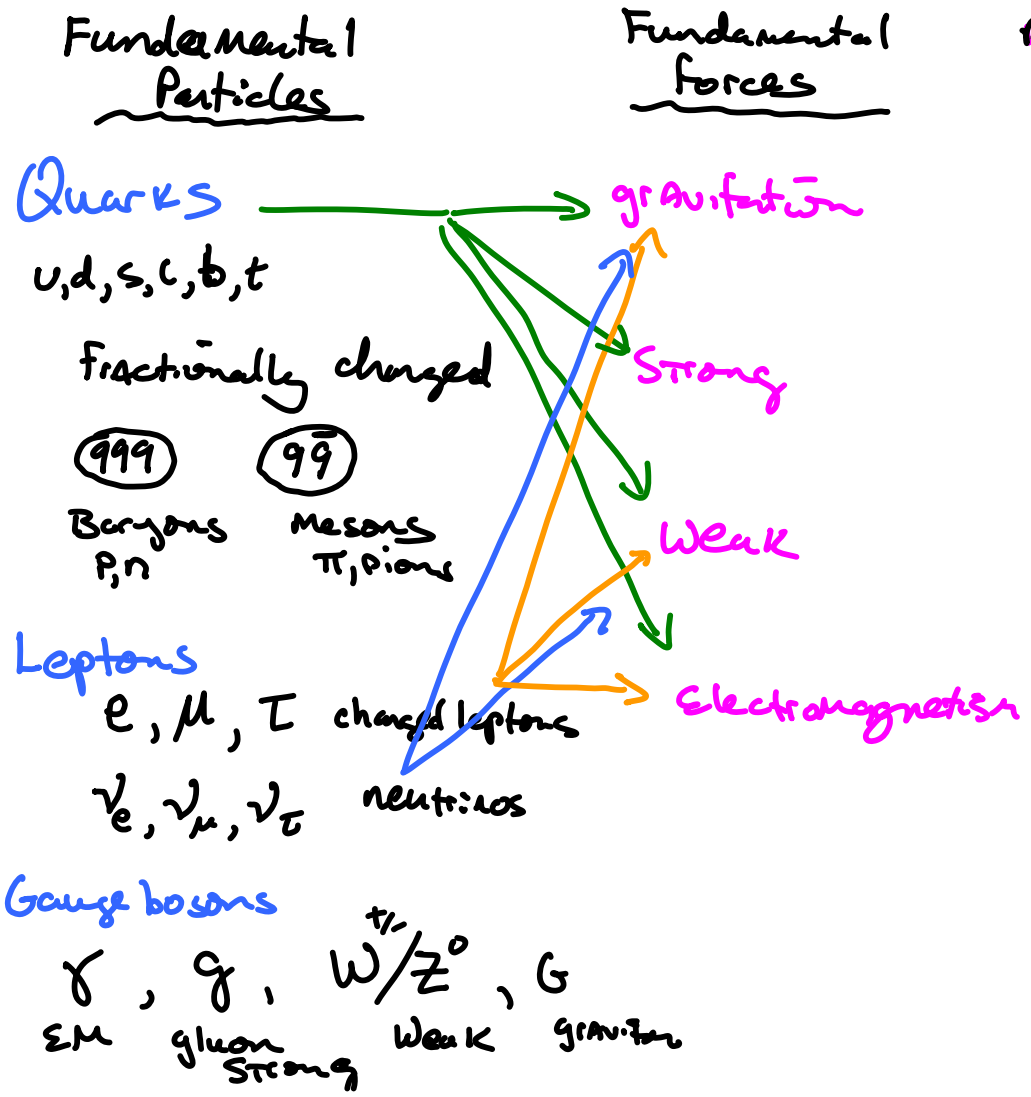
Physics 102 - March 28, 2011



Have pushed into inner space about as far as we can go.

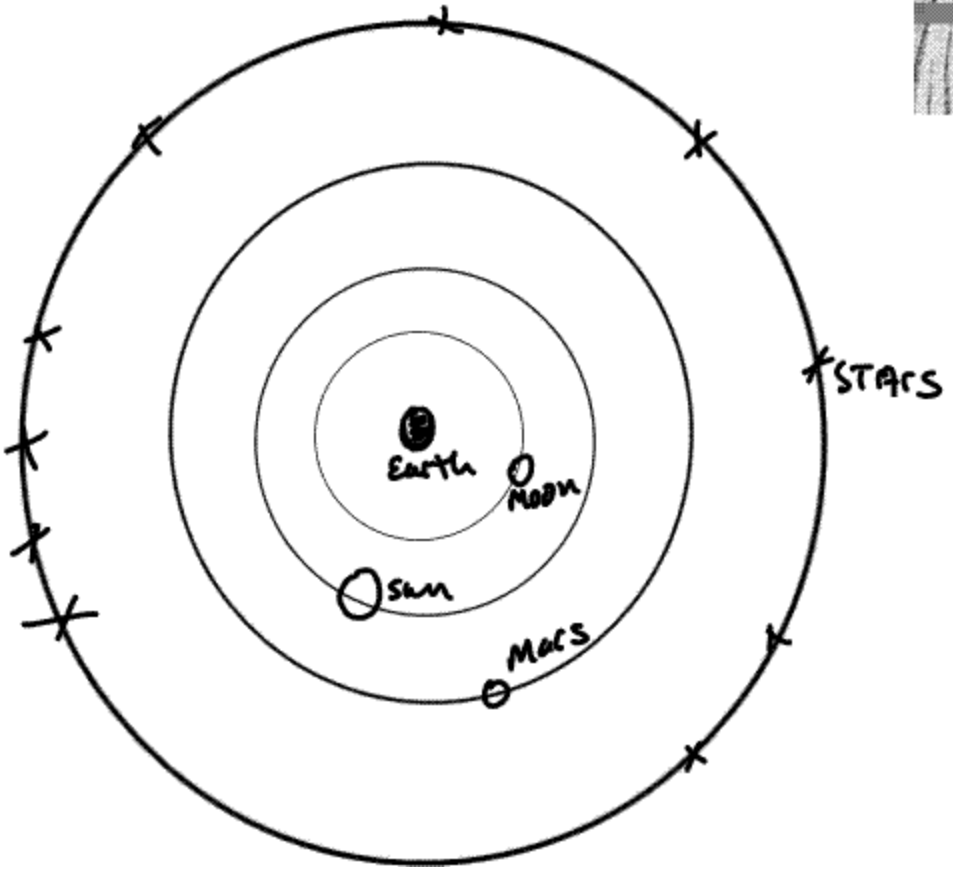
Now let's look at Man's place in the cosmos and cosmology - The origin and evolution of our universe.

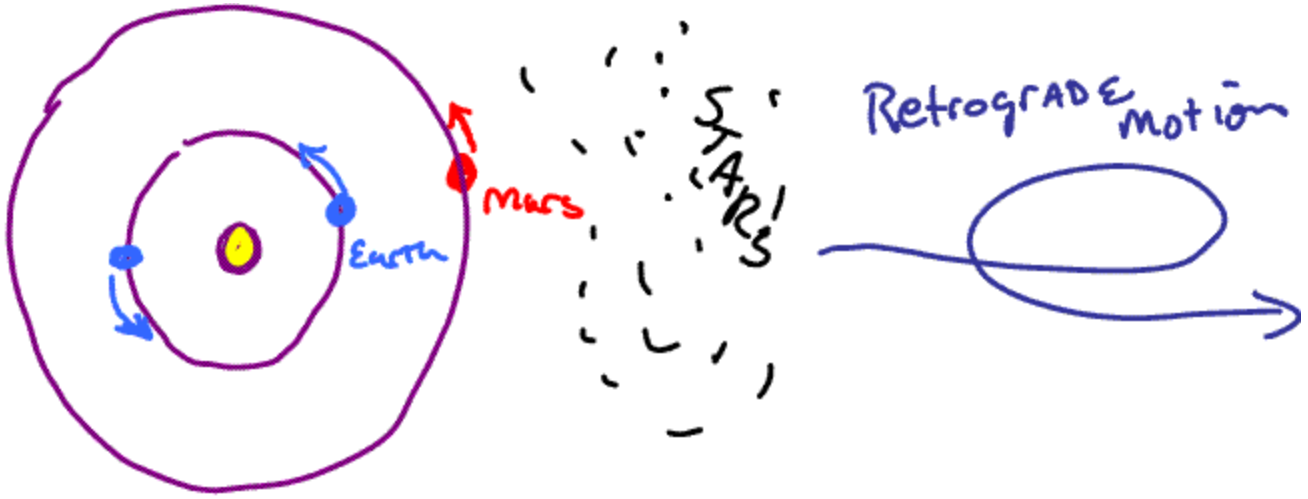
Move from inner space to outer space

Pythagorian theory

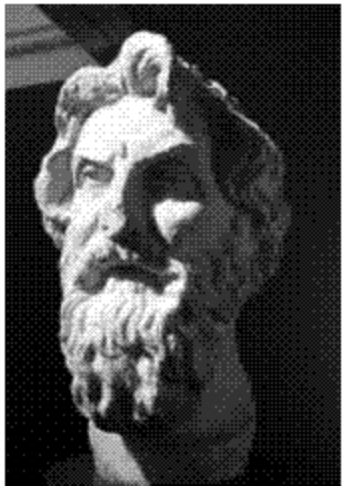
Early Greek view of the universe

Pythagoras of Samos ~500BC





Plato ~400 BC ~ Multiple spheres

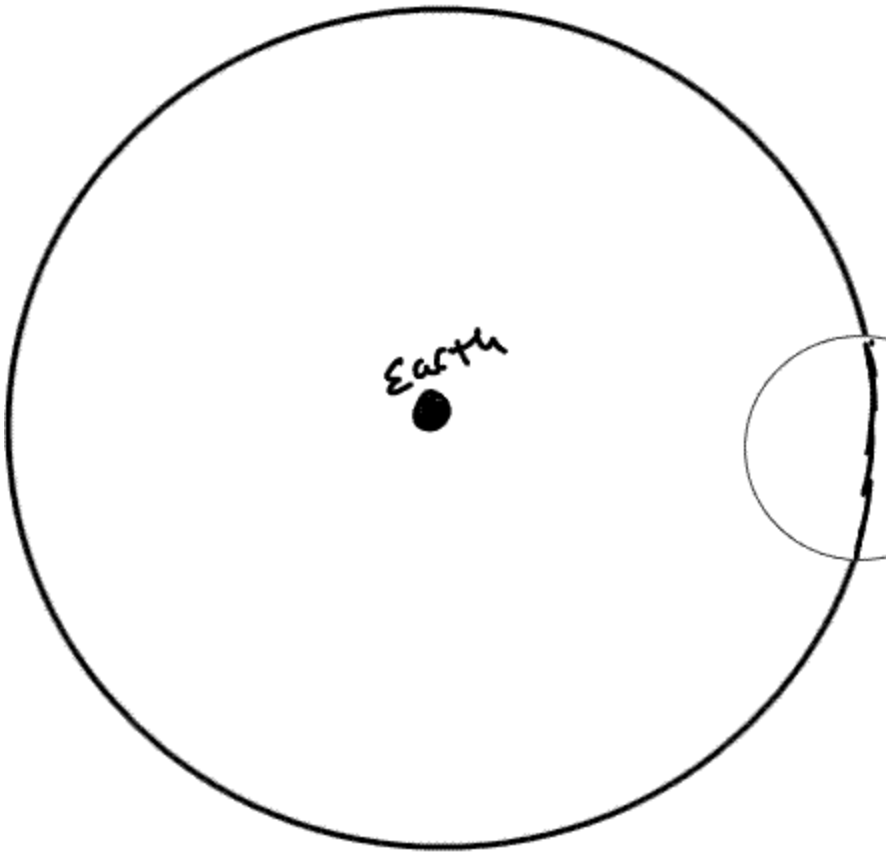


Aristarchus ~310 - 230 BC
(Greek)

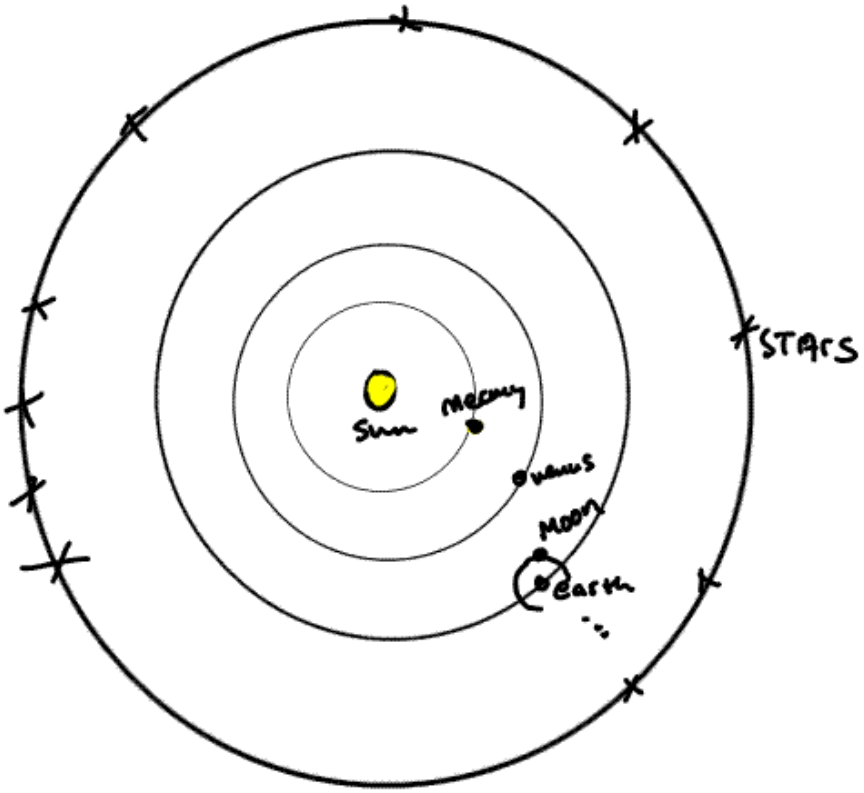
Proposed sun-centered universe
→ rejected

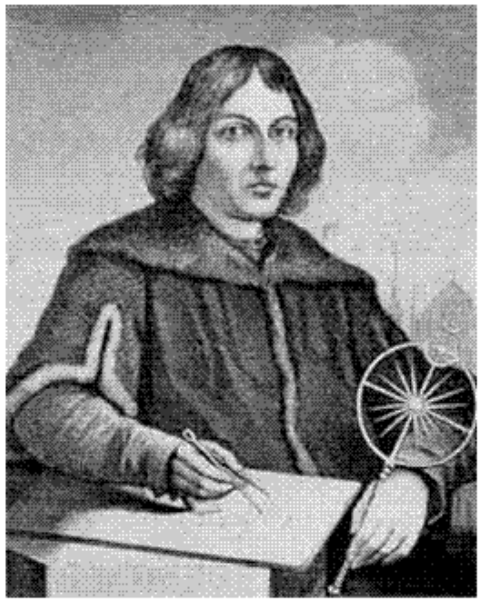
Ptolemy

~100 AD



Sun Centered Universe





Nicolaus Copernicus

1473-1543

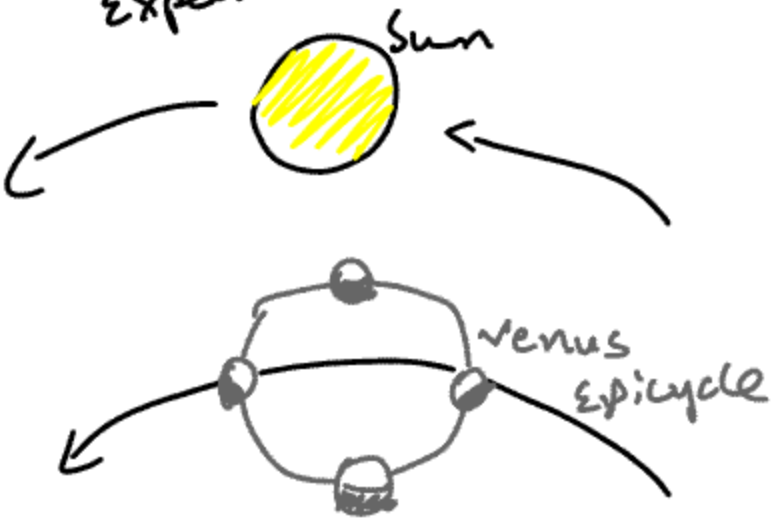
(Poland)

On the Revolutions of the Heavenly Spheres

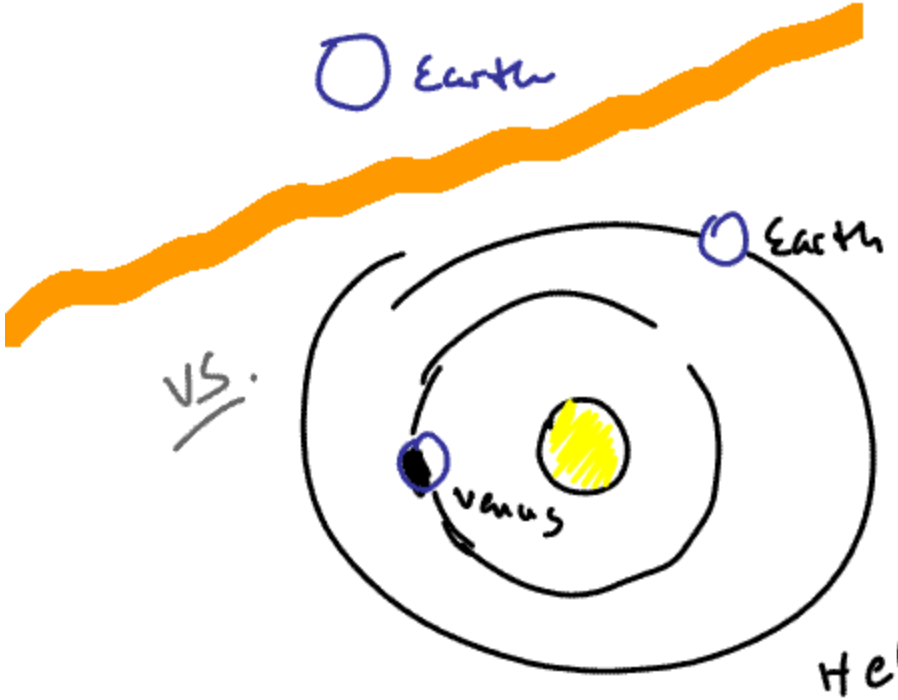
Please read "The Copernican Myths"

in Reserve reading on Blackboard

Ptolemy Expectation



Galileo Galilei
(1564 - 1642)



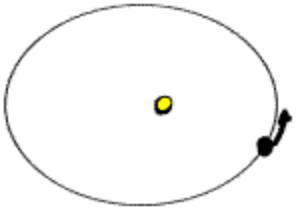
Observed phases of venus

Heliocentric expectation

Brahe's data did NOT fit perfectly with Copernicus' theory

Tycho Brahe
1546 - 1601
(Dane)
careful observations
of positions
of sun, moon, planets

Johannes Kepler
1571 - 1630
(German)



⇒ Elliptical orbits
fits the data!

Determined 3 laws
that mathematically
describe orbits seen -
relate periods, areas, axes ....

Sir Isaac Newton

1643 - 1727

(England)

universal law of gravitation

$$F = G\frac{M_1 M_2}{r^2}$$

+

Laws of Motion

$\Rightarrow$ derived Kepler's

3 laws of planetary motion

Copernican Principle:

Earth is not in a central, favored position in the universe.

Humans do not occupy a privileged position in the universe

Mediocrity Principle:

There is nothing special about humans/Earth

If you observe a phenomenon (or an exceptional event), it should be assumed the event occurs other times/places under the correct circumstances

Anthropic Principle

Brandon Carter - Australian astrophysicist

1973 "Although our situation is not necessarily central, it is inevitably privileged to some extent."

Weak anthropic Principle (Carter): Our location (space and time) in the universe is necessarily privileged to the extent of being compatible with our existence as observers.

Strong anthropic Principle (Carter): The universe MUST be such as to admit the creation of observers within it at some stage

John Barrow, Frank Tipler (1986)

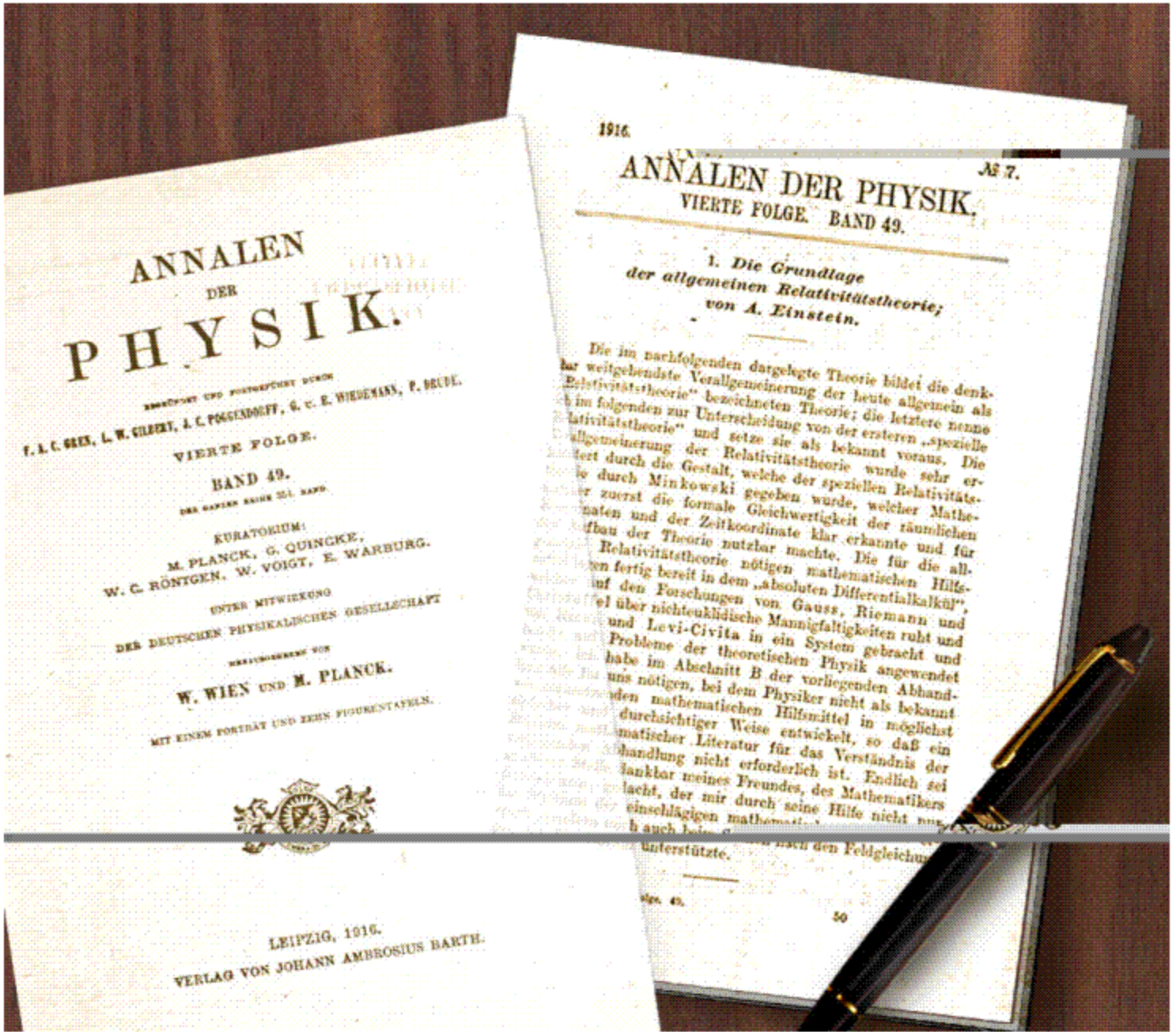
Weak anthropic Principle (Barrow + Tipler):

The observed values of all physical and cosmological quantities are NOT equally probable but they must take on values restricted by the requirement that there exist sites where carbon-based life can evolve and by the requirements that the universe be old enough for it to have already done so.

Strong anthropic Principle (Barrow + Tipler):

The Universe must have those properties which allow life to develop within it at some stage in its history.

The Theory of General Relativity – Einstein 1916



ANNALEN
DER
PHYSIK.

BEGRÜNDET UND FORTGEFÜHRT DURCH
F. A. C. GREN, L. W. GILBERT, J. C. POGGENDORFF, G. C. E. WIEDEMANN, P. DRUDE.

VIERTE FOLGE.

BAND 49.

DER GANZEN REIHE 354. BAND.

KURATORIUM:
M. PLANCK, G. QUINCKE,
W. C. RÖNTGEN, W. VOIGT, E. WARBURG.

UNTER MITWIRKUNG
DER DEUTSCHEN PHYSIKALISCHEN GESELLSCHAFT

HERAUSGEGEBEN VON
W. WIEN UND M. PLANCK.

MIT EINEM PORTRÄT UND ZEHN FIGURENTAFELN.

LEIPZIG, 1916.
VERLAG VON JOHANN AMBROSIUS BARTH.

1916.

ANNALEN DER PHYSIK.

№ 7.

VIERTE FOLGE. BAND 49.

1. *Die Grundlage der allgemeinen Relativitätstheorie;*
von A. Einstein.

Die im nachfolgenden dargelegte Theorie bildet die denkbar weitgehendste Verallgemeinerung der heute allgemein als „Relativitätstheorie" bezeichneten Theorie; die letztere nenne ich im folgenden zur Unterscheidung von der ersteren „spezielle Relativitätstheorie" und setze sie als bekannt voraus. Die Verallgemeinerung der Relativitätstheorie wurde sehr erleichtert durch die Gestalt, welche der speziellen Relativitätstheorie durch Minkowski gegeben wurde, welcher Mathematiker zuerst die formale Gleichwertigkeit der räumlichen Koordinaten und der Zeitkoordinate klar erkannte und für den Aufbau der Theorie nutzbar machte. Die für die allgemeine Relativitätstheorie nötigen mathematischen Hilfsmittel lagen fertig bereit in dem „absoluten Differentialkalkül", welcher auf den Forschungen von Gauss, Riemann und Christoffel über nichteuklidische Mannigfaltigkeiten ruht und welcher von Ricci und Levi-Civita in ein System gebracht und bereits die Probleme der theoretischen Physik angewendet hat. Ich habe im Abschnitt B der vorliegenden Abhandlung alle uns nötigen, bei dem Physiker nicht als bekannt voraussetzbaren mathematischen Hilfsmittel in möglichst durchsichtiger Weise entwickelt, so daß ein Studium mathematischer Literatur für das Verständnis der vorliegenden Abhandlung nicht erforderlich ist. Endlich sei es mir dankbar meines Freundes, des Mathematikers Grossmann, gedacht, der mir durch seine Hilfe nicht nur [illegible] einschlägigen mathemat[illegible] auch bei [illegible] unterstützte.

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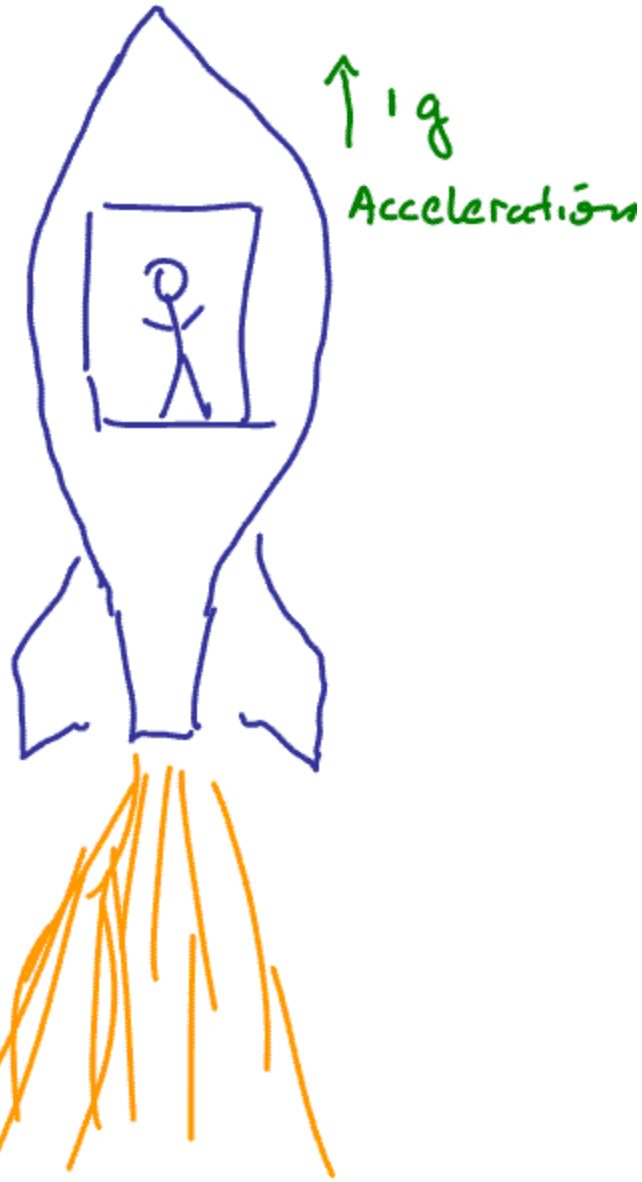
50

Vs



accelerated reference frames

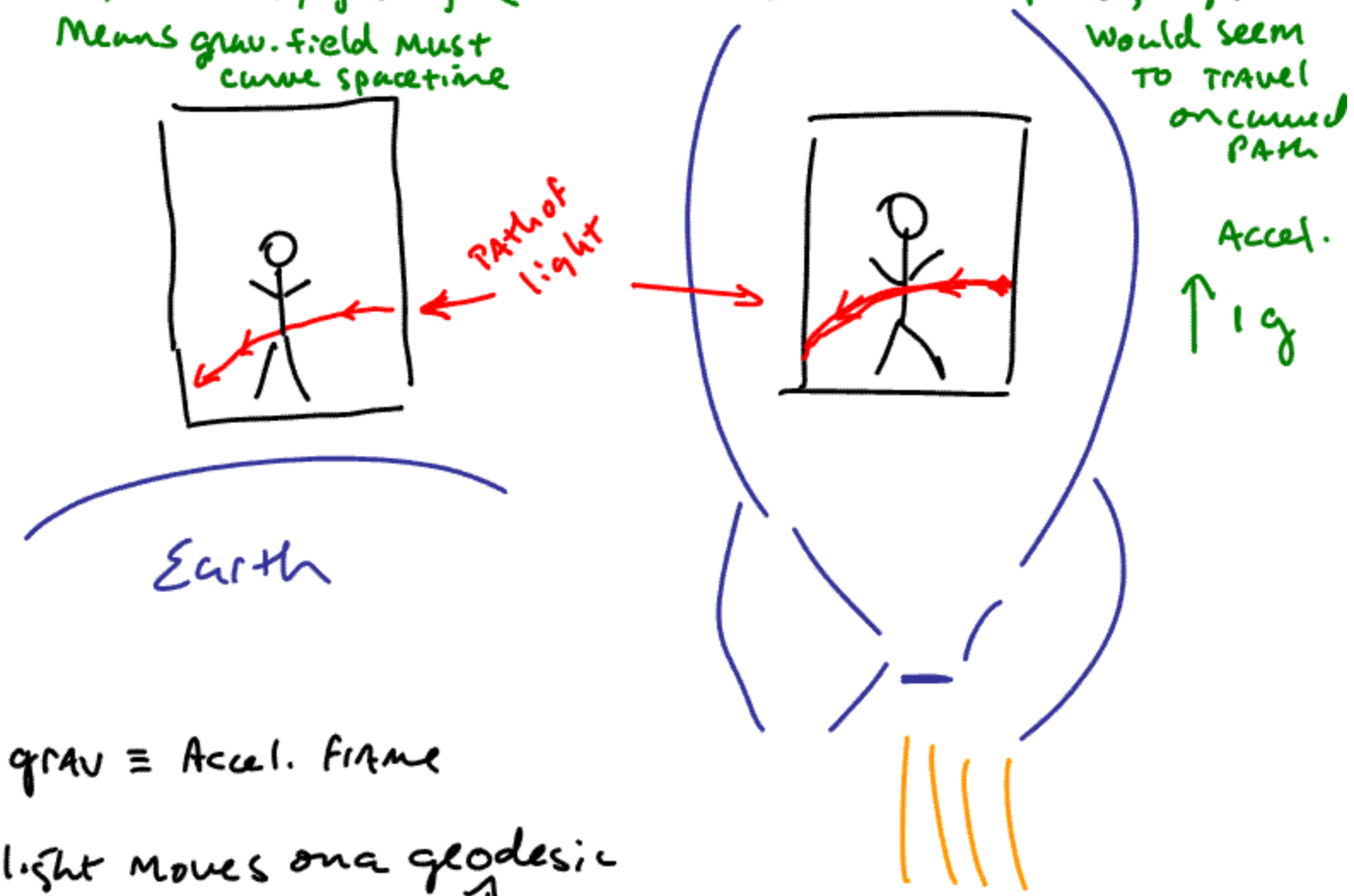
|||

gravitational field

If you are in a closed box —
you can't tell if you are at rest on earth's surface or accelerating in a rocket at 1g.

Equivalence of gravity ⟸ In accelerated rocket ship case, light would seem to travel on curved path

Means grav. field must curve spacetime



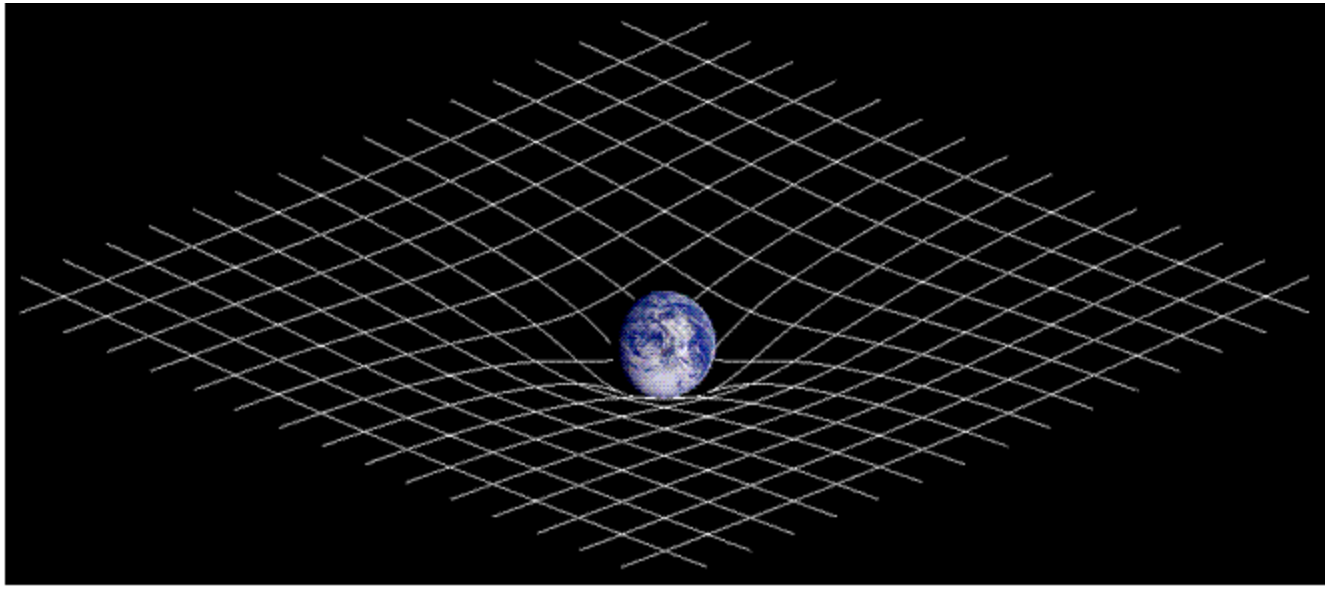
grav ≡ Accel. frame

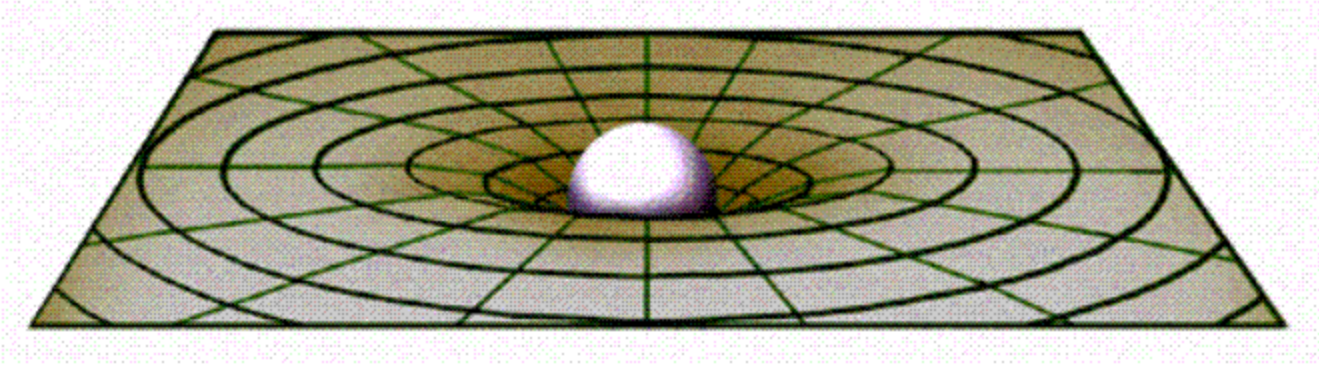
light moves on a geodesic

↑

Shortest dist. between two points

So, Einstein interprets gravitation as a curvature of spacetime





Imagine that mass causes curvature / depression in the fabric of spacetime ... is it true??

The fecund multiverse - cosmological natural selection

Fruitful in offspring

Lee Smolin
"The Life of the Cosmos"
Oxford Univ. Press 1997

What happens inside a Black hole?

Beasts Dwell here
→ Singularity

Classical general relativity:
curvature of spacetime is ∞
Physics as we know it ends

Quantum gravity to the rescue?

Physical Parameters + laws of daughter universe similar to but NOT identical to parent universe?

Parent universe

Collapse inside Black Hole

Bounce due to quantum gravity effects

Time

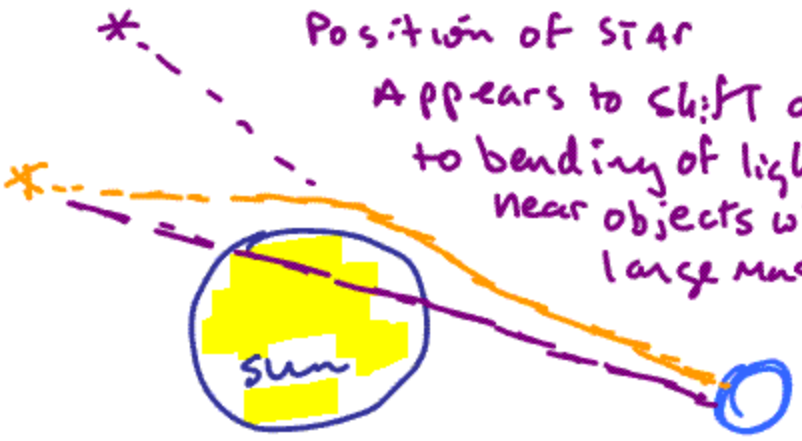
Event horizon of original Black Hole still Present

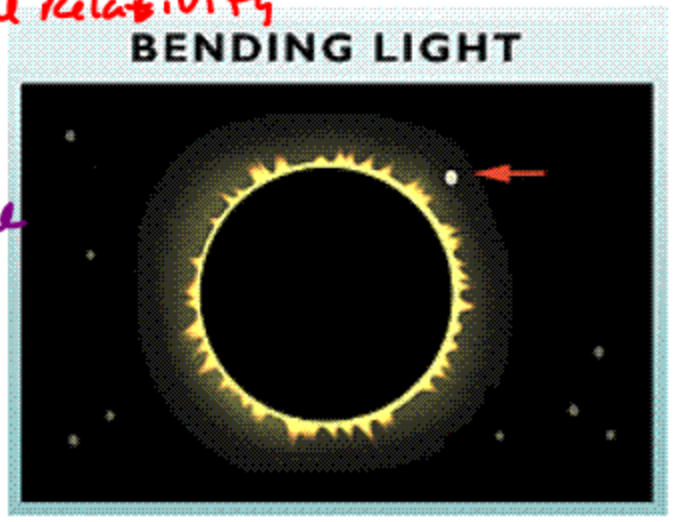
Big Bang Birth of a universe

Original universe and offspring disconnected

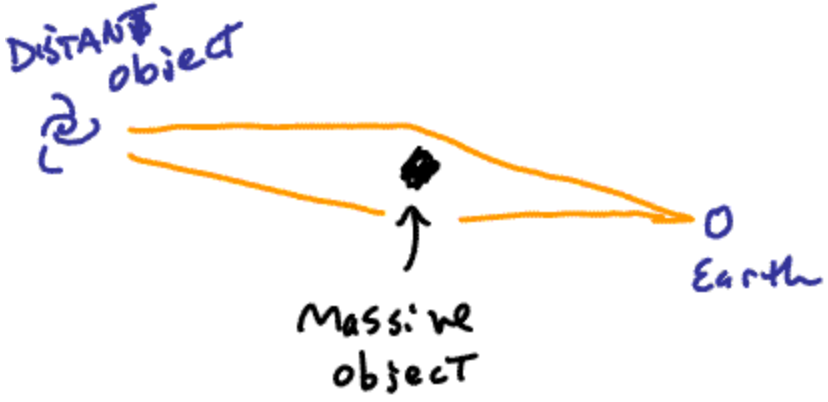
daughter universe

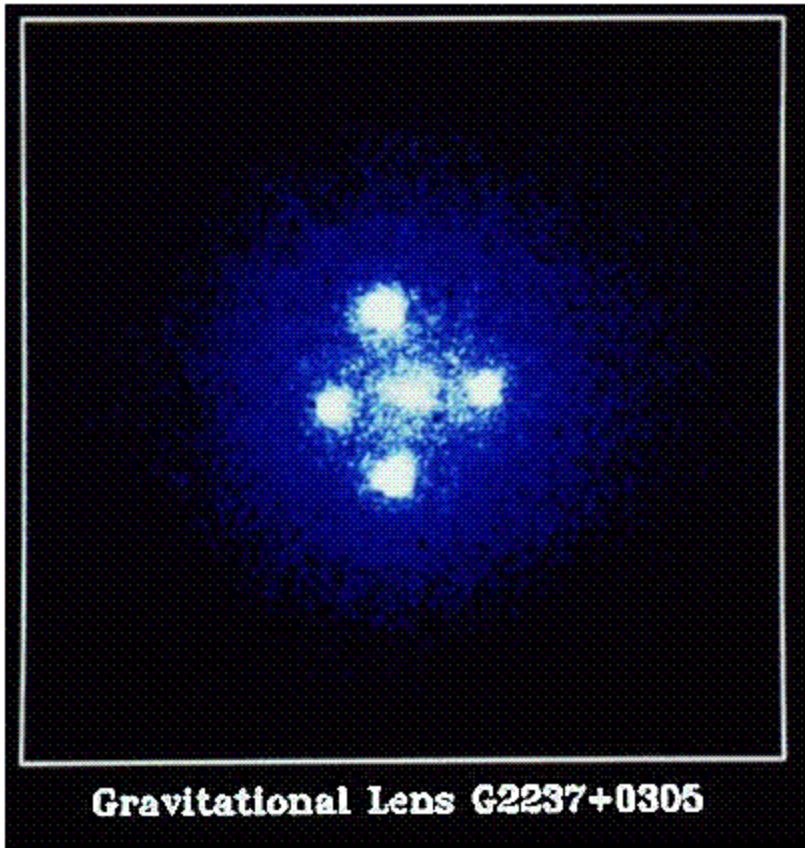
Experimental evidence supporting General Relativity

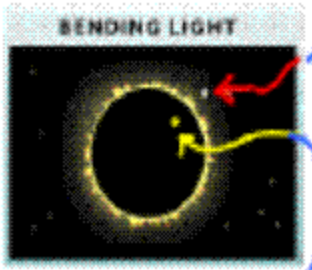




Gravitational Lensing





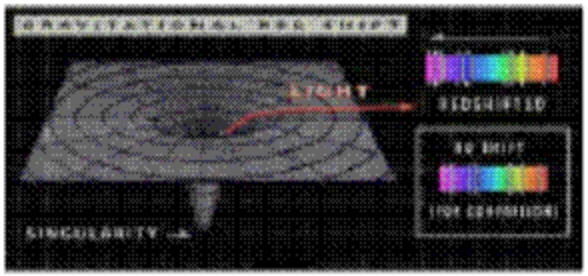


Apparent position

Actual Position

- Bending of light by gravitational field ✓

- Gravitational Redshift of light ✓



- Perihelion advance of Mercury ✓

- Gravitational Waves ?

Amplitude ~ 10^{-16} m

LIGO

Cosmology

Not quite the same thing

Scientific Study of the large scale structure of the universe — Attempt to understand to origin, evolution and fate of the universe

http://wmap.gsfc.nasa.gov/m_uni.html good online reference for this class

Cosmetology

The business of being a beautician — The treatment of skin, hair and nails

http://careerplanning.about.com/cs/occupations/p/cosmetology.htm

while weie at it ...

Astronomy

Astrology