind

By DENNIS OVERBYE

Dr. Stephen W. Hawking threw in the towel yesterday, or at least an encyclopedia.

Dr. Hawking, the celebrated Cambridge University cosmologist and best-selling author, declared at a scientific conference in Dublin that he had been wrong in a controversial assertion he made 30 years ago about black holes, the fearsome gravitational abysses that can swallow matter and energy, even light.

As atonement he presented Dr. John Preskill, a physicist from the California Institute of Technology, with a baseball encyclopedia.

- I have not conceded. Why?
- Southwest 3756, OAK - BUR  
February 22



AMPS Firewall Conundrum

# My Prime Source of Wisdom

● 1968 - 1988



● 1988 -

- \*Chronology protection
- \*Standard quantum limit
- \*quantum nondemolition for LIGO



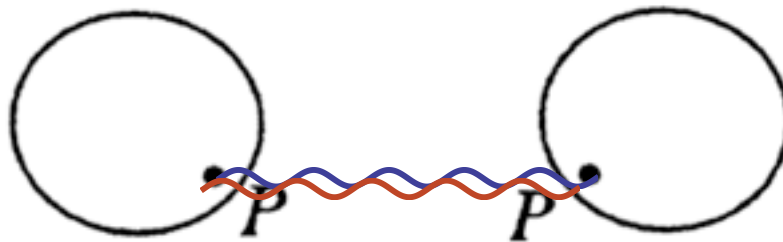
# Chronology Protection

- \*How strong is the divergence?
- \*Will back-action destroy the wormhole before semiclassical theory fails?
- \*How affected by supersymmetry?
- \*How universal?

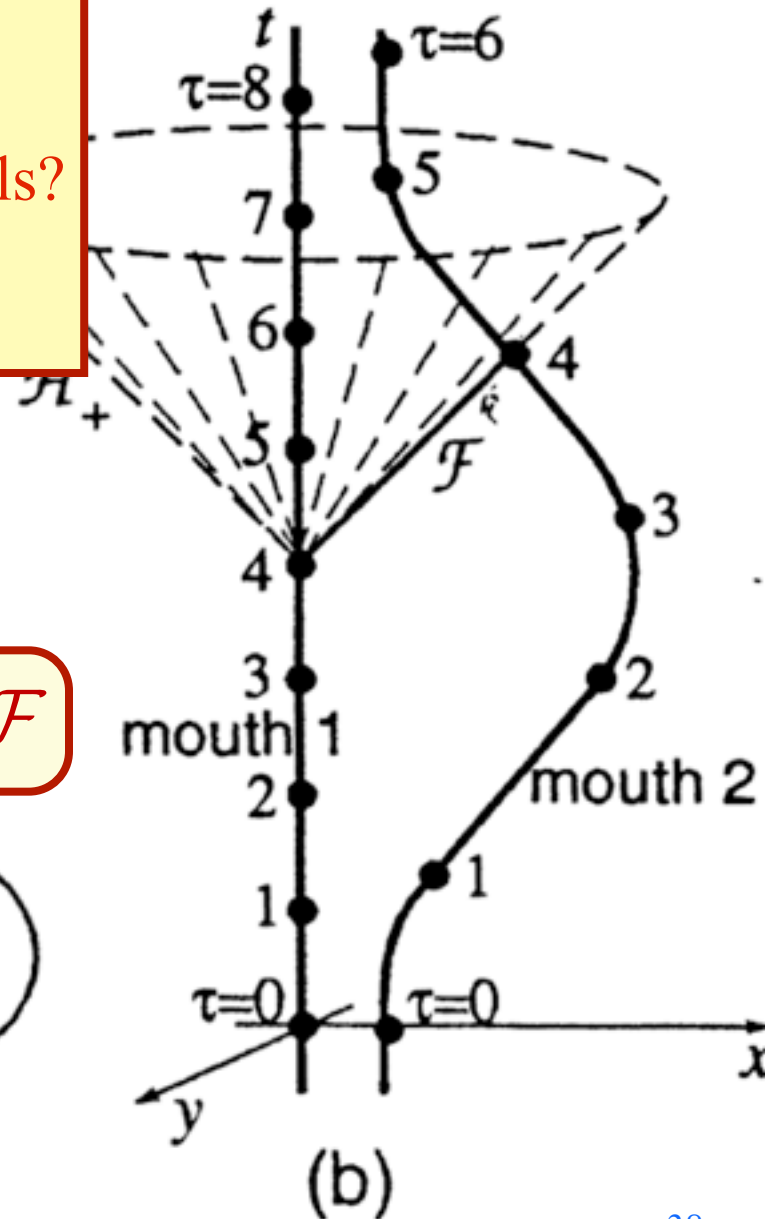
with Sung-Won Kim



$\langle 0 | T_{\mu\nu}^{\text{ren}} | 0 \rangle$  diverges at Fountain  $\mathcal{F}$



(a)



(b)

# A few highlights of subsequent research

- Using Feynman path integrals, one can evolve quantum fields across a Chronology horizon, into and through a region with closed timelike curves (e.g. Hartle 1996), *BUT*
- The evolution is **nonunitary** (e.g. Politzer 1992) and pure states evolve into mixed states (e.g. Cassidy 1994)
- Nevertheless, **probabilities are conserved**
- But the two-point function is singular for free scalar field at some points on any compactly generated Chronology horizon (Kay, Radzikowski & Wald 1997)

Excellent review: Friedman & Higuchi, arXiv:0801.0735

# Thankyou, John!

