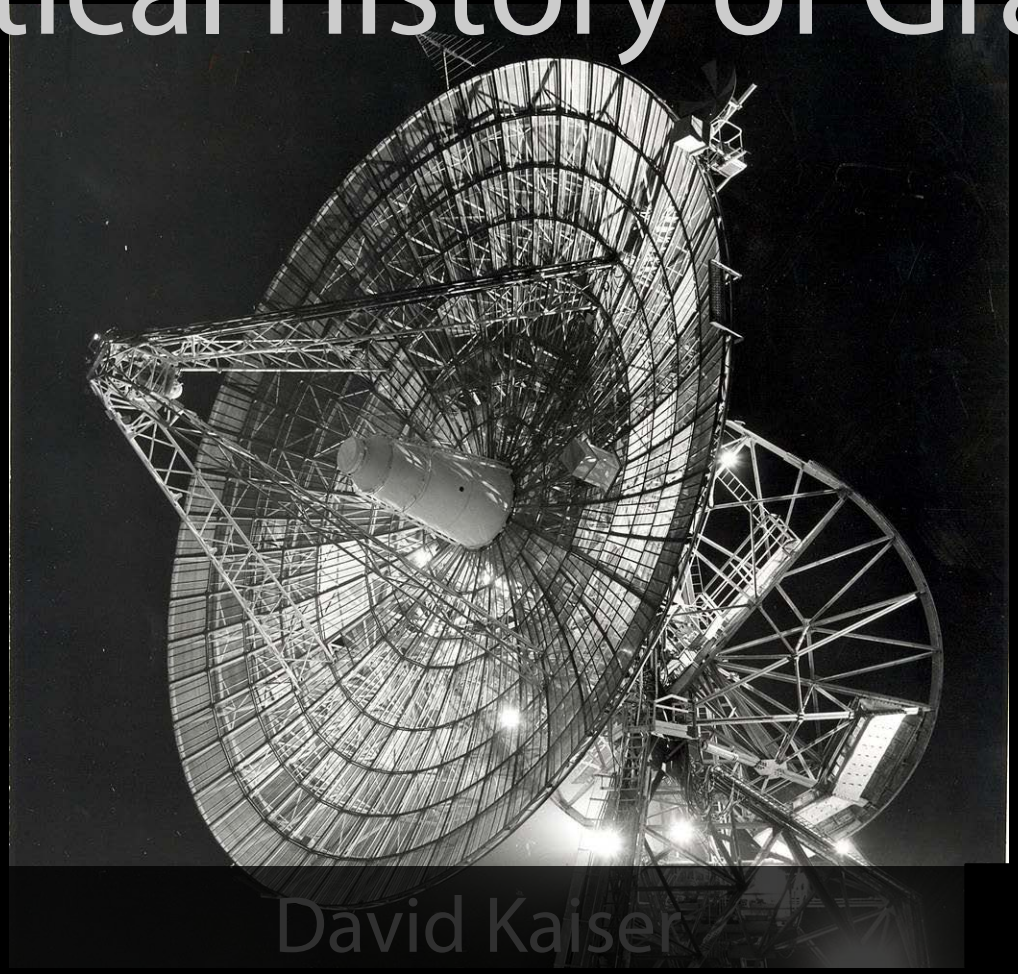
A Political History of Gravity



David Kaiser

Image is in the public domain.

Einstein and Politics

Freedom of Information and Privacy Acts

Subject: ALBERT EINSTEIN

File Number: 61-7099

Section: 1

DEPARTMENT OF JUSTICE — FEDERAL BUREAU OF INVESTIGATION

THE WOMAN PATRIOT CORPORATION
710 Jackson Place,NW.
Washington,D.C.

Frothingham,
ookline,Mass.,
ont Hill,
nt,Boston.

Secretary-Treasurer,
Washington,D.C.

Board of Directors
Miss Mary G.Kilbreth Chairman,Southampton,N.Y.; Mrs.Rufus M.Gibbs,Baltimore; Mrs.Paul Killiam, Cambridge,Mass; Mrs.Frederic W. Longfellow, N.Y.C. Mrs.Francis E.Slattery Brighton,Mass.; Mrs. Frederic Jay Cotton, Boston; and the Officers ex-officio.

COPY OF CHARGES FILED AGAINST ADMISSION OF ALBERT EINSTEIN TO THE UNITED STATES

61-7099 -1

DEC 1 1932

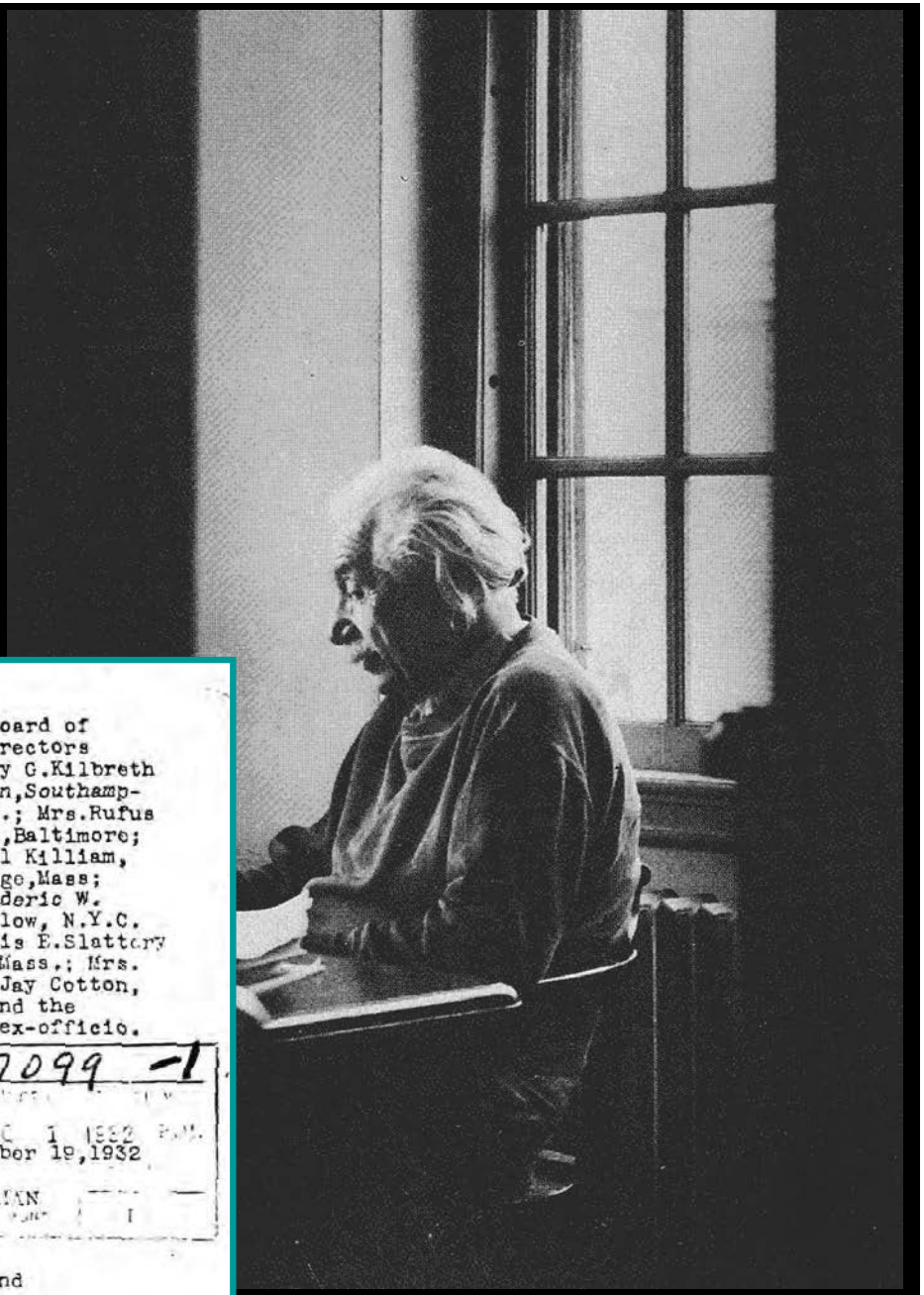
November 19,1932

DEC 2 - 193

Honorable A.Dana Hodgdon,Chief
Visa Division,Department of State,
Washington,D.C.

Dear Sir:

It is respectfully requested, in view of the mandatory Alien Exclusion Laws of the United States, and the laws making it a felony for any person knowingly to assist or permit certain classes of inadmissible aliens to enter the United States, that the American Consul General at Berlin, or Geneva, or any other American consular office at which application by Professor Albert Einstein for a passport visa may be made, be instructed to refuse and withhold such passport visa to Professor Einstein; or, if such passport visa has been issued, to suspend or revoke the same,

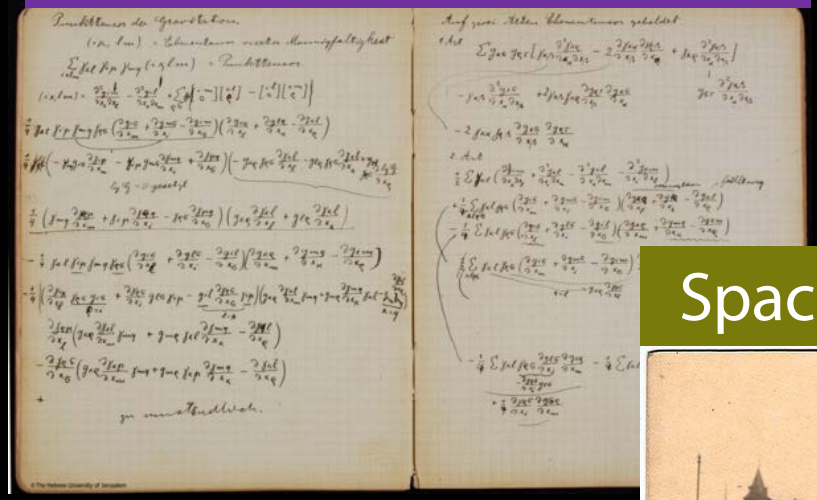


"Temple of Relativity"

"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)

"The Happiest Thought..."



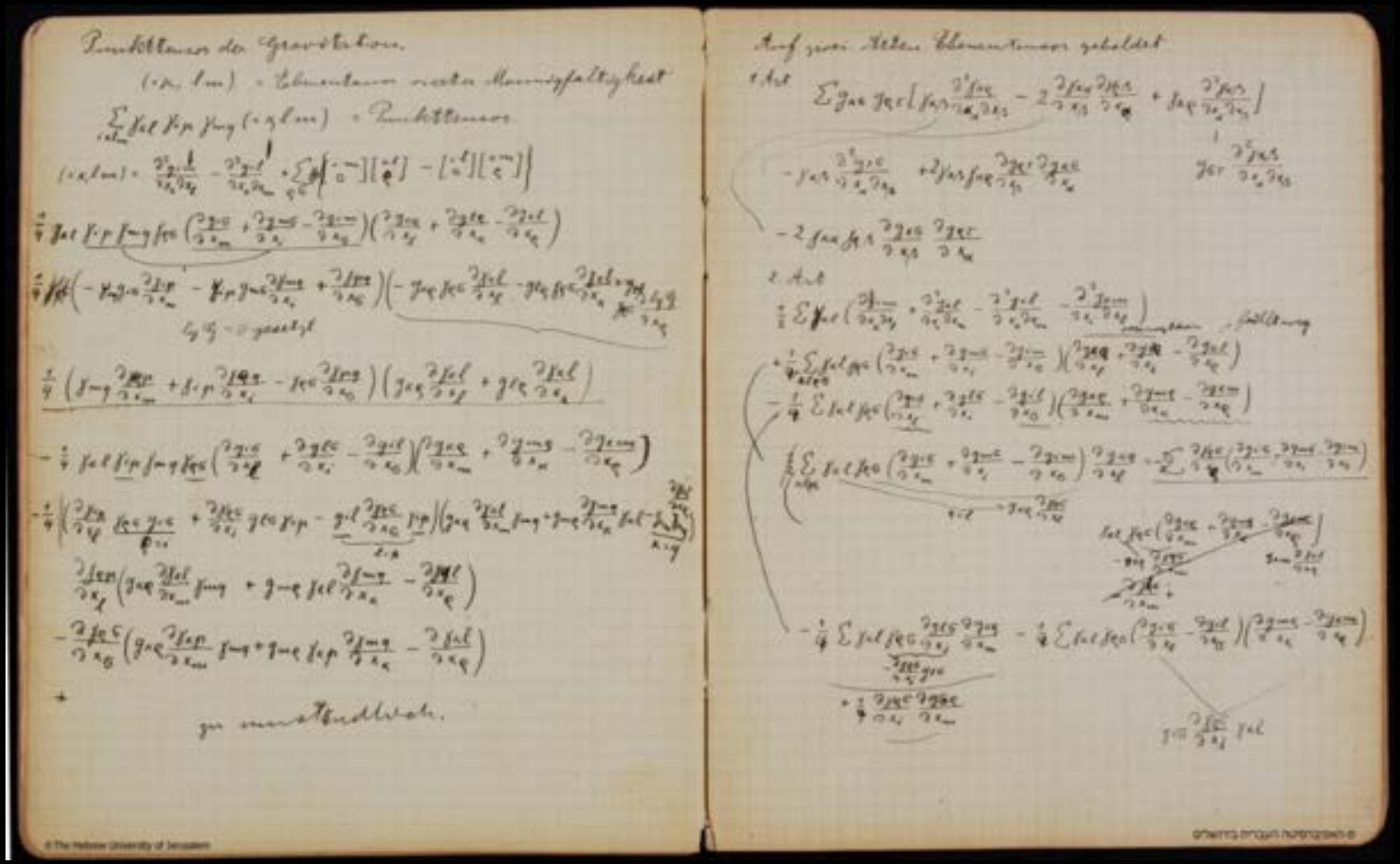
Spacetime in the Trenches

Image is in the public domain.

Radar, Missiles, and Gravity

Long Gestation

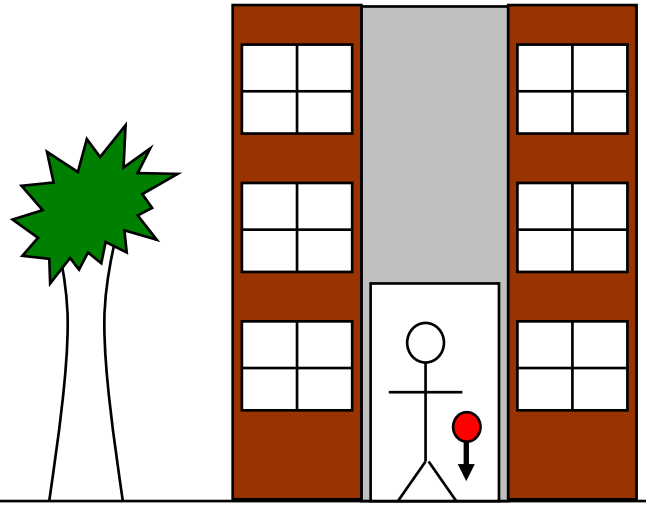
Einstein labored for nearly 10 years on his theory of gravitation. After several false starts, he arrived at his field equations in November 1915.



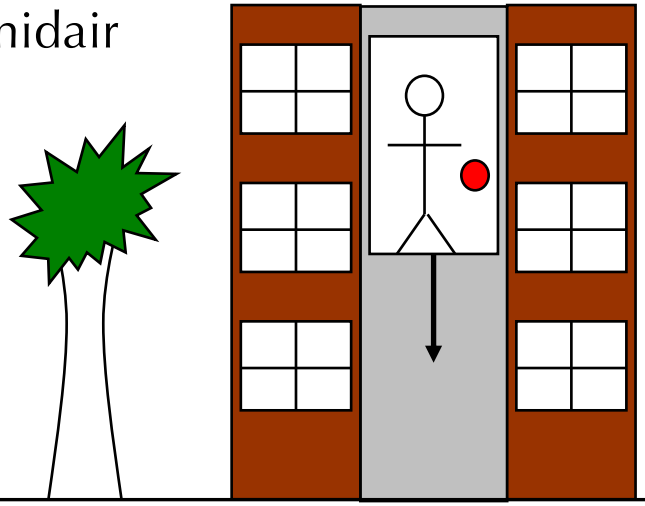
Einstein's Zurich notebook, ca. 1913

Dropping the Ball

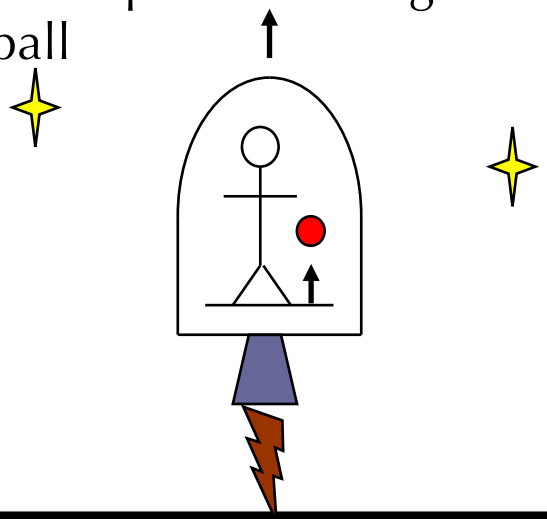
Elevator at rest: ball falls to floor



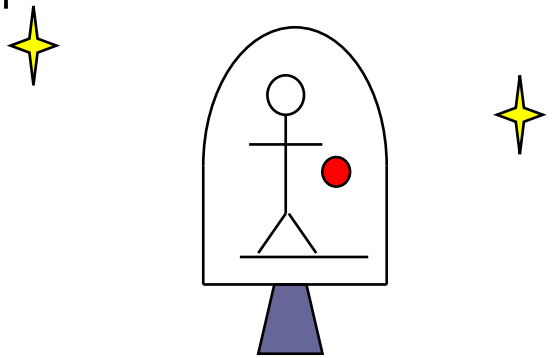
Elevator in free fall: ball hangs in midair



Spaceship accelerating: floor rises to ball



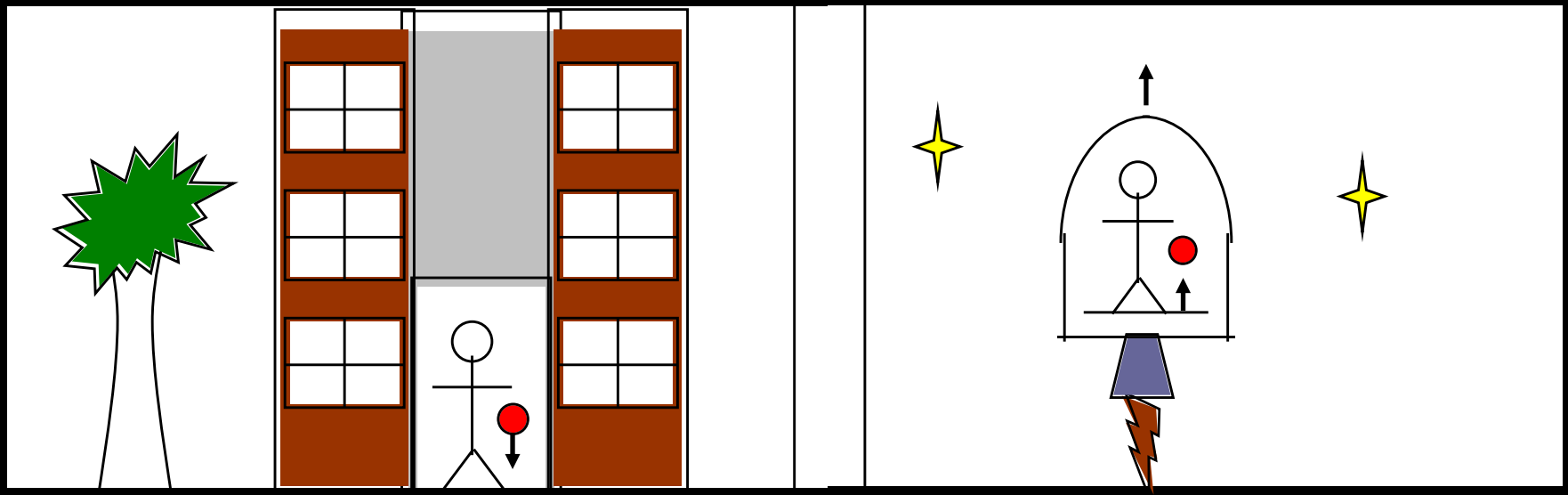
Spaceship at rest: ball hangs in midair



An "Asymmetry in the Explanation"

Einstein: There aren't really *4* phenomena — only *2*! The ball either falls toward the floor or it doesn't.

The same phenomenon had been given separate descriptions:



The earth's ***gravitational attraction*** pulls the ball downward.

No forces push on the ball, so it stays at rest, while the floor ***accelerates*** upward.

But no experiment could *distinguish* between the two descriptions.

Gravity and acceleration are interchangeable.

An "Asymmetry in the Explanation"

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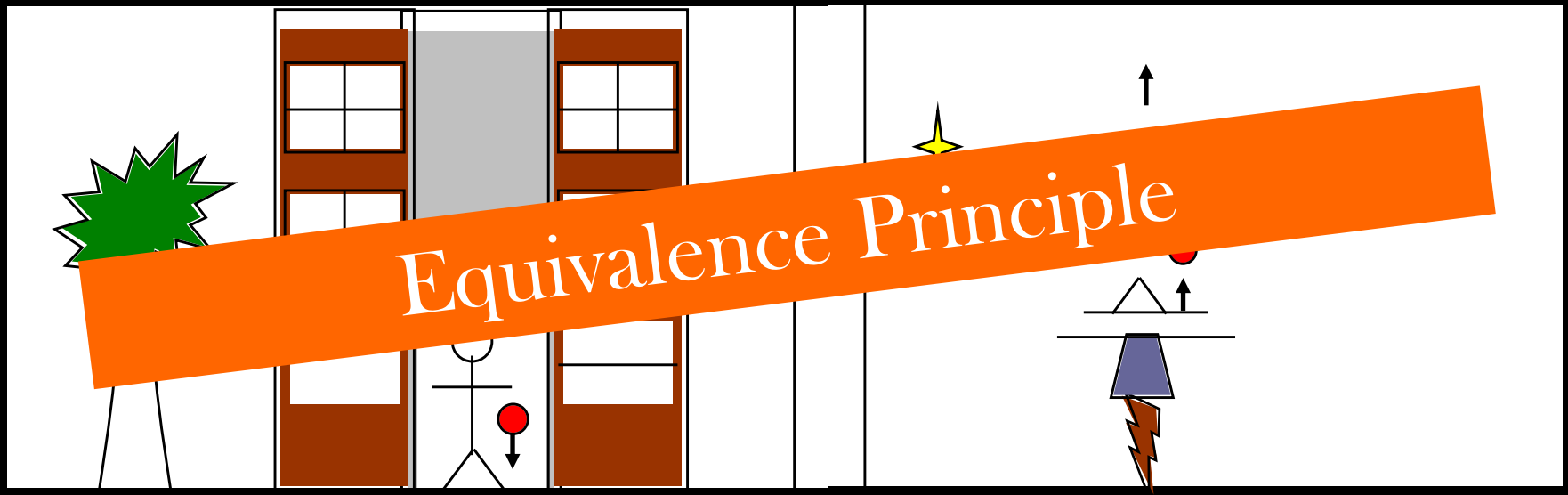

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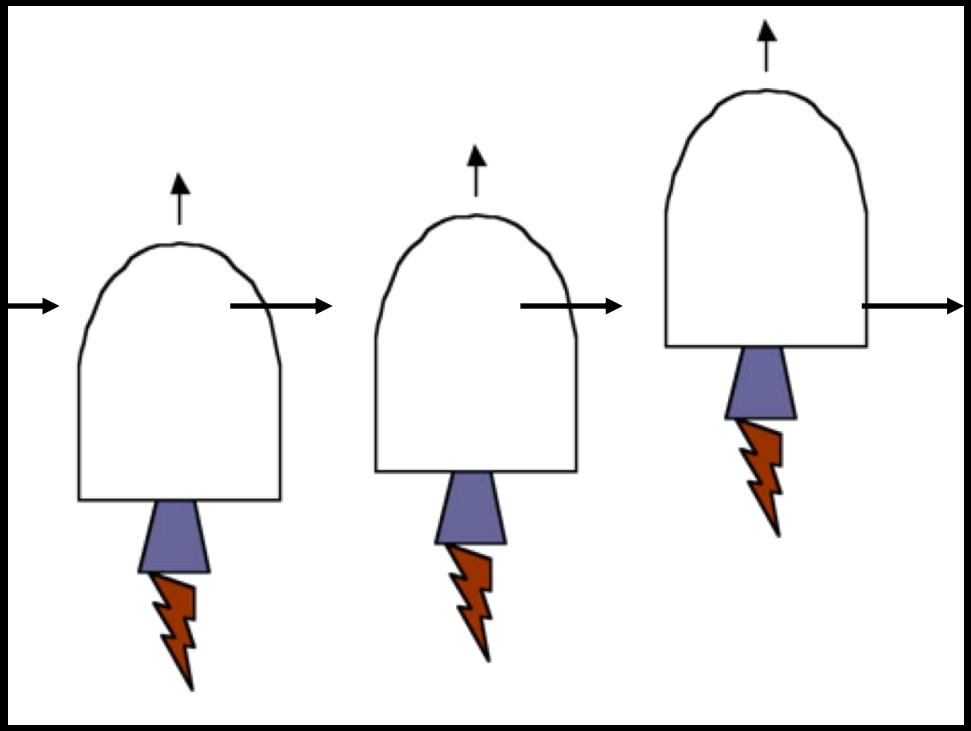
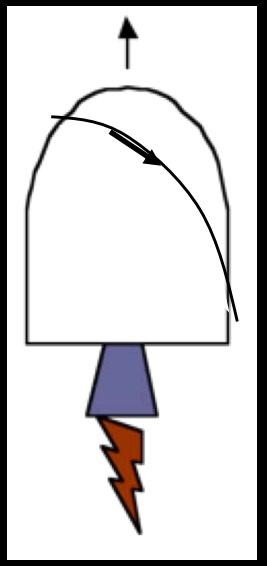
Follow the Light Beam



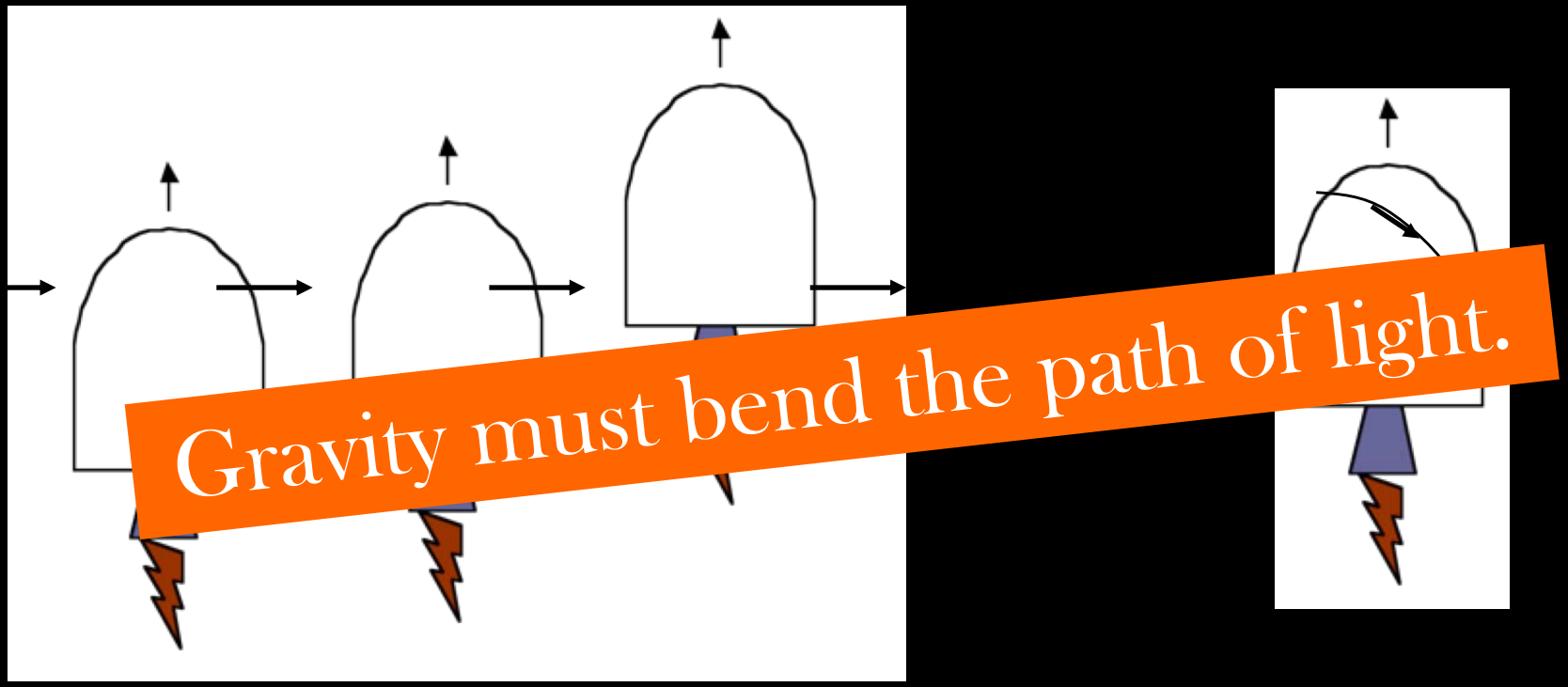
View outside spaceship



View inside spaceship

Inside the accelerating spaceship, the light beam appears to bend toward the floor. Enter the ***Equivalence Principle***: the same phenomenon must occur when the spaceship is *at rest* in a *gravitational field*.

Follow the Light Beam



View outside spaceship

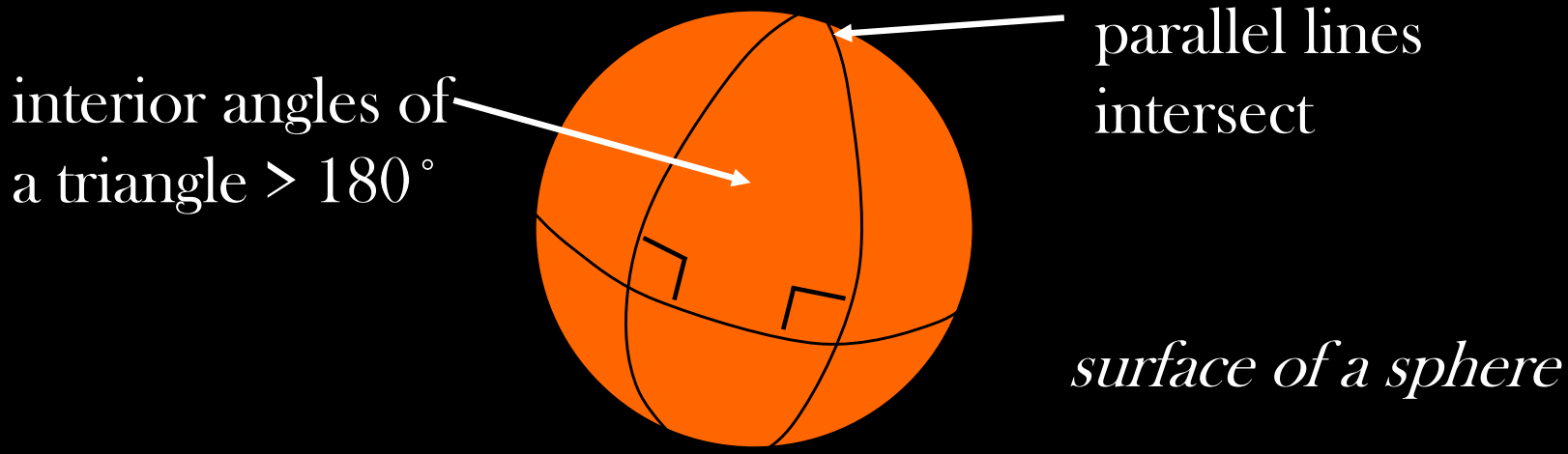
View inside spaceship

Inside the accelerating spaceship, the light beam appears to bend toward the floor. Enter the ***Equivalence Principle***: the same phenomenon must occur when the spaceship is *at rest* in a *gravitational field*.

Spacetime is Curved

Light is special: nothing travels faster than light, and everyone agrees on its speed. So people can use light to chart the ***shortest distances*** between two points. Light becomes a ***mapping tool***.

If a light beam's path is curved by gravity, this is like saying that spacetime itself is curved by gravity. The geometry of spacetime need *not* be *Euclidean*.



A little help from his friends

In 1912, Einstein found himself back in Zürich with his friend from school days, Marcel Grossmann—who was now a professional mathematician. Einstein eventually arrived at the field equations of *General Relativity*.

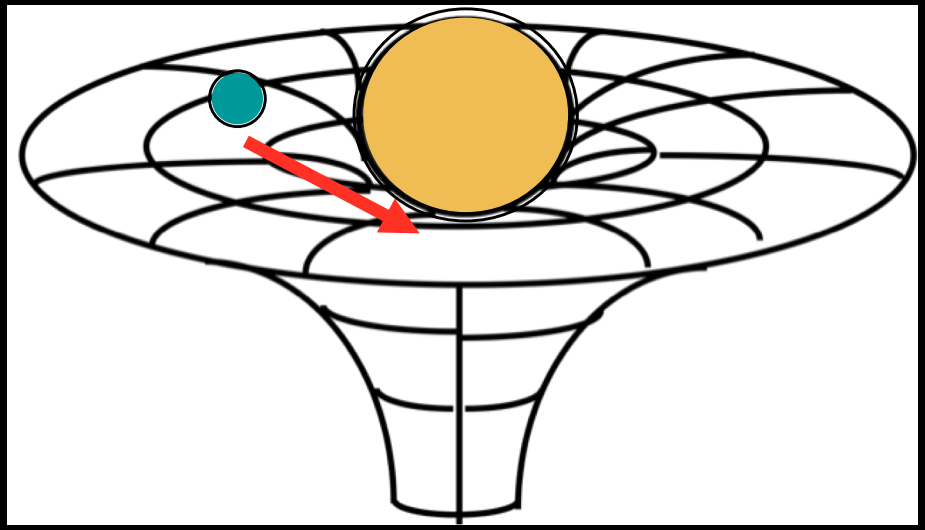
Marcel Grossmann and Albert Einstein

$$R_{\mu\nu} - \frac{}{2} g_{\mu\nu} R = \pi .$$

curvature of spacetime = distribution of matter and energy

Geometry Supreme

To Einstein, gravitation was *nothing but geometry*. There was no "force" of gravity: objects simply followed the shortest paths through curved spacetime.



The earth "falls" in its orbit around the sun because the sun makes a bigger "dent" in the surrounding spacetime than does the earth.

Questions?

Spacetime and War

Relativity on the Eastern Front

One of the early adepts was the Russian mathematician, ***Vsevolod Frederiks***, who had been studying in Göttingen.

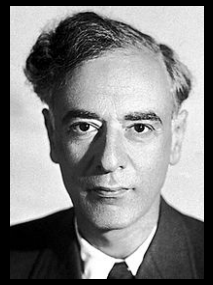
Göttingen Institute for Theoretical Physics

Frederiks was detained as a civilian prisoner of war. Upon his release, he returned to his native St. Petersburg and helped train Russia's first experts in general relativity.

Friedmann

Fock

Gamow



Landau

Equations in the Trenches

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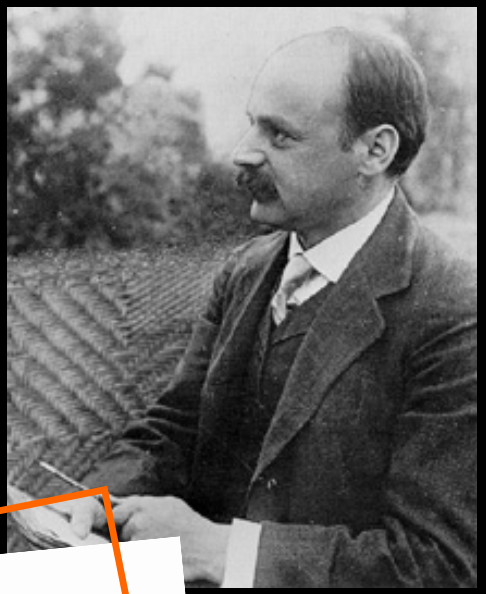
Another colleague, ***Karl Schwarzschild***, discovered his now-famous solution to Einstein's equations as a diversion while serving in the German Army on the Russian front.



K. Schwarzschild, ca. 1908

Image is in the public domain.

ON THE GRAVITATIONAL FIELD OF A MASS POINT
ACCORDING TO EINSTEIN'S THEORY †

BY K. SCHWARZSCHILD

(Communicated January 13th, 1916.)

TRANSLATION AND FOREWORD BY

S. Antoci* and A. Loinger**

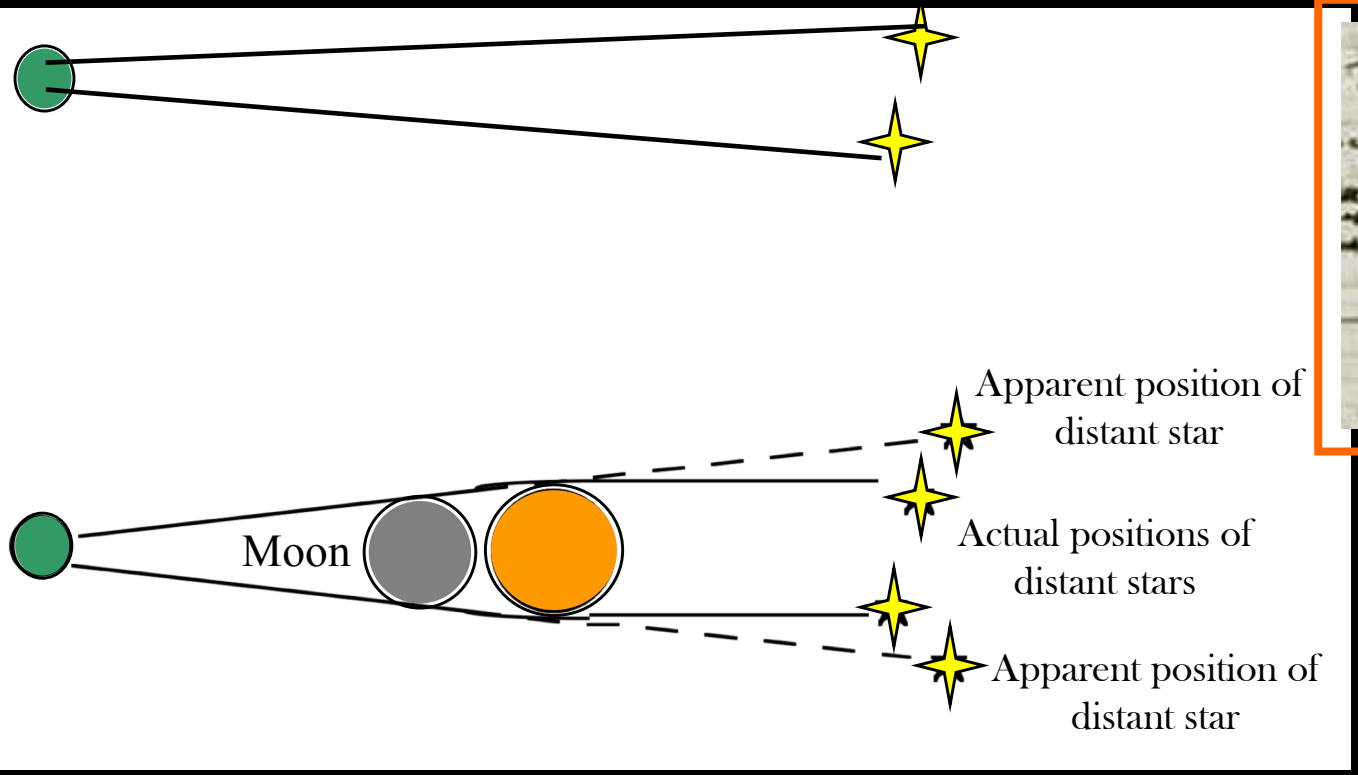
† Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften zu Berlin, Phys.-Math. Klasse 1916, 189-196.

Soon after publishing his paper, he died from a rare skin disease contracted on the Russian front.

Eclipse and Imprisonment

Still another of Einstein's colleagues, the German astronomer ***Erwin Freundlich***, tried to test a crucial prediction of Einstein's theory: that gravity could bend the path of starlight.

E. Freundlich



Einstein letter, 1913

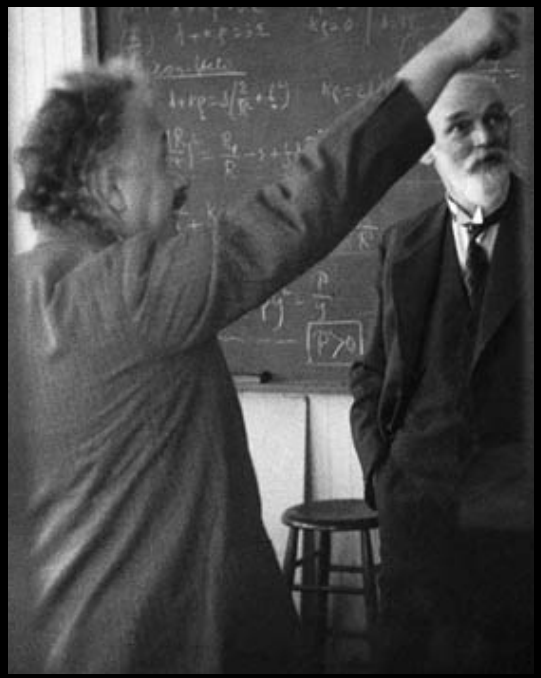
Freundlich found himself on the wrong side of the Russian border when war broke out, and was sent to a prison camp.

Relativity on the Western Front

Even after war had broken out, Einstein made several trips to visit colleagues in Leiden, since the Netherlands was still a neutral country.

Einstein visiting Paul Ehrenfest's group in Leiden, 1920s

He coached astronomers like ***Willem de Sitter*** in the intricacies of his new theory.



Einstein and de Sitter, ca. 1932

Beyond the Blockade

The war choked off all direct contact between scientists in Germany and Britain. ***Arthur Eddington*** learned about general relativity from Willem de Sitter, who sent him extensive English-language primers.

A. S. Eddington, ca. 1920
Image is in the public domain.

Eddington, a Quaker and conscientious objector, completed his wartime national service by preparing a new eclipse expedition to test Einstein's prediction about the bending of starlight.

Eddington's Announcement

Immediately after the war, a British expedition led by *Eddington* was successful.

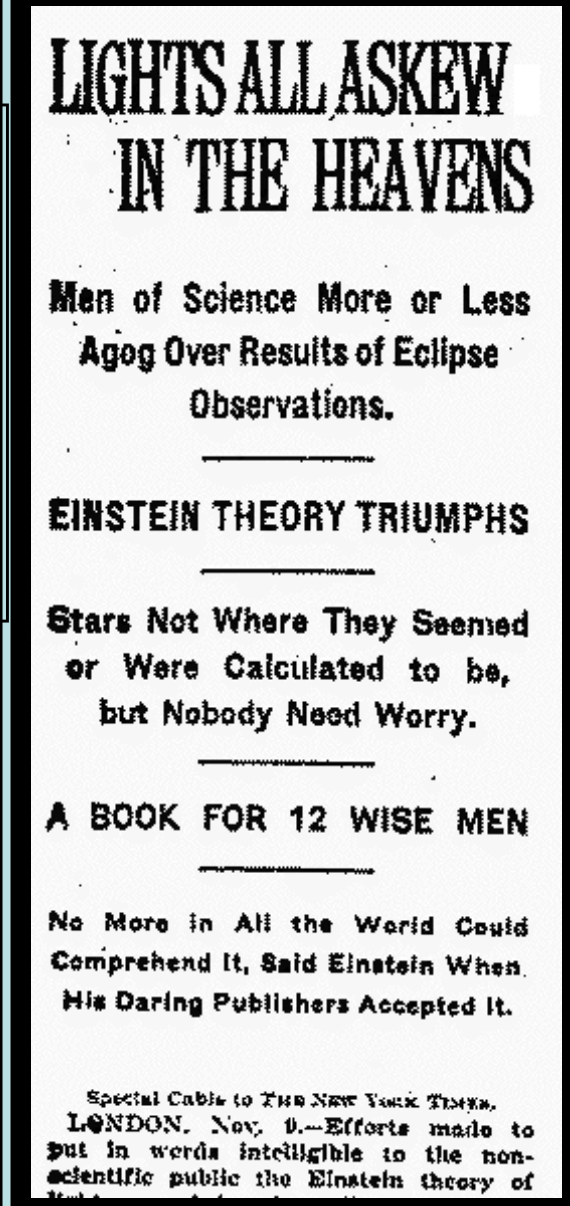
Nov 1918: *Armistice*

May 1919: *Eclipse expedition*

Nov 1919: *Results announced*

Worldwide fame:

Einstein in New York City, 1921.



LIGHTS ALL ASKEW IN THE HEAVENS

Men of Science More or Less Agog Over Results of Eclipse Observations.

EINSTEIN THEORY TRIUMPHS

Stars Not Where They Seemed or Were Calculated to be, but Nobody Need Worry.

A BOOK FOR 12 WISE MEN

No More in All the World Could Comprehend It, Said Einstein When His Daring Publishers Accepted It.

Special Cable to THE NEW YORK TIMES.
LONDON, Nov. 9.—Efforts made to put in words intelligible to the non-scientific public the Einstein theory of

Backlash: deutsche Physik

Einstein told the London *Times*, 1919: "Today I am described in Germany as a 'German servant,' and in England as a 'Swiss Jew.' Should it ever be my fate to be represented as a *bête noire*, I should, on the contrary, become a 'Swiss Jew' for the Germans and a 'German savant' for the English."

Johannes Stark
Image is in the public domain.

Philipp Lenard

Große Naturforscher

Eine Geschichte der Naturforschung in Lebensbeschreibungen

Von

Philipp Lenard

Heidelberg

Aller Fortschritt und alle Kultur der Menschheit sind nicht aus der Majorität geboren, sondern beruhen ausschließlich auf der Genialität und der Tatkraft der Persönlichkeit.
Der Führer.

Sechste Auflage · Mit 70 Bildnissen

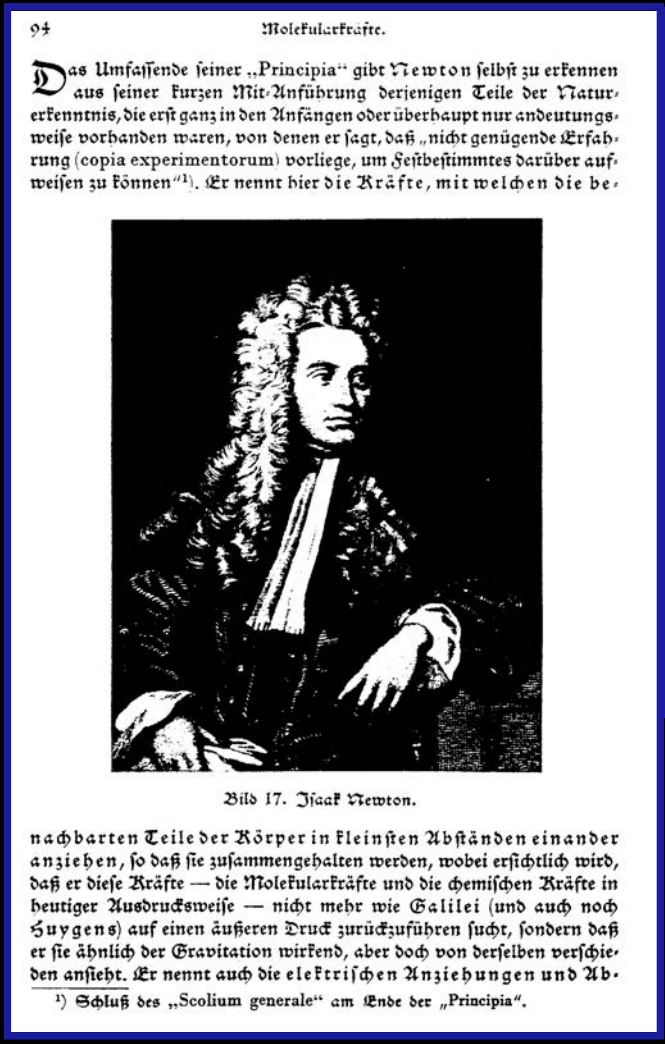
ICH HABS GEWAGT

J. F. Lehmanns Verlag / München 1943

Stark and Lenard Attack

Two-part strategy: 1. Einstein's work was repugnant to the Aryan sensibility. 2. Key results had been plagiarized from early Aryan researchers.*("First of all, you're wrong, and second of all, we got there first!")*

"The concept of force, which was introduced by Aryan scientists [like Newton and Galileo!], obviously arises from the personal experience of human labor, of manual creation, which has been and is the essential content of the life of Aryan man."



94 Molekularkräfte.

Das Umfassende seiner „Principia" gibt Newton selbst zu erkennen aus seiner kurzen Mit-Anführung derjenigen Teile der Naturerkenntnis, die erst ganz in den Anfängen oder überhaupt nur andeutungsweise vorhanden waren, von denen er sagt, daß „nicht genügende Erfahrung (copia experimentorum) vorliege, um Festbestimmtes darüber aufweisen zu können"[1]. Er nennt hier die Kräfte, mit welchen die be-

Bild 17. Isaak Newton.

nachbarten Teile der Körper in kleinsten Abständen einander anziehen, so daß sie zusammengehalten werden, wobei ersichtlich wird, daß er diese Kräfte — die Molekularkräfte und die chemischen Kräfte in heutiger Ausdrucksweise — nicht mehr wie Galilei (und auch noch Huygens) auf einen äußeren Druck zurückzuführen sucht, sondern daß er sie ähnlich der Gravitation wirkend, aber doch von derselben verschieden ansieht. Er nennt auch die elektrischen Anziehungen und Ab-

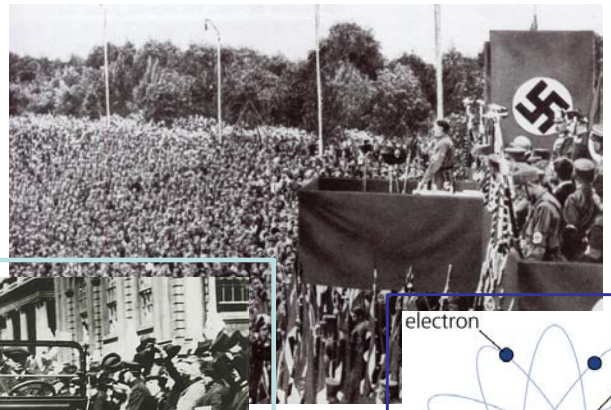
[1]) Schluß des „Scolium generale" am Ende der „Principia".

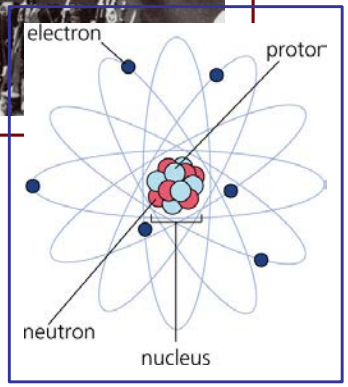
The little-known Johann Soldner had written a paper in 1803 (which Stark and Lenard republished in 1921), in which he had used Newtonian gravity to derive the bending of light near the sun. (Soldner's result was one-half of Einstein's value.)

Questions?

What Goes Up...

Annual number of publications on *GR* worldwide, 1915-1960





MIT: From Rad Lab to RLE

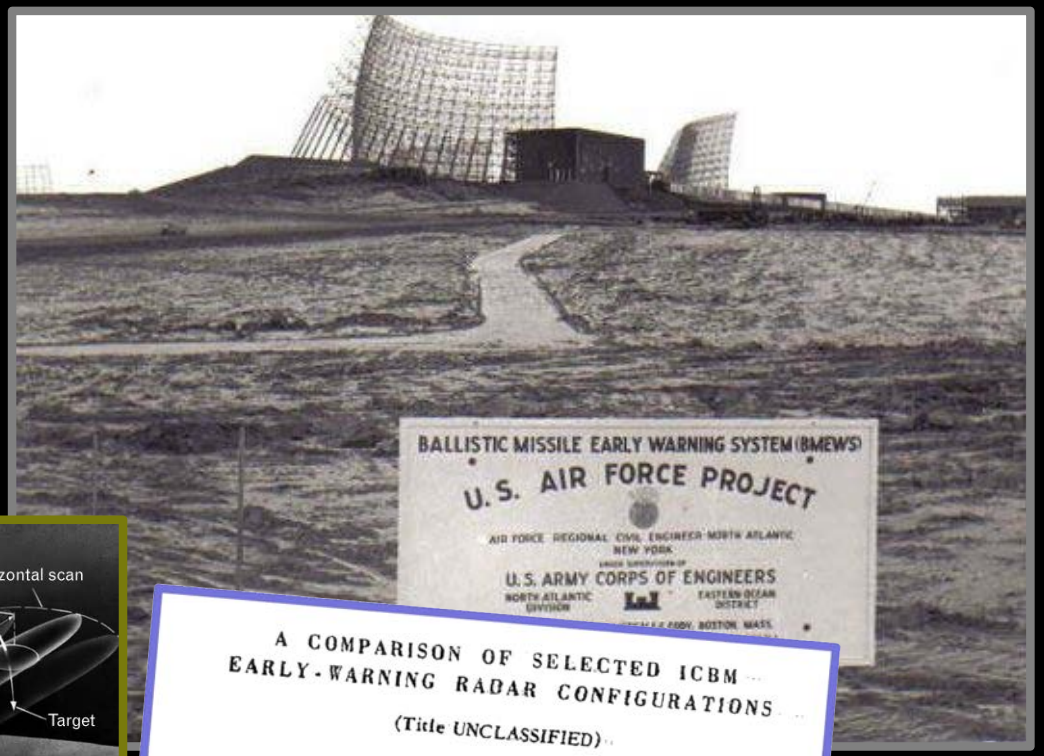
MIT Rad Lab, WWII

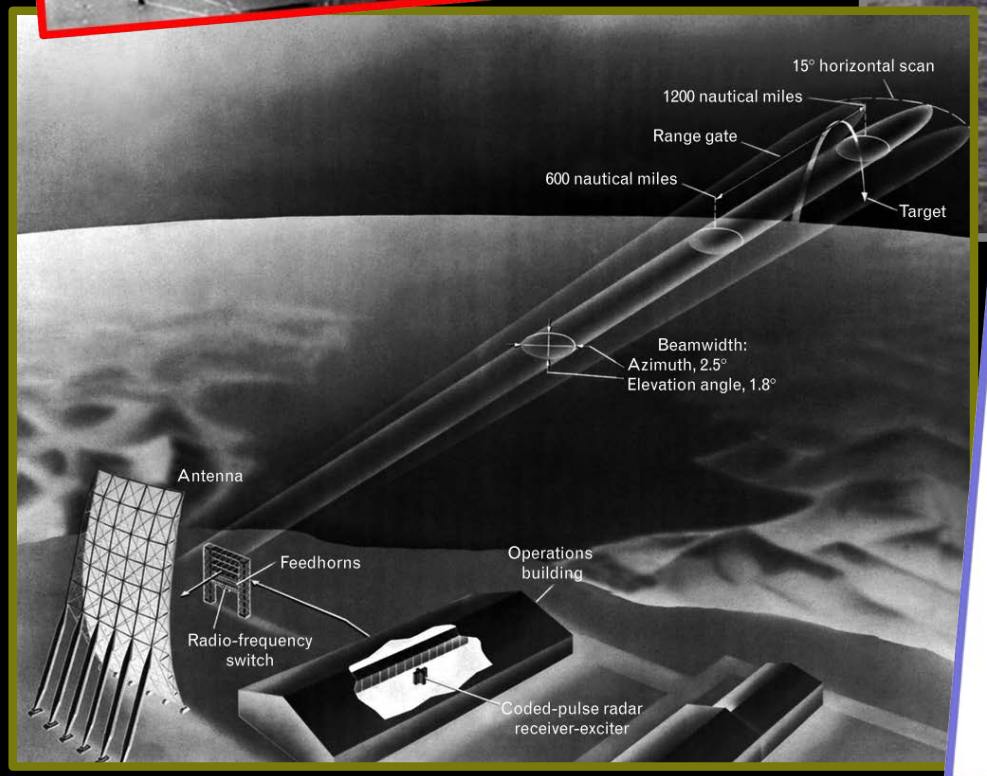
Ben Wilson

1945

rle AT MIT

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

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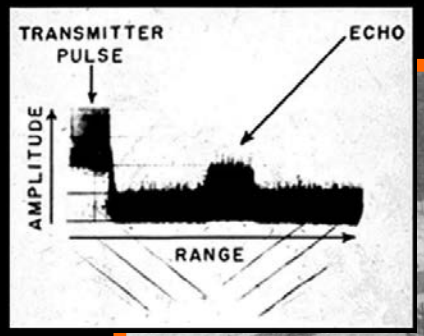
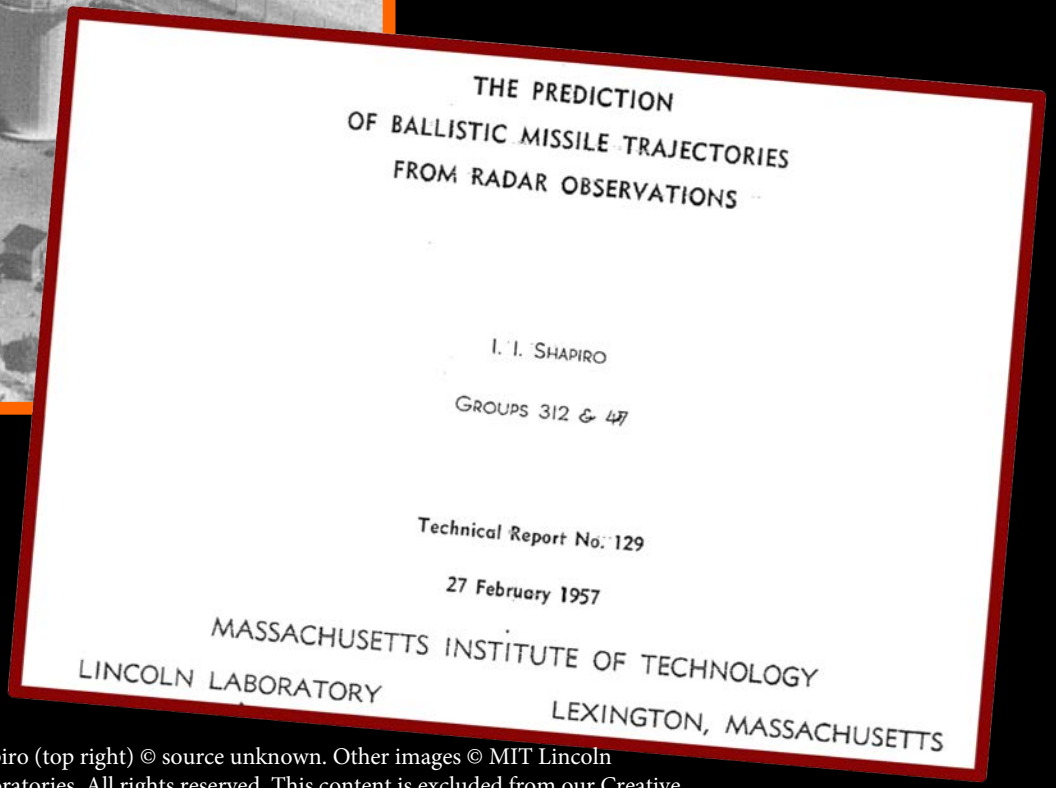
DOWNGRADED AT 3 YEAR INTERVALS;
DECLASSIFIED AFTER 12 YEARS.
DOD DIR 5200.10

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

Target Practice

d

"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;

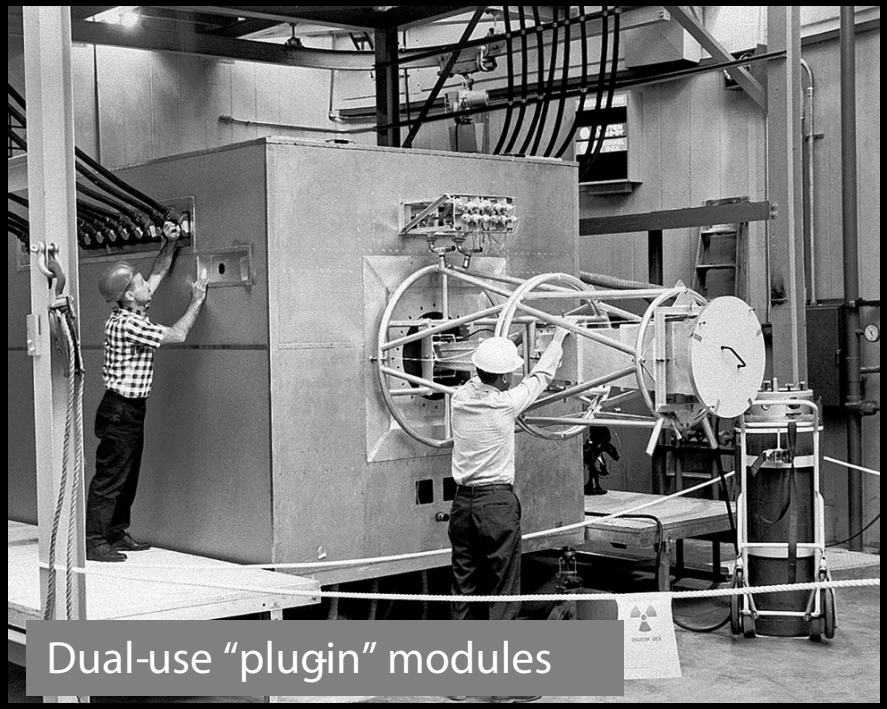
"Planetary Ephemeris Program": use radar inputs to estimate future position of objects in the sky; builds on statistical procedure for BMEWS.

Millstone control room

New Challenges

The Lab would pursue dual-use projects with Haystack: expanded planetary radar astronomy plus more advanced missile defense.

Haystack radar, 1964



Dual-use "plug-in" modules

"These [astronomical] studies may have important consequences to the design of future radars for such purposes as missile discrimination or space-vehicle detection, where extremely high resolution and high effective radiated power are essential."

Carl Overhage to Lt. Gen. Roscoe C. Wilson, 30 Aug 1960

A Secret Briefing

LIGHT

GEORGE W. STROKE

TECHNICAL REPORT 348

JANUARY 9, 1959

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
RESEARCH LABORATORY OF ELECTRONICS
CAMBRIDGE, MASSACHUSETTS

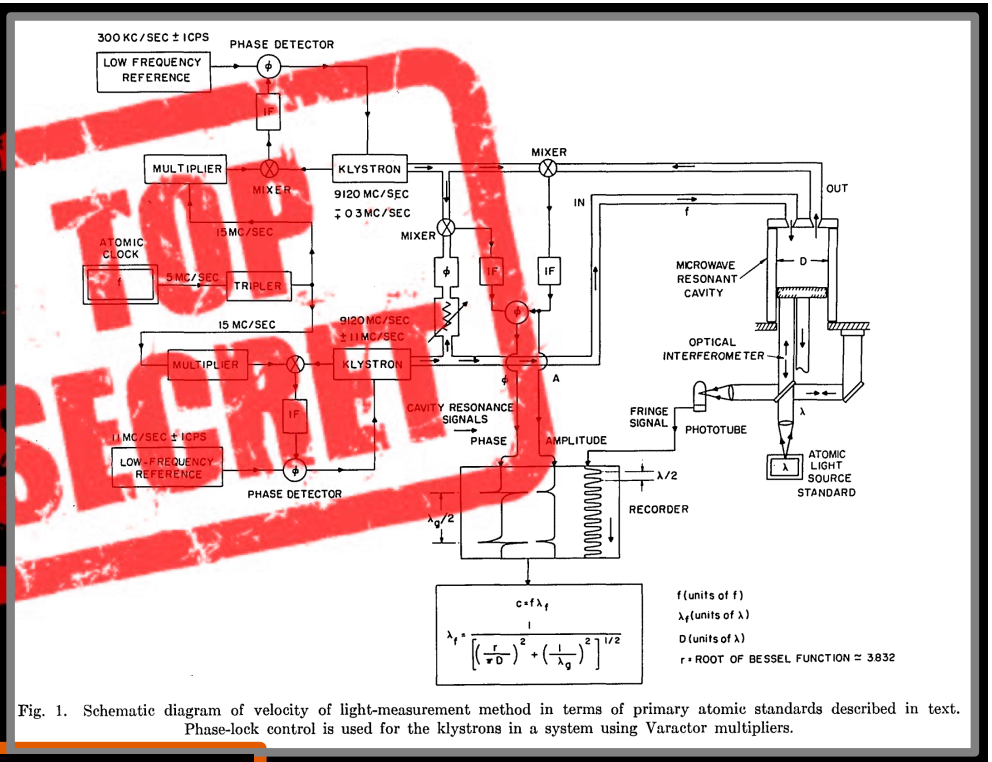


Fig. 1. Schematic diagram of velocity of light-measurement method in terms of primary atomic standards described in text. Phase-lock control is used for the klystrons in a system using Varactor multipliers.

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

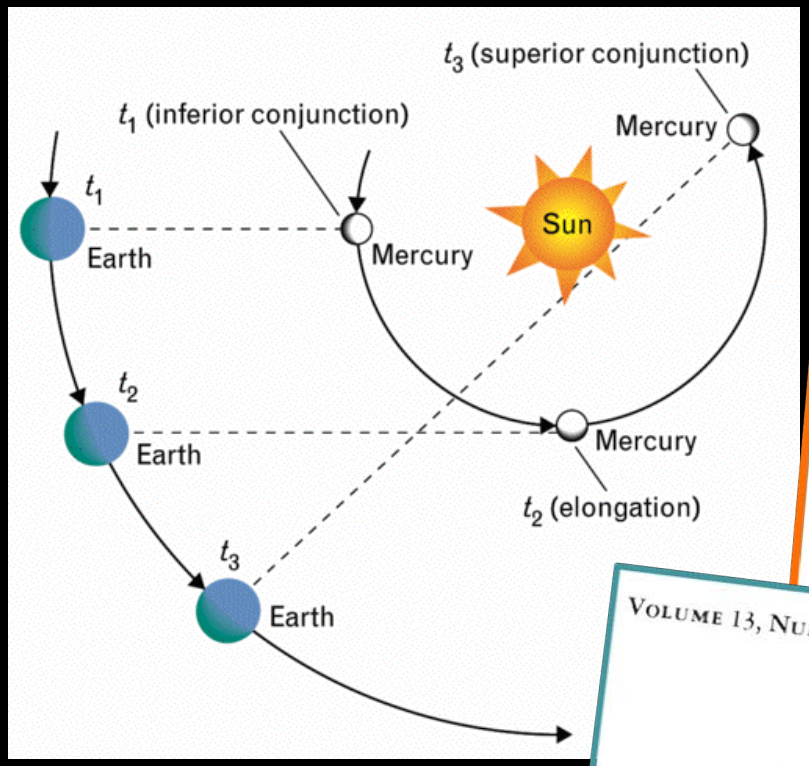
$$c = c_o\left(1 + \frac{\Phi}{c^2}\right)$$

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



MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

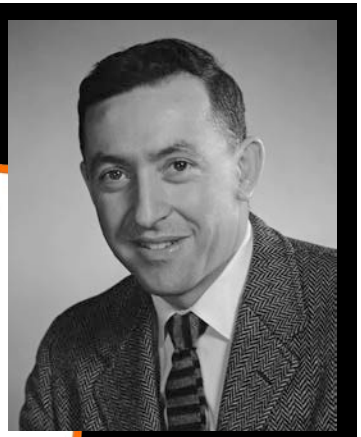
EFFECTS OF GENERAL RELATIVITY ON INTERPLANETARY TIME-DELAY MEASUREMENTS

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

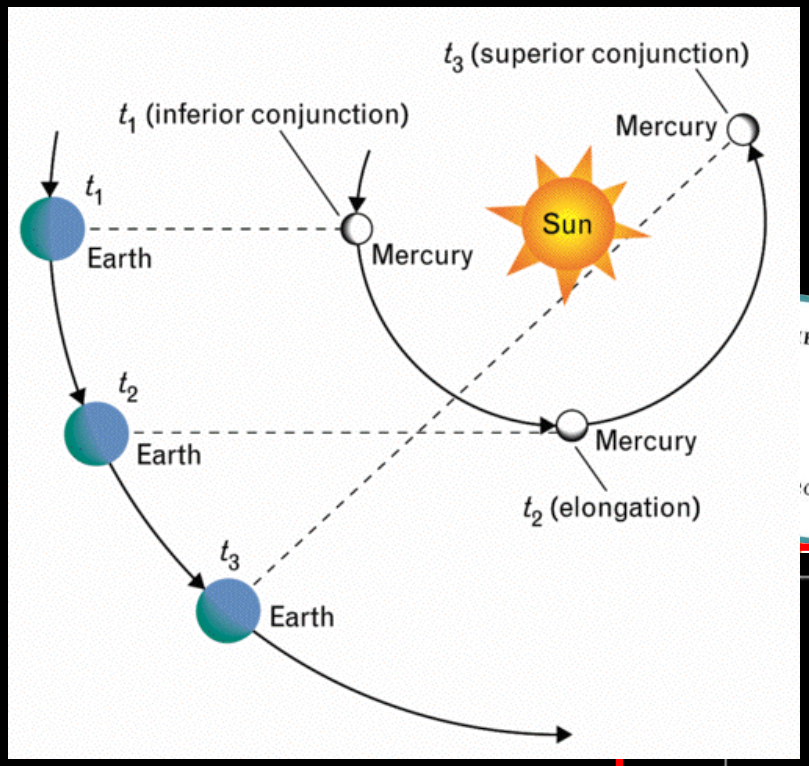
Irwin I. Shapiro

Lincoln Laboratory,* Massachusetts Institute of Technology, Lexington, Massachusetts

(Received 13 November 1964)

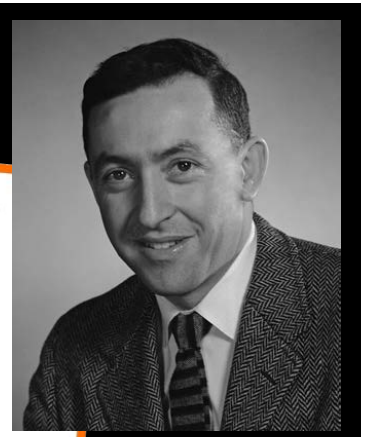
Radar echo would be 10^{27} times weaker than the transmitted signal; the time-delay would be about 200μsec.

Successful Test



MASSACHUSETTS INSTITUTE OF TECHNOLOGY
LINCOLN LABORATORY

EFFECTS OF GENERAL RELATIVITY
ON INTERPLANETARY TIME-DELAY MEASUREMENTS

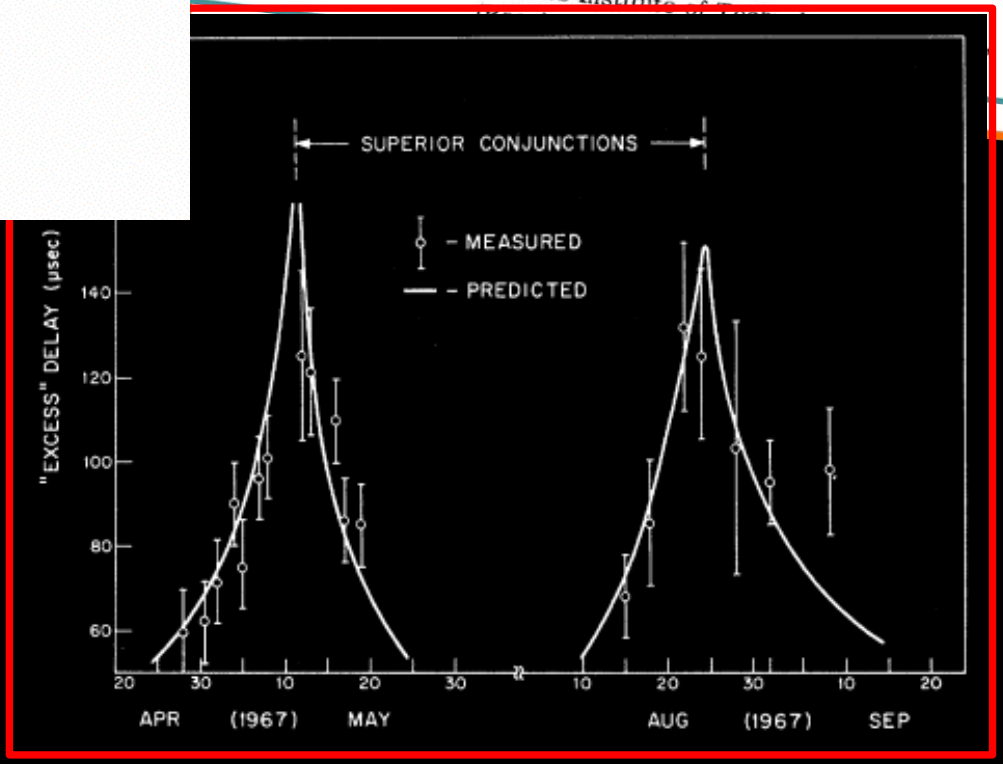


I. I. Shapiro

BER 26 PHYSICAL REVIEW LETTERS 28 DECEMBER 1964

FOURTH TEST OF GENERAL RELATIVITY

oln Laboratory,* Massachusetts Institute of Tech... Irwin I. Shapiro ... Massachusetts



Data matched GR prediction to± 20%. Follow-up tests provided some of the most precise tests of GR to date, ± 0.001%.

Gravity and Politics

Ideology and Representation

Information, Access, and Circulation

Resources and Ir

War, Peace, and Gravity

The fortunes of Einstein's "temple of relativity"—erected during World War I, rejected by the Nazis, and reborn during the Cold War —rose and fell with the political tides. Even the most abstract theory could not escape what Einstein had called "the fetters of everyday life."

STS.042J / 8.225J Einstein, Oppenheimer, Feynman: Physics in the 20th Century
Fall 2020