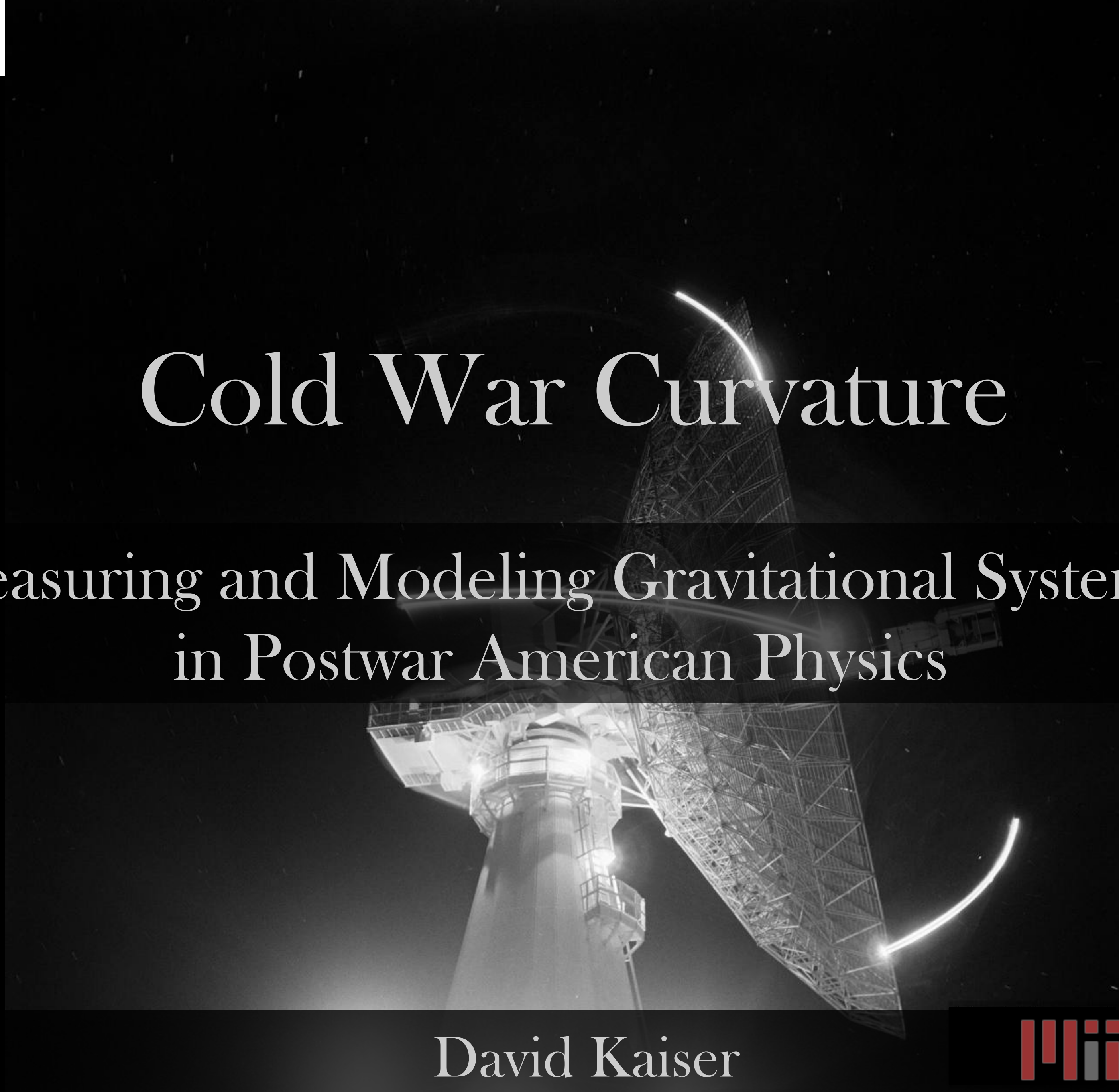


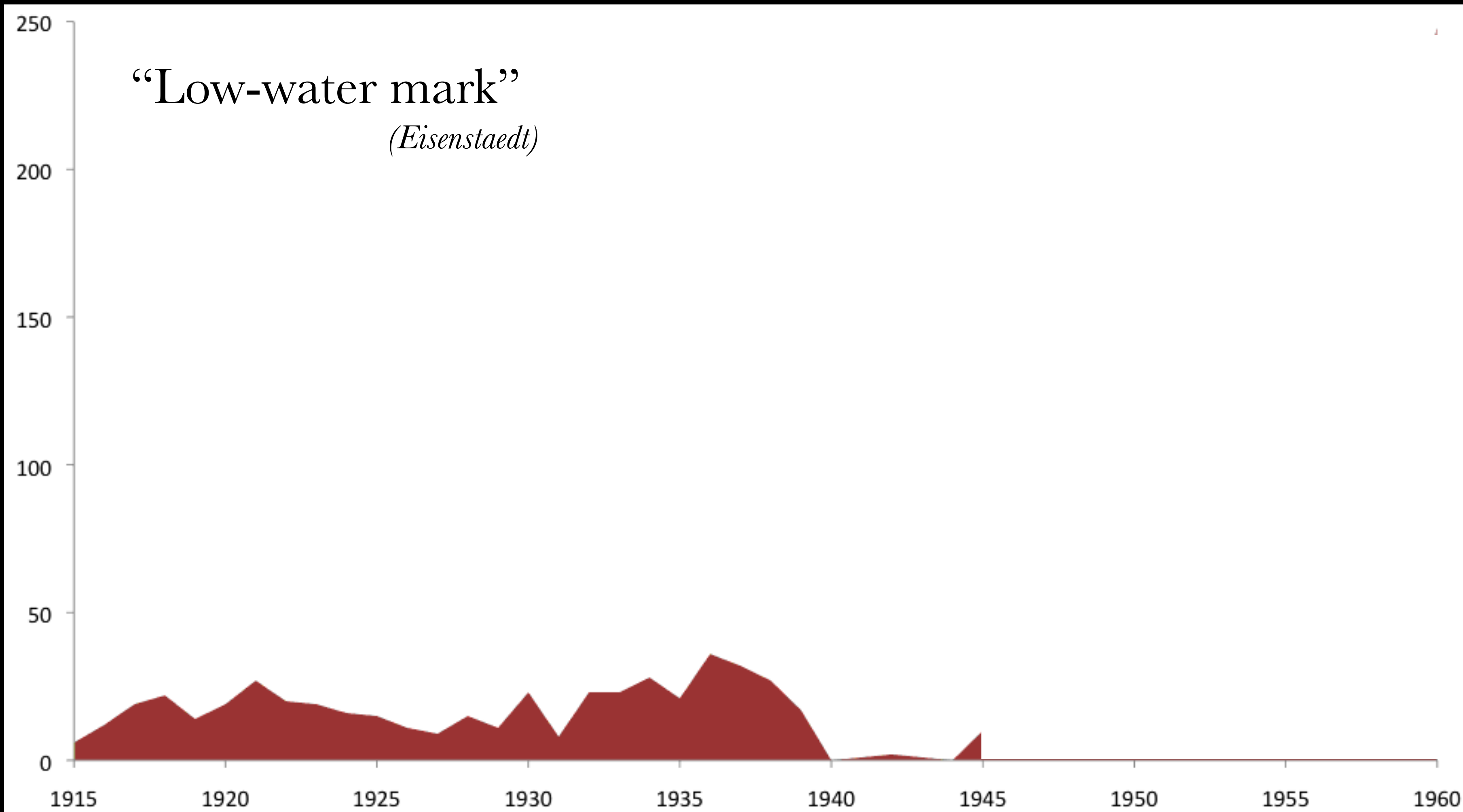
Cold War Curvature

Measuring and Modeling Gravitational Systems in Postwar American Physics

David Kaiser

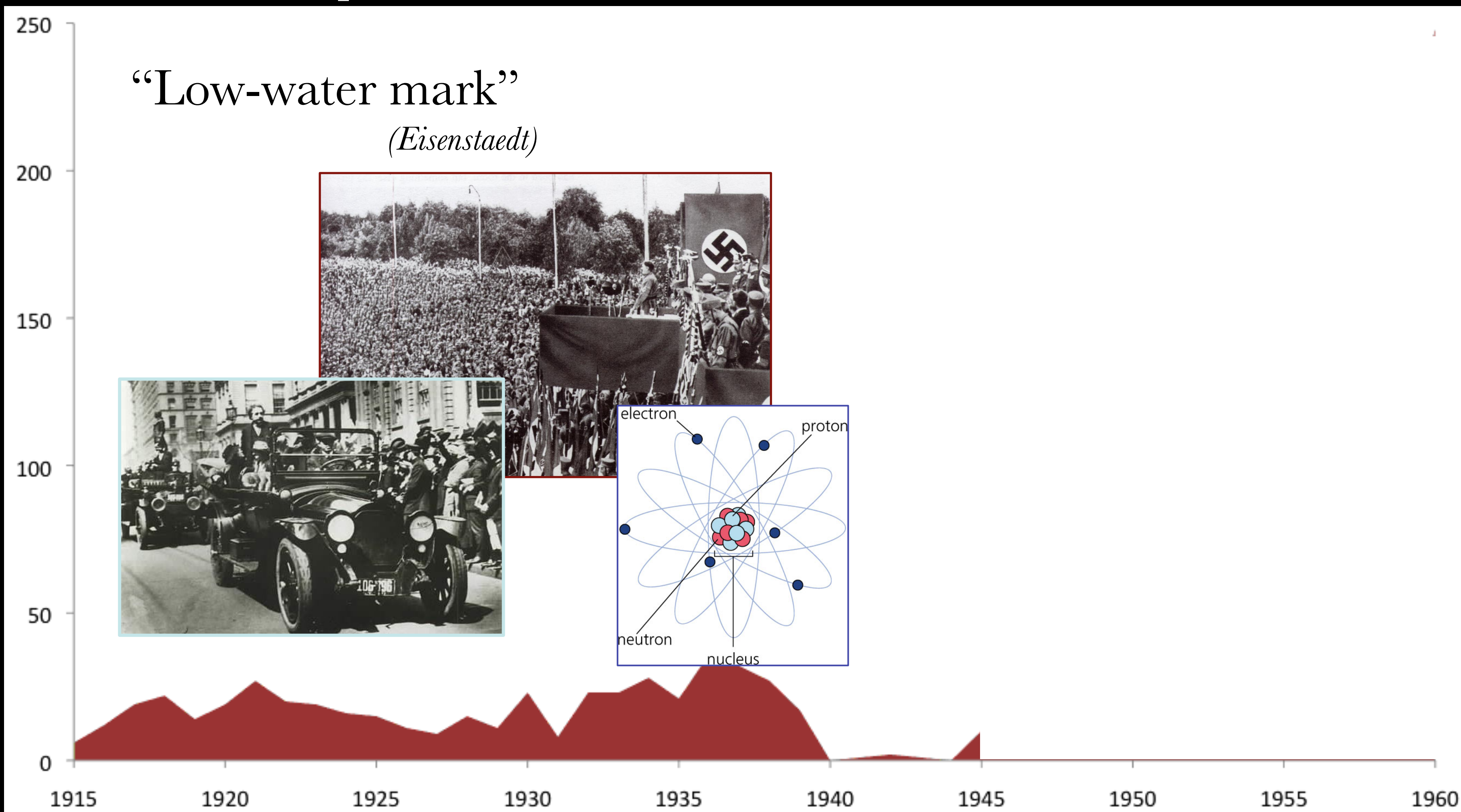
What Goes Up...

No. publications on *GR* worldwide, 1915-1960



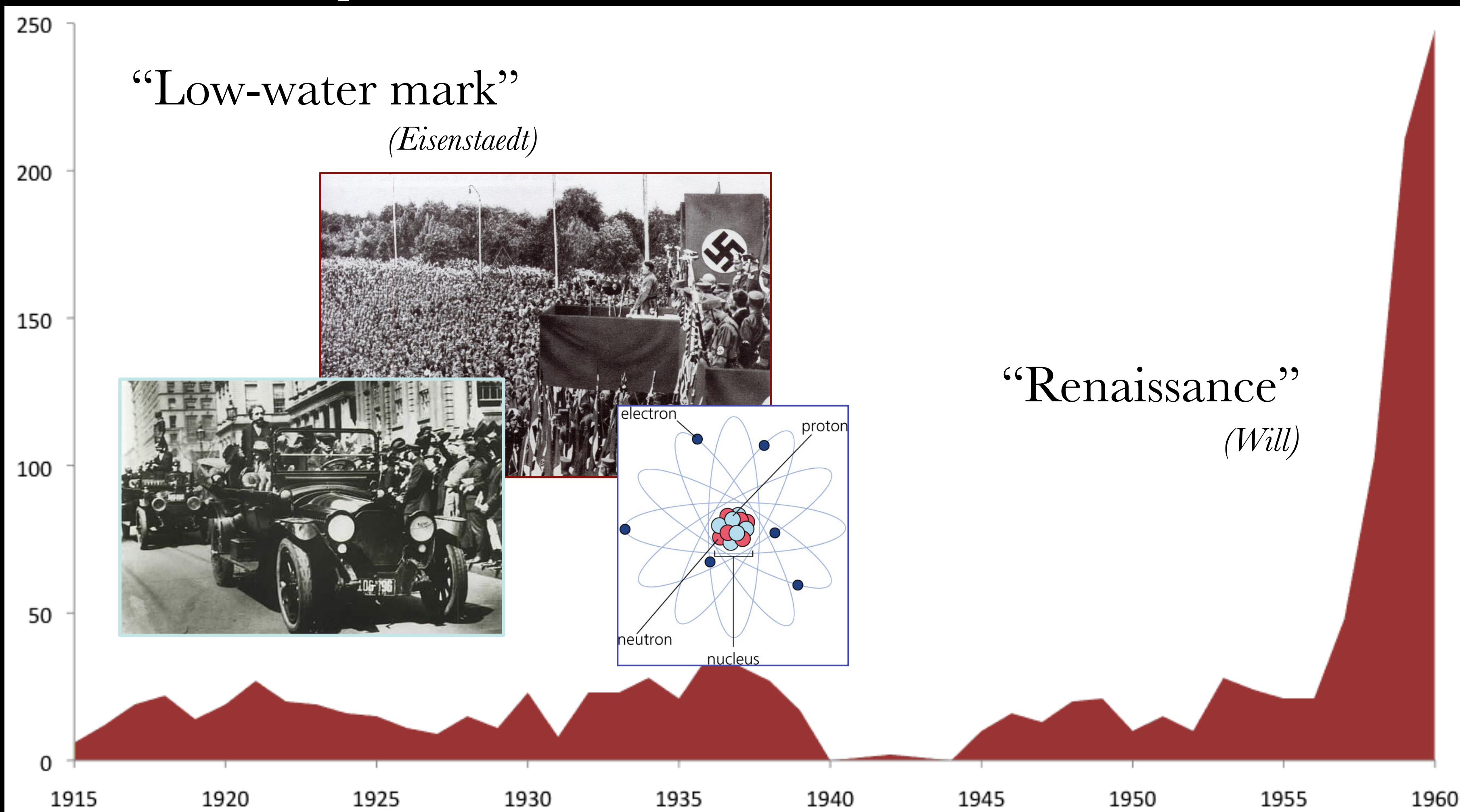
What Goes Up...

No. publications on *GR* worldwide, 1915-1960



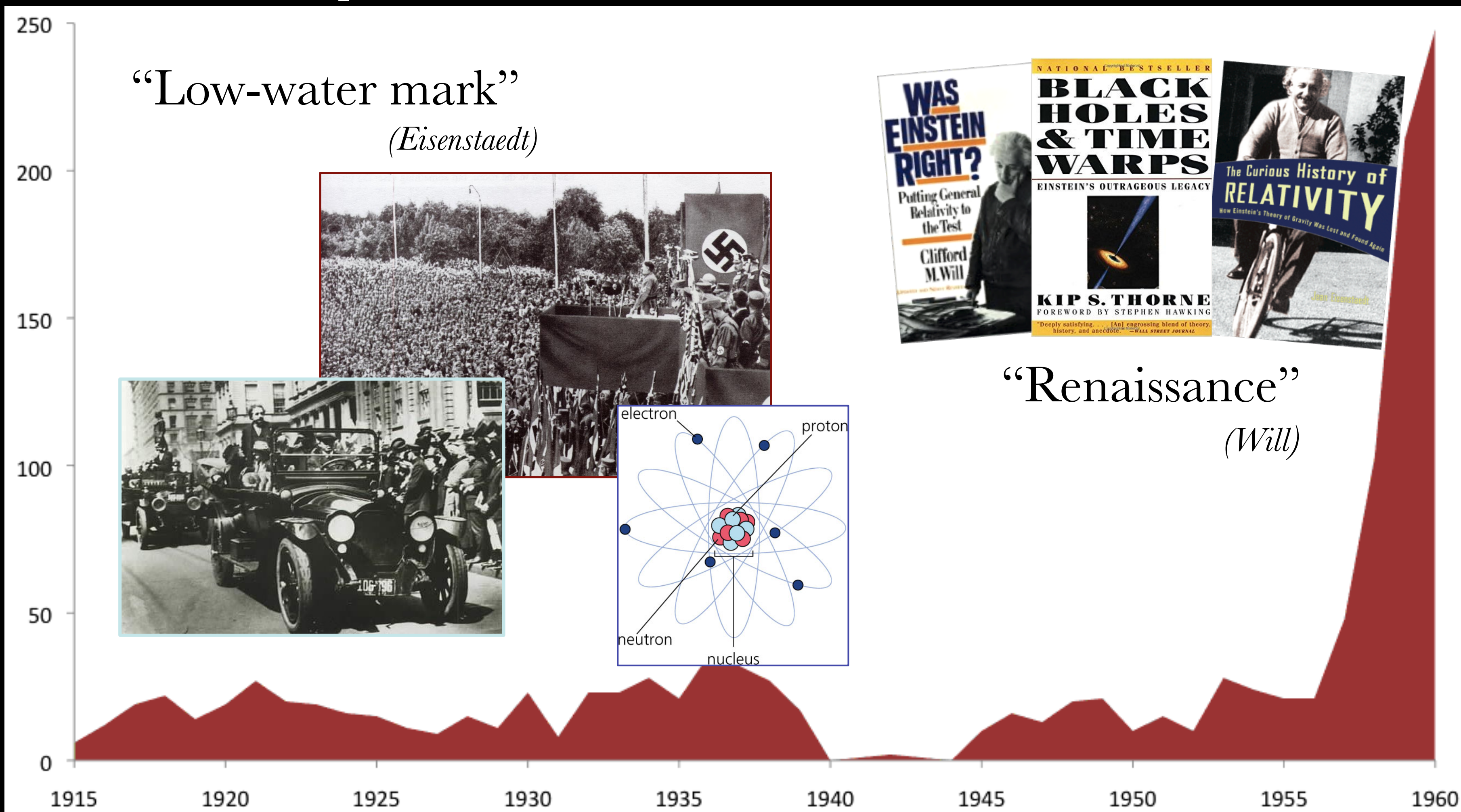
What Goes Up...

No. publications on *GR* worldwide, 1915-1960



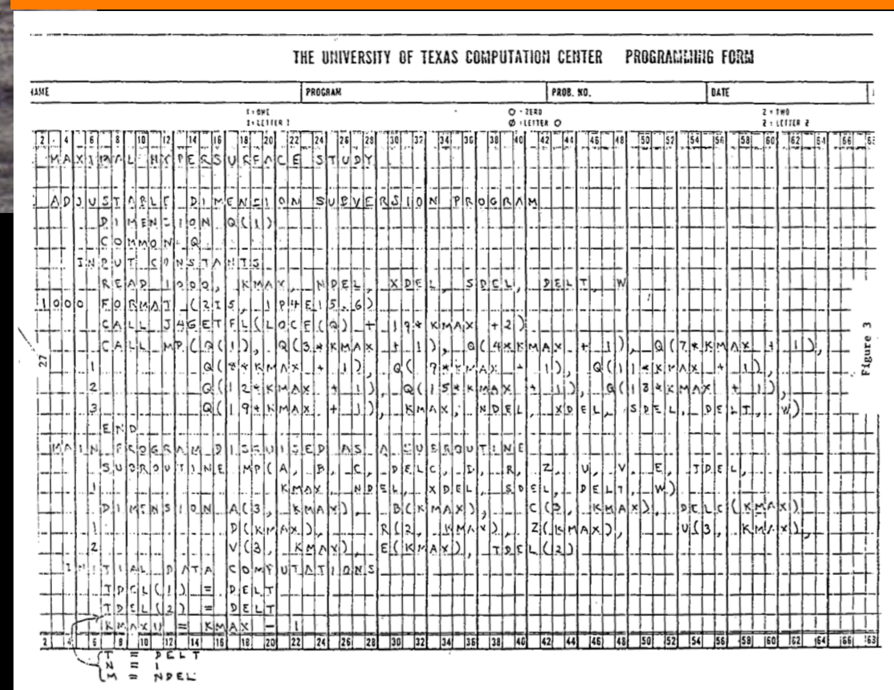
What Goes Up...

No. publications on *GR* worldwide, 1915-1960



Calculating Times

Coordinated Blasts



THE UNIVERSITY OF TEXAS COMPUTATION CENTER PROGRAMMING FORM

NAME | PROGRAM | PROB. NO. | DATE

```
 MAXIMAL HYPERSURFACE STUDY

 ADJUSTABLE DIMENSION SUBVERSION PROGRAM
      DIMENSION Q(1)
      COMMON Q
    INPUT CONSTANTS
      READ 1000, KMAX, NDEL, XDEL, SDEL, DELT, W
1000  FORMAT (2I5, 1P4E15.6)
      CALL J4GETFL(LOCF(Q) + 19*KMAX +2)
      CALL MP(Q(1), Q(3*KMAX + 1), Q(4*KMAX + 1), Q(7*KMAX + 1),
     1          Q(8*KMAX + 1), Q(7*KMAX + 1), Q(11*KMAX + 1),
     2          Q(12*KMAX + 1), Q(15*KMAX + 1), Q(18*KMAX + 1),
     3          Q(19*KMAX + 1), KMAX, NDEL, XDEL, SDEL, DELT, W)
      END
 MAIN PROGRAM DISGUISED AS A SUBROUTINE
      SUBROUTINE MP(A, B, C, DELC, D, R, Z, U, V, E, TDEL,
     1          KMAX, NDEL, XDEL, SDEL, DELT, W)
      DIMENSION A(3, KMAX), B(KMAX), C(3, KMAX), DELC(KMAX),
     1          D(KMAX), R(2, KMAX), Z(KMAX), U(3, KMAX),
     2          V(3, KMAX), E(KMAX), TDEL(2)
 INITIAL DATA COMPUTATIONS
      TDEL(1) = DELT
      TDEL(2) = DELT
      KMAXU = KMAX - 1
   T = DELT
   N = 1
   M = NDEL
```

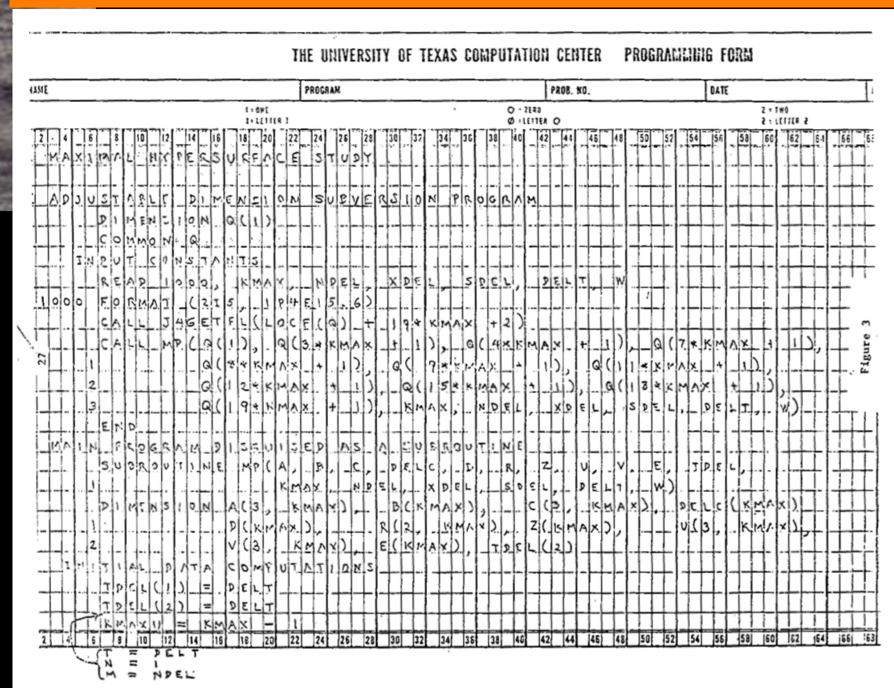
27

Figure 3

Calculating Times

Ben Wilson

Coordinated Blasts



THE UNIVERSITY OF TEXAS COMPUTATION CENTER PROGRAMMING FORM

NAME | PROGRAM | PROB. NO. | DATE

```
 MAXIMAL HYPERSURFACE STUDY

 ADJUSTABLE DIMENSION SUBVERSION PROGRAM
      DIMENSION Q(1)
      COMMON Q
  INPUT CONSTANTS
      READ 1000, KMAX, NDEL, XDEL, SDEL, DELT, W
 1000 FORMAT (2I5, 1P4E15.6)
      CALL J4GETFL(LOCF(Q) + 19*KMAX +2)
      CALL MP (Q(1), Q(3*KMAX + 1), Q(4*KMAX + 1), Q(7*KMAX + 1),
     1        Q(8*KMAX + 1), Q(9*KMAX + 1), Q(11*KMAX + 1),
     2        Q(12*KMAX + 1), Q(15*KMAX + 1), Q(18*KMAX + 1),
     3        Q(19*KMAX + 1), KMAX, NDEL, XDEL, SDEL, DELT, W)
      END
 MAIN PROGRAM DISGUISED AS A SUBROUTINE
      SUBROUTINE MP(A, B, C, DELC, D, R, Z, U, V, E, TDEL,
     1              KMAX, NDEL, XDEL, SDEL, DELT, W)
      DIMENSION A(3, KMAX), B(KMAX), C(3, KMAX), DELC(KMAX),
     1              D(KMAX), R(2, KMAX), Z(KMAX), U(3, KMAX),
     2              V(3, KMAX), E(KMAX), TDEL(2)
  INITIAL DATA COMPUTATIONS
      TDEL(1) = DELT
      TDEL(2) = DELT
      KMAX1 = KMAX - 1
```

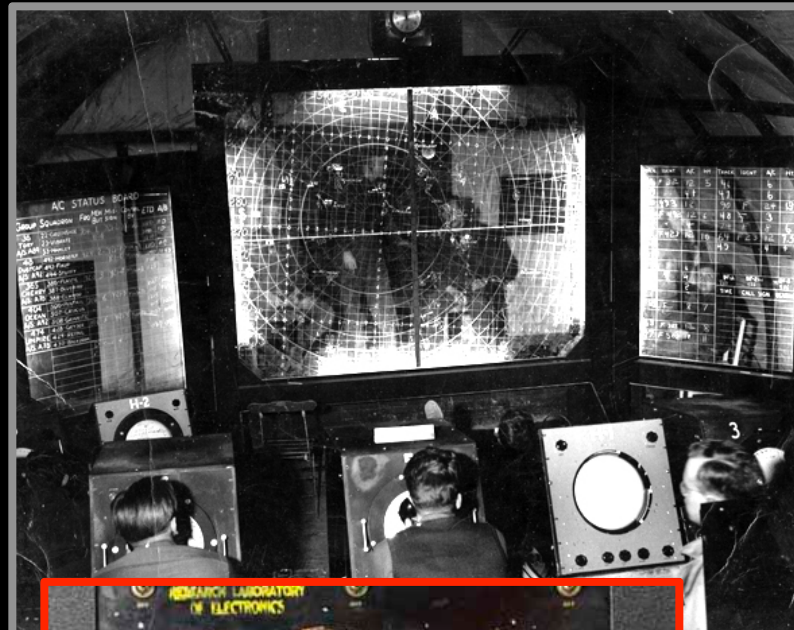
T = DELT
N = 1
M = NDEL

27

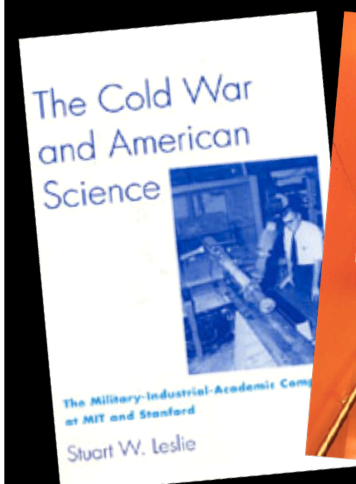
Figure 3

MIT: From Rad Lab to RLE

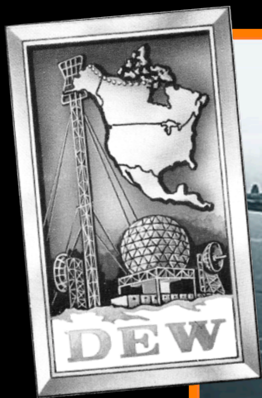
MIT Rad Lab, WWII

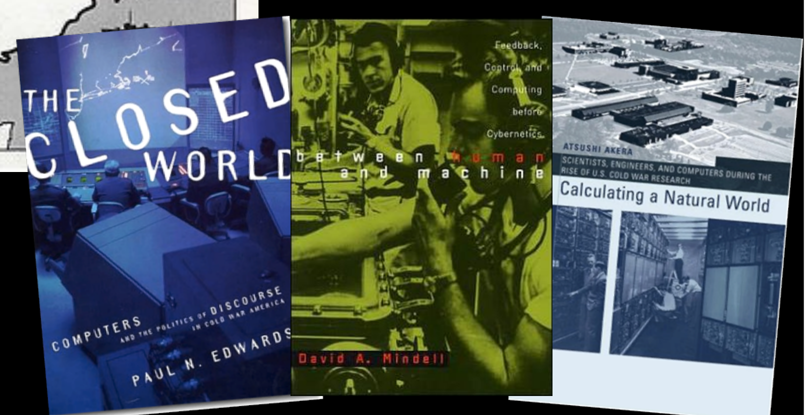


1945

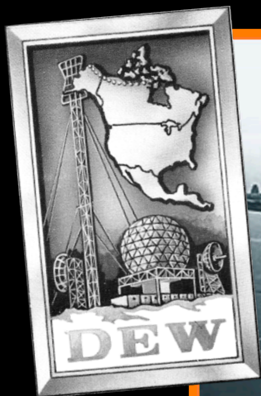


Lincoln Laboratory



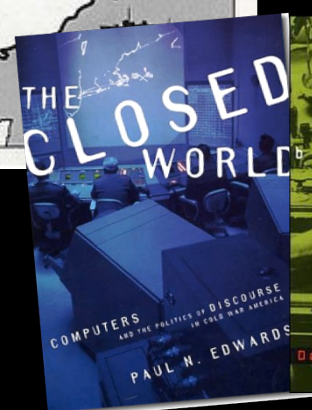


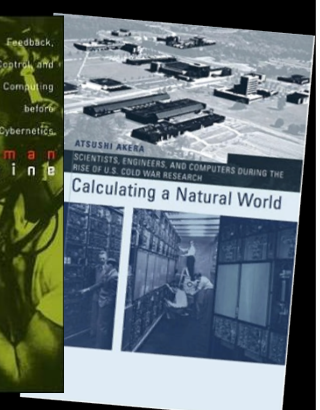
Lincoln Laboratory



Project Whirlwind

SAGE:
- Semi-Automatic
- Ground
- Environment

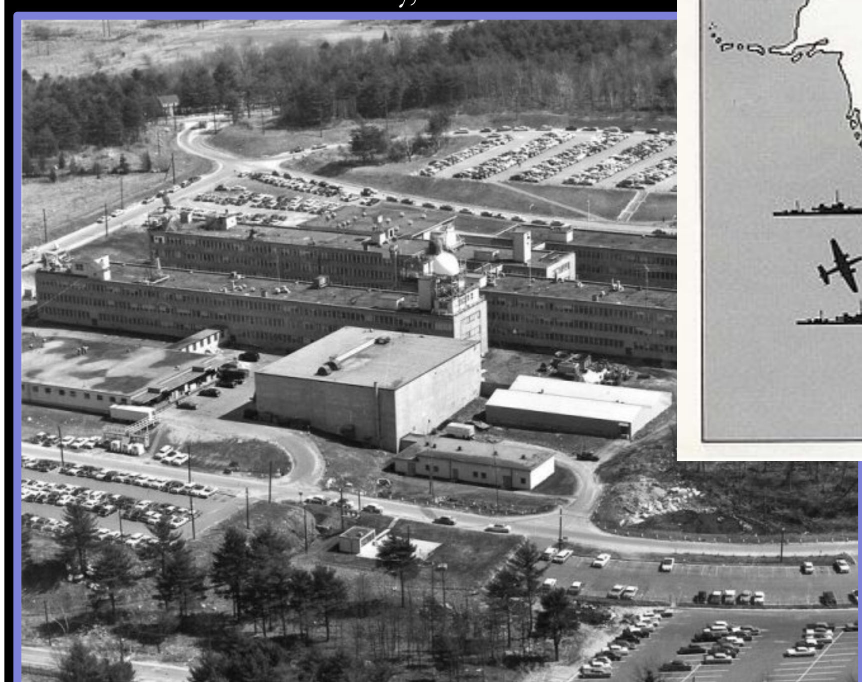




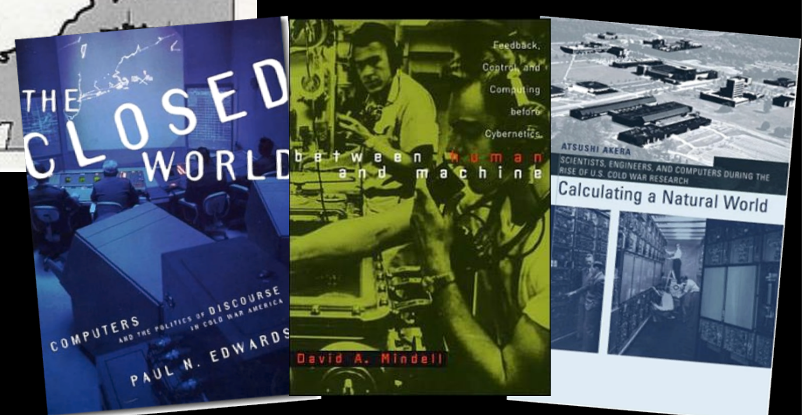
Lincoln Laboratory

Project Whirlwind

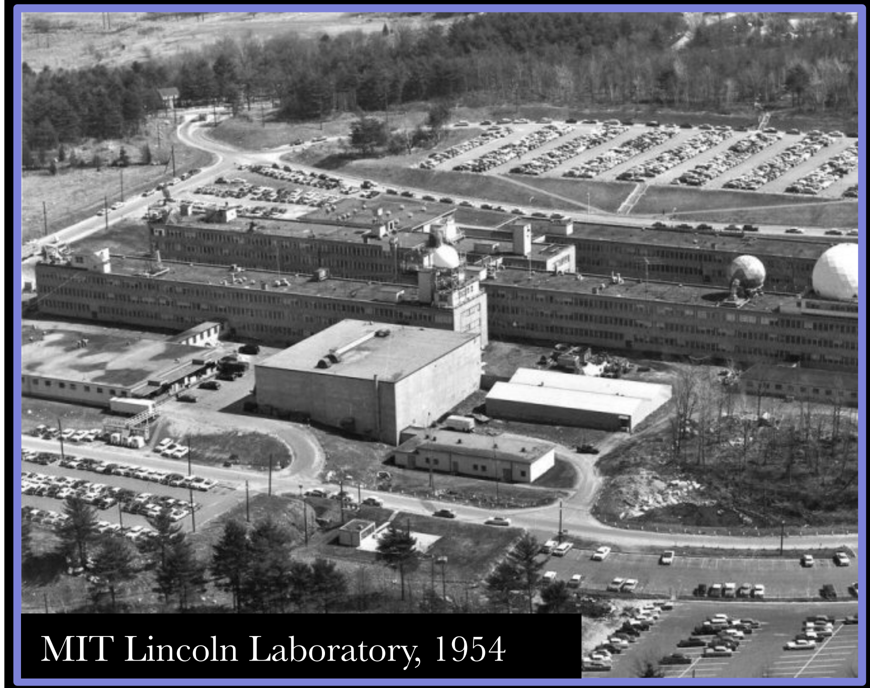
MIT Lincoln Laboratory, 1954



SAGE:
Semi-Automatic
Ground
Environment

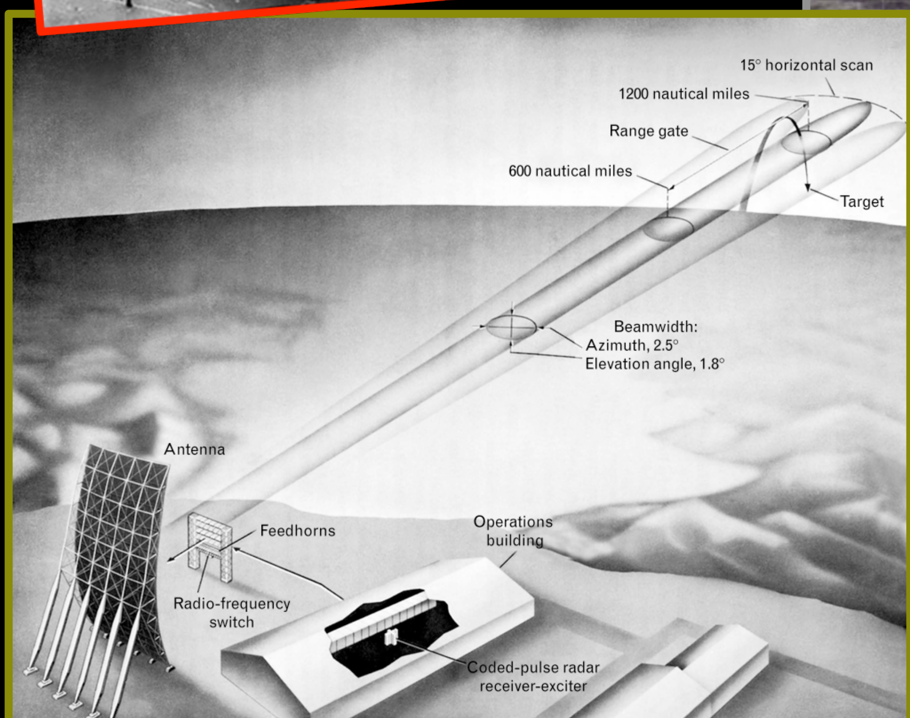


Ballistic Missile Detection

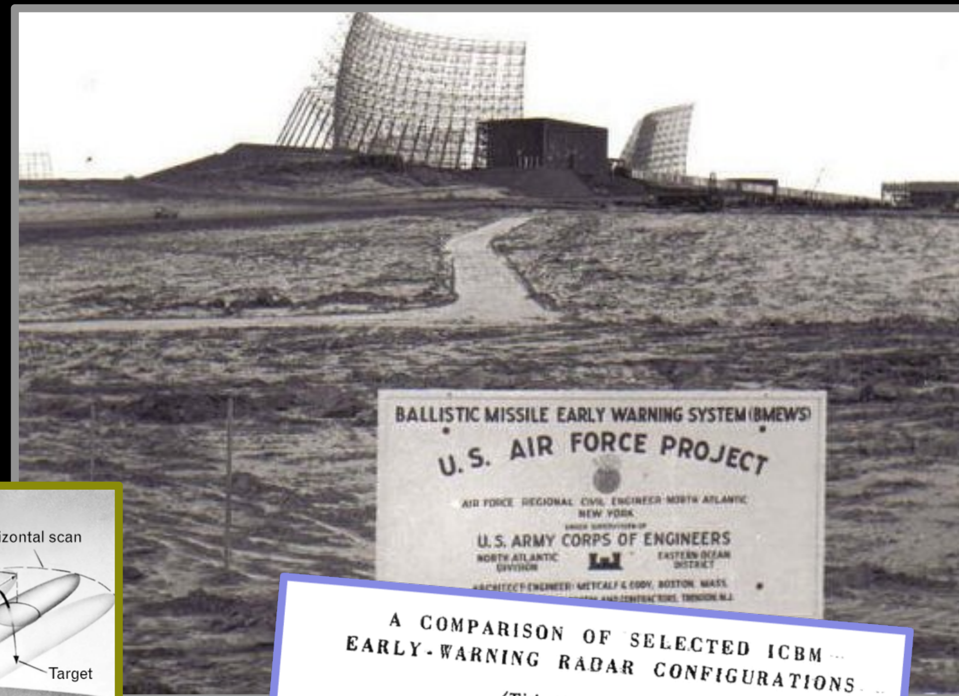


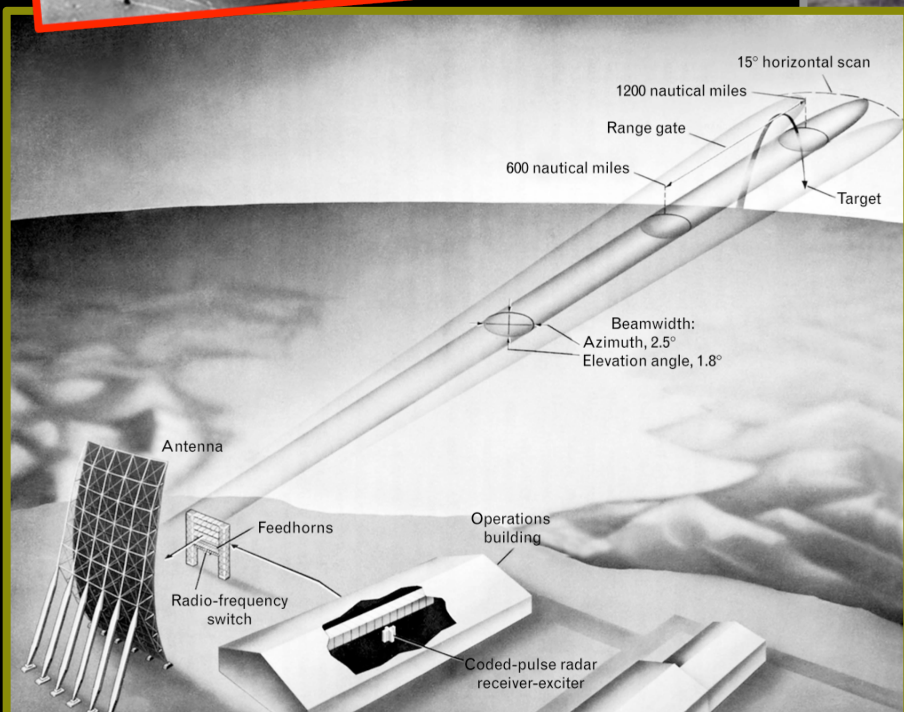
MIT Lincoln Laboratory, 1954

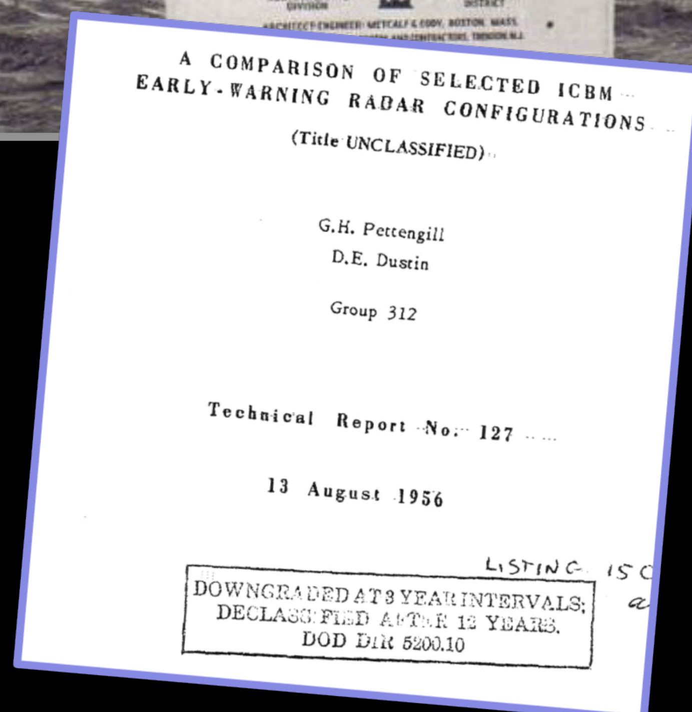
Ballistic Missile Detection



Ballistic Missile Detection







A COMPARISON OF SELECTED ICBM EARLY-WARNING RADAR CONFIGURATIONS

(Title UNCLASSIFIED)

G.H. Pettengill

D.E. Dustin

Group 312

Technical Report No. 127

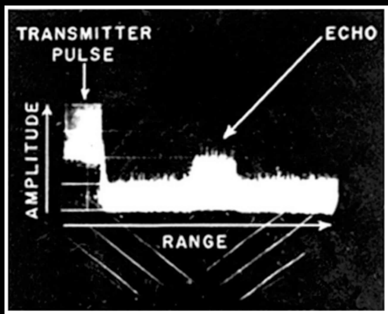
13 August 1956

DOWNGRADED AT 3 YEAR INTERVALS; DECLASSIFIED AFTER 12 YEARS. DOD DIR 5200.10

Trajectory Estimation

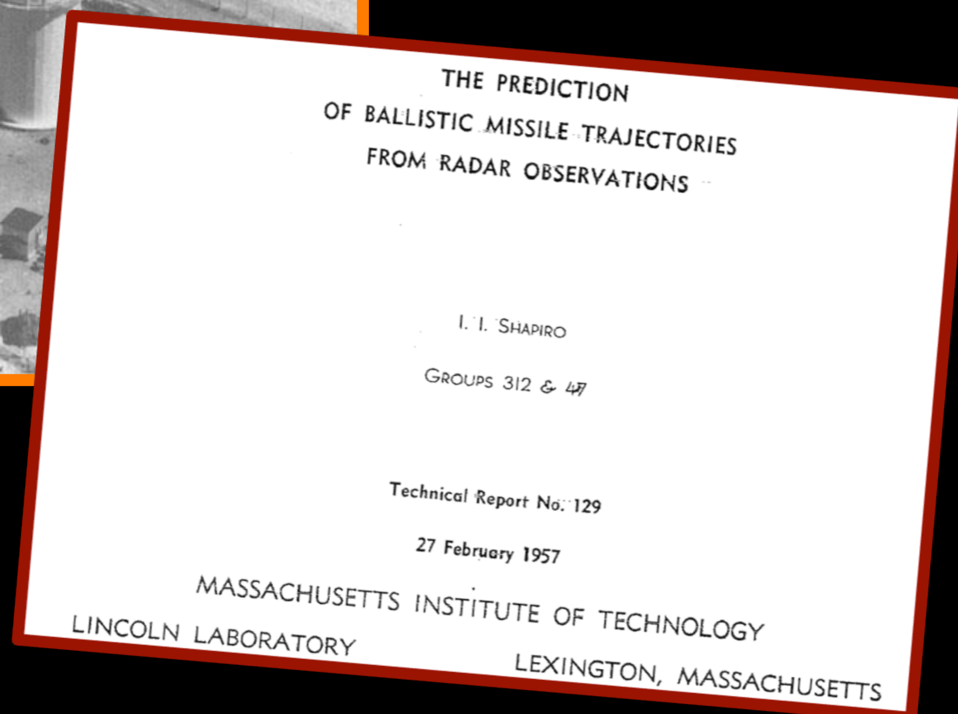
Millstone radar, 1957

Trajectory Estimation



Millstone radar, 1957

Irwin I. Shapiro



THE PREDICTION
OF BALLISTIC MISSILE TRAJECTORIES
FROM RADAR OBSERVATIONS

I. I. SHAPIRO

GROUPS 312 & 47

Technical Report No. 129

27 February 1957

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY LEXINGTON, MASSACHUSETTS

"Clutter environments": use Doppler signatures of individual reflections to distinguish signal from noise.

Target Practice

Target Practice

"This recording technique appears to be especially promising for those experiments in which *a priori* knowledge is lacking in several respects and only a brief period is available for observation."

Lincoln Lab director Carl Overhage to Lt. General Roscoe Wilson (Air Force), 24 March 1959

Target Practice

"This recording technique appears to be especially promising for those experiments in which *a priori* knowledge is lacking in several respects and only a brief period is available for observation."

Lincoln Lab director Carl Overhage to Lt. General Roscoe Wilson (Air Force), 24 March 1959

Test of equipment and design:

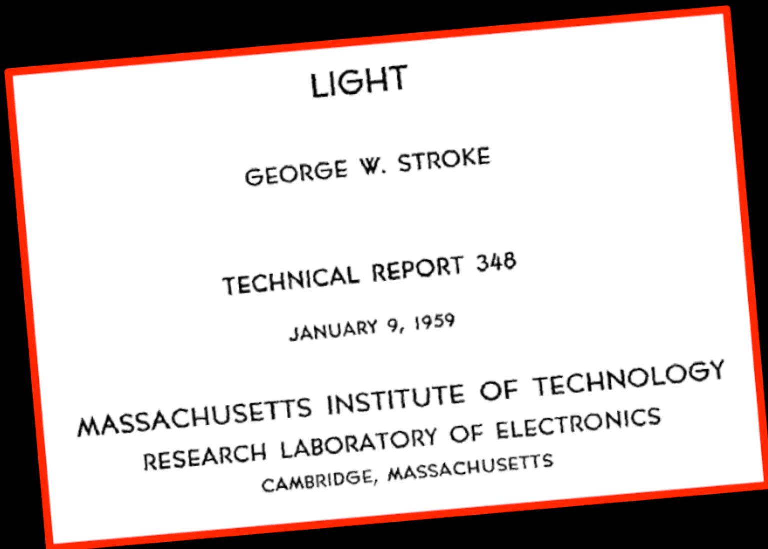
use magnetic tape for data recording;

use certain types of digital code for real-time data processing;

"Planetary Ephemeris Program": use radar inputs to estimate future position of objects in the sky; builds on statistical procedure for BMEWS.

Millstone control room

A Secret Briefing


LIGHT

GEORGE W. STROKE

TECHNICAL REPORT 348

JANUARY 9, 1959

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
RESEARCH LABORATORY OF ELECTRONICS
CAMBRIDGE, MASSACHUSETTS

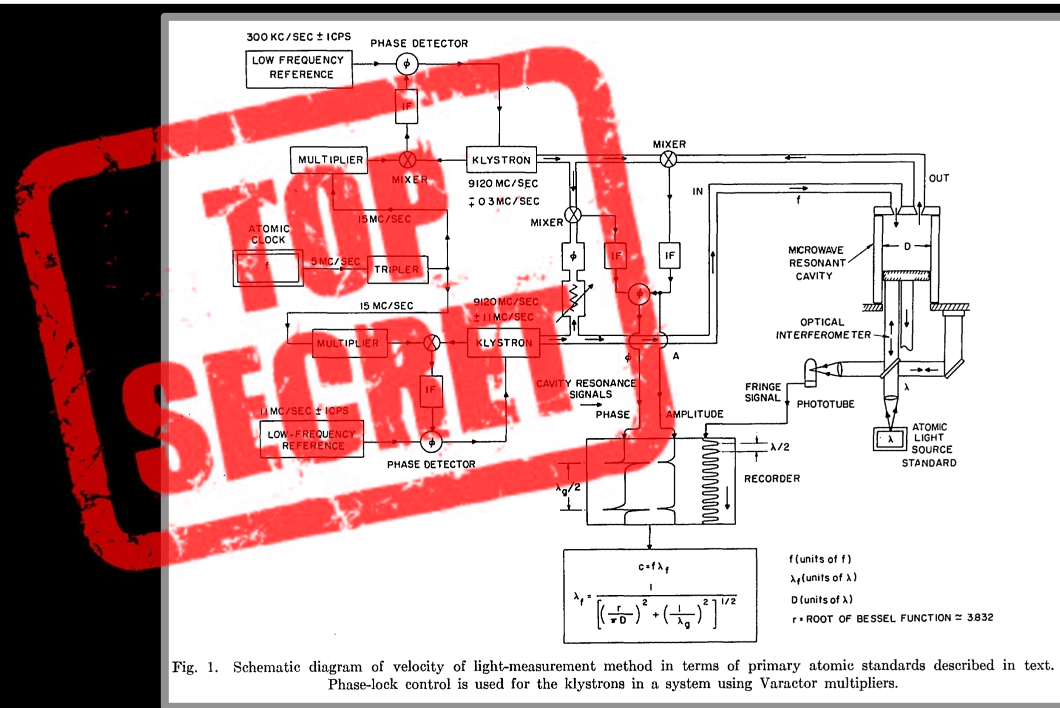
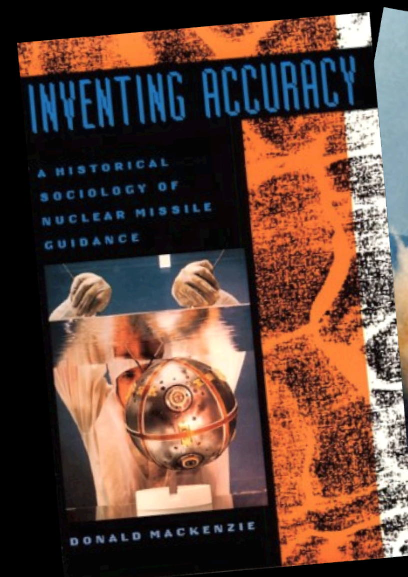


Fig. 1. Schematic diagram of velocity of light-measurement method in terms of primary atomic standards described in text. Phase-lock control is used for the klystrons in a system using Varactor multipliers.



US Navy Polaris missile

A Secret Briefing

LIGHT

GEORGE W. STROKE

TECHNICAL REPORT 348

JANUARY 9, 1959

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
RESEARCH LABORATORY OF ELECTRONICS
CAMBRIDGE, MASSACHUSETTS

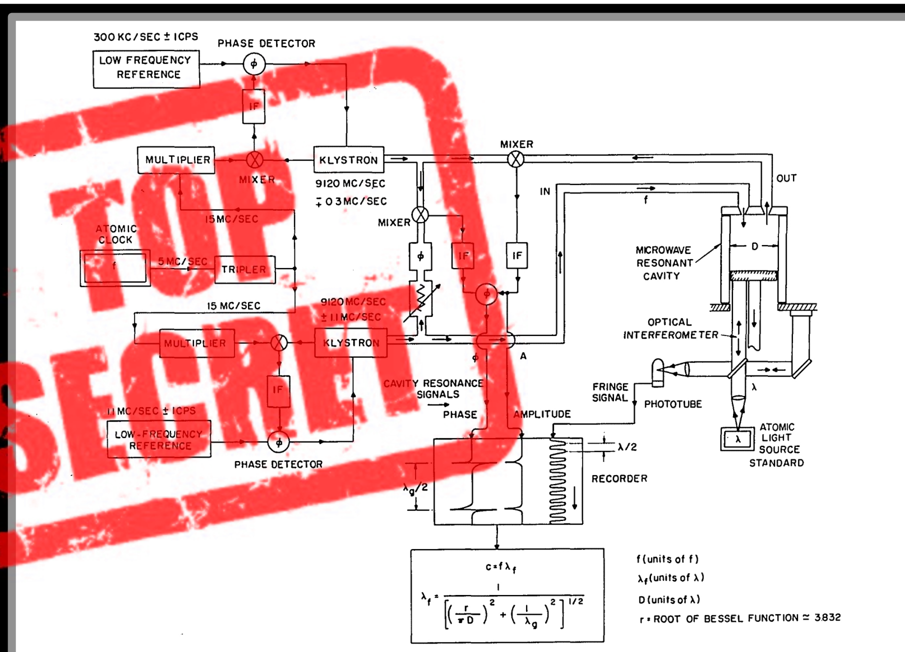


Fig. 1. Schematic diagram of velocity of light-measurement method in terms of primary atomic standards described in text. Phase-lock control is used for the klystrons in a system using Varactor multipliers.

3.3 RESULTS OF THE GENERAL THEORY OF RELATIVITY (1916)

The propagation of light is influenced by gravitation. This is one of the fundamental results of Einstein's general theory of relativity which has been put to experimental test and found to be valid (16).

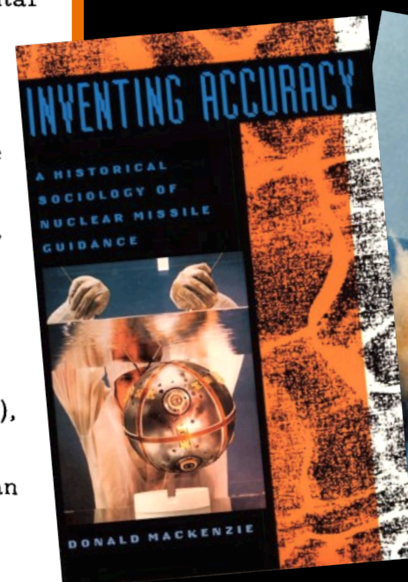
Three important results involving light need to be singled out (4).

(i) The velocity of light, measured by the same magnitude c independently of the state of motion of the frame in which the measurement is being carried out, should depend on the gravitational potential Φ of the field in which it is being measured, according to the equation

$$c = c_o\left(1 + \frac{\Phi}{c^2}\right)$$

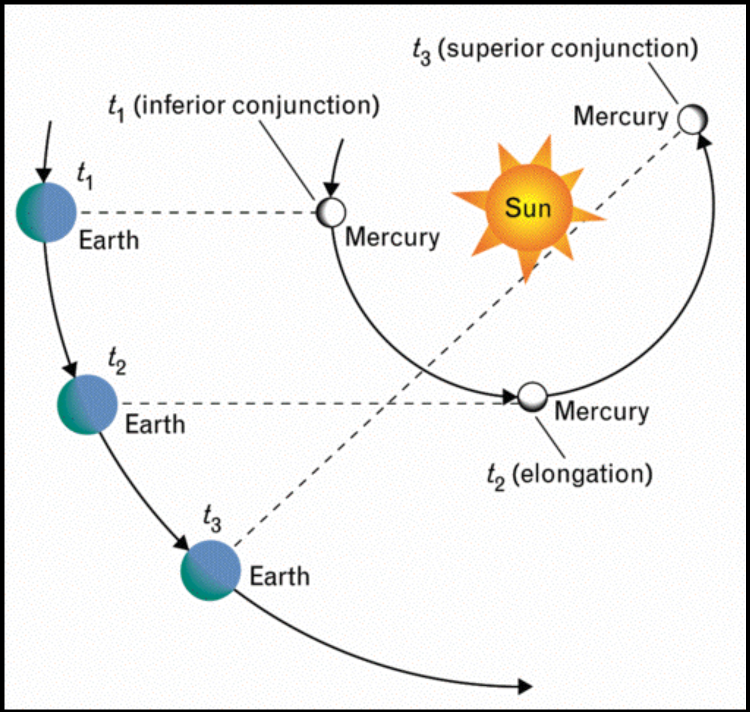
where $\Phi = -GM/R$ [G is the universal constant of gravitation (6.670×10^{-8} cgs units), M, the mass of the heavenly body (grams), and R, the radius of the body (cm)].

For example, the term Φ/c^2 is approximately 3000 times greater on the sun than on earth, so that the measurements of c are smaller by 2 parts in a million on the sun, as compared with measurements on earth.



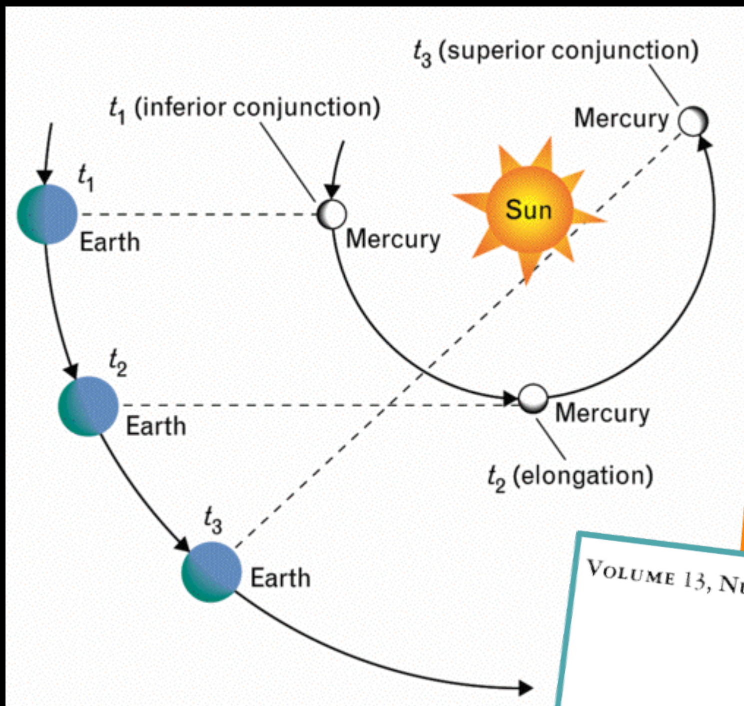
US Navy Polaris missile

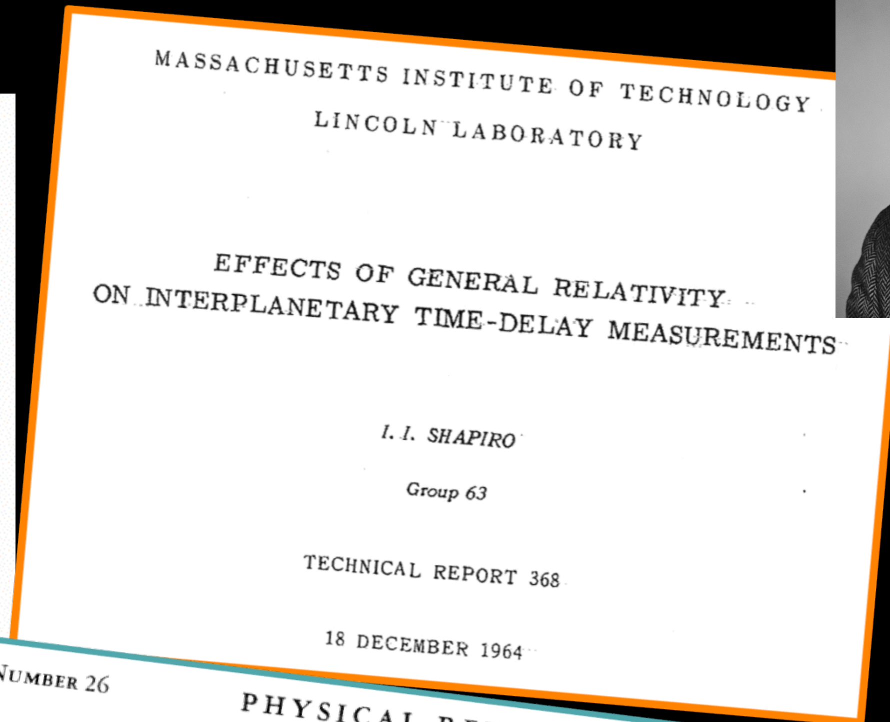
A New Test



I. I. Shapiro

A New Test




MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

EFFECTS OF GENERAL RELATIVITY
ON INTERPLANETARY TIME-DELAY MEASUREMENTS

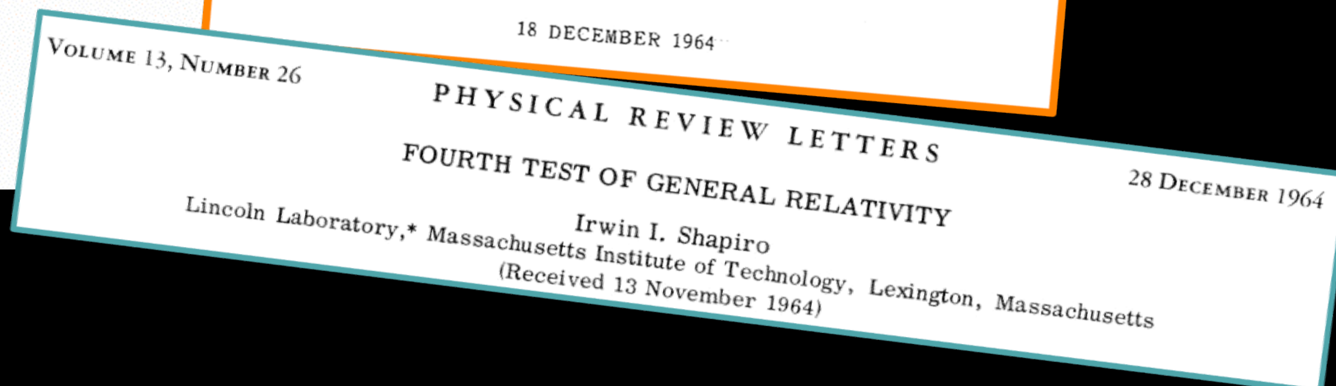
I. I. SHAPIRO

Group 63

TECHNICAL REPORT 368

18 DECEMBER 1964


I. I. Shapiro

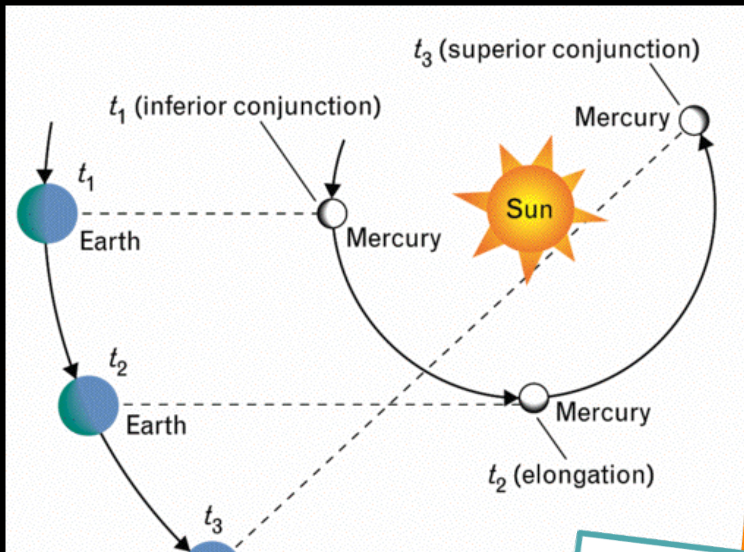

VOLUME 13, NUMBER 26 PHYSICAL REVIEW LETTERS 28 DECEMBER 1964

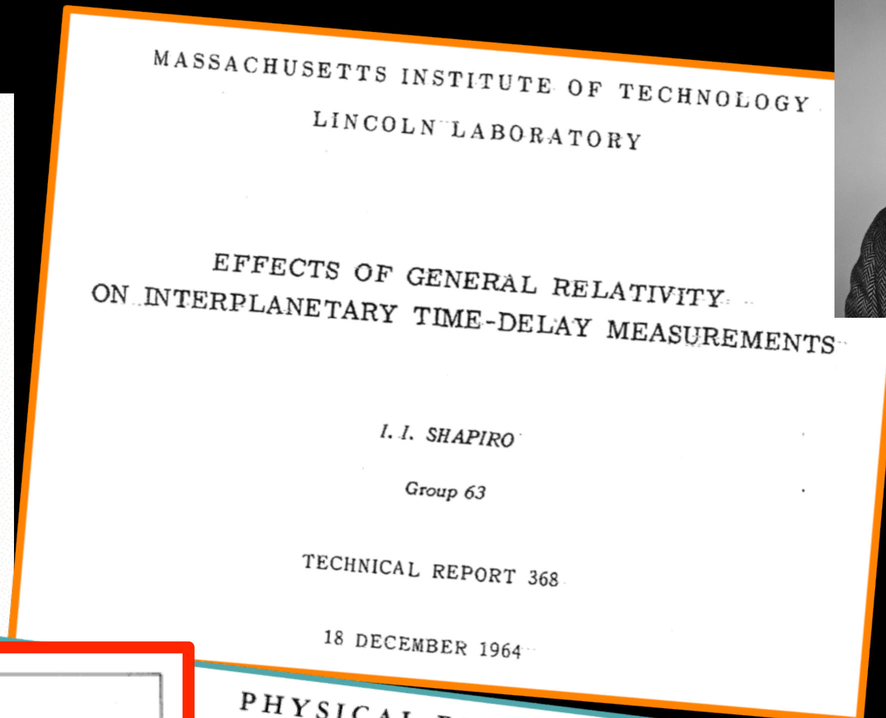
FOURTH TEST OF GENERAL RELATIVITY

Irwin I. Shapiro
Lincoln Laboratory,* Massachusetts Institute of Technology, Lexington, Massachusetts
(Received 13 November 1964)

Radar echo would be 10^{27} times weaker than the transmitted signal; the time-delay would be about 200µsec.

A New Test




MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

EFFECTS OF GENERAL RELATIVITY ON INTERPLANETARY TIME-DELAY MEASUREMENTS

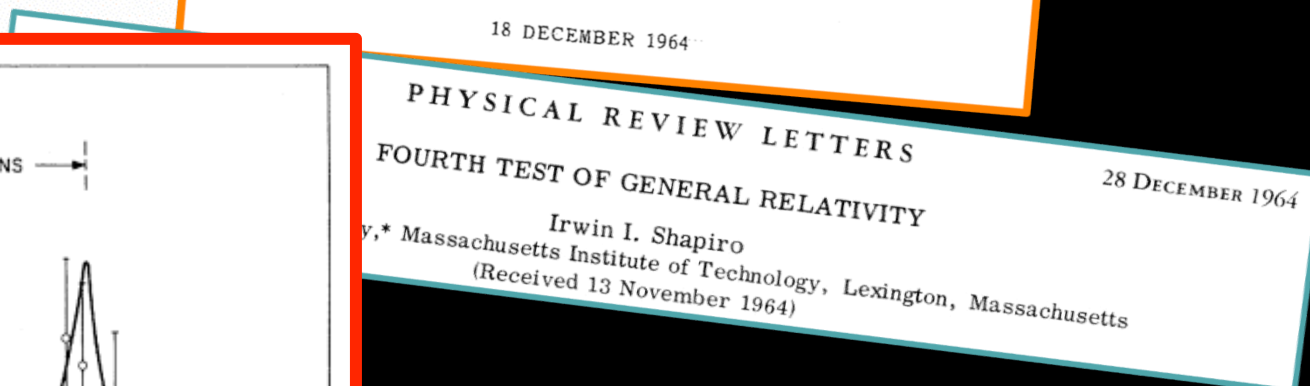
I. I. SHAPIRO

Group 63

TECHNICAL REPORT 368

18 DECEMBER 1964

I. I. Shapiro

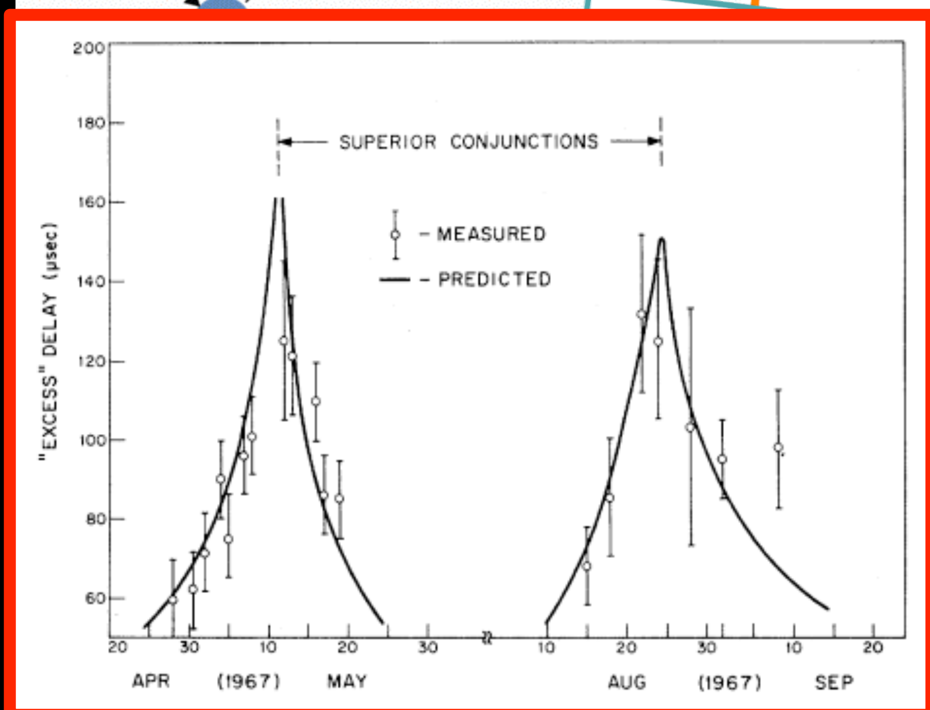

PHYSICAL REVIEW LETTERS — 28 DECEMBER 1964

FOURTH TEST OF GENERAL RELATIVITY

Irwin I. Shapiro

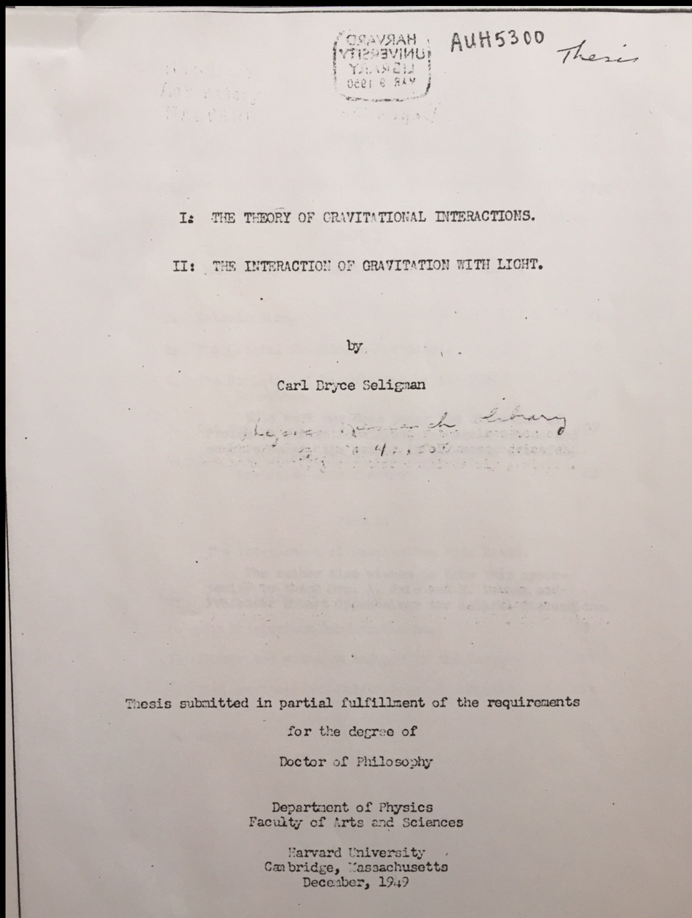
...y,* Massachusetts Institute of Technology, Lexington, Massachusetts

(Received 13 November 1964)



Radar echo would be 10^{27} times weaker than the transmitted signal; the time-delay would be about 200μsec.

From H-Bombs to the Cosmos


AUH5300 Thesis

I: THE THEORY OF GRAVITATIONAL INTERACTIONS.

II: THE INTERACTION OF GRAVITATION WITH LIGHT.

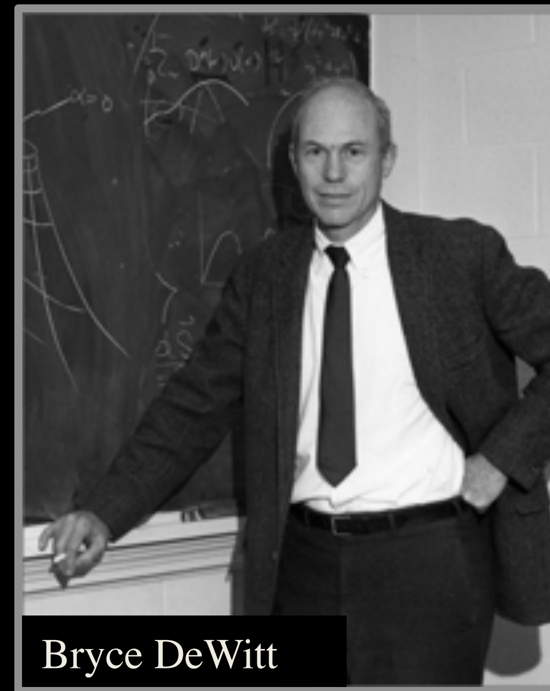
by

Carl Bryce Seligman

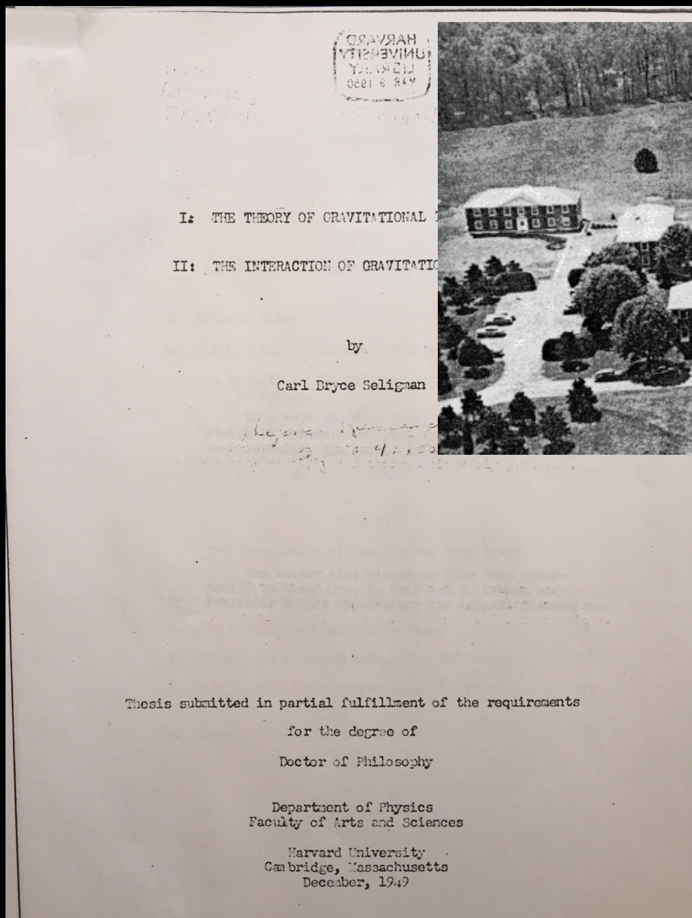
Thesis submitted in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy

Department of Physics
Faculty of Arts and Sciences

Harvard University
Cambridge, Massachusetts
December, 1949


Bryce DeWitt

From H-Bombs to the Cosmos


I: THE THEORY OF GRAVITATIONAL

II: THE INTERACTION OF GRAVITATIO

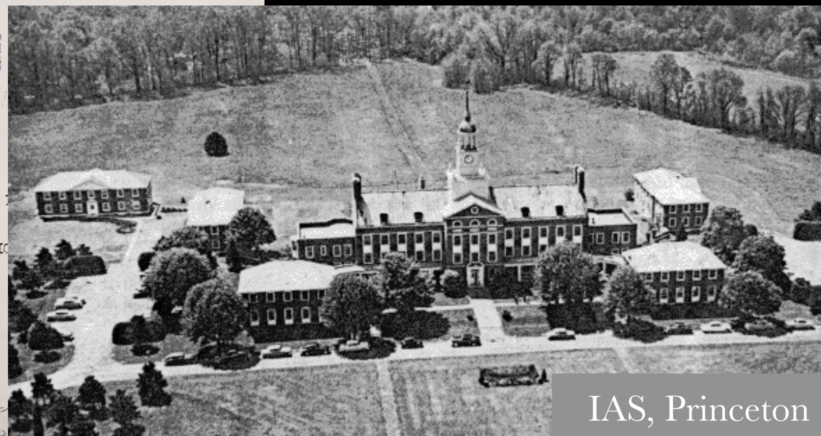
by

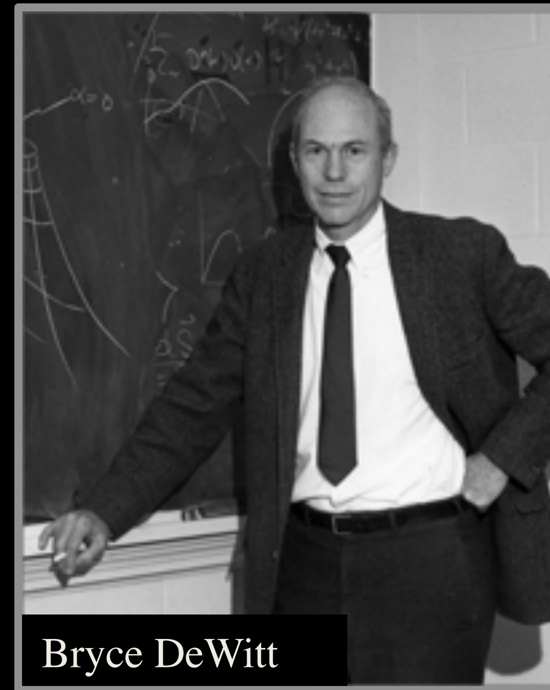
Carl Bryce Seligman

Thesis submitted in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy

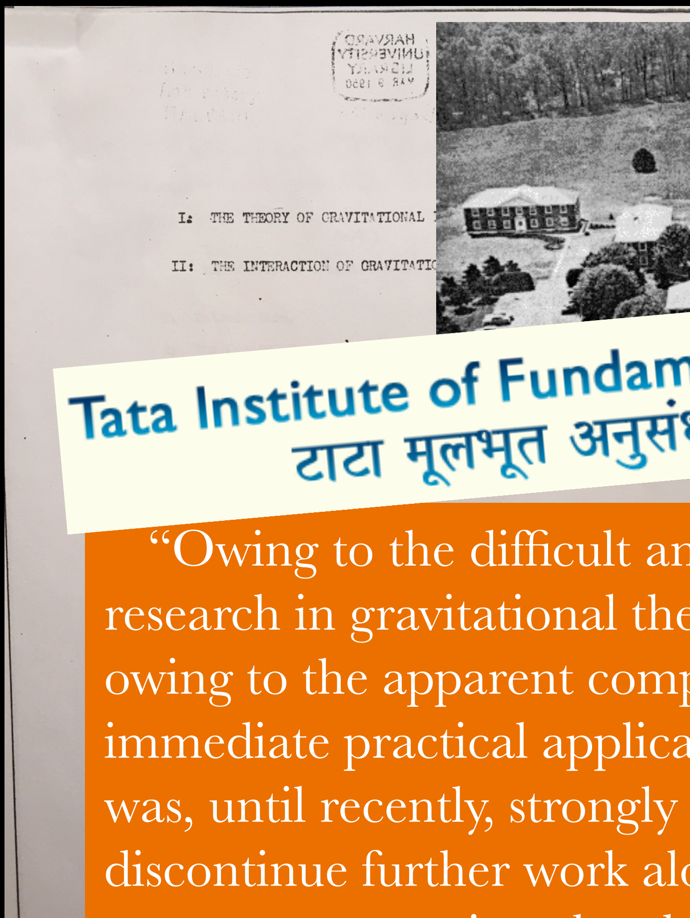
Department of Physics
Faculty of Arts and Sciences

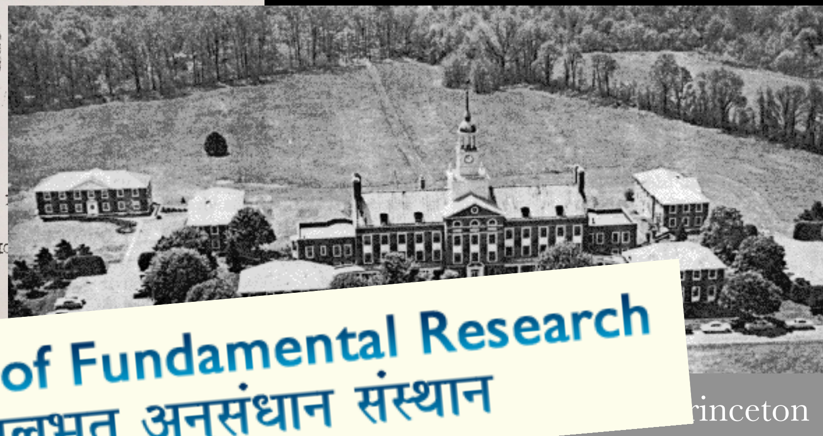
Harvard University
Cambridge, Massachusetts
December, 1949


IAS, Princeton

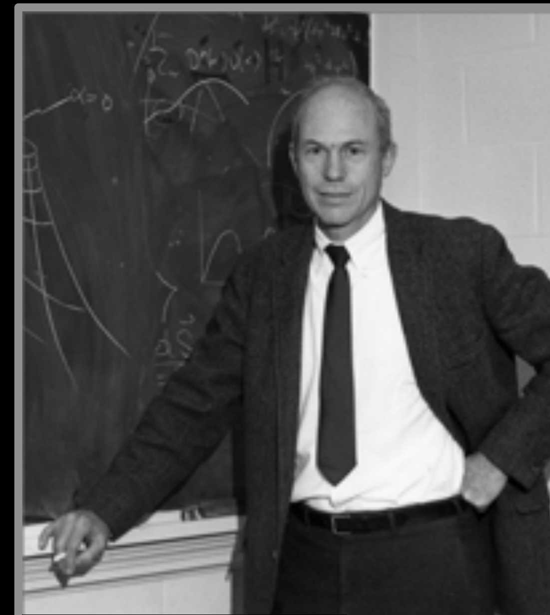

Bryce DeWitt

From H-Bombs to the Cosmos





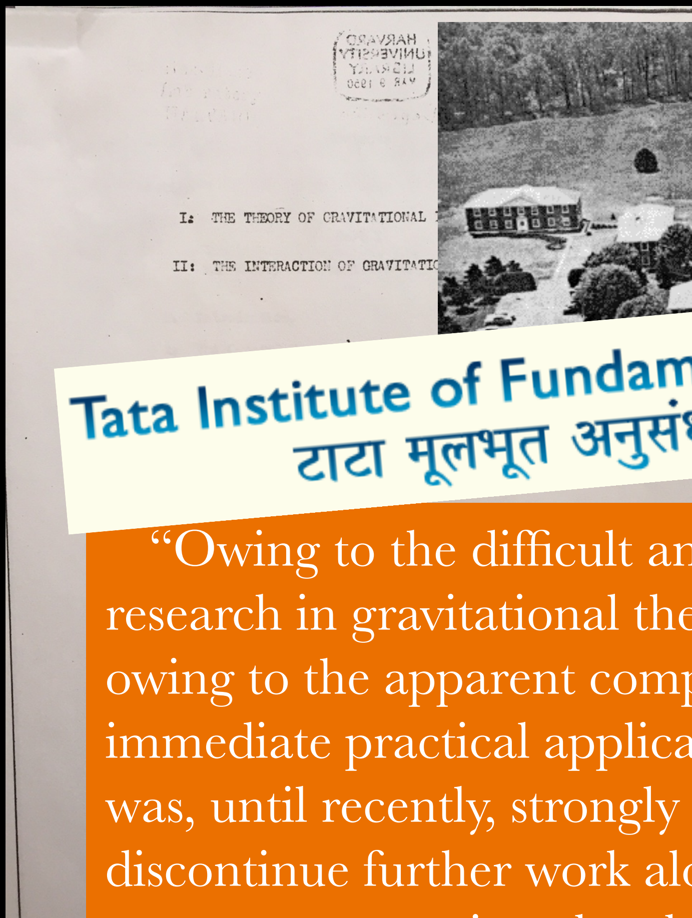
Tata Institute of Fundamental Research
टाटा मूलभूत अनुसंधान संस्थान


Bryce DeWitt

"Owing to the difficult and tedious nature of research in gravitational theory, and also owing to the apparent complete lack of any immediate practical application of its results, I was, until recently, strongly resolved to discontinue further work along these lines and to turn my attention elsewhere."

DeWitt to Raymond Birge, 11 November 1951

From H-Bombs to the Cosmos

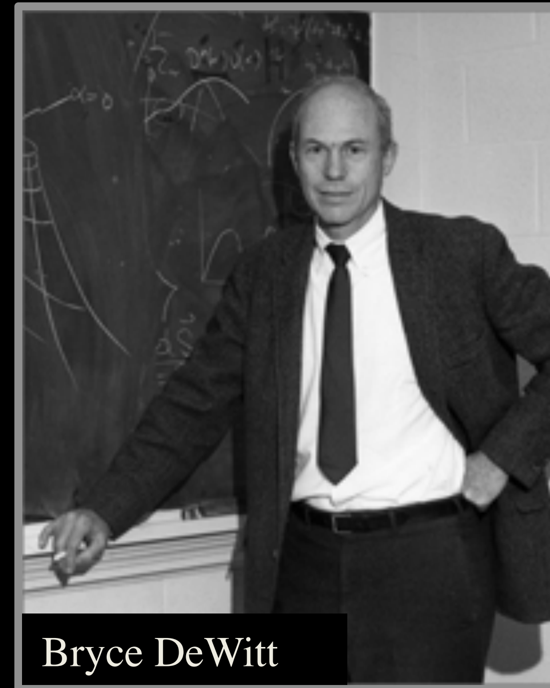


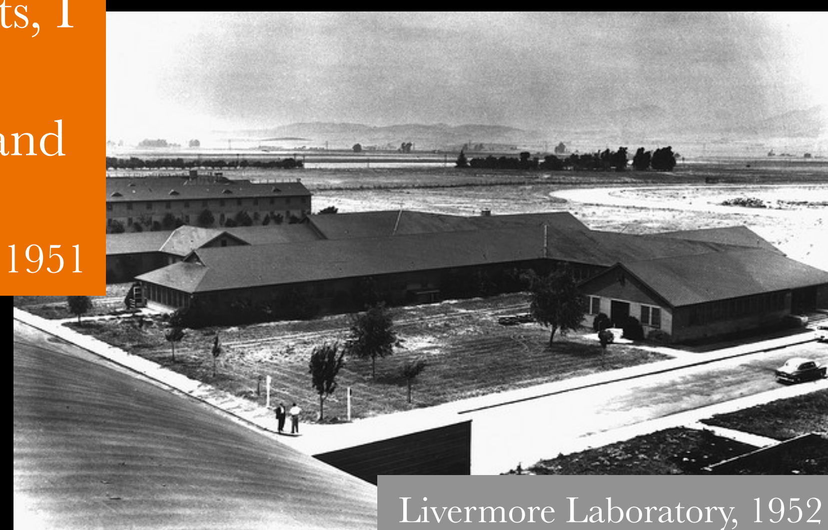

rinceton

Tata Institute of Fundamental Research
टाटा मूलभूत अनुसंधान संस्थान

"Owing to the difficult and tedious nature of research in gravitational theory, and also owing to the apparent complete lack of any immediate practical application of its results, I was, until recently, strongly resolved to discontinue further work along these lines and to turn my attention elsewhere."

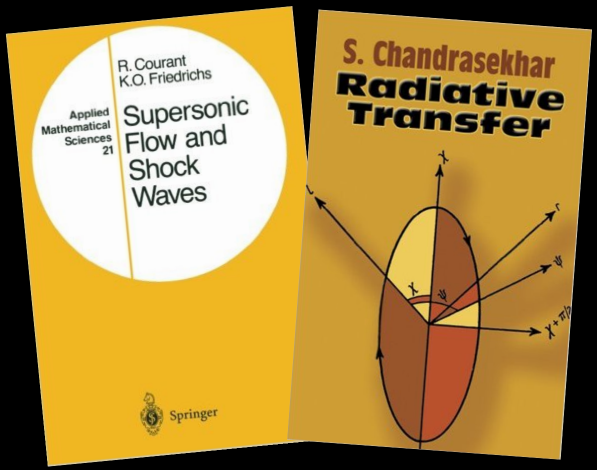
DeWitt to Raymond Birge, 11 November 1951


Bryce DeWitt


Livermore Laboratory, 1952

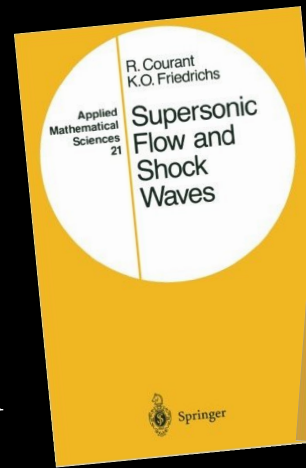
Simulating Flow

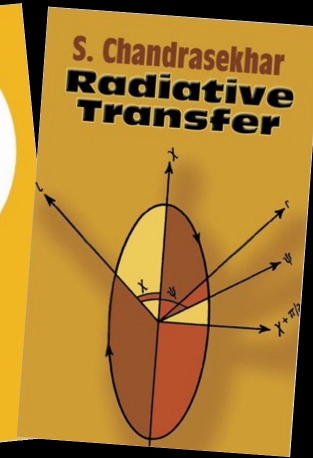
DeWitt arrived at Livermore in September 1952, was sent to the “leper colony” while awaiting clearance, and told to read about radiative transfer and shockwaves.

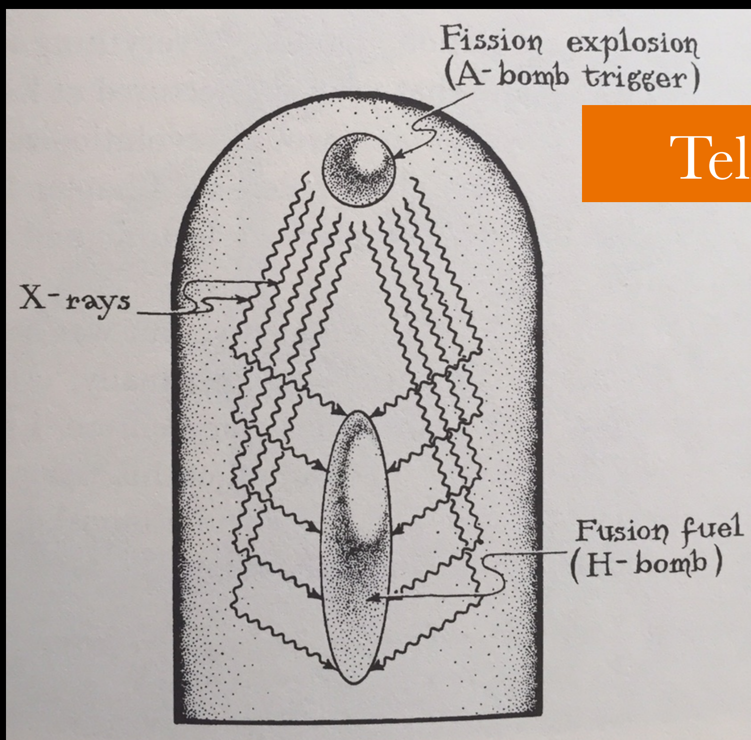


Simulating Flow

DeWitt arrived at Livermore in September 1952, was sent to the “leper colony” while awaiting clearance, and told to read about radiative transfer and shockwaves.





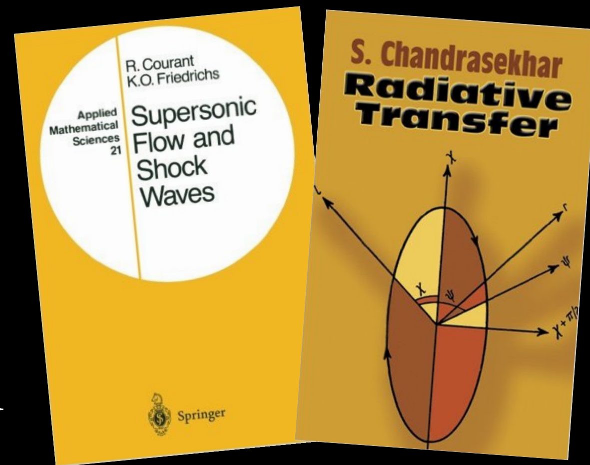


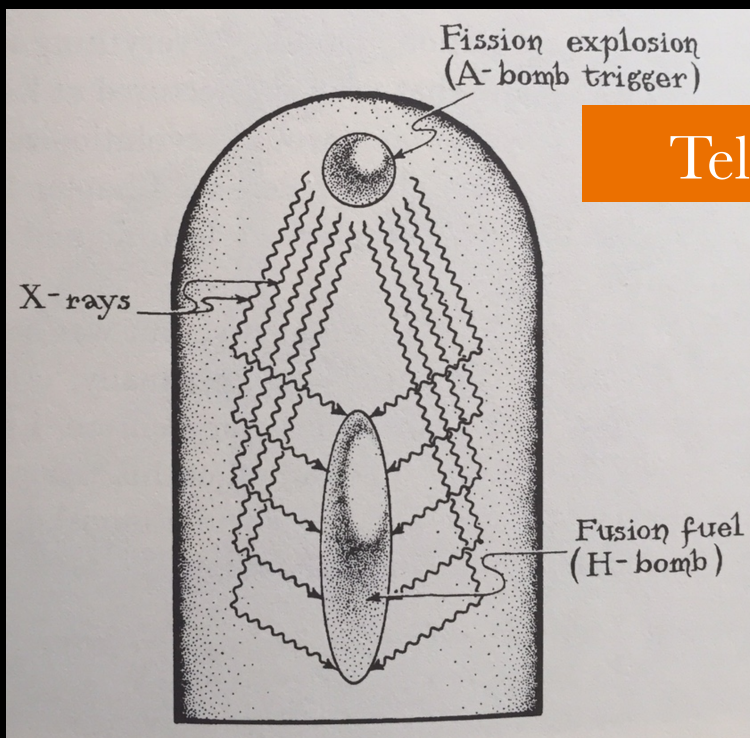
Teller-Ulam idea, 1951

M. Zimet in Thorne, *Black Holes & Time Warps*

Simulating Flow

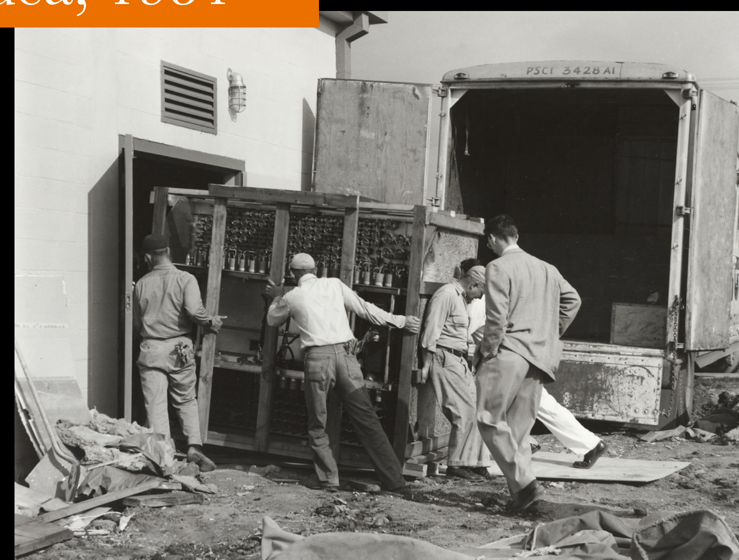
DeWitt arrived at Livermore in September 1952, was sent to the "leper colony" while awaiting clearance, and told to read about radiative transfer and shockwaves.





M. Zimet in Thorne, *Black Holes & Time Warps*

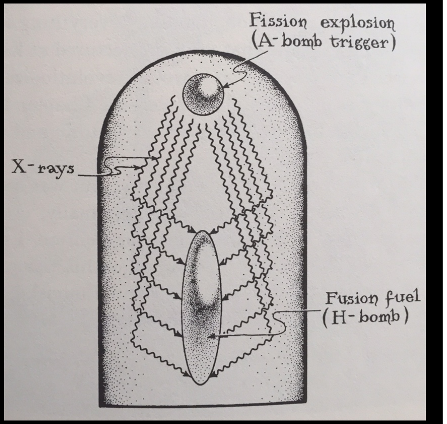
Teller-Ulam idea, 1951



UNIVAC-1 being delivered to Livermore, March 1953

Teller’s Assignment

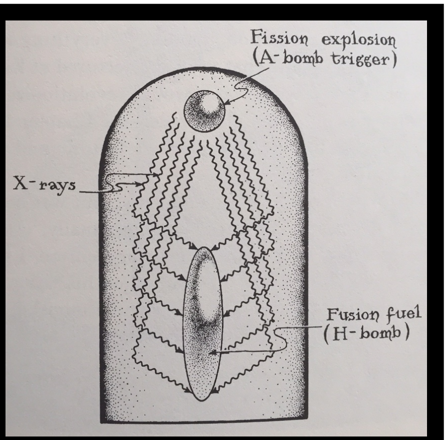
Early numerical codes had assumed spherical symmetry (1d), but essential details of H-bomb designs required 2d simulations.



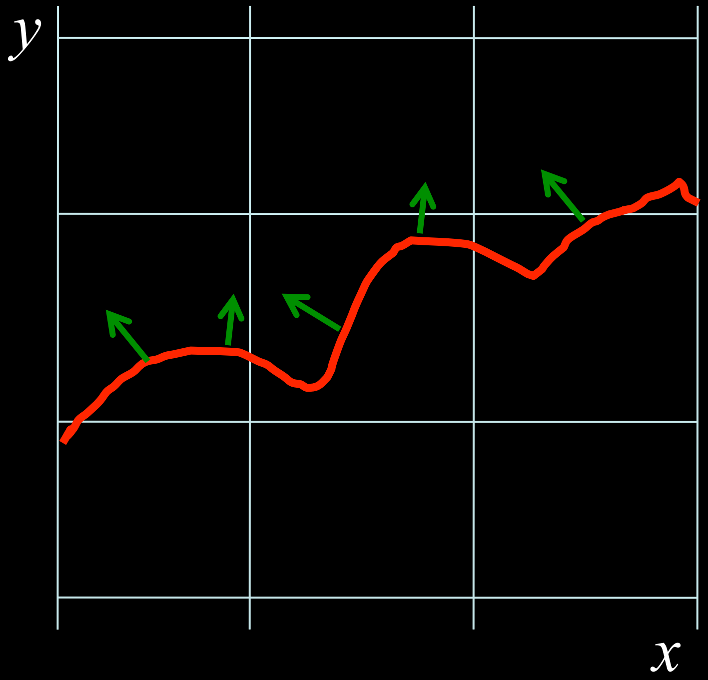
M. Zimet in Thorne,
Black Holes & Time Warps

Teller's Assignment

Early numerical codes had assumed spherical symmetry (1d), but essential details of H-bomb designs required 2d simulations.



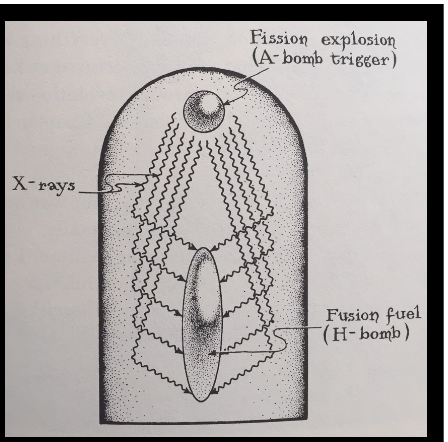
M. Zimet in Thorne, *Black Holes & Time Warps*



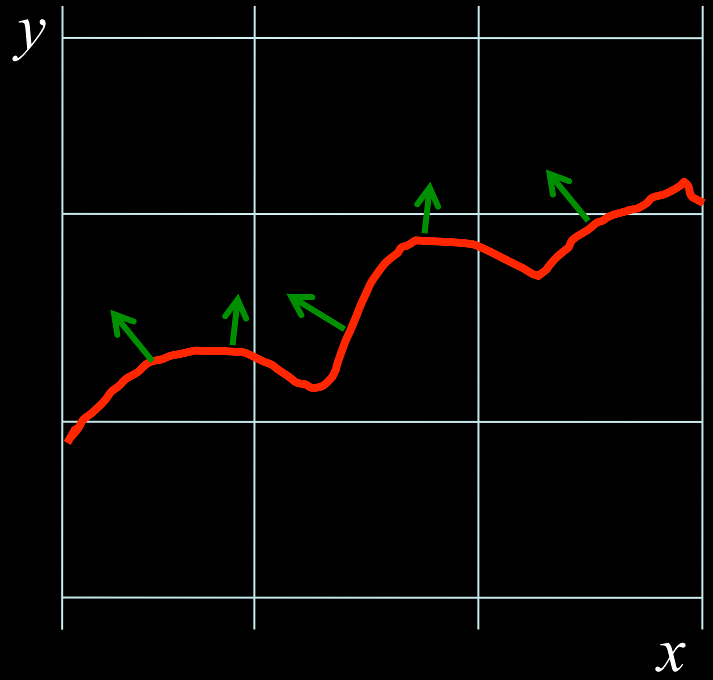
Eulerian coordinates:
fixed grid

Teller's Assignment

Early numerical codes had assumed spherical symmetry (1d), but essential details of H-bomb designs required 2d simulations.



M. Zimet in Thorne, *Black Holes & Time Warps*

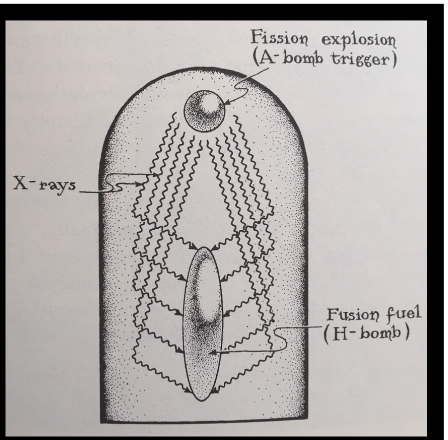


Eulerian coordinates: fixed grid

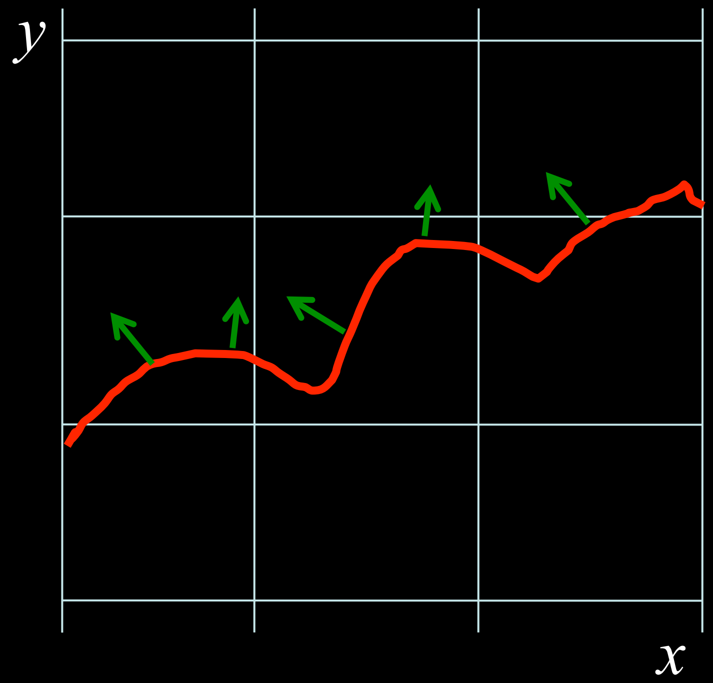
Difficulties: boundary conditions at each time-step, t; moving interfaces; radiation and shock waves exited the lattice too quickly.

Teller's Assignment

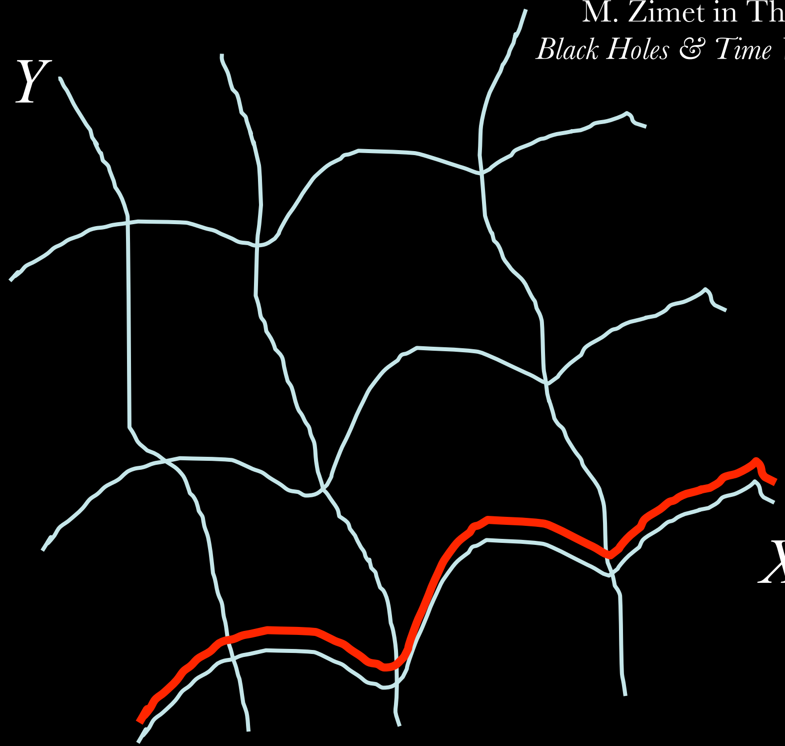
Early numerical codes had assumed spherical symmetry (1d), but essential details of H-bomb designs required 2d simulations.



M. Zimet in Thorne, *Black Holes & Time Warps*



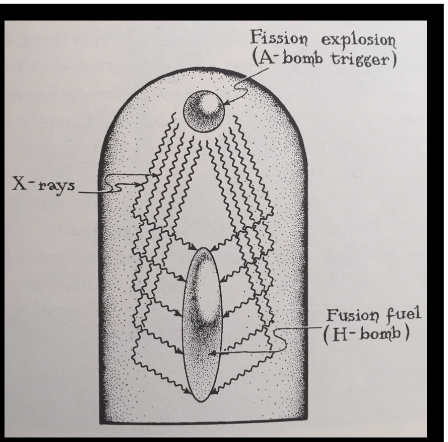
Eulerian coordinates: fixed grid



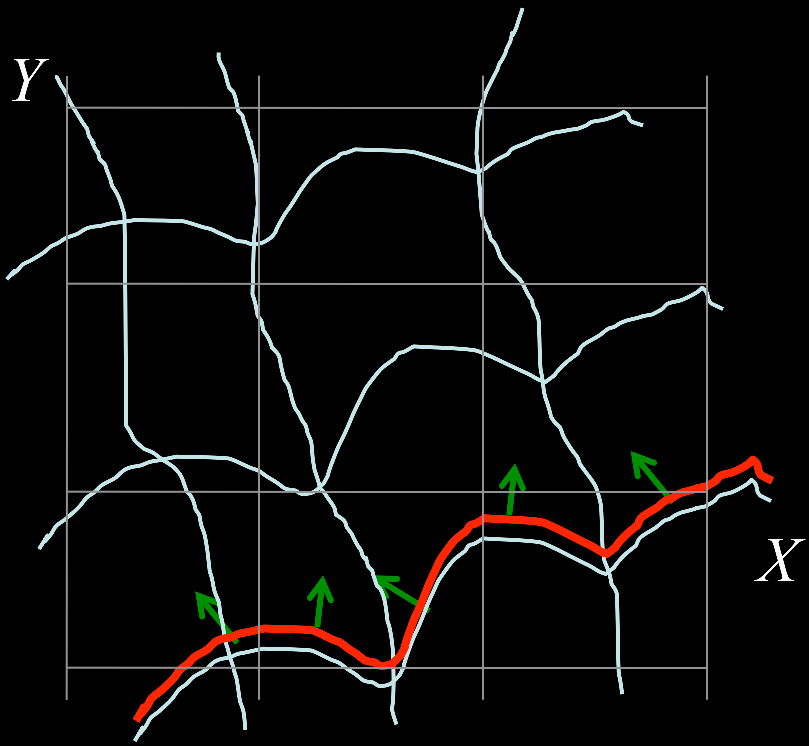
Lagrangian coordinates: flow with fluid elements

Teller's Assignment

Early numerical codes had assumed spherical symmetry (1d), but essential details of H-bomb designs required 2d simulations.



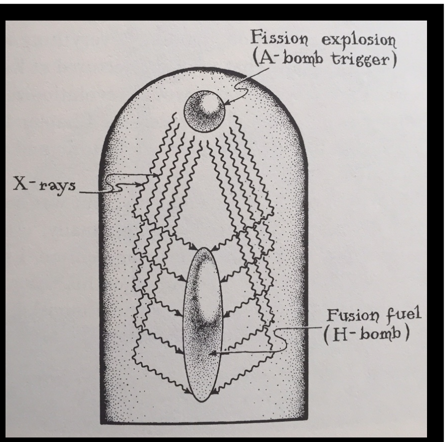
M. Zimet in Thorne,
Black Holes & Time Warps



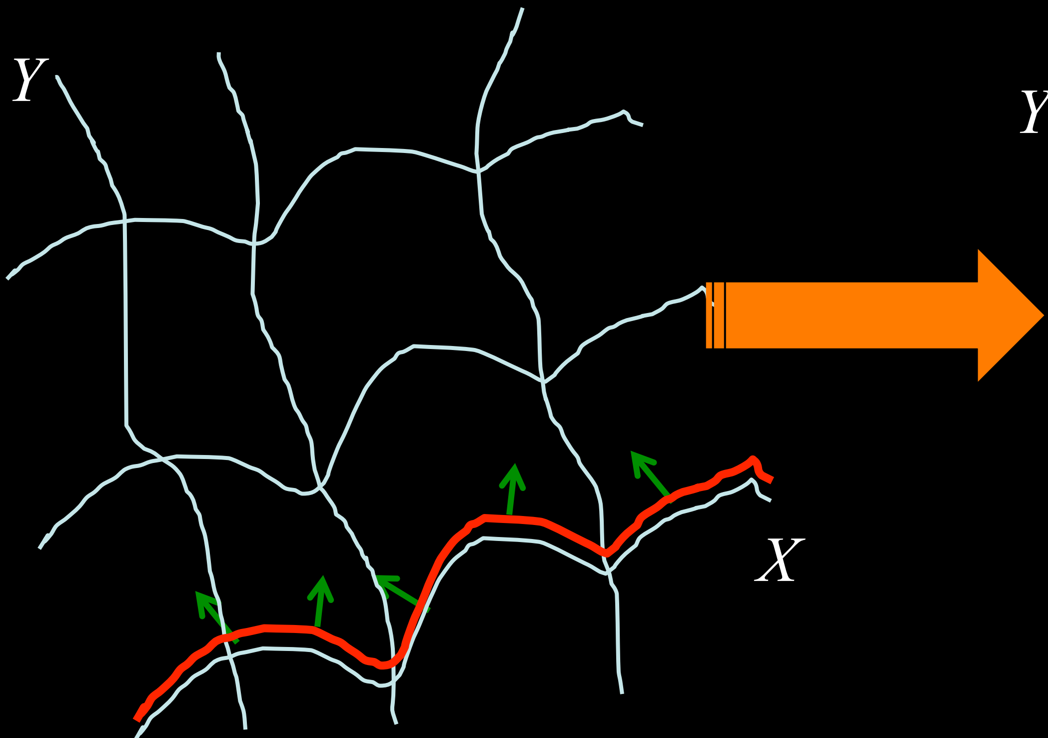
Lagrangian coordinates, with respect to Eulerian grid

Teller's Assignment

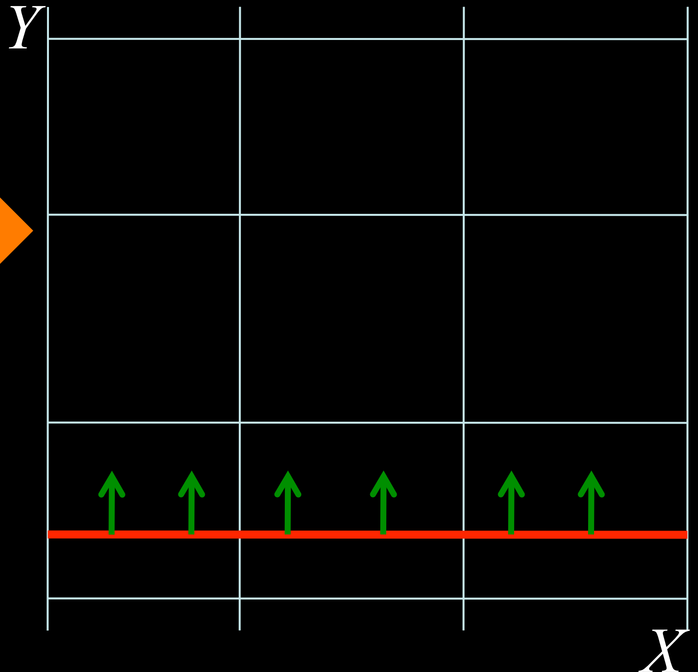
Early numerical codes had assumed spherical symmetry (1d), but essential details of H-bomb designs required 2d simulations.



M. Zimet in Thorne,
Black Holes & Time Warps



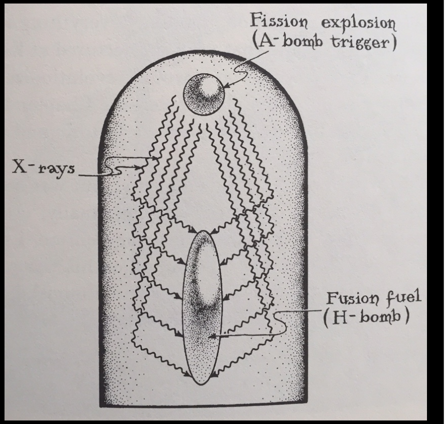
Lagrangian coordinates, with respect to Eulerian grid



Lagrangian coordinate grid

Teller's Assignment

At Livermore, DeWitt invented the first 2d Lagrangian hydrodynamics numerical code.



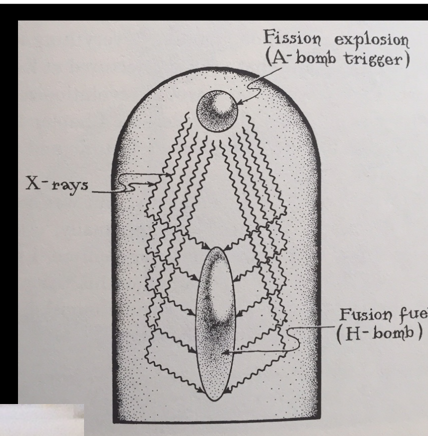
M. Zimet in Thorne, *Black Holes & Time Warps*

"One evening, breaking the rules of the lab, I decided to work on the problem at home, actually writing things down on paper. I took the hydrodynamic equations in two dimensions and differenced them."

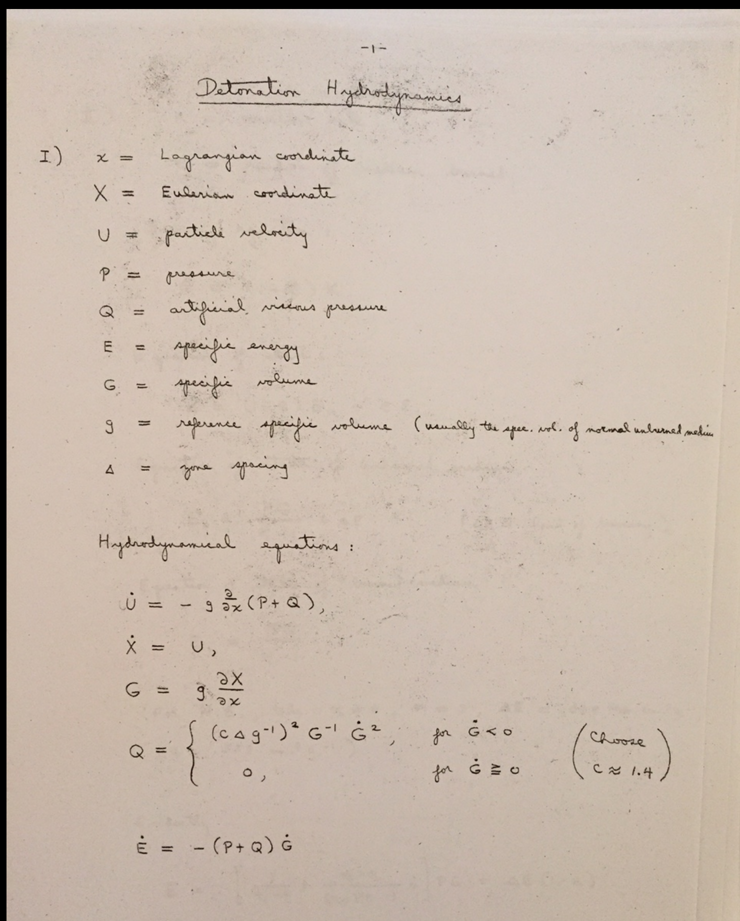
DeWitt at 1982 celebration for Jim Wilson

Teller's Assignment

At Livermore, DeWitt invented the first 2d Lagrangian hydrodynamics numerical code.



M. Zimet in Thorne, *Black Holes & Time Warps*



-1-

Detonation Hydrodynamics

I) x = Lagrangian coordinate

X = Eulerian coordinate

U = particle velocity

P = pressure

Q = artificial viscous pressure

E = specific energy

G = specific volume

g = reference specific volume (usually the spec. vol. of normal unburned medium)

Δ = zone spacing

Hydrodynamical equations:

$$\dot{U} = -g\frac{\partial}{\partial x}(P+Q),$$

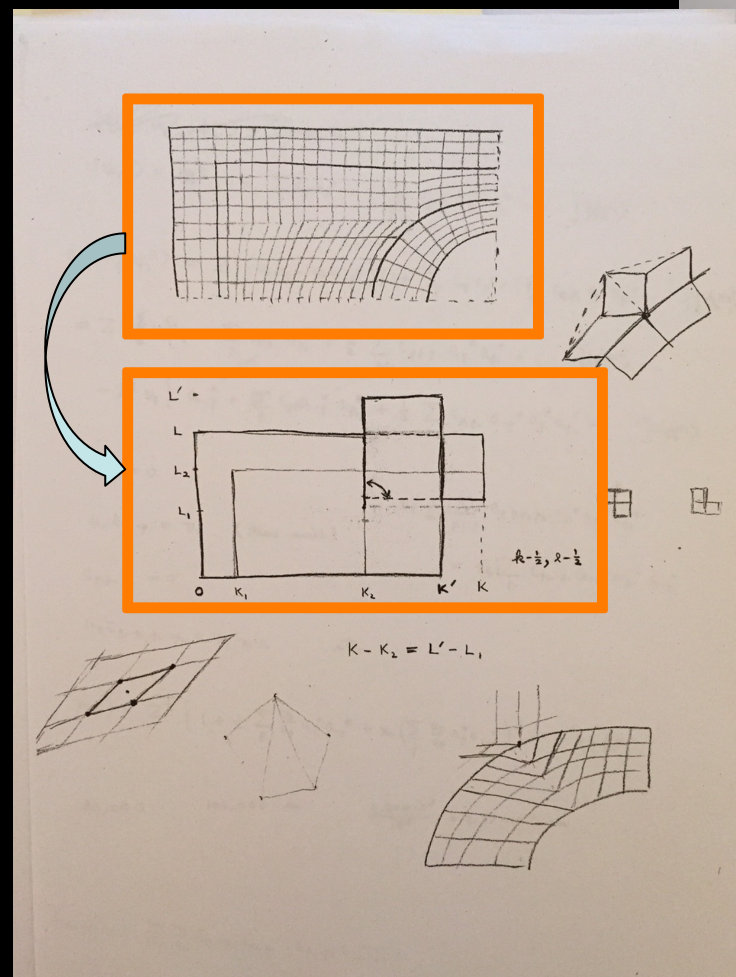
$$\dot{X} = U,$$

$$G = g\frac{\partial X}{\partial x}$$

$$Q = \begin{cases} (c\Delta g^{-1})^2 G^{-1}\dot{G}^2, & \text{for } \dot{G} < 0 \\ 0, & \text{for } \dot{G} \geqq 0 \end{cases} \quad \begin{pmatrix} \text{Choose} \\ c \approx 1.4 \end{pmatrix}$$

$$\dot{E} = -(P+Q)\dot{G}$$

DeWitt papers, U. Texas-Austin, n.d., ca. 1953



Teller's Assignment

At Livermore, DeWitt invented the first 2d Lagrangian hydrodynamics numerical code.

A Numerical Method for Two-Dimensional Lagrangian Hydrodynamics

Bryce DeWitt

Radiation Laboratory, University of California, Livermore, California

With the increasing availability of high speed computing machines having large fast-memory storage it becomes possible to undertake the numerical investigation of hydrodynamic shock problems in two dimensions. Here is presented in outline a simple scheme for setting up the difference equations of such problems in purely Lagrangian form.

Introduce the following notation: x, y = Lagrangian coordinates, X, Y = Eulerian coordinates, U, V = velocity components, P = pressure, Q = artificial longitudinal viscous pressure(1), and G = specific volume. Then the basic hydrodynamical equations are

$$\left.\begin{aligned}\dot{U} &= -G\,\partial(P+Q)/\partial X\\ \dot{V} &= -G\,\partial(P+Q)/\partial Y\end{aligned}\right\}, \qquad (1)$$

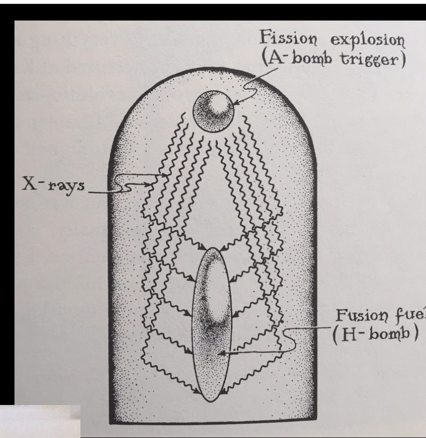
$$\dot{X} = U, \quad \dot{Y} = V, \qquad (2)$$

$$\dot{G} = G\left[\partial U/\partial X + \partial V/\partial Y\right], \qquad (3)$$

$$d(PG^{\gamma}) = -(\gamma - 1)Q\,G^{\gamma-1}\,dG \qquad (4)$$

Livermore report 4250, Dec 10, 1953

DeWitt papers, U. Texas-Austin, n.d., ca. 1953



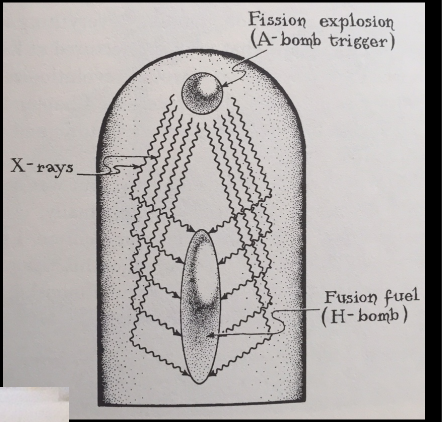
M. Zimet in Thorne, *Black Holes & Time Warps*

FOIA.GOV

First requests filed in June 2006... Still waiting for a 1954 (classified) report, "Difference Equations for Tony."

Teller's Assignment

At Livermore, DeWitt invented the first 2d Lagrangian hydrodynamics numerical code.



M. Zimet in Thorne, *Black Holes & Time Warps*

A Numerical Method for Two-Dimensional Lagrangian Hydrodynamics

Bryce DeWitt

Radiation Laboratory, University of California, Livermore, California

I)

With the increasing availability of high speed computing machines

having larg

numerical i

Here is pre

equations o

Introd

X, Y = Eule

Q = artific

Then the ba

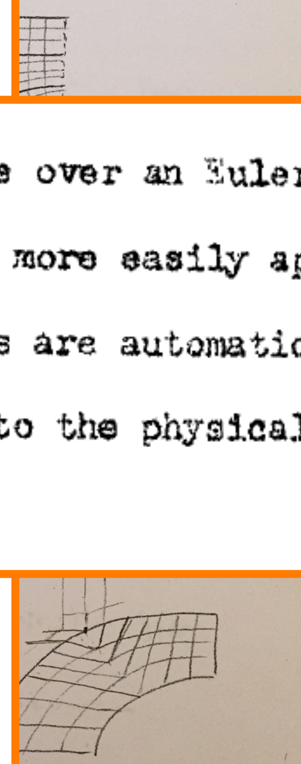
The advantages of a Lagrangian scheme over an Eulerian one are obvious: 1) Boundary conditions are much more easily applied. 2) Moving interfaces as well as boundaries are automatically taken care of. 3) Computations are always confined to the physical region of interest.

$$\dot{V} = -G\partial(P + Q)/\partial Y \Big\}, \quad (1)$$

$$\dot{X} = U, \quad \dot{Y} = V, \quad (2)$$

$$\dot{G} = G\left[\partial U/\partial X + \partial V/\partial Y\right], \quad (3)$$

$$d(PG^{\gamma}) = -(\gamma - 1)Q\, G^{\gamma-1}\, dG \quad (4)$$



Livermore report 4250, Dec 10, 1953

DeWitt papers, U. Texas-Austin, n.d., ca. 1953

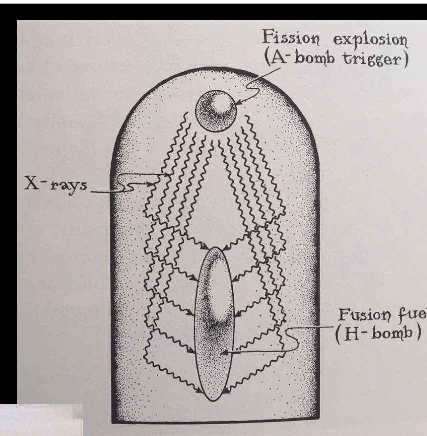
Teller's Assignment

At Livermore, DeWitt invented the first 2d Lagrangian hydrodynamics numerical code.

"I was told that I had to have a program coded and run before a certain date in June [1954]. There was going to be a test shot and the lab wanted some numbers. Well, it's one thing to have these simple-looking equations, and another to apply them. I had to sit down and think about things that had never occurred to me before."

He worked closely with a programmer, who taught him how to improve the data input; and DeWitt also learned tricks like inserting "artificial viscosity" to improve numerical stability.

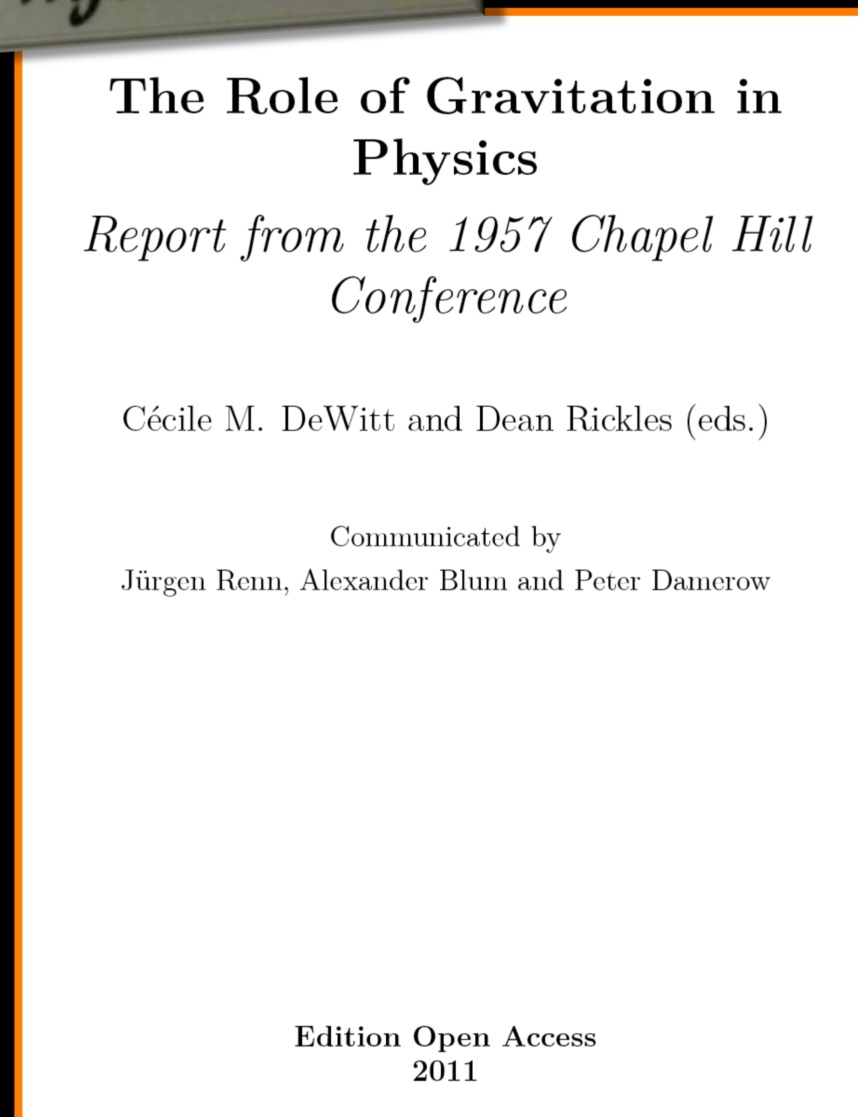
DeWitt at a 1982 celebration for Jim Wilson



M. Zimet in Thorne, *Black Holes & Time Warps*

First requests filed in June 2006... Still waiting for a 1954 (classified) report, "Difference Equations for Tony."

Transition (Back) to Gravity


The Role of Gravitation in Physics

Report from the 1957 Chapel Hill Conference

Cécile M. DeWitt and Dean Rickles (eds.)

Communicated by
Jürgen Renn, Alexander Blum and Peter Damerow

Edition Open Access
2011

Transition (Back) to Gravity

3. Hydrodynamic representation of the gravitational field equations and machine computations of gravitational interactions.
   a. Search for a suitable hydrodynamic representation in a Lagrangian coordinate system in which singularities remain fixed.
   b. Study of how to handle the supplementary conditions in the initial value problem.
   c. Setting up of appropriate difference equations and preparation of a program for machine computation.
   d. Overseeing the actual running of the problem on the machine.
   e. Interpretation of the results.

Progress Report, 1956

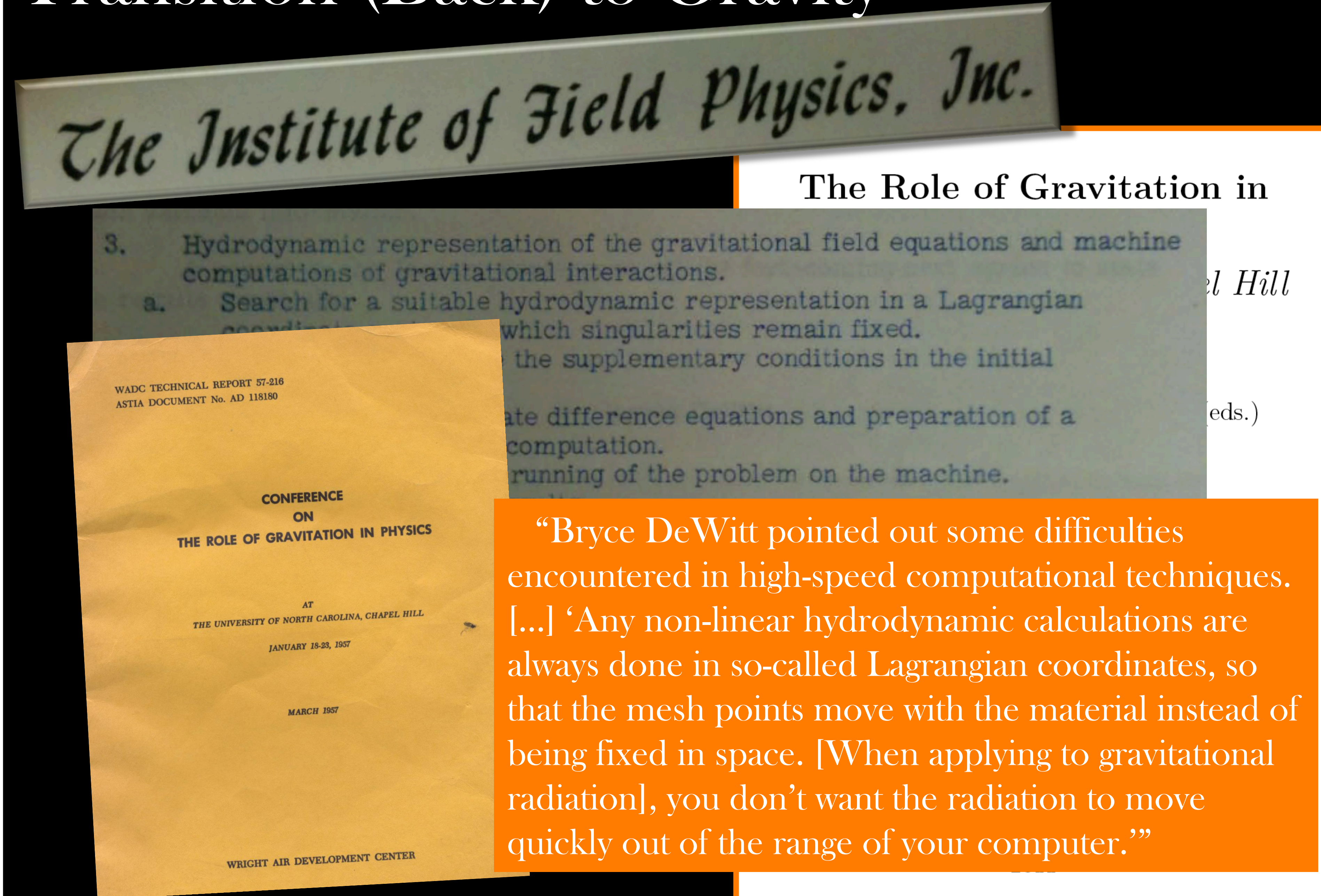
The Role of Gravitation in

...l Hill

...(eds.)

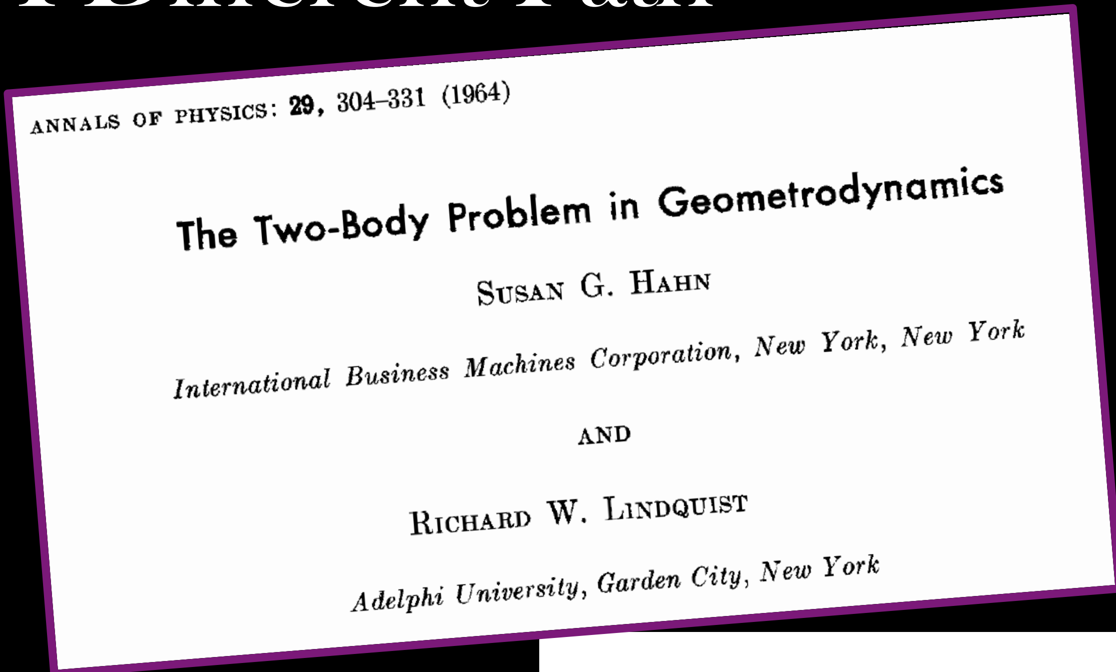
Edition Open Access
2011

Transition (Back) to Gravity



"Bryce DeWitt pointed out some difficulties encountered in high-speed computational techniques. [...] 'Any non-linear hydrodynamic calculations are always done in so-called Lagrangian coordinates, so that the mesh points move with the material instead of being fixed in space. [When applying to gravitational radiation], you don't want the radiation to move quickly out of the range of your computer.'"

A Different Path



ANNALS OF PHYSICS: **29**, 304–331 (1964)

The Two-Body Problem in Geometrodynamics

SUSAN G. HAHN

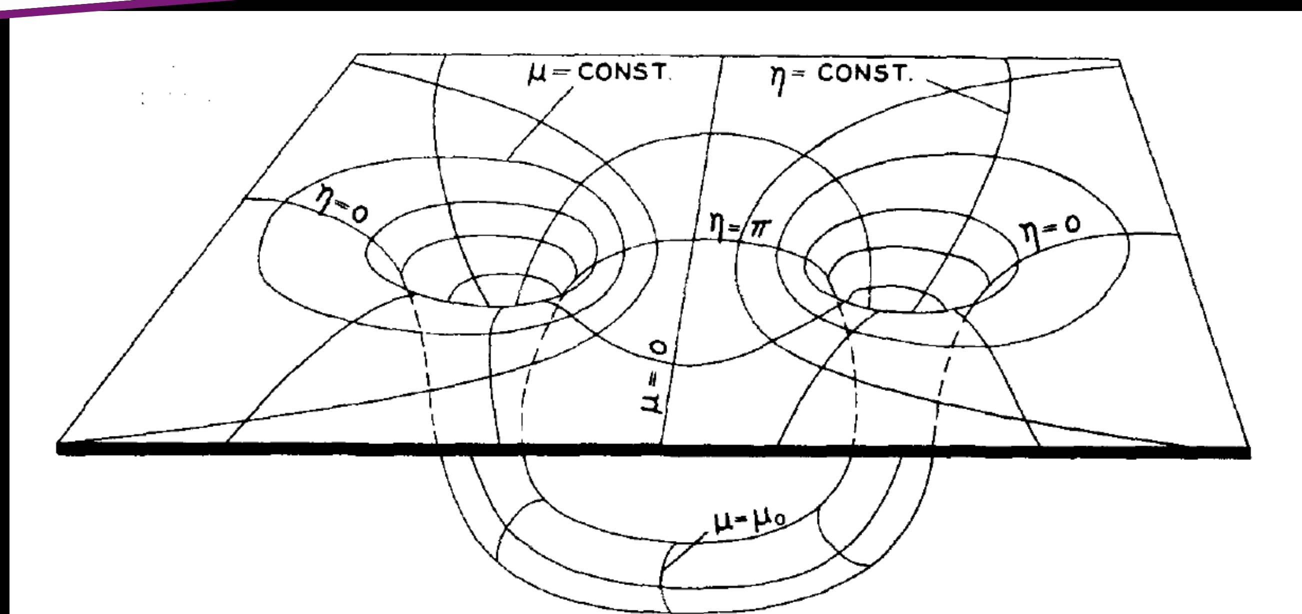
International Business Machines Corporation, New York, New York

AND

RICHARD W. LINDQUIST

Adelphi University, Garden City, New York

Adopted Gaussian-normal coordinates, with vanishing shift vector, $\beta^i = 0$. Could only compute 50 time-steps; lattice points bunched up near the singularity.



Building a Program

ČADEŽ, Andrej, 1942-
COLLIDING BLACK HOLES.

University of North Carolina at Chapel Hill,
Ph.D., 1971
Physics, general

SMARR, Larry Lee, 1948-
THE STRUCTURE OF GENERAL RELATIVITY WITH A
NUMERICAL ILLUSTRATION: THE COLLISION OF
TWO BLACK HOLES.

The University of Texas at Austin, Ph.D., 1975
Physics, general

EPPLEY, Kenneth Robert, 1948-
THE NUMERICAL EVOLUTION OF THE COLLISION OF
TWO BLACK HOLES.

Princeton University, Ph.D., 1975
Physics, general

Building a Program

ČADEŽ, Andrej, 1942-
COLLIDING BLACK HOLES.

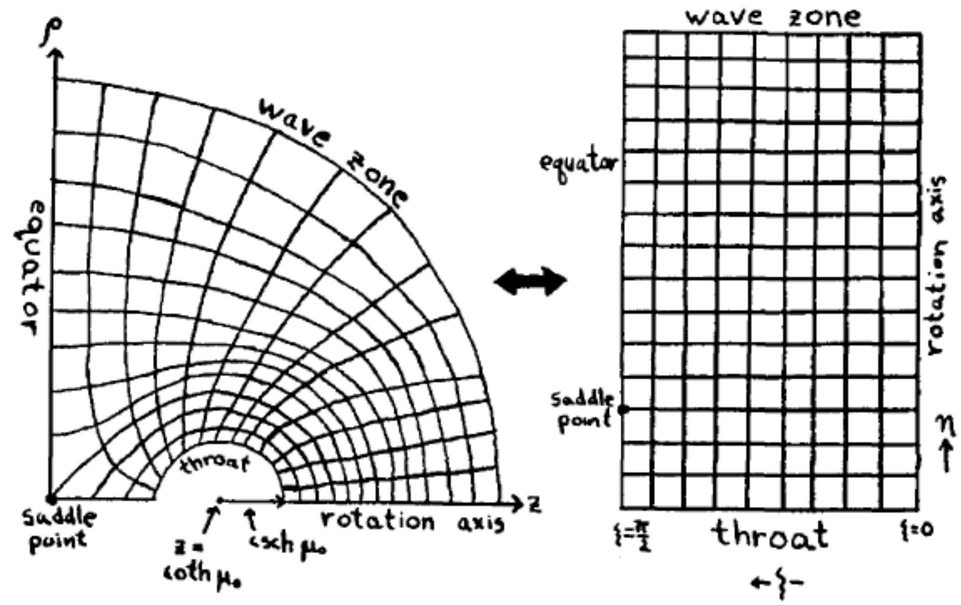
University of North Carolina at Chapel Hill,
Ph.D., 1971
Physics, general

SMARR, Larry Lee, 1948-
THE STRUCTURE OF GENERAL RELATIVITY WITH A
NUMERICAL ILLUSTRATION: THE COLLISION OF
TWO BLACK HOLES.

The University of Texas at Austin, Ph.D., 1975
Physics, general

EPPLEY, Kenneth Robert, 1948-
THE NUMERICAL EVOLUTION OF
TWO BLACK HOLES.

Princeton University, Ph.D.
Physics, general



Smarr dissertation, p. 126.

Adopt a nonzero shift vector, β^i, proportional to the 3-velocity of the new coordinate lines with respect to Eulerian gridlines.

Building a Program

CADEŽ, Andrej, 1942-
COLLIDING BLACK HOLES.

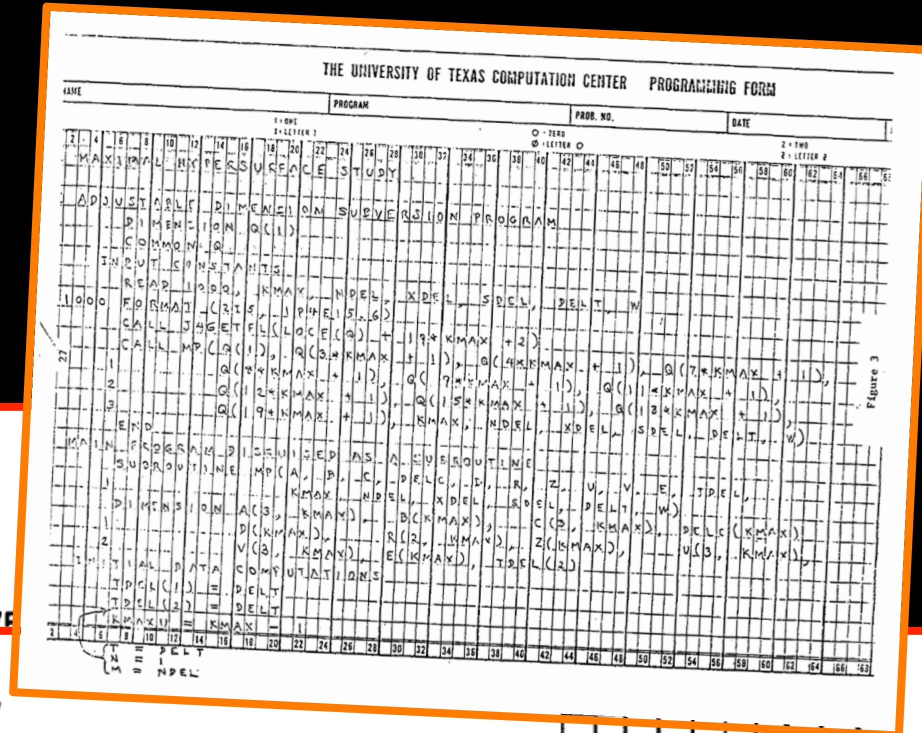
University of North Carolina at Chapel Hill,
Ph.D., 1971
Physics, general

SMARR, Larry Lee, 1948-
THE STRUCTURE OF GENERAL RELATIVITY WITH A
NUMERICAL ILLUSTRATION: THE COLLISION OF
TWO BLACK HOLES.

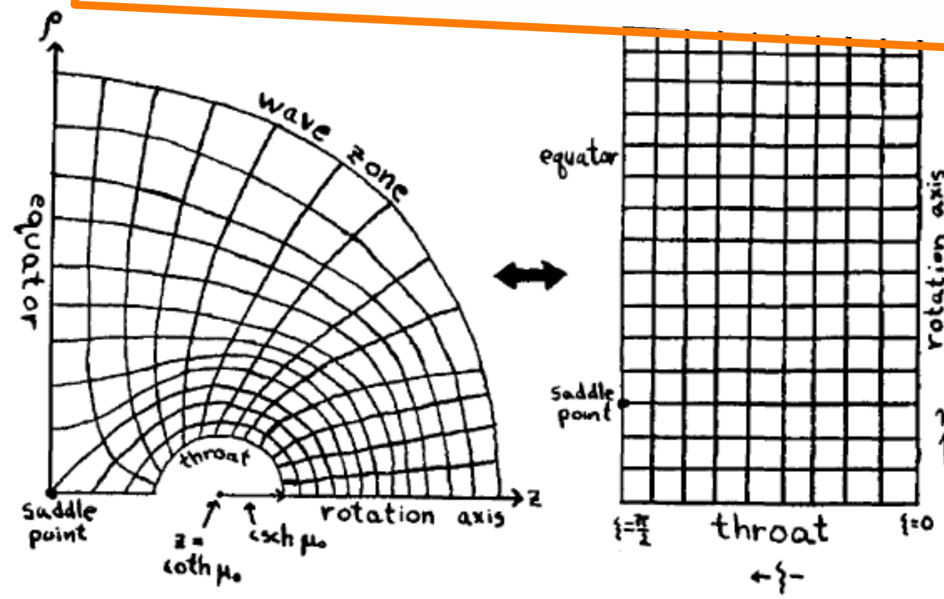
The University of Texas at Austin, Ph.D., 1975
Physics, general

EPPLEY, Kenneth Robert, 1948-
THE NUMERICAL EVOLUTION OF
TWO BLACK HOLES.

Princeton University, Ph.D.
Physics, general



Adopt a nonzero shift vector, β^i, proportional to the 3-velocity of the new coordinate lines with respect to Eulerian gridlines.



Smarr dissertation, p. 126.

Building a Program

PHYSICAL REVIEW D VOLUME 7, NUMBER 10 15 MAY 1973

Maximally Slicing a Black Hole*

Frank Estabrook and Hugo Wahlquist
Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California 91103

Steven Christensen, Bryce DeWitt, Larry Smarr, and Elaine Tsiang
Relativity Center, Department of Physics, The University of Texas, Austin, Texas 78712

PHYSICAL REVIEW D VOLUME 14, NUMBER 10 15 NOVEMBER 1976

Collision of two black holes: Theoretical framework*

Larry Smarr
Princeton University Observatory, Princeton, New Jersey 08540

Andrej Čadež
Univerza v Ljubljani, Fakulteta za Naravoslovje in Tehnologijo, Odsek za Fiziko, 61000 Ljubljana, Yugoslavia

Bryce DeWitt
Center for Relativity, Department of Physics, University of Texas, Austin, Texas 78712

Kenneth Eppley
Department of Physics and Astronomy University of North Carolina, Chapel Hill, North Carolina 27514

SPACE-TIMES GENERATED BY COMPUTERS:
BLACK HOLES WITH GRAVITATIONAL RADIATION*

Larry Smarr†

Center for Astrophysics and
Department of Physics
Harvard University
Cambridge, Massachusetts 02138

Sources of
Gravitational Radiation

PROCEEDINGS OF THE BATTELLE SEATTLE WORKSHOP
July 24 - August 4, 1978

edited by
LARRY L. SMARR
Center for Astrophysics and
Lyman Laboratory of Physics
Harvard University

Cambridge University Press
Cambridge
London . New York . Melbourne

Building a Program

American Scientist, Volume 66

Larry L. Smarr
William H. Press

1978

Our Elastic Spacetime: Black Holes and Gravitational Waves

A new computer program shows that the old analogy of spacetime as a rubber sheet is remarkably valid

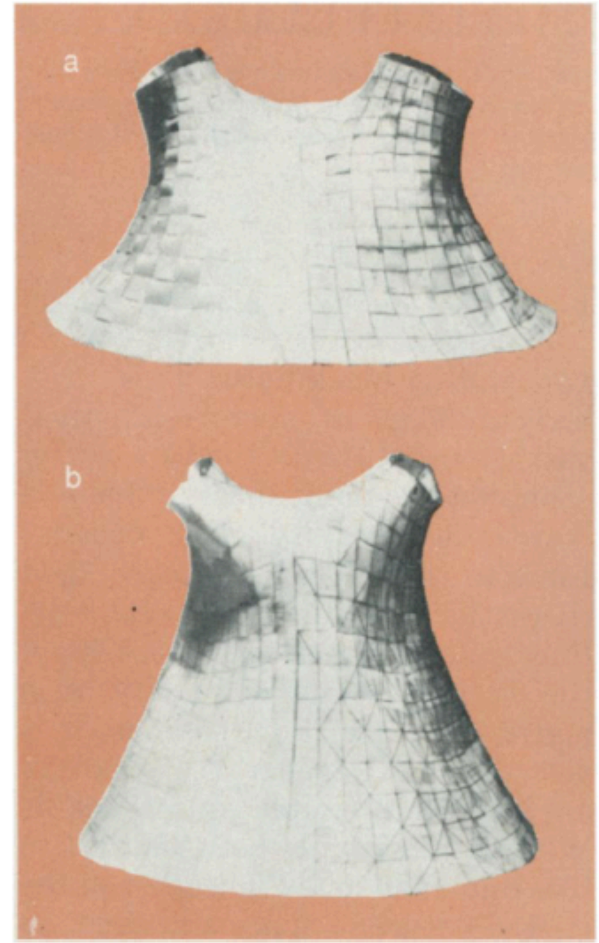


Figure 6. These "straw hats for a horse"—embedding diagrams (analogies of Fig. 2) for two colliding black holes—show the proper distances and angles between grid lines. (*a*) At the initial instant the two holes are at rest rather close to one another. The open ends are slightly inside of where the surface of the holes were initially. Note that the holes are already curving the surrounding space substantially. (*b*) After the collision of the two holes, the bag has stretched out much more. The new location of the surface of the last black hole is somewhere on the long neck. The grid squares have been deformed by the motion of the holes.

Building a Program

American Scientist, Volume 66

Larry L. Smarr
William H. Press

Our Elastic Spacetime: Black Holes and Gravitational Waves

A new computer program shows that the old analogy of spacetime as a rubber sheet is remarkably valid

1978

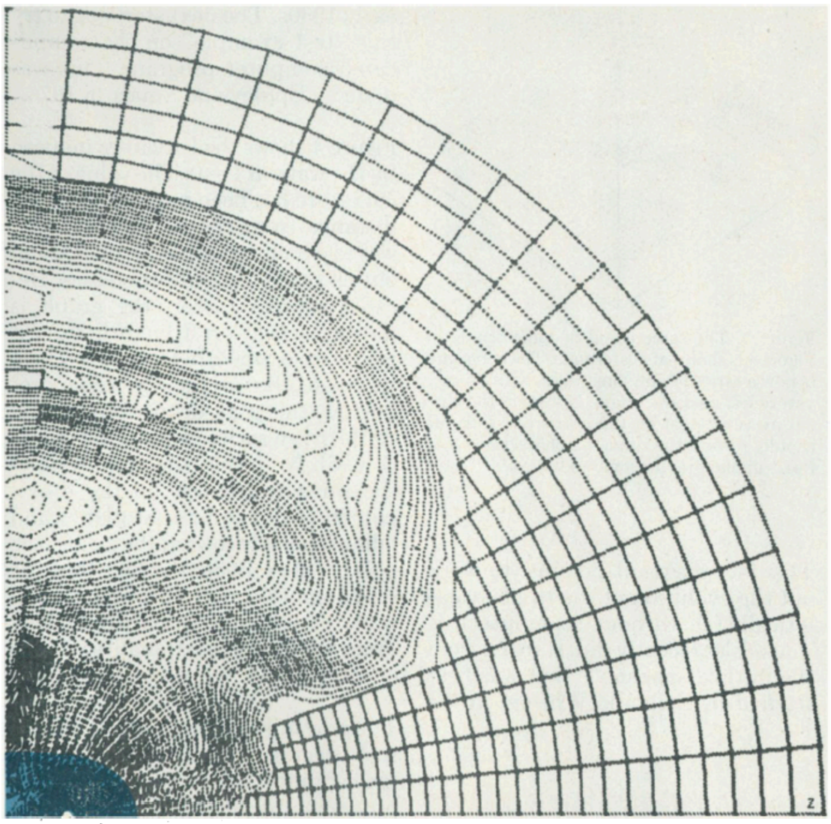


Figure 7. The colliding holes of Fig. 6 sent out ripples of gravitational radiation. Here a contour map of the curvature is shown after the collision. Just as in Fig. 5, there are several pulses with their maximum values on the z-axis. The final hole is shown in color. Note that the wavelength of the radiation is large compared to the holes, because of the gravitational redshift.

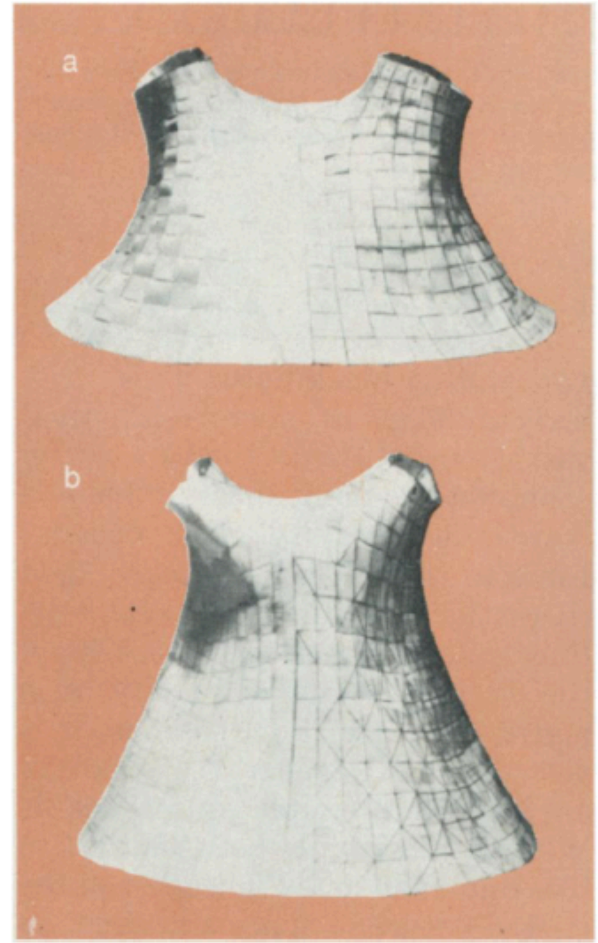


Figure 6. These "straw hats for a horse"—embedding diagrams (analogies of Fig. 2) for two colliding black holes—show the proper distances and angles between grid lines. (*a*) At the initial instant the two holes are at rest rather close to one another. The open ends are slightly inside of where the surface of the holes were initially. Note that the holes are already curving the surrounding space substantially. (*b*) After the collision of the two holes, the bag has stretched out much more. The new location of the surface of the last black hole is somewhere on the long neck. The grid squares have been deformed by the motion of the holes.

Building a Program

American Scientist, Volume 66

Larry L. Smarr
William H. Press

Our Elastic Spacetime: Black Holes and Gravitational Waves

A new computer program shows that the old analogy of spacetime as a rubber sheet is remarkably valid

1978

"On sufficient advance notice, a large quantity of beer, food, scissors, scotch tape, and graduate students are assembled. The graduate students cut the squares out and tape them into strips. Other students then weave the strips together, basket fashion, into a final embedding diagram. [...] (Incidentally, the DeWitt technique for constructing embedding diagrams lends some credence to the complaint that graduate school these days is only so much advanced basketweaving.)"

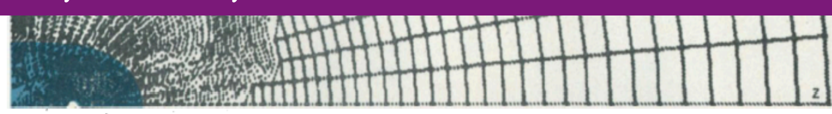


Figure 7. The colliding holes of Fig. 6 sent out ripples of gravitational radiation. Here a contour map of the curvature is shown after the collision. Just as in Fig. 5, there are several pulses with their maximum values on the z-axis. The final hole is shown in color. Note that the wavelength of the radiation is large compared to the holes, because of the gravitational redshift.

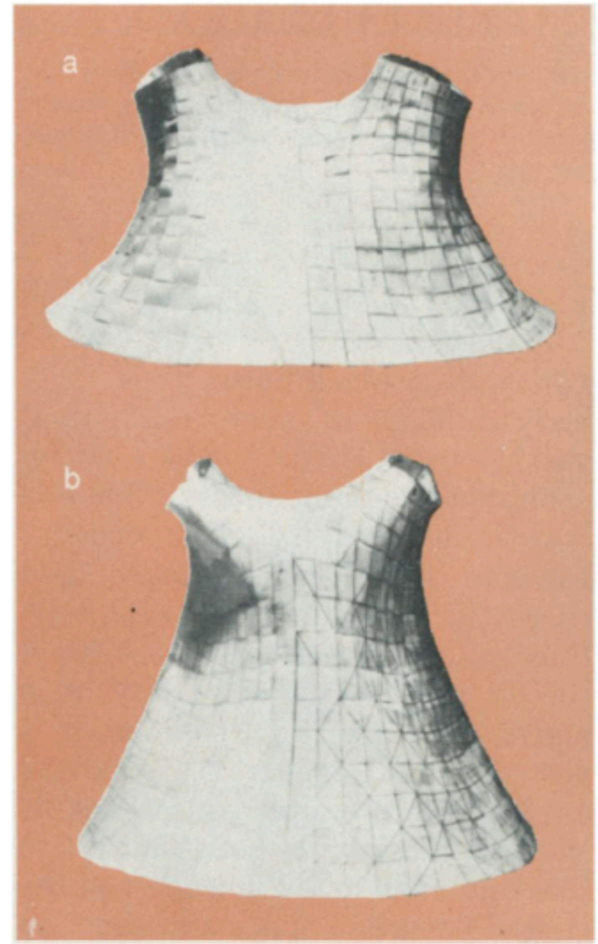
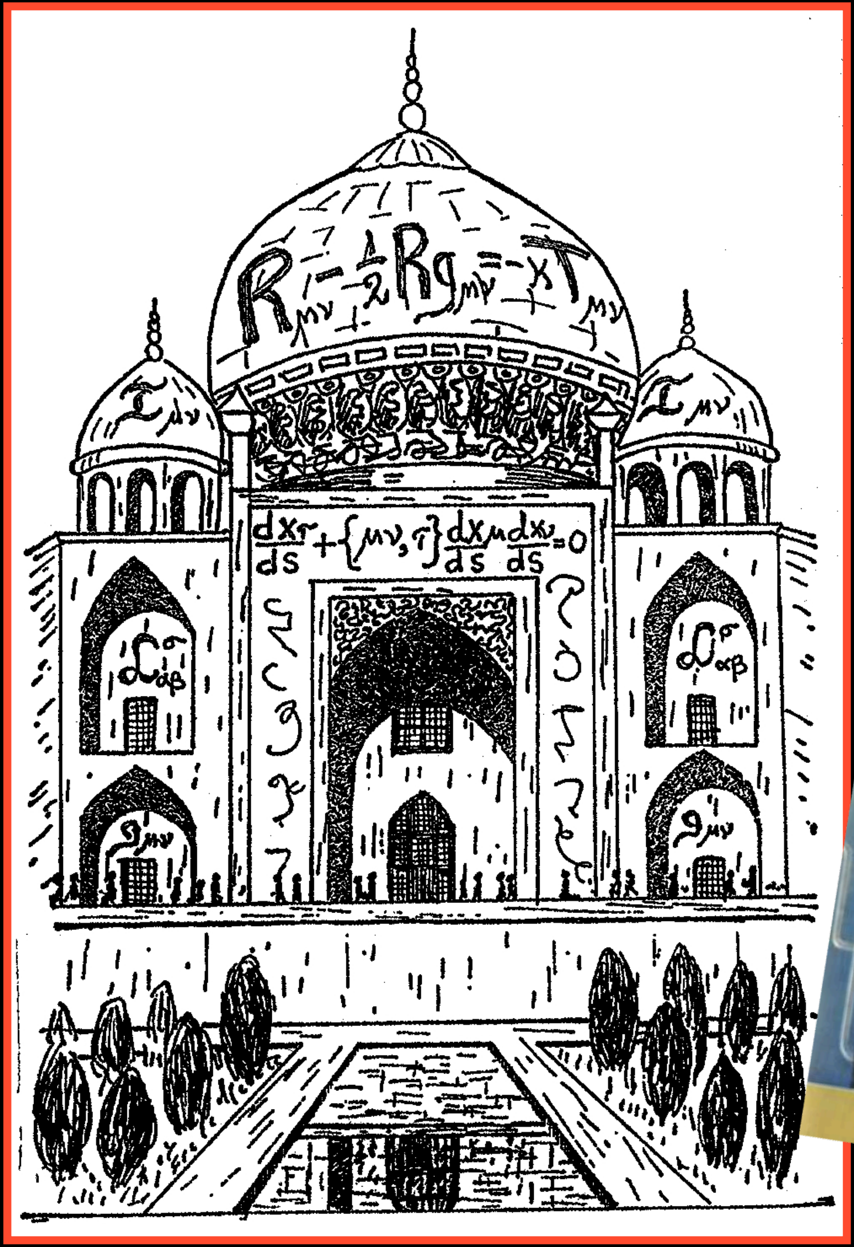
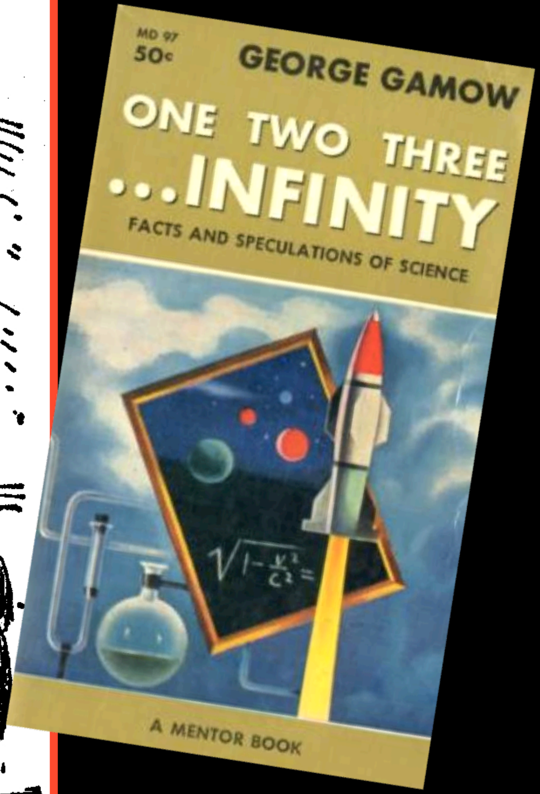


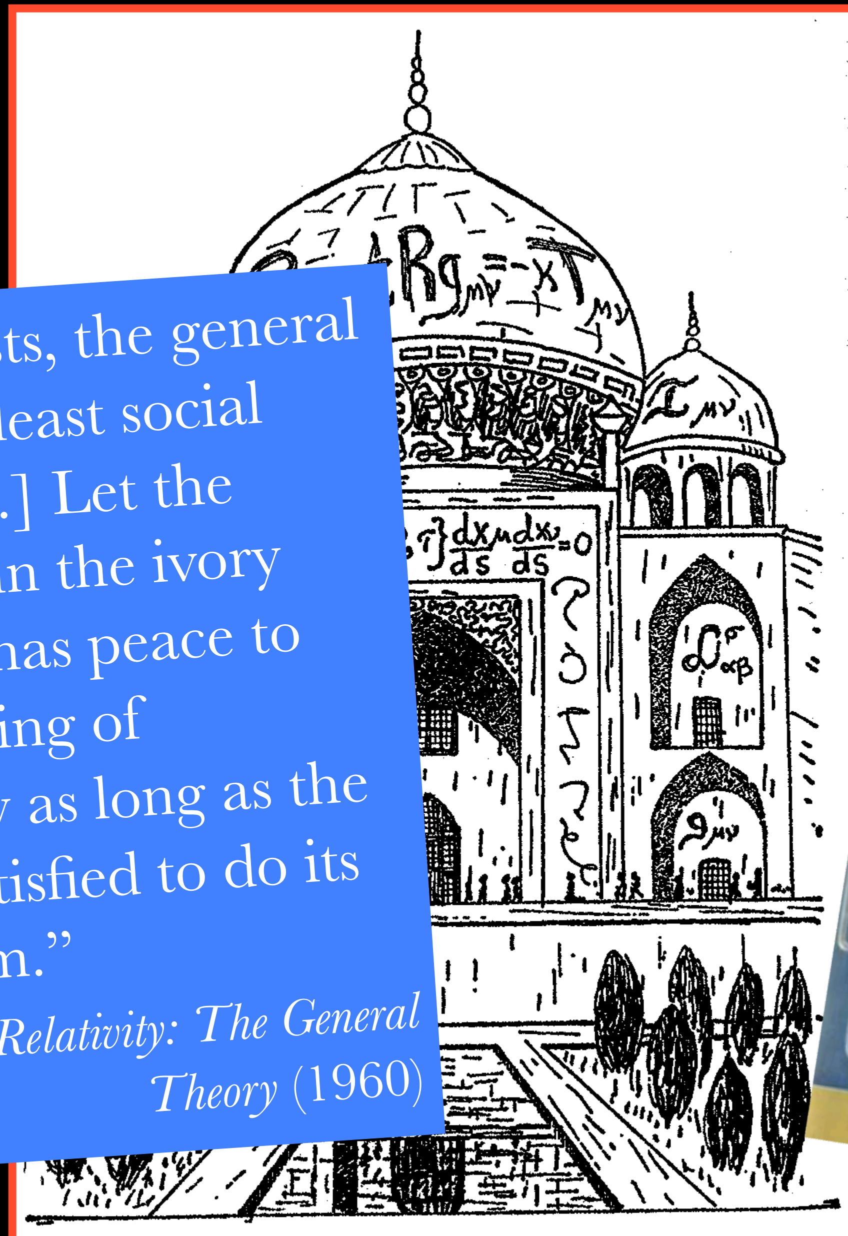
Figure 6. These "straw hats for a horse"—embedding diagrams (analogies of Fig. 2) for two colliding black holes—show the proper distances and angles between grid lines. (*a*) At the initial instant the two holes are at rest rather close to one another. The open ends are slightly inside of where the surface of the holes were initially. Note that the holes are already curving the surrounding space substantially. (*b*) After the collision of the two holes, the bag has stretched out much more. The new location of the surface of the last black hole is somewhere on the long neck. The grid squares have been deformed by the motion of the holes.

Gravity and Politics



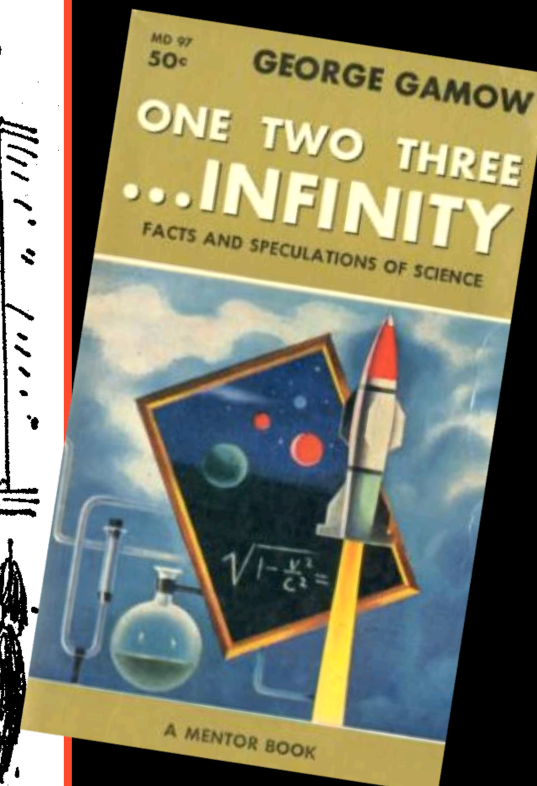


Gravity and Politics

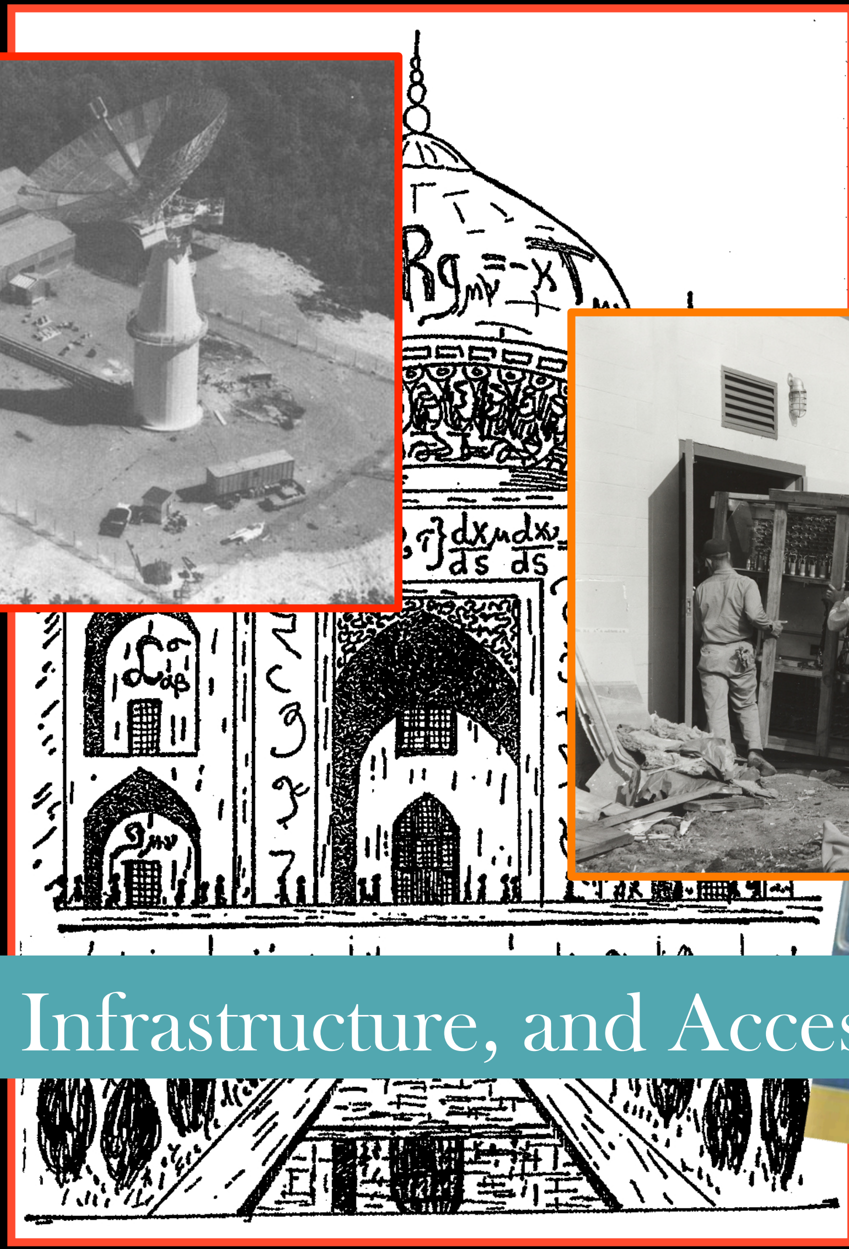


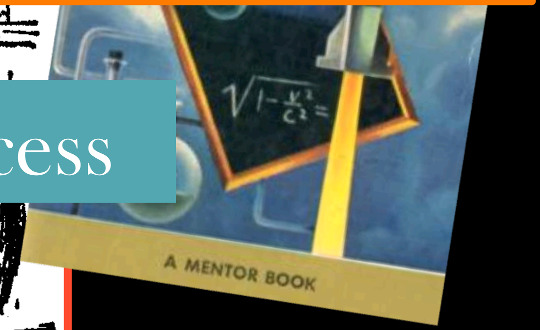
"Of all physicists, the general relativist has the least social commitment. [...] Let the relativist rejoice in the ivory tower where he has peace to seek understanding of Einstein's theory as long as the busy world is satisfied to do its jobs without him."

J. L. Synge, *Relativity: The General Theory* (1960)



Gravity and Politics





Resources, Infrastructure, and Access

[redacted]

Gravity and Politics Today?

Log in

page | talk page | view source | history

Conservapedia

The Trustworthy Encyclopedia

search

Go | Search

popular links

- Main Page
- Educational Index
- Debate Topics
- Recent changes
- All pages

Counterexamples to Relativity

The theory of relativity is a mathematical system that allows no exceptions. It is heavily promoted by liberals who like its encouragement of relativism and its tendency to mislead people in how they view the world.[1] Here is a list of 32 counterexamples: any one of them shows that the theory is incorrect.

1. The Pioneer anomaly.
2. Anomalies in the locations of spacecraft that have flown by Earth ("flybys").[2]
3. Increasingly precise measurements of the advance of the perihelion of Mercury show a shift greater than predicted by Relativity, well beyond the margin of error.[3]
4. The discontinuity in momentum as velocity approaches "c" for infinitesimal mass, compared to the momentum of light.
5. The logical problem of a force which is applied at a right angle to the velocity of a relativistic mass - does this act on the rest mass or the relativistic mass?
6. The observed lack of curvature in overall space.[4]
7. The universe shortly after its creation, when quantum effects dominated and contradicted Relativity.
8. The action-at-a-distance of quantum entanglement.[5]
9. The action-at-a-distance by Jesus, described in John 4:46-54.

Despite censorship of dissent about relativity, evidence contrary to the theory is discussed outside of liberal universities.[37]

November 2010…

Gravity and Politics Today?

Log in

page | talk page | view source | history

Conservapedia
The Trustworthy Encyclopedia

search

Go | Search

popular links

- Main Page
- Educational Index
- Debate Topics
- Recent changes
- All pages

Counterexamples to Relativity

The theory of relativity is a mathematical system that allows no exceptions. It is heavily promoted by liberals who like its encouragement of relativism and its tendency to mislead people in how they view the world.[1] Here is a list of 32 counterexamples: any one of them shows that the theory is incorrect.

1. The Pioneer anomaly.
2. Anomalies in the locations of spacecraft that have flown by Earth ("flybys").[2]
3. Increasingly precise measurements of the advance of the perihelion of Mercury show a shift greater than predicted by Relativity, well beyond the margin of error.[3]
4. The discontinuity in momentum as velocity approaches "c" for infinitesimal mass, compared to the momentum of light.
5. The logical problem of a force which is applied at a right angle to the velocity of a relativistic mass - does this act on the rest mass or the relativistic mass?
6. The observed lack of curvature in overall space.[4]
7. The universe shortly after its creation, when quantum effects dominated and contradicted Relativity.
8. The action-at-a-distance of quantum entanglement.[5]
9. The action-at-a-distance by Jesus, described in John 4:46-54.

Despite censorship of dissent about ... [7]

salon.com

http://www.salon.com/tech/htww/2010/11/11/defending_einstein_from_the_new_barbarians

THURSDAY, NOV 11, 2010 18:12 ET

Defending Einstein from the new barbarians

Politically motivated attacks on science are nothing new. The Nazis hated the general theory of relativity

BY ANDREW LEONARD

HOW THE WORLD WORKS

November 2010…