

THE SCIENCE OF JOHN ARCHIBALD WHEELER

HIS MOTIVATIONS:

■ WHAT ARE THE FUNDAMENTAL BUILDING BLOCKS OF THE UNIVERSE?

1934-1954: PARTICLES



1954-1974: CURVED (WARPED) SPACE TIME



1974 → Today: QUANTUM INFORMATION

In pursuing this quest
Wheeler has produced an
enormous legacy for science!





JOHN WHEELER, ABOARD A
STEAMER, BOUND FOR COPENHAGEN
SUMMER 1934



Niels Bohr, 1934.

*(Photograph by John Wheeler, courtesy of Niels Bohr Archive,
Copenhagen.)*

TECHNICAL CONTRIBUTIONS TO NUCLEAR & PARTICLE PHYSICS

e.g.:

- Invented the **S-Matrix**
- proved it symmetric & unitary

- Formulated theories of
Resonating group structure

Clustering theory

μ mesic atoms

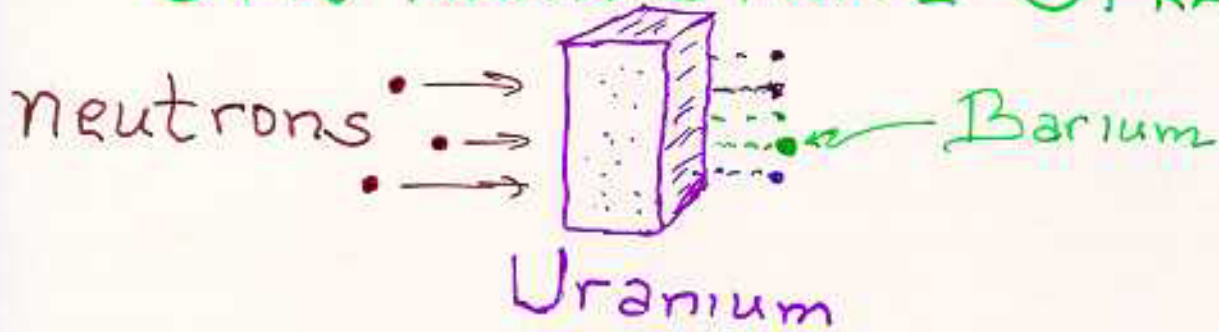
polyelectrons ($e^+ e^-$ atoms)

relativistic dispersion relations

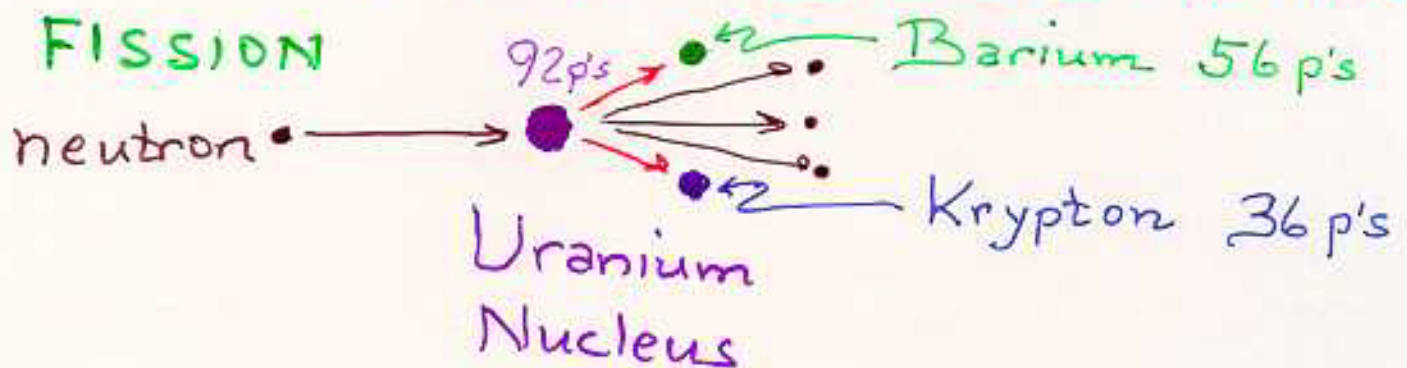
BOHR & WHEELER - 1939:

THEORY OF NUCLEAR FISSION

- December 1938, Berlin Germany
OTTO HAHN & FRITZ STRASSMAN



- Explanation: OTTO FRISCH & LISE MEITNER



- Spring 1939, Bohr & Wheeler

Uranium Nucleus is like a drop of water



Need: Large Z^2/A ; even # p's, odd # n's

Predictions:

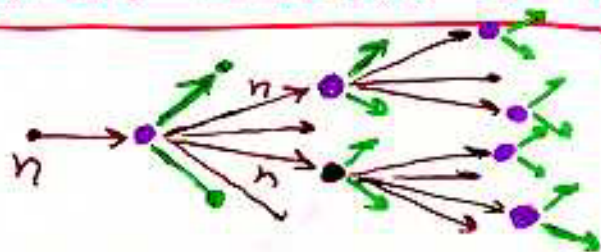
- Must be ^{235}U (92 p's, 143 n's) not ^{238}U
 ^{239}Pu will also fission

WORLD WAR II & MANHATTAN PROJECT

BOHR-WHEELER THEORY PUBLISHED **SEPT 1, 1939**

GERMAN INVASION OF POLAND

ATOMIC BOMB?



- Chain Reaction

↳ Theory: **Zel'dovich** & Khariton
RUSSIA · 1939

- Two POSSIBLE FUELS

^{235}U : very hard to separate from ^{238}U

^{239}Pu : does not exist in Nature

Must be made in a Reactor

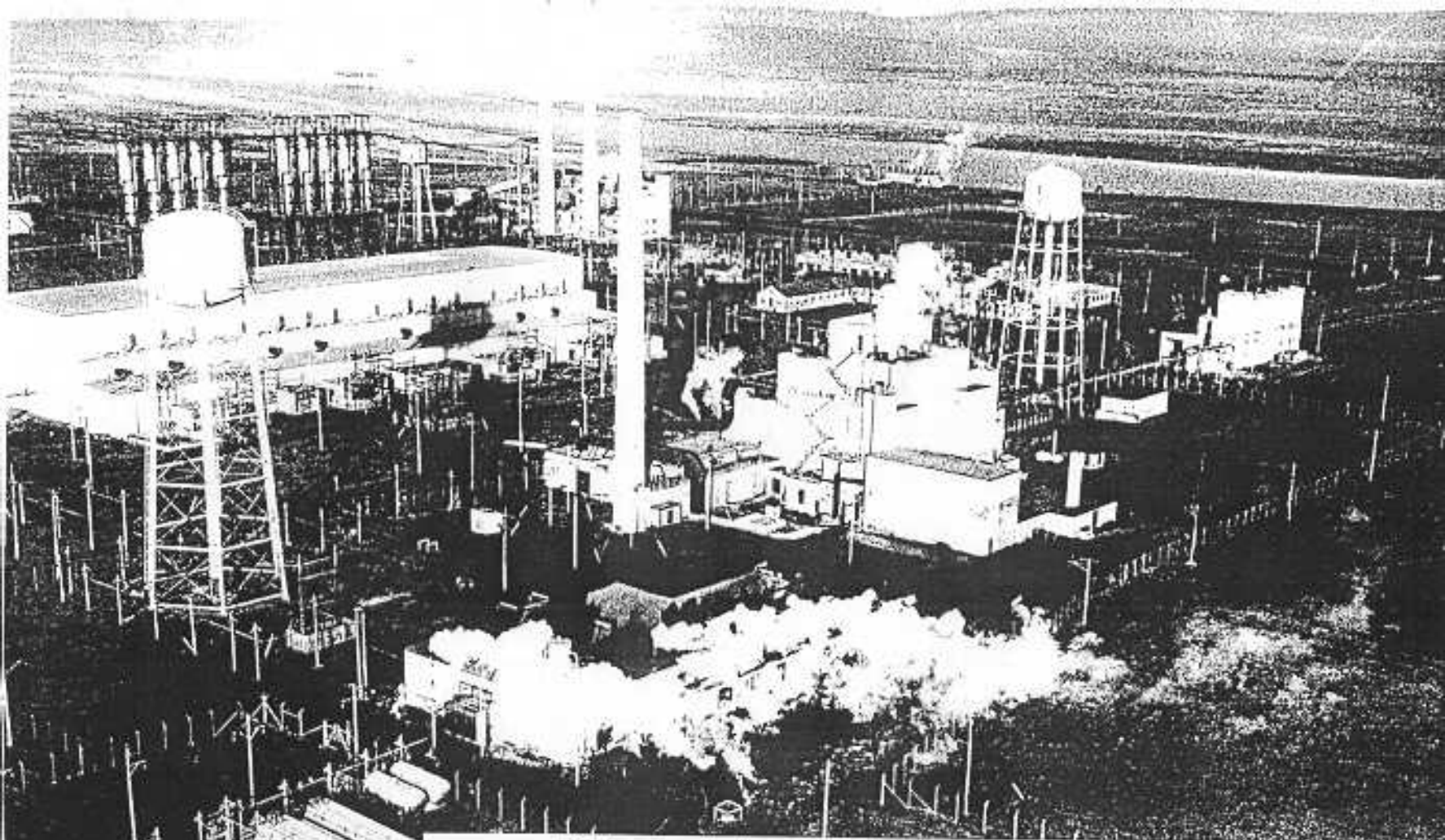
Pearl Harbor : Dec. 1941

JENA, GERMANY - SUMMER 1980



JOHN ARCHIBALD
WHEELER

YAKOV BORISOVICH
ZEL'DOVICH



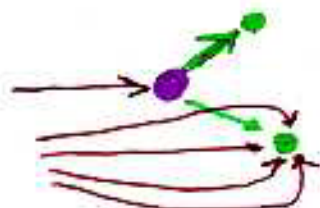
B Reactor in the days of operation. The reactor building is between the stack in the center and the water tower at right. The water treatment facility is the large building behind the water tower on the left. The building in the background with the two smokestacks is the coal fired steam plant which provided heat and steam power for the entire facility. The steam power was available for the emergency generation of electricity as well as other uses.

DEC 1941: PEARL HARBOR

JAN 1942: Compton, Fermi, Wheeler, ...
- Chicago: Design Reactors

Wheeler (age 30): Began design of
Production Reactor

FEB 20 1942: Wheeler identified possible
problem: "POISONING" OF REACTOR



SEPT 1942: DUPONT CONTRACTED TO DESIGN
CONSTRUCT & OPERATE PRODUCTION
REACTORS.

WHEELER: SCIENTIST LIAISON

NOV 1942: HANFORD CHOSEN

SEPT 1944: B REACTOR GOES CRITICAL
- IS POISONED! Wheeler deduces ¹³⁵Xe

- Wheeler-Graves solution implemented

JAN 1945: 1 kg ²³⁹Pu in hand

JULY 1945: Pu A-bomb tested

AUG 1945: ²³⁵U Bomb - Hiroshima. ²³⁹Pu - Nagasaki

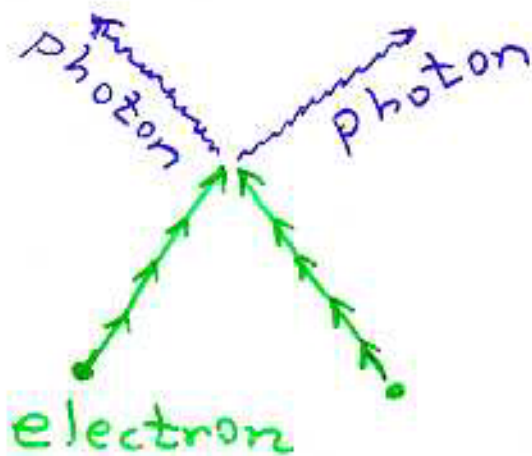


Dick Feynman, Los Alamos Laboratory ID photo, 1940s.
*(Photograph from Los Alamos National Laboratory, courtesy of
AIP Emilio Segrè Visual Archives.)*

RICHARD FEYNMAN & JOHN WHEELER

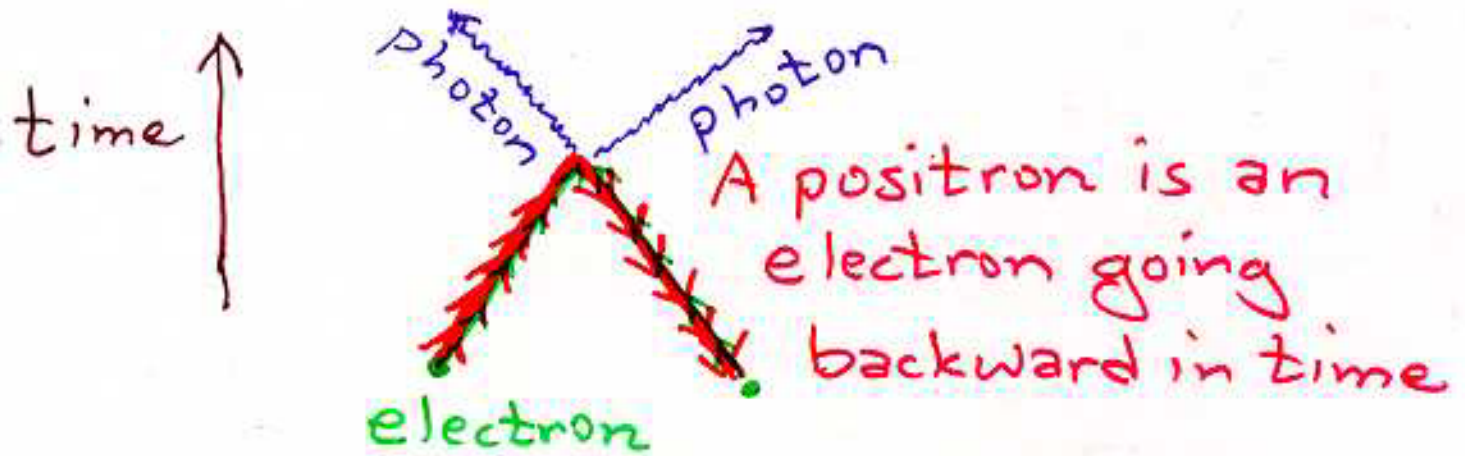
Wheeler: "I know why all electrons are identical? Because they are the same electron!"

time ↑

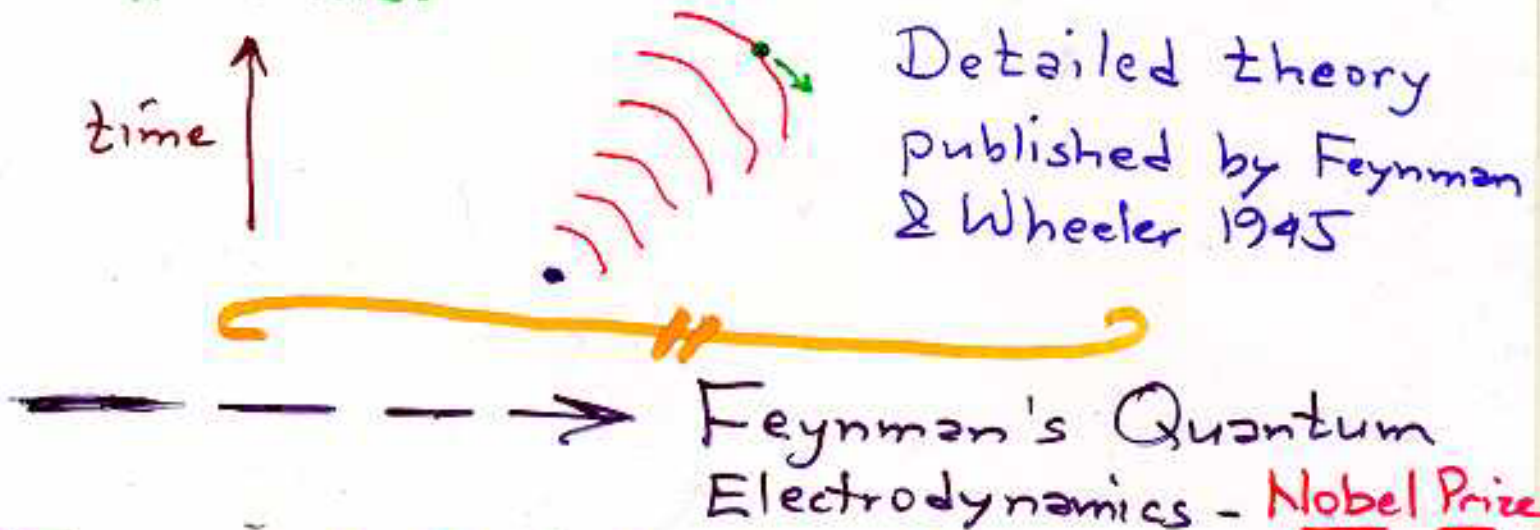


RICHARD FEYNMAN & JOHN WHEELER

Wheeler: "I know why all electrons are identical? Because they are the same electron!"



Wheeler: "There is no such thing as an electromagnetic wave. There is only action-at-a-distance forces between particles, forward & backward in time."



Feynman: On Wheeler's Craziiness

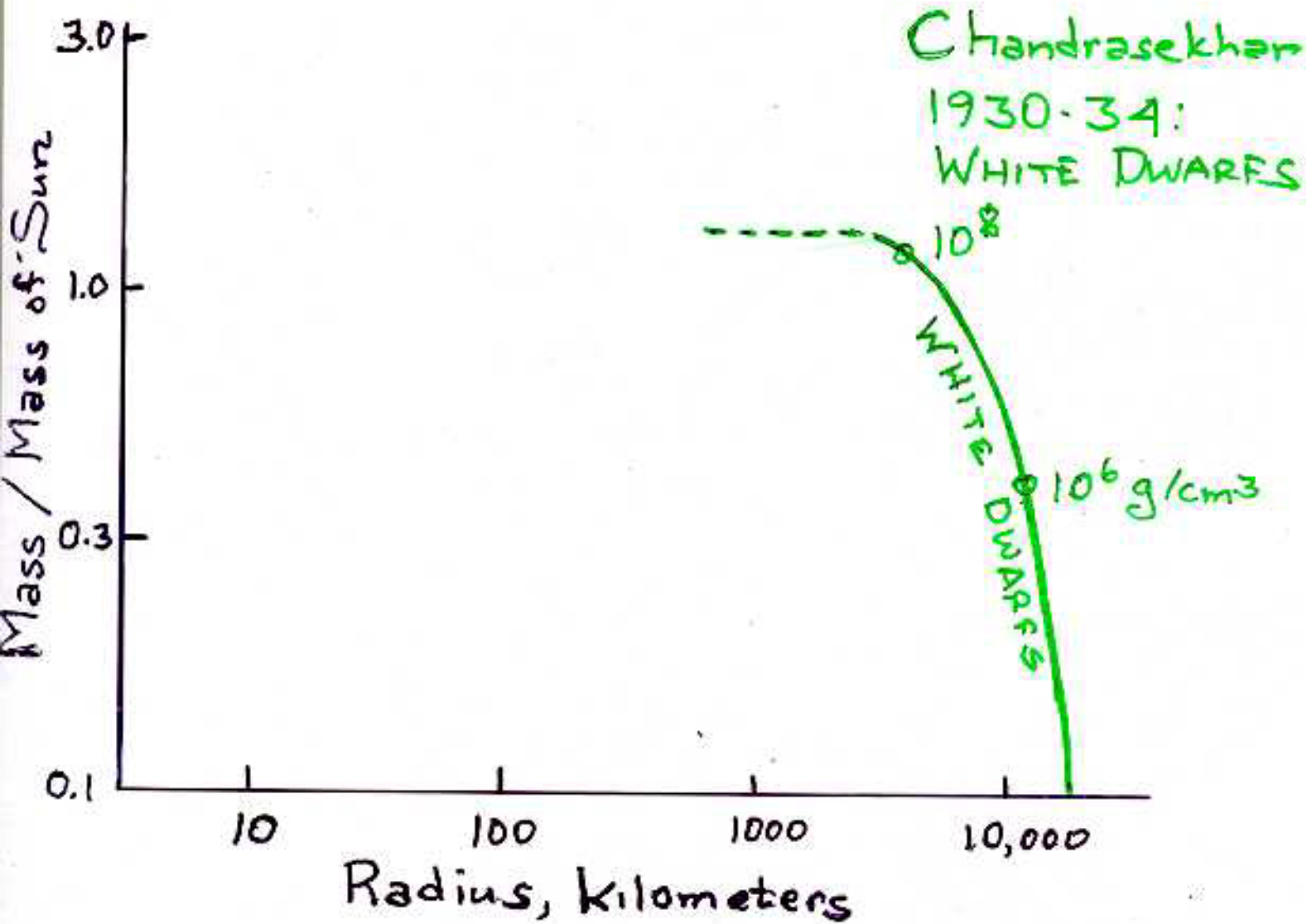
JOHN WHEELER, 1953 -

Emerging from H-Bomb Design

Embarks on Quest to Understand Space-
Time
Curvature



THE FINAL GRAVES OF STARS



NEUTRON STAR

Zwicky
Oppenheimer
Volkoff 34-38

GIGANTIC ATOMIC NUCLEUS:

• \downarrow 10^{-13} cm.
 \uparrow

A = 1: Hydrogen

• \updownarrow 6×10^{-13} cm

A = 238: Uranium



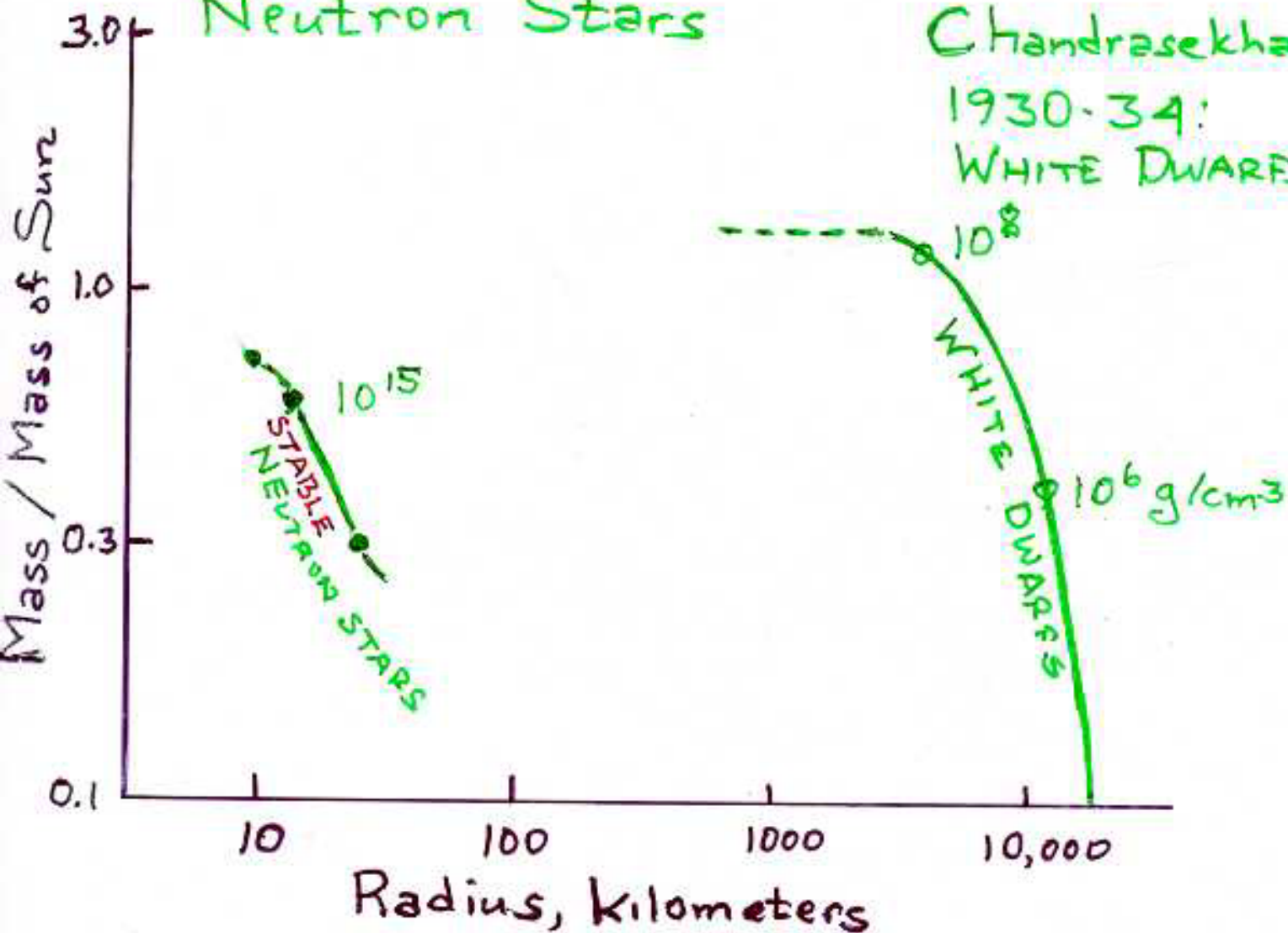
$$A = 2 \times 10^{57}$$

$$M = 1.4 M_{\text{SUN}}$$

THE FINAL GRAVES OF STARS

Oppenheimer & Volkoff:
Neutron Stars

Chandrasekhar
1930-34:
WHITE DWARFS

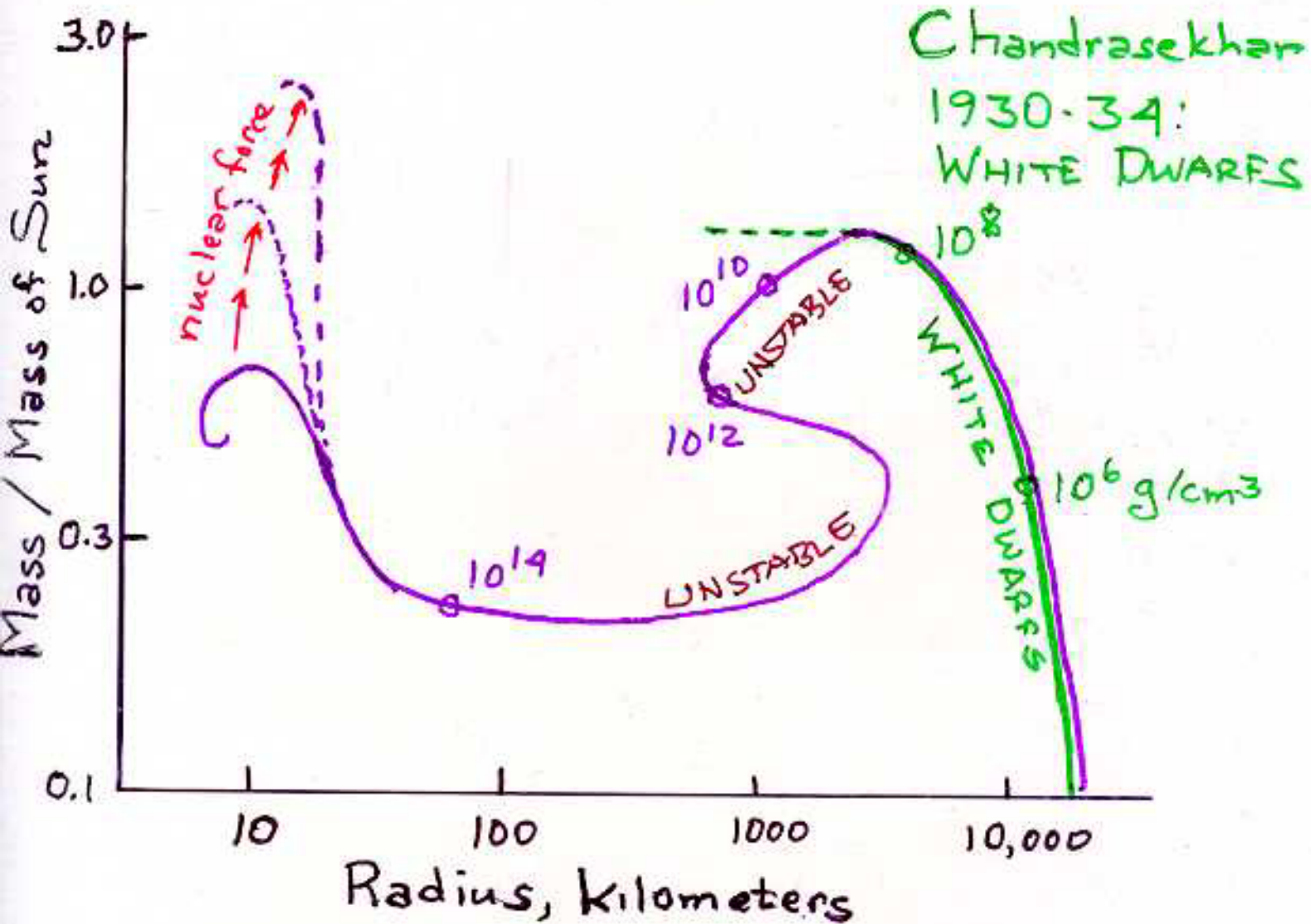


JOHN WHEELER & STUDENTS (HARRISON & WAKANO)
[1956-57] Are there any others?

What objects can exist between
White dwarfs & neutron stars?

THE FINAL GRAVES OF STARS

WHAT IS THE FATE OF MASSIVE STARS?

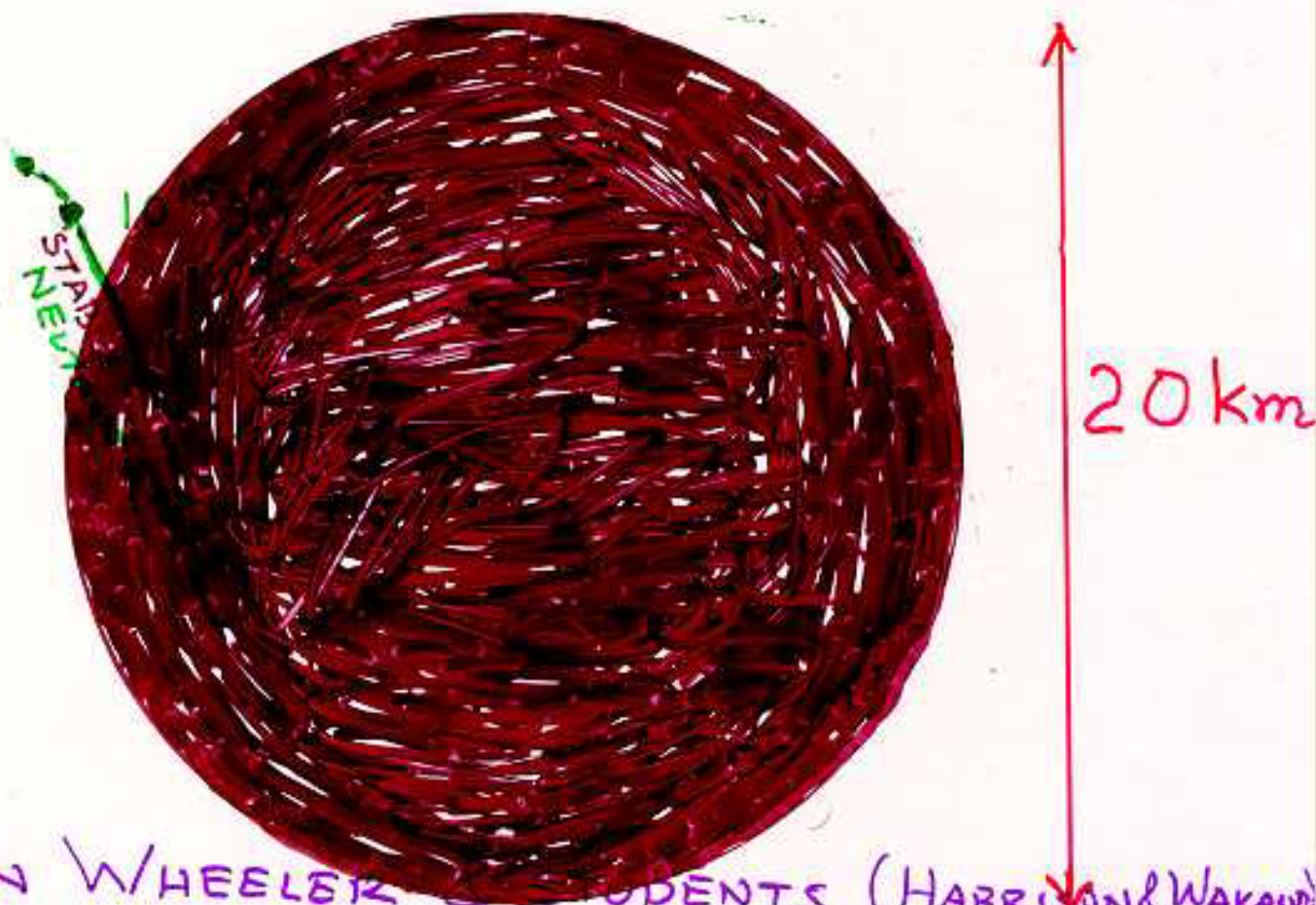


NEUTRON STAR

Zwicky
Oppenheimer
Volkoff 34-38

GIGANTIC ATOMIC NUCLEUS:

Oppenheimer & Volkoff: $\bullet \uparrow 6 \times 10^{-13} \text{ cm}$
A = Neutrons Stars A = 238: Uranium



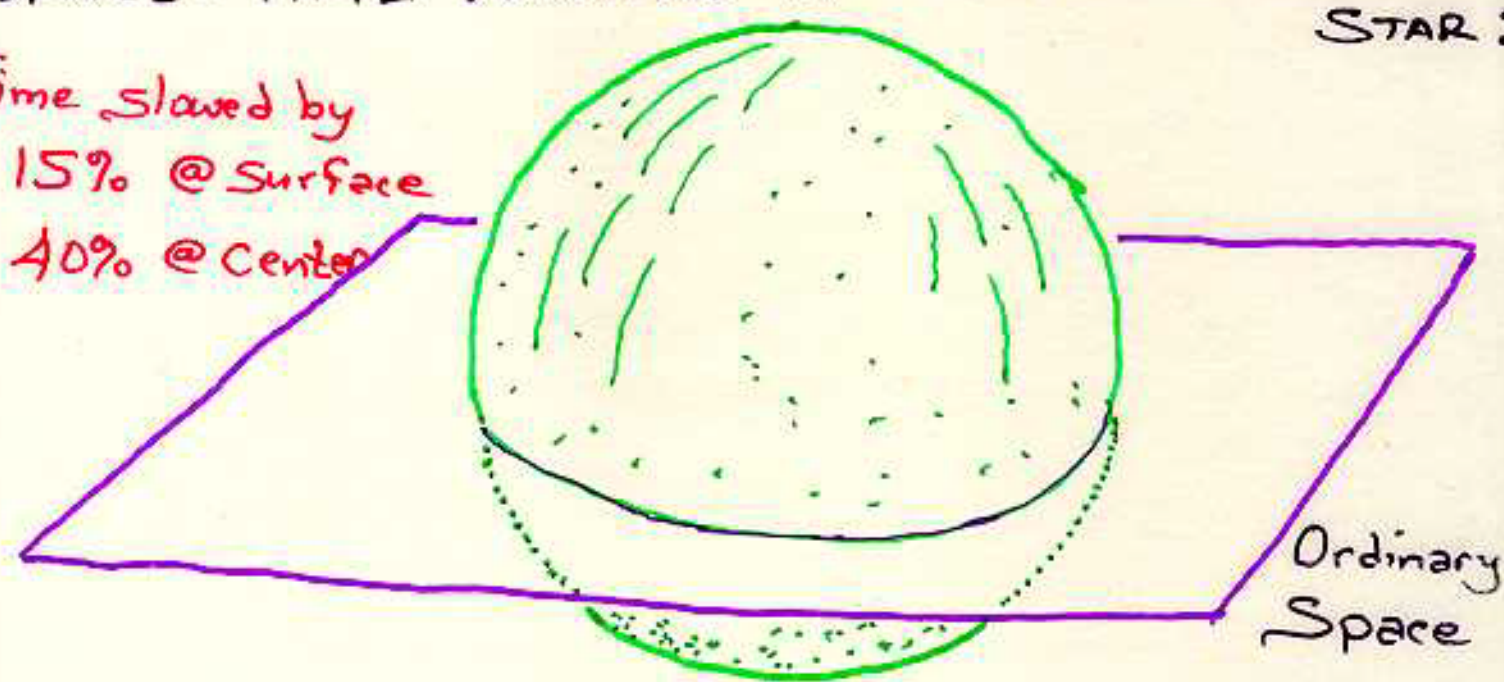
JOHN WHEELER'S STUDENTS (HARRISON & WAKANO)

[1956-57] Are there any others?
 $A = 2 \times 10^{57}$

What objects can exist between
white dwarfs & neutron stars?

SPACE-TIME WARPAGE IN MOST MASSIVE NEUTRON STAR:

Time slowed by
15% @ Surface
40% @ Center



Ordinary Space



Circumference
diameter ≈ 2
(not π)

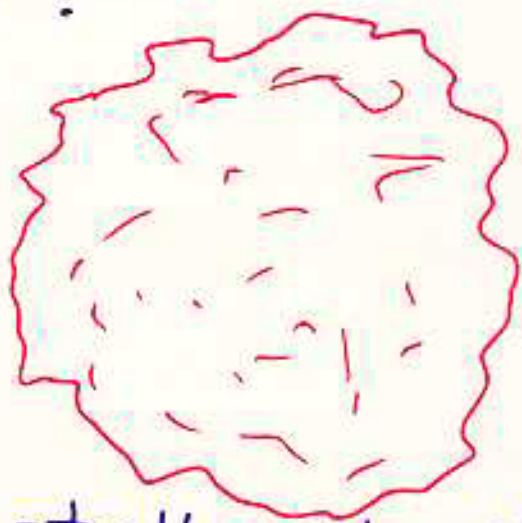
Hyper space

Wheeler: 1966

How might neutron stars be discovered?

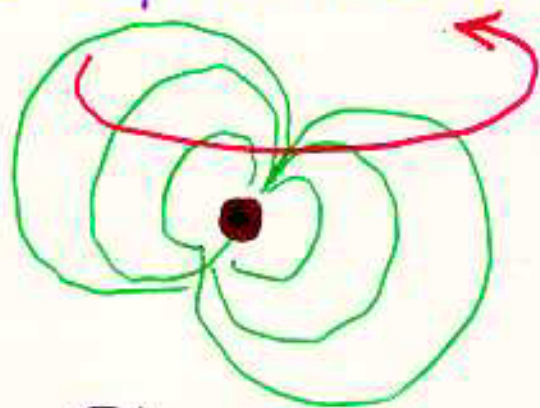
Crab Nebula

- remnant of supernova explosion (stellar death)
- neutron star in core?



How is Crab Energized?

Wheeler's speculation:



Neutron Star:

Spinning, Magnetized

THE DISCOVERY OF NEUTRON STARS

Anthony Hewish & Jocelyn Bell - 1968



PULSAR



rotation



THE FATE OF MASSIVE STARS

- My first encounter with
John Wheeler:



• ← Singularity

- This answer is unacceptable.

CRISIS!

- Perhaps the laws of
{ Spacetime curvature } unified
{ quantum mechanics }

- **QUANTUM GRAVITY**

will take over & govern the
endpoint of collapse

THE FATE OF MASSIVE STARS

- My first encounter with

John Wheeler:

Oppenheimer:
The endpoint
is hidden



Singularity

- This answer is unacceptable.

CRISIS!

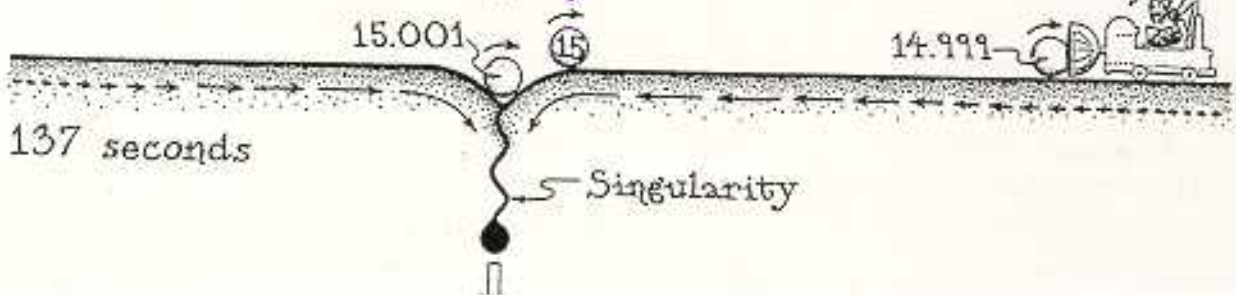
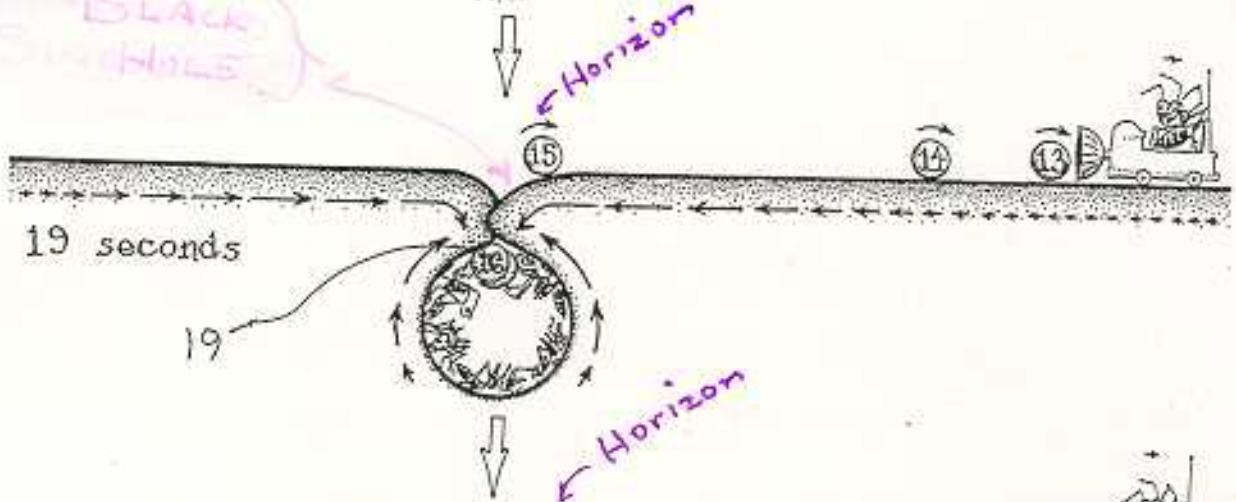
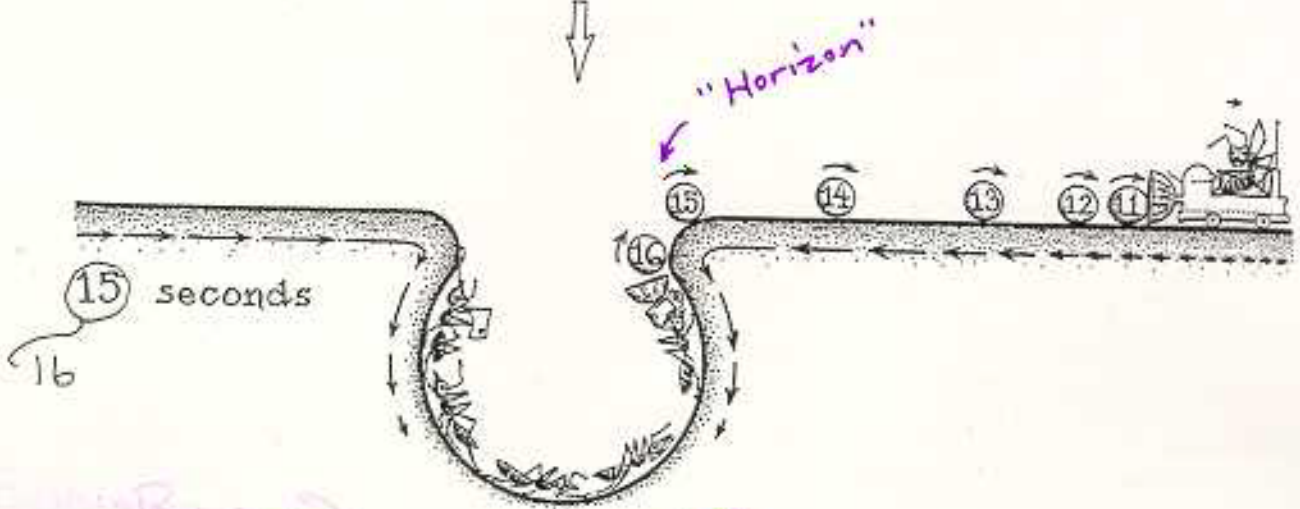
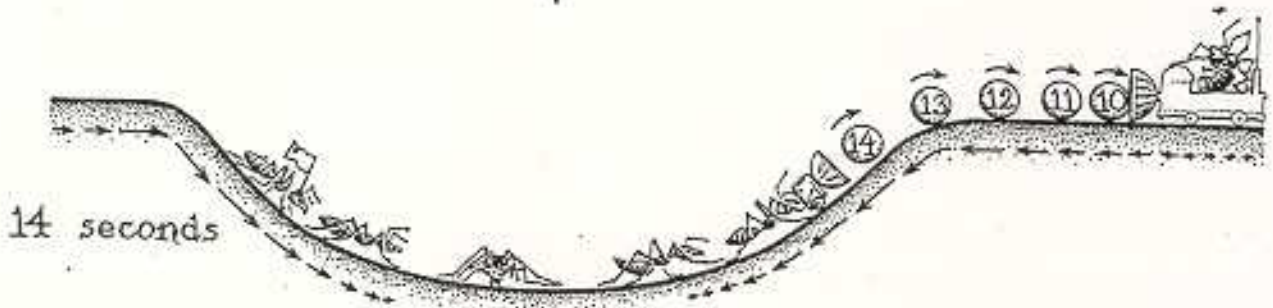
- Perhaps the laws of
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QUANTUM GRAVITY

will take over & govern the
endpoint of collapse

OPPENHEIMER & SNYDER - AS TRANSLATED BY BECKEDORFF & MISNER ^{637: F2}

Curvature of Space Depicted Via Parable of the Ants



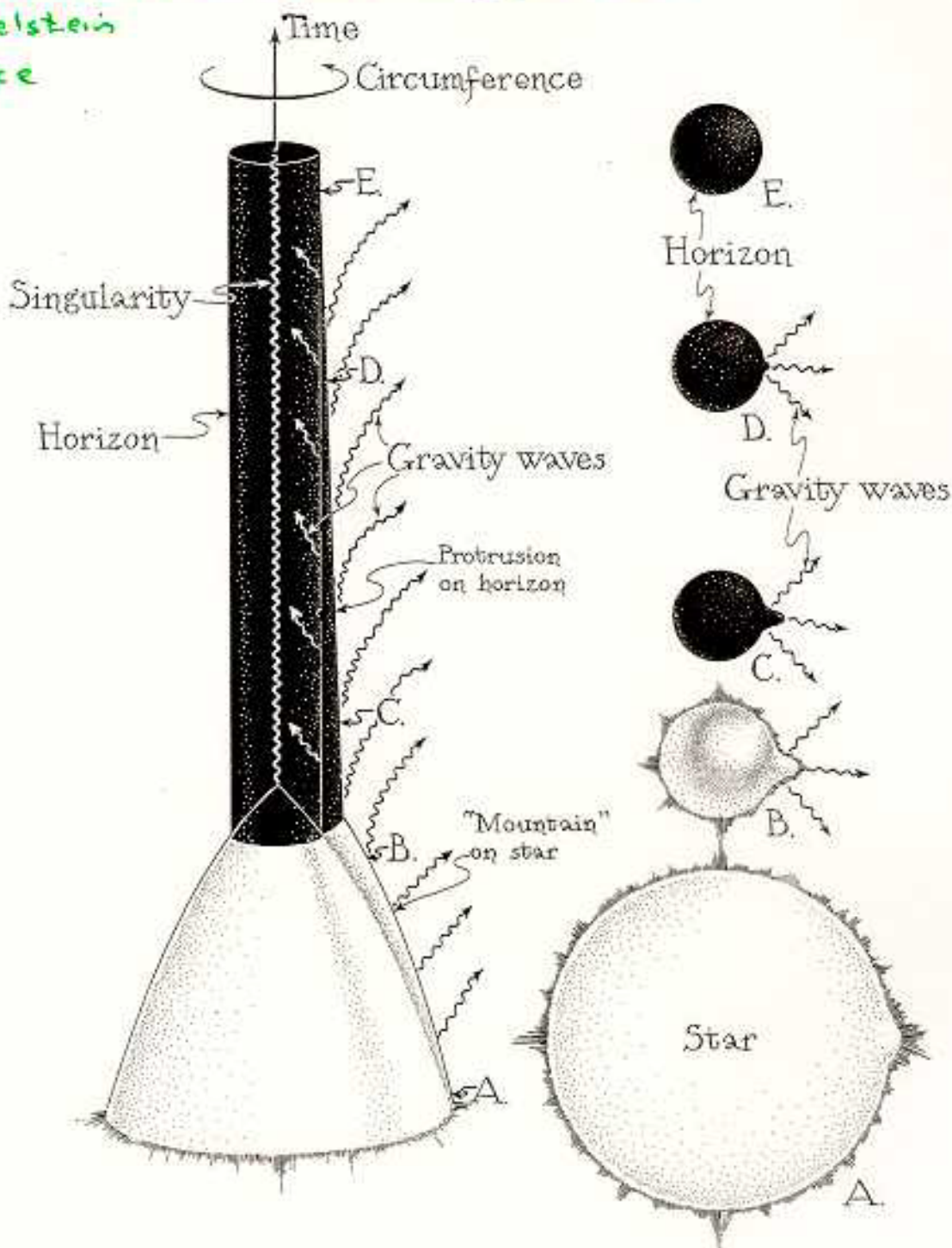
... time interval \rightarrow ... charges. ...

BLACK
SINGULARITY

STABILITY OF THE COLLAPSED OBJECT

John Wheeler & Tullio Regge 1957

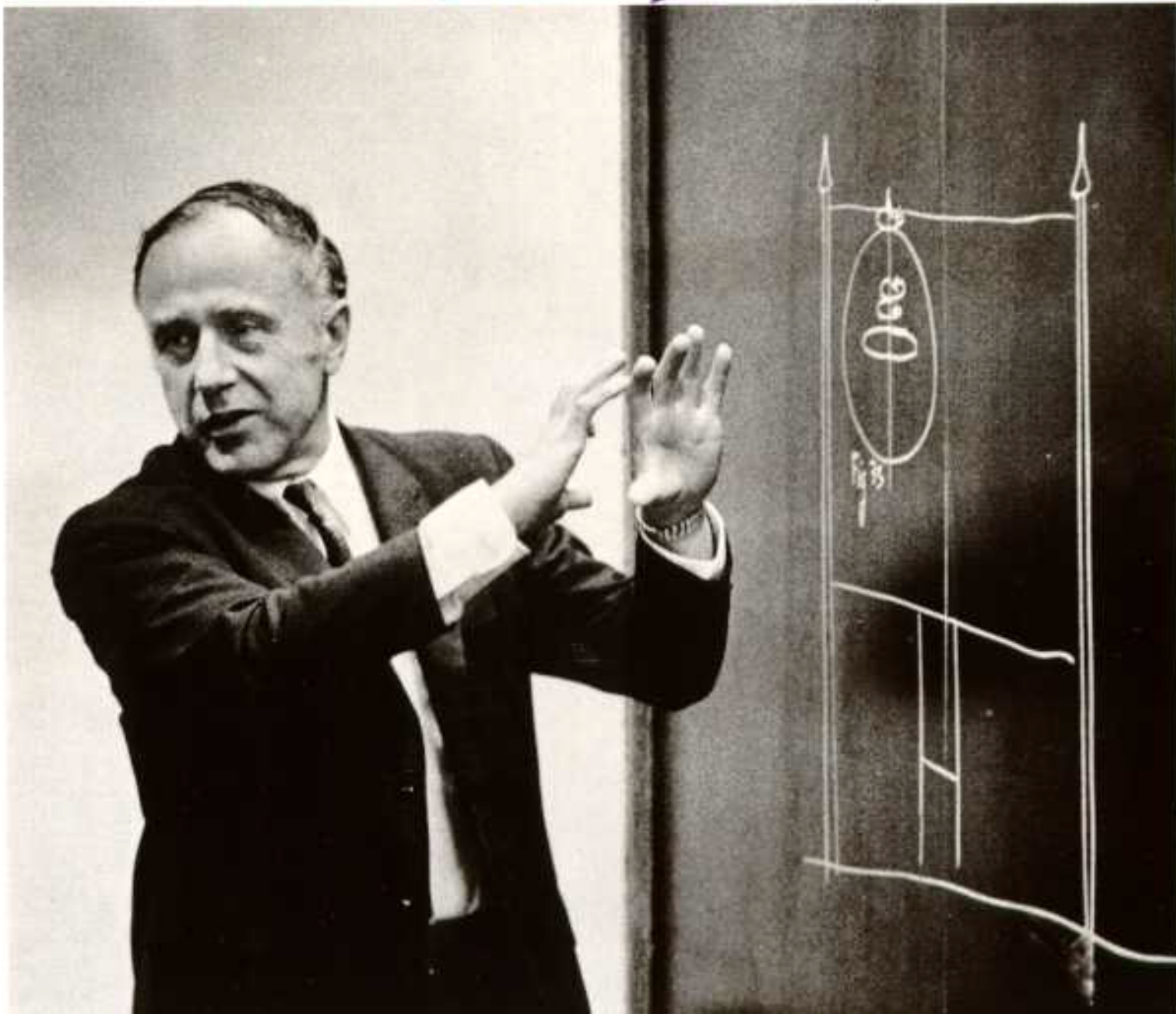
...L. Edelman
...R. Price



1967 - WHEELER RENAMES THE FINAL OBJECT

BLACK HOLE

1971: John Wheeler's 60th BIRTHDAY CONFERENCE



CANT SEPARATE
VARIABLES IN

EQN FOR
SMALL PERTURBS
OF KERR &
MIX MASTER.

BLACK HOLES
ARE
UNOBSERVABLE

"GRAV.
HAS
NOTHING
TO DO
WITH P&X"

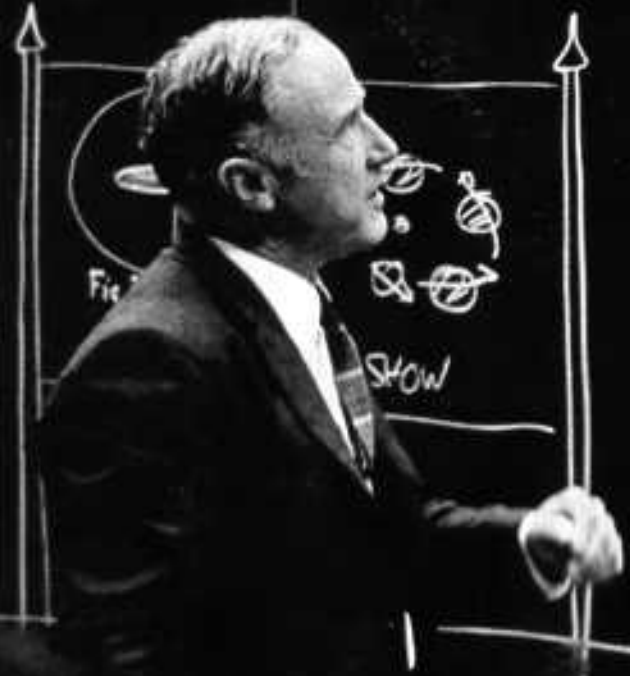
OBSERVE
1ST BLACK
HOLE

- (1) X-RAYS AFTER
- (2) GRAV. RADN AT TIME

(3) TOOTH PASTE & } → JET.
ERGOSPHERE

IMPOSSIBLE
TO QUANTIZE

TRAP - FALSE IND
OF GRAV. RA

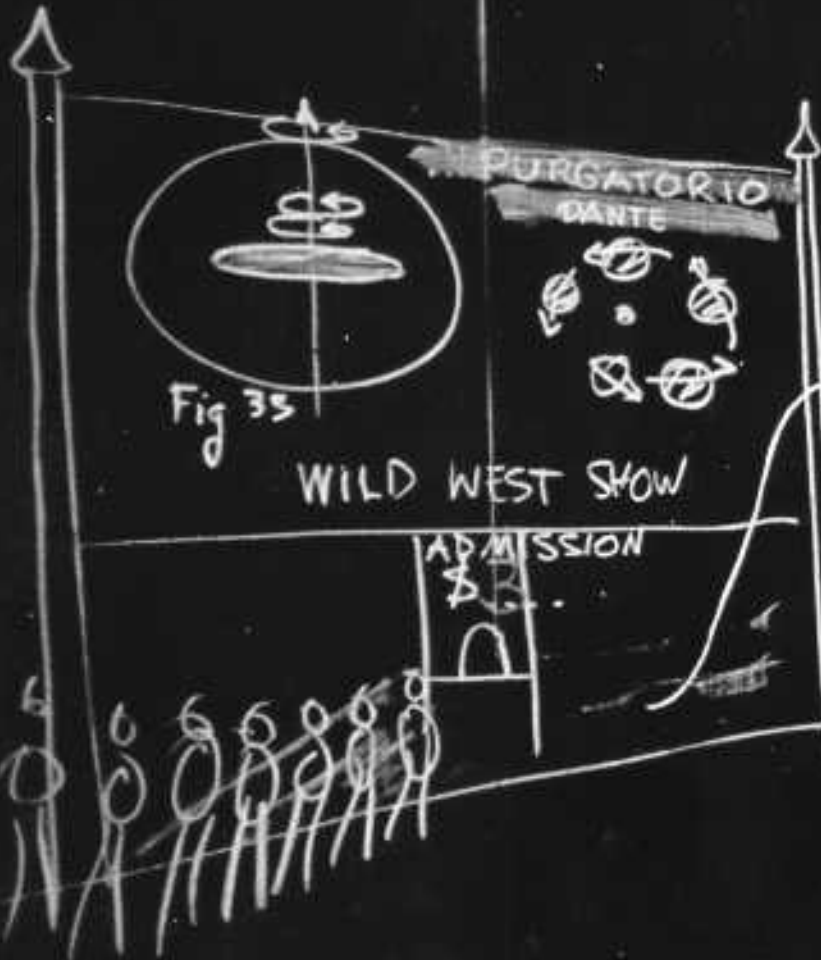


Fig

SHOW

P&X

to



EON FOR SMALL PERTURBATIONS OF KERR & MAXWELL
 CANT SEPARATE VARIABLES IN
 BACK HOLES ARE UNOBSERVABLE
 GRAY HAS NOTHING TO DO WITH
 THE THIN SANDWICH HILL
 THE LAST HANDBOOK
 PETER - SPOKE TO DO WITH THINGS
 LEVEL'S PROB - DO URGENT TO BE LEFT TO THE MATHEMATICIAN
 LEVIN'S MATHS
 HEDD OF ATOMS 1976
 CENTRAL...
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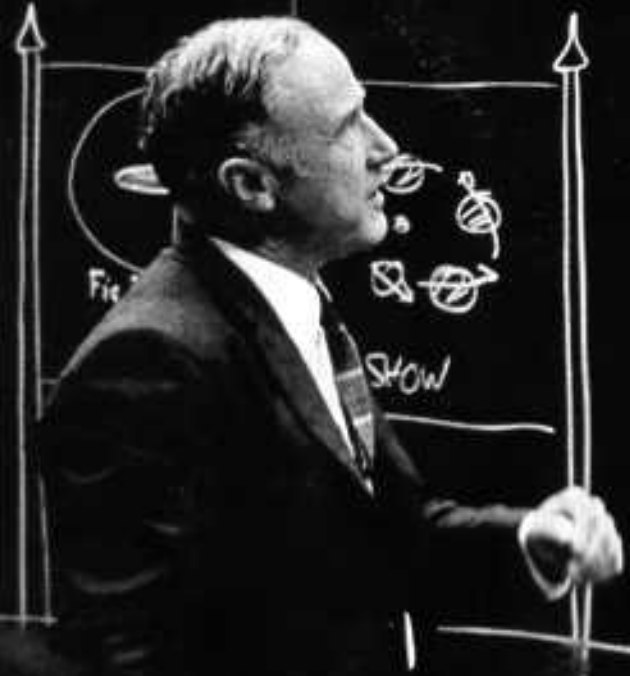
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Fig

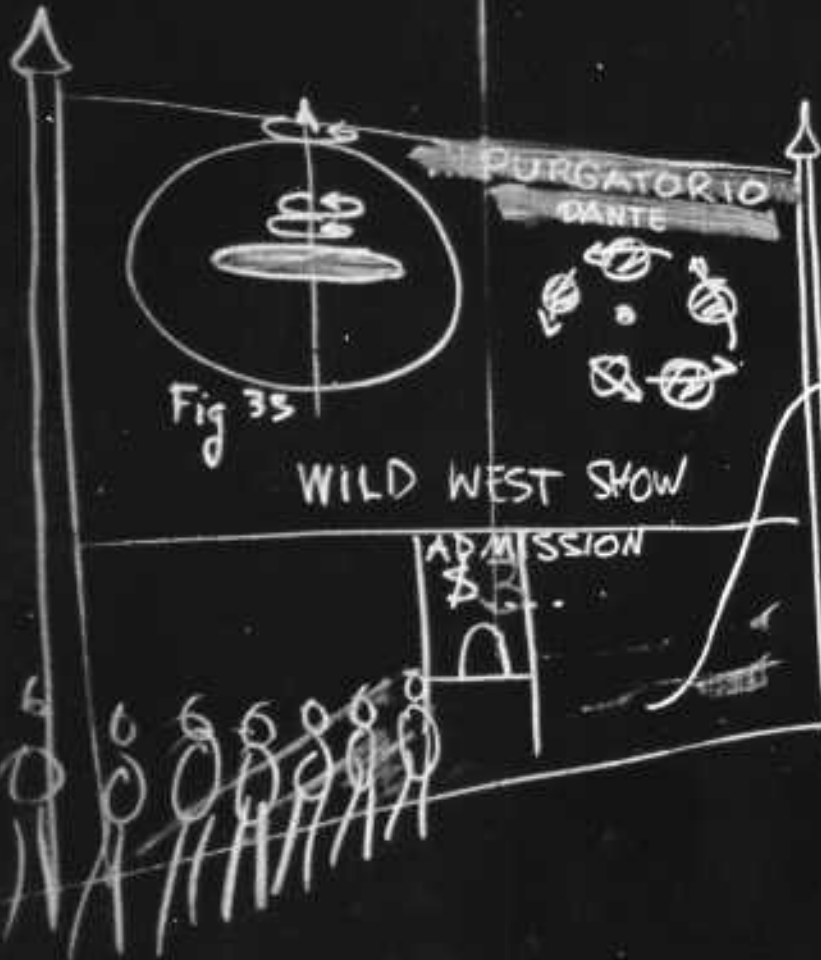
SHOW

PAX

to



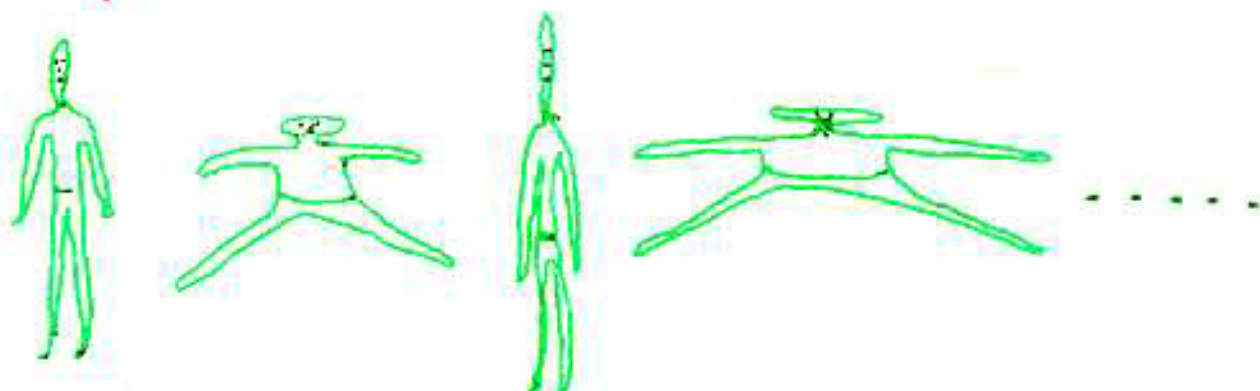
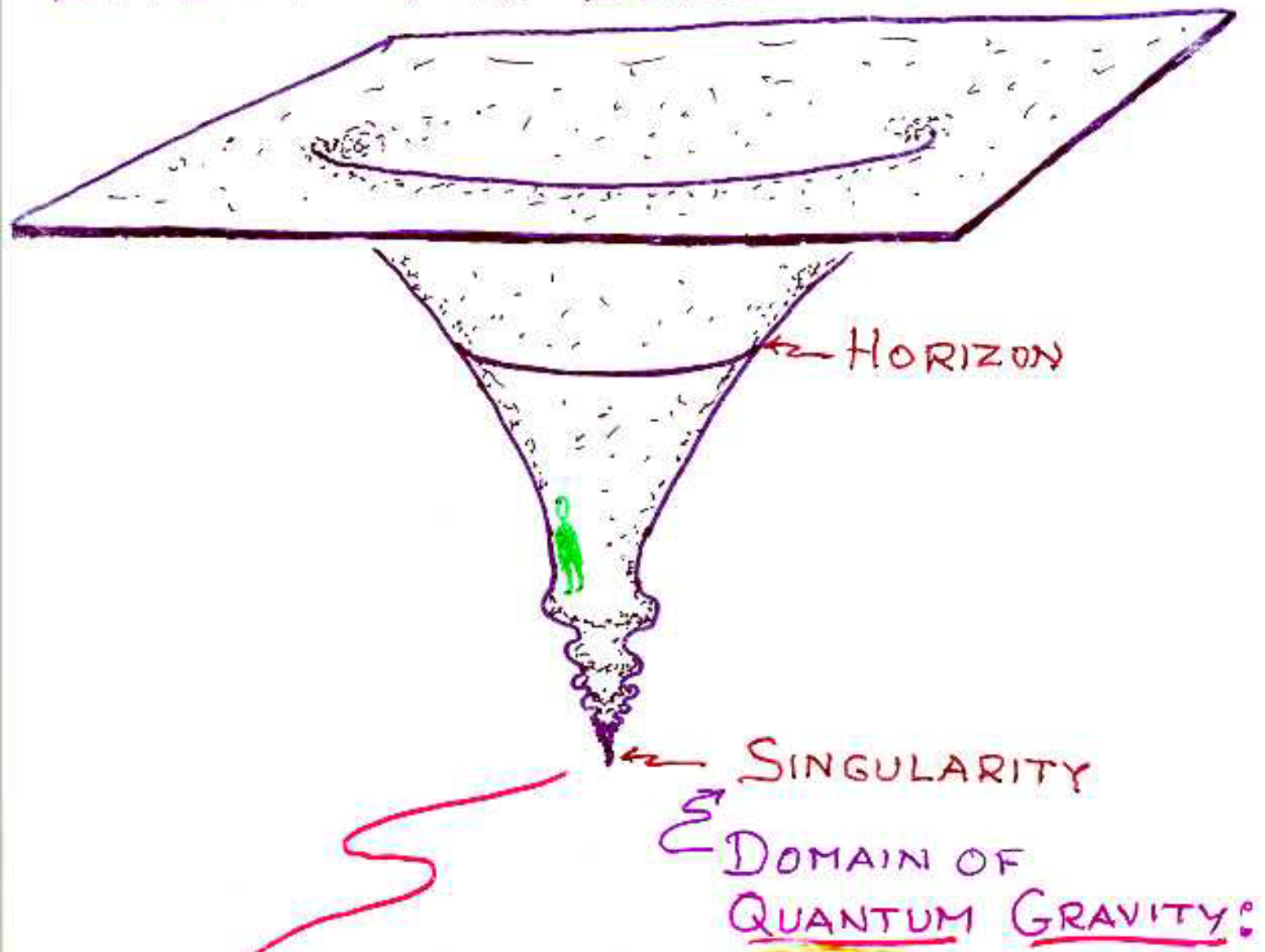
Kip Thorne, Charlie Misner, and me in 1993, the twentieth anniversary of the publication of *Gravitation*.
(Photograph by Susanne Kemp Misner.)



EON FOR SMALL PERTURBATIONS OF KERR & MADAMSTER
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SINGULARITY AT BLACK HOLE'S CORE

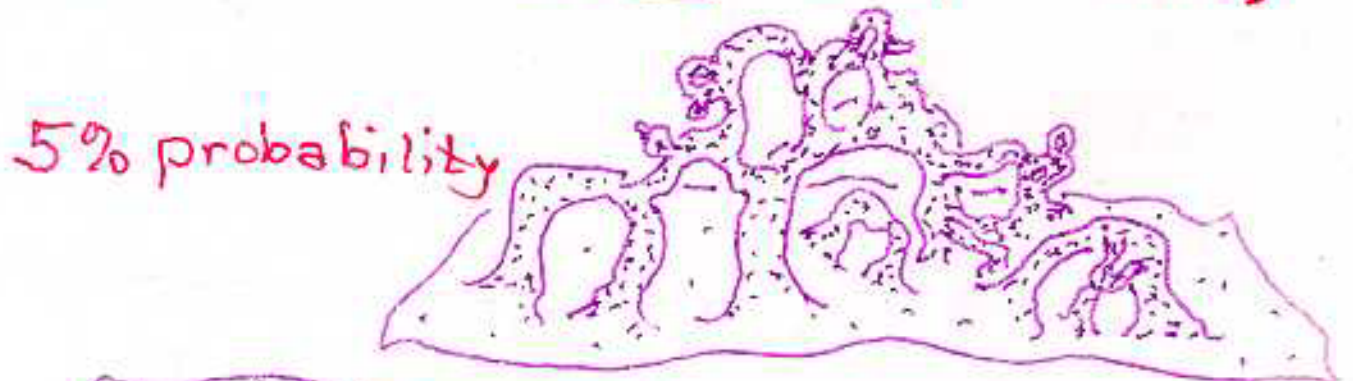
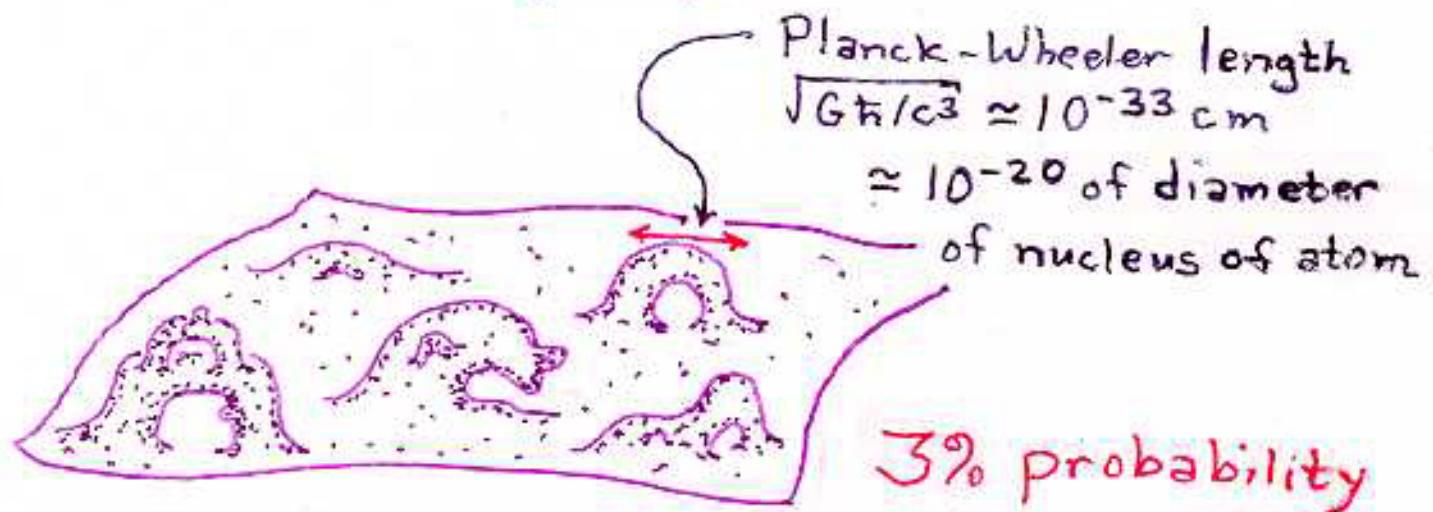


"MIXMASTER" OSCILLATIONS OF WARPAGE

NATURE OF THE SINGULARITY

A place where space and time,
as we know them,

- Cease to exist
- Are replaced by a probabilistic foam

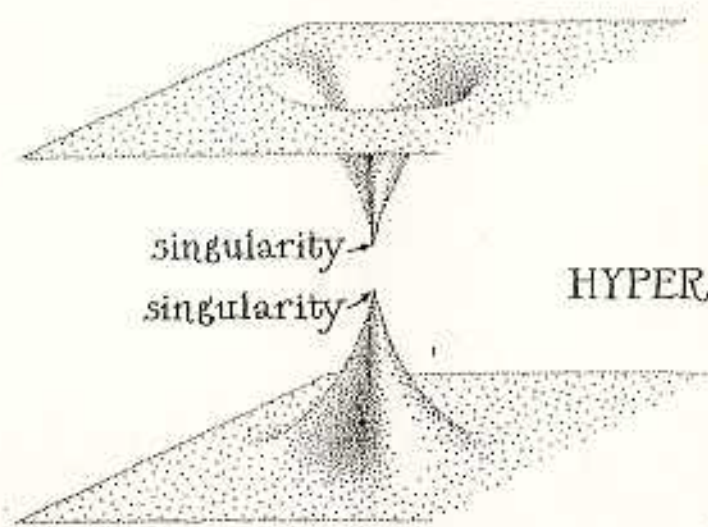


Governed by Laws of
Quantum Gravity

- With space & time gone,
Matter, as we know it,
must cease to exist...

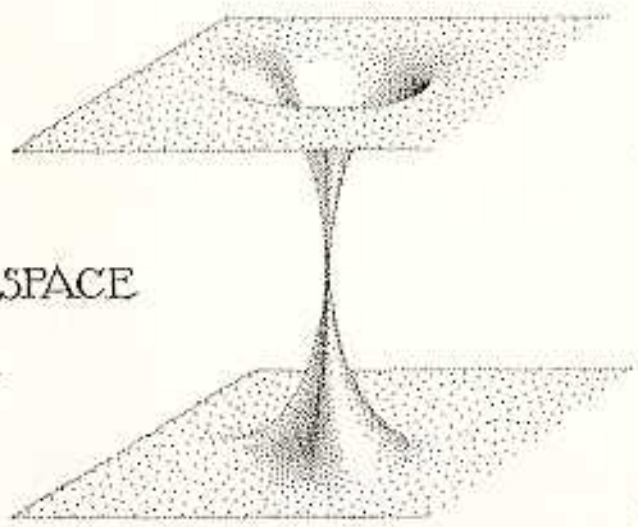
Wheeler-
DeWitt
Equation

Wormholes in Vacuum



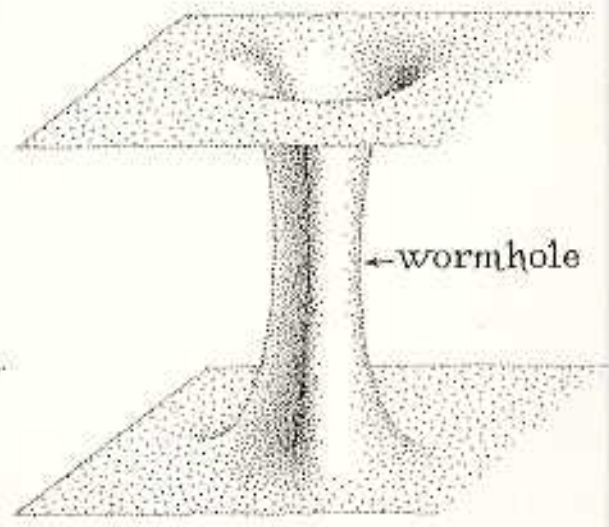
singularity
singularity

(a)



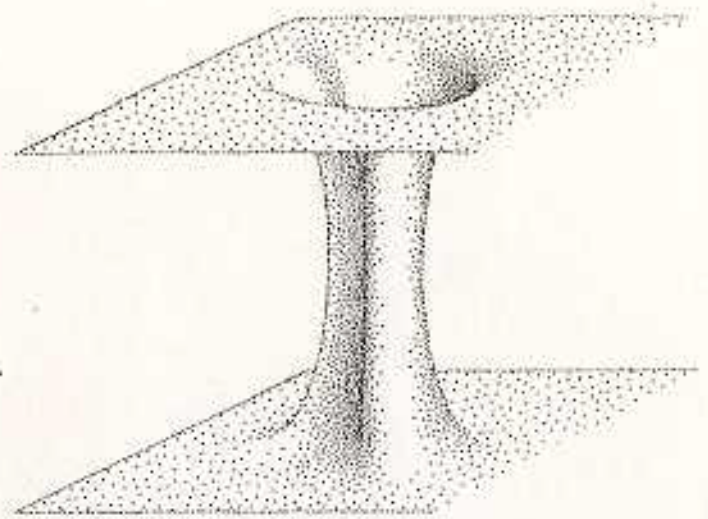
HYPERSPACE

(b)

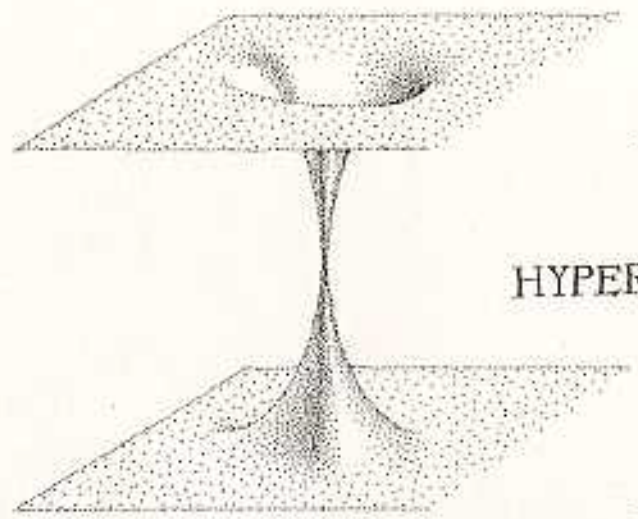


wormhole

(c)

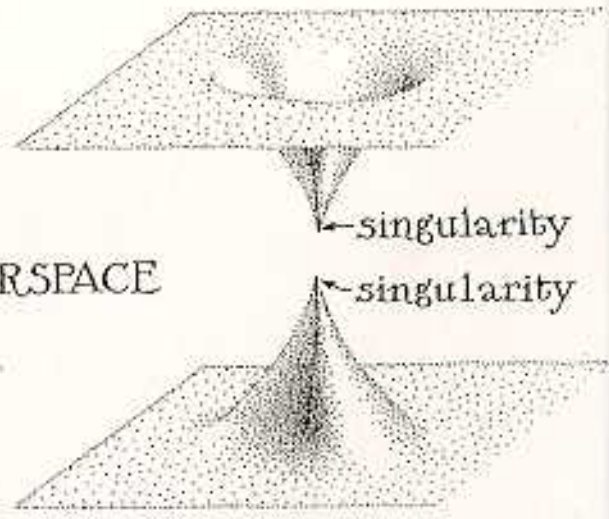


(d)



HYPERSPACE

(e)



singularity
singularity

(f)

Wheeler → Thorne → Sagan [Contact] → Star Trek,

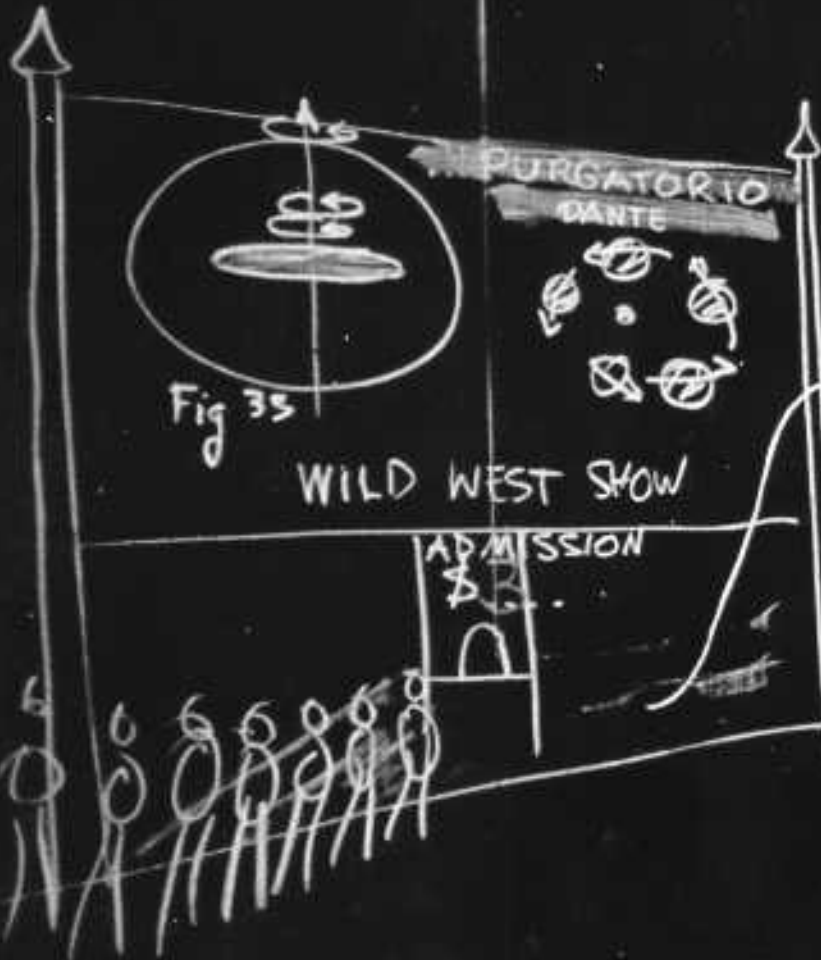


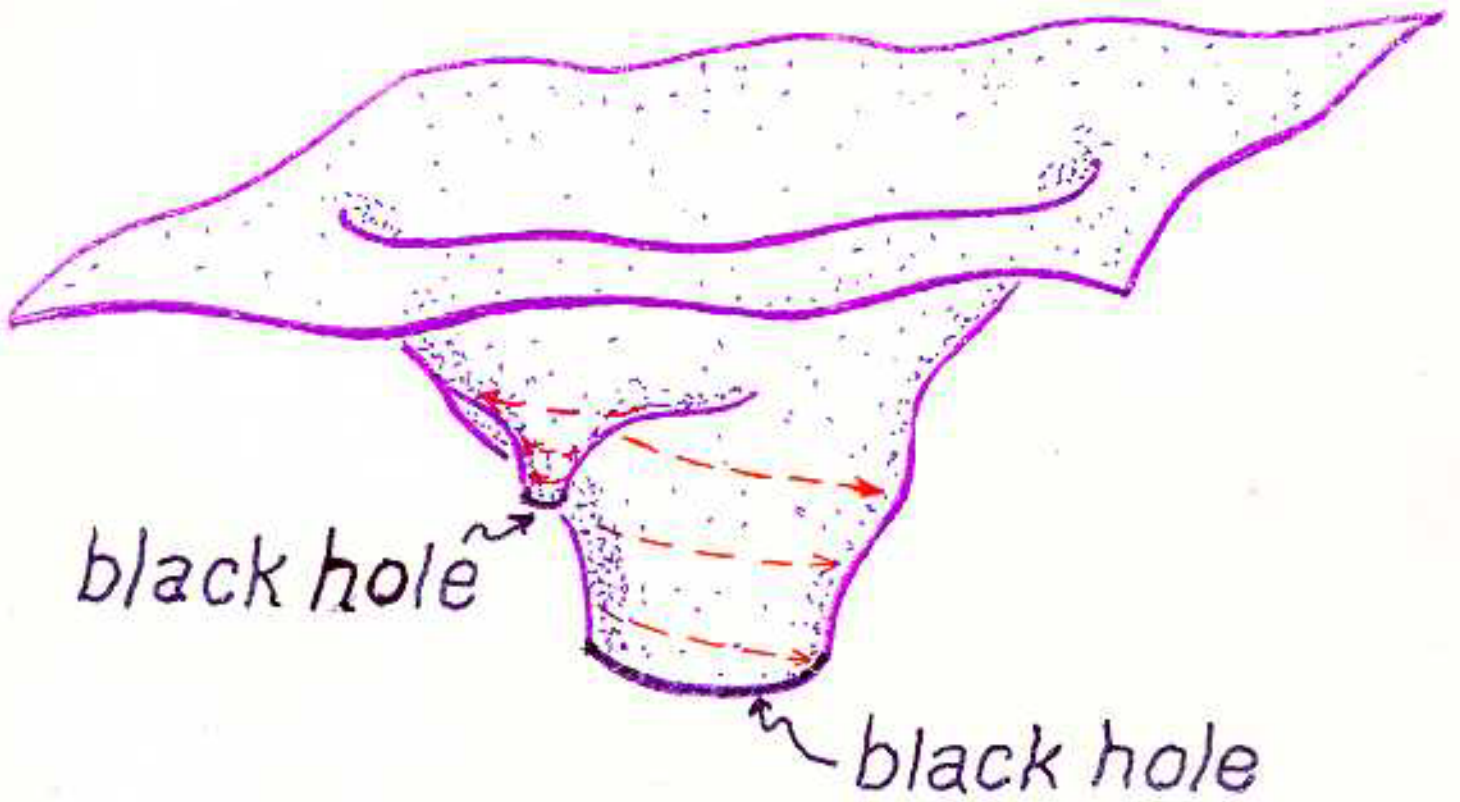
Fig 35

WILD WEST SHOW

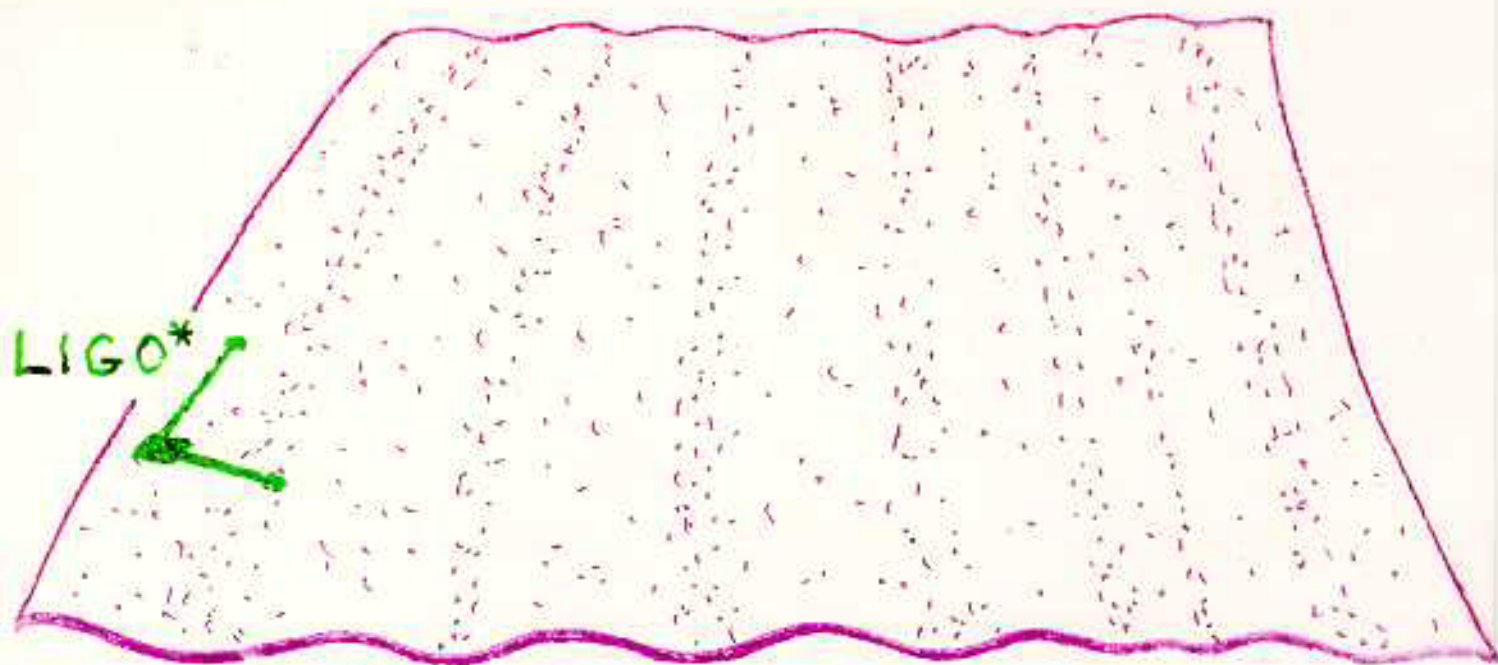
ADMISSION \$

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 CENTRAL...
 WE & PROSPERITY
 JET
 HILLS
 1978 1931 1934 1937
 7-10

BLACK-HOLE BINARY



gravitational waves ↷

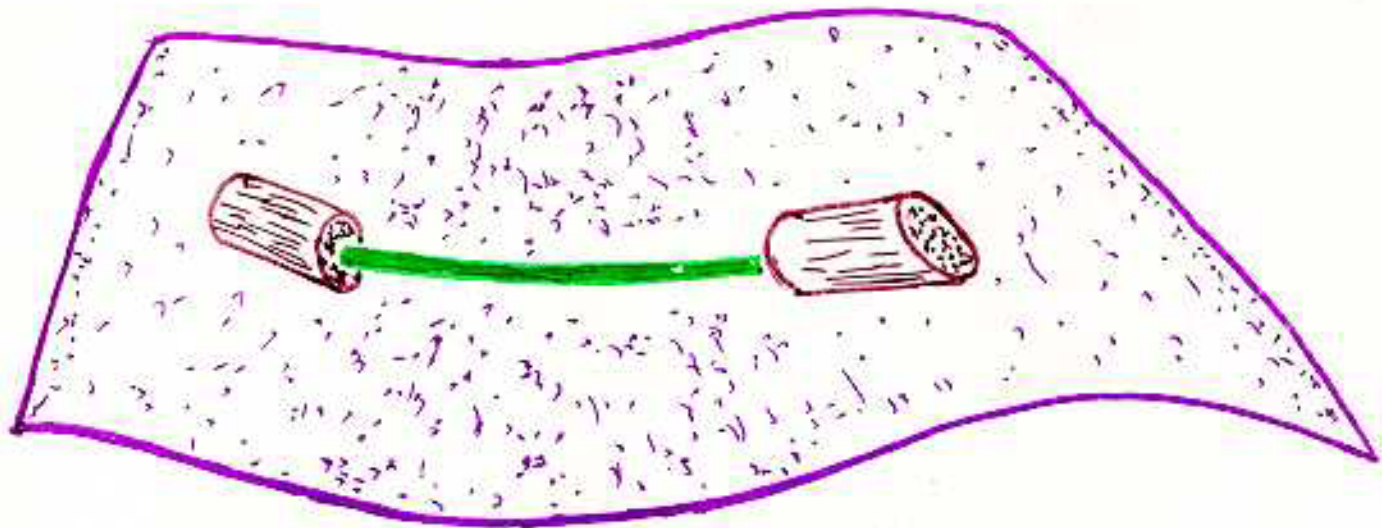


MAP OF BLACK HOLE



* Laser Interferometer Gravitational-Wave Observatory

- Livingston, Louisiana
- Hanford, Washington



LASER INTERFEROMETER GRAVITATIONAL-WAVE OBSERVATORY



LIGO

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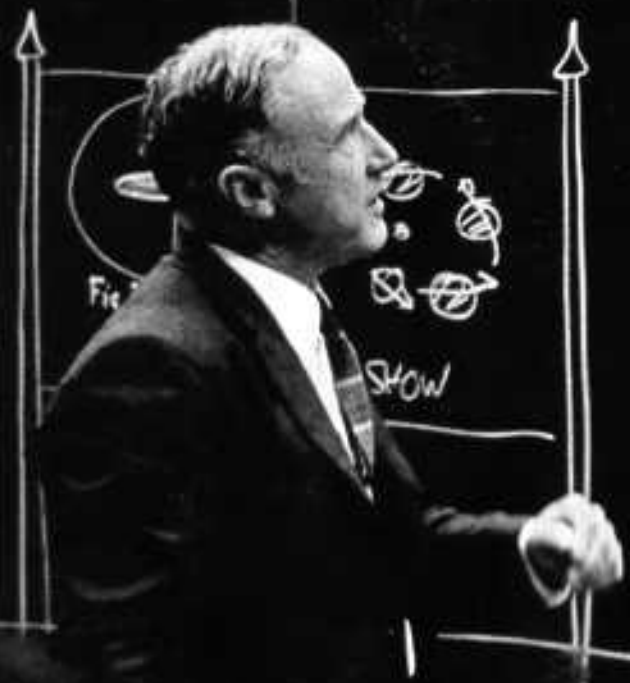
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Fig

SHOW

P&X

to

*Kip - Just to let you know
what's going on on the island.
Janice has arranged all this --
that - raising profusities go on
and on in this gang!
- John*

You are invited to

A Fireworks Show

at

High Island

(or some nearby location determined by the State of Maine)

conducted by

Blue Hill Pyrotechnics

after sunset on
Friday August 16, 1991

IN CELEBRATION OF
THE OCCASION OF

THE 80TH BIRTHDAY OF JOHN ARCHIBALD WHEELER

FIRE PROTECTION AND CROWD CONTROL
WITH ASSISTANCE FROM THE
SOUTH BRISTOL FIRE COMPANY

RAINDATE: SUNDAY AUGUST 18
CALL (207) 644-8138 FOR FINAL DETAILS

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what's going on on the island.
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Fire Crackers

A-Bomb

H-Bomb

Supernovae

Big Bang

S-Matrix Water-Drop Theory of Fission

Electrons Going Backward in Time

Black Holes Quantum Foam Wormholes

.....



With Janette in High Island, 1980s.
(Photograph by Beverly White Spicer.)

"It looks strange, and it looks strange, and it looks very strange, and then it suddenly does not look strange at all, and you can't understand what made it look strange in the first place." - Gertrude Stein