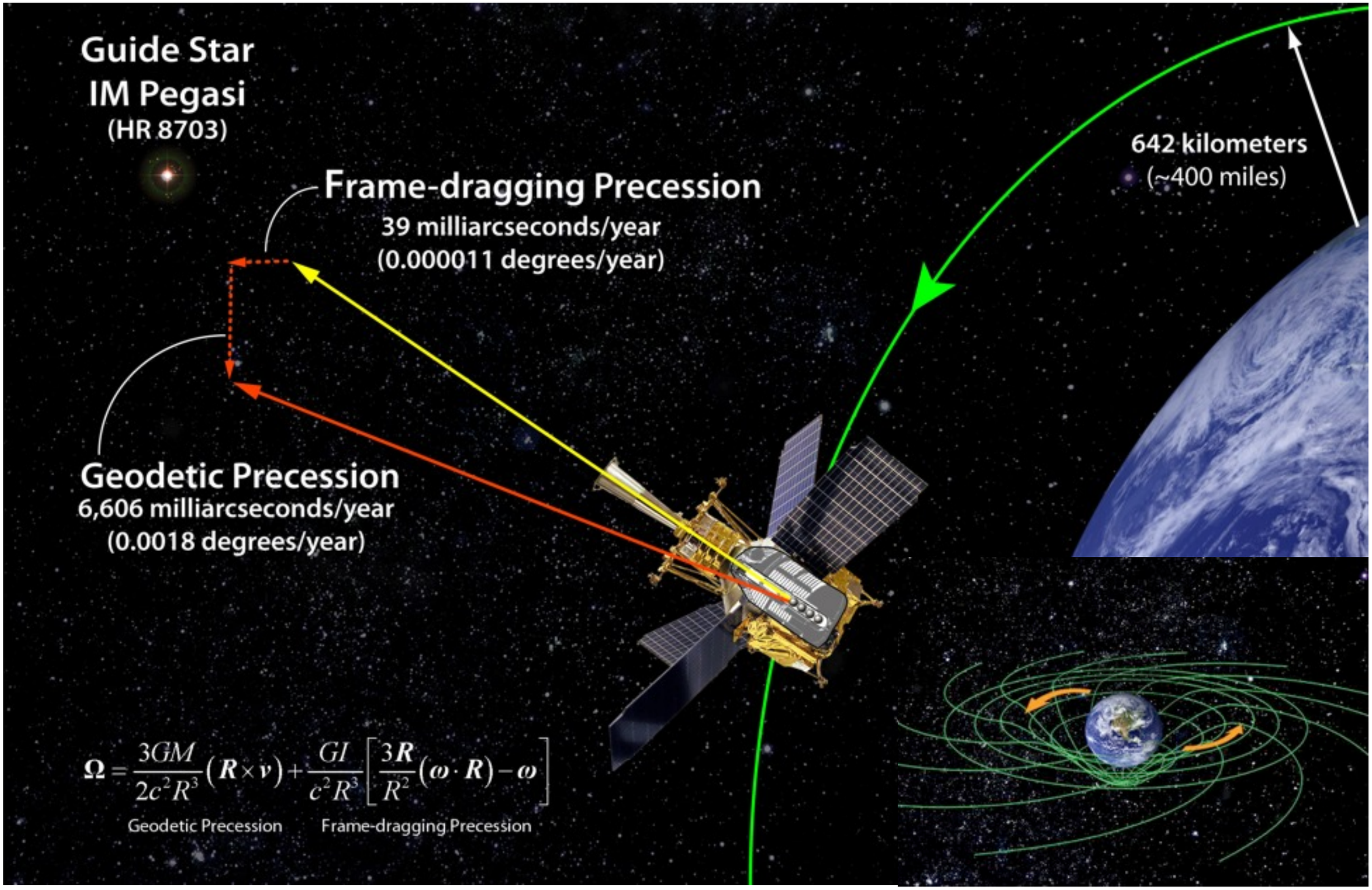
Not your Grandfather's Gravity!

John Ashmead



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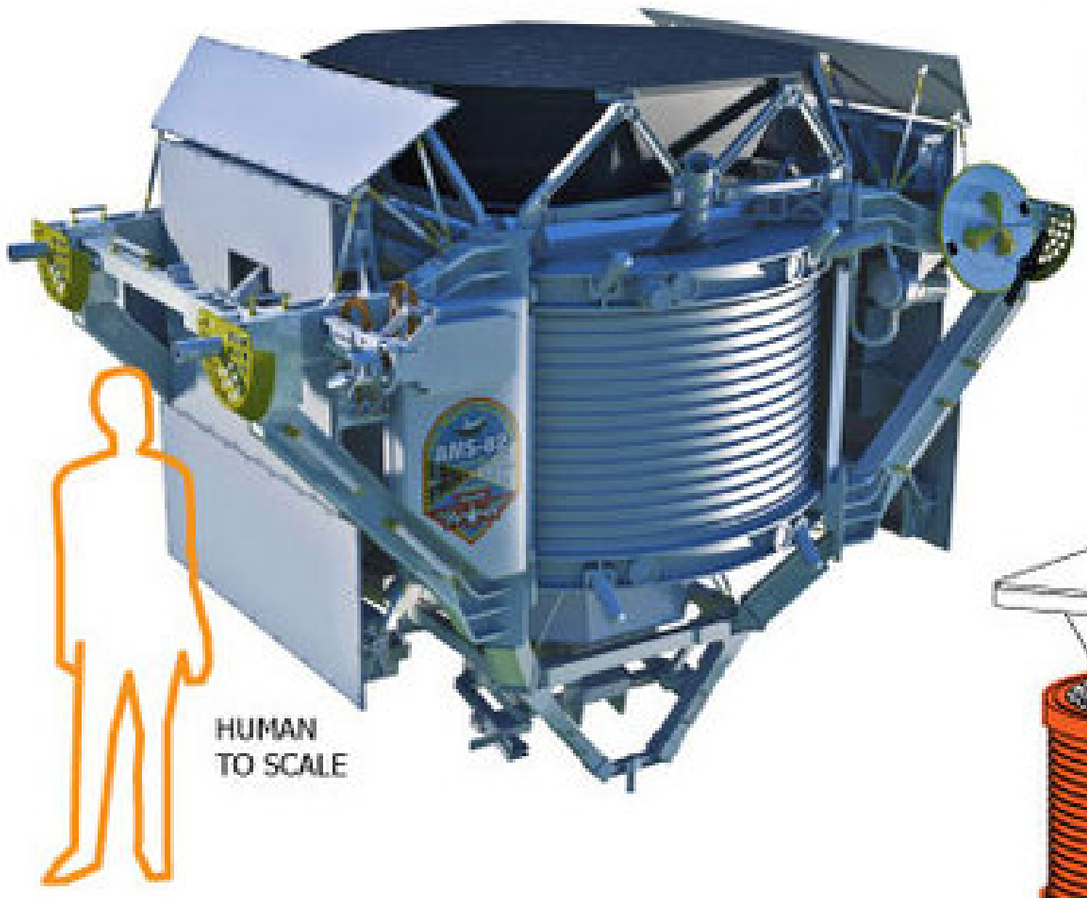
Endeavor blasts off

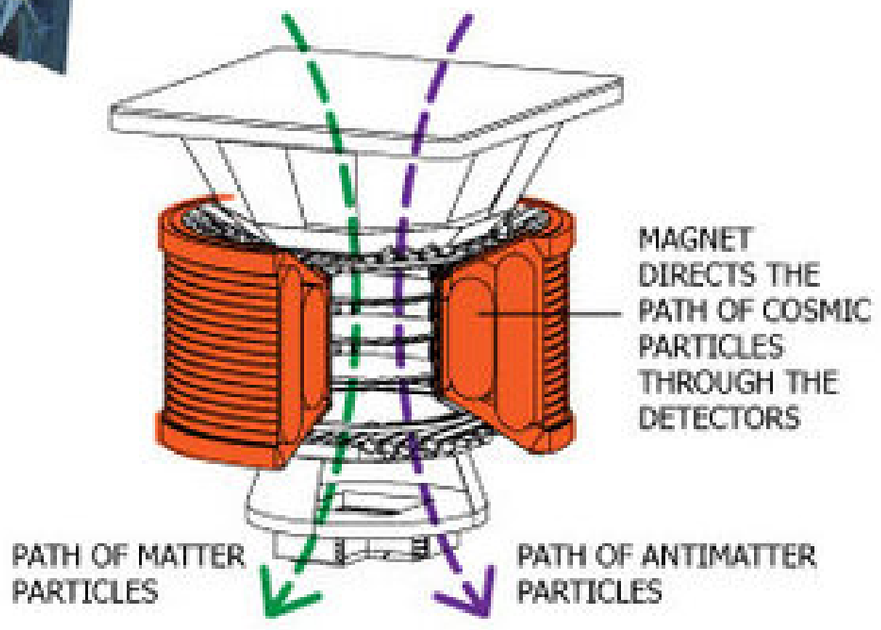
AMS-02 ALPHA MAGNETIC SPECTROMETER



Dimensions: 9.8 x 9.8 x 9.8 ft (3 x 3 x 3 m)
Weight: 7 tons

AMS-02 uses a large magnet to create a magnetic field that will bend the path of cosmic particles.

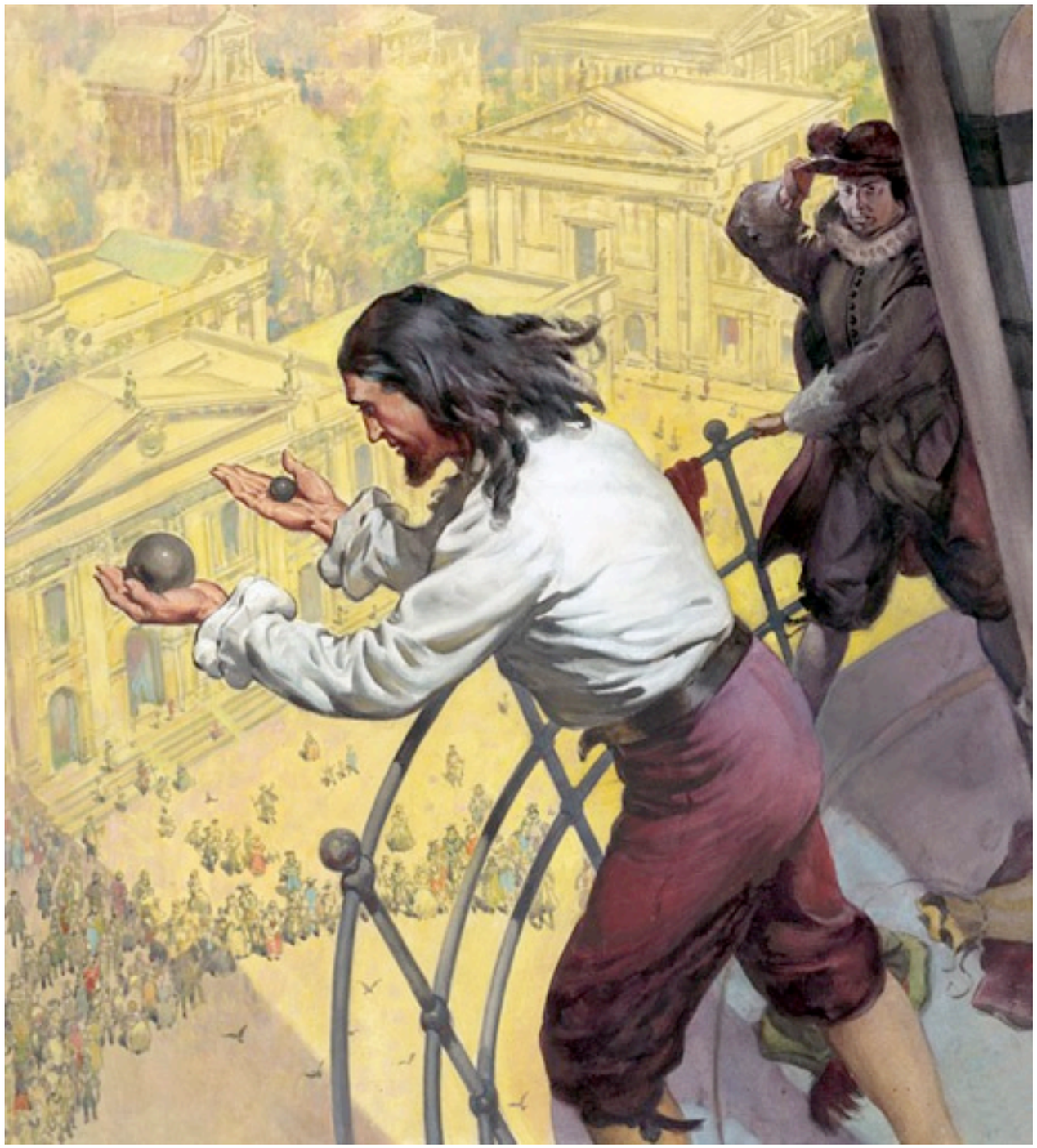
Eight detector instruments provide information on the particles as they pass through, potentially detecting antimatter or dark matter in the mix.



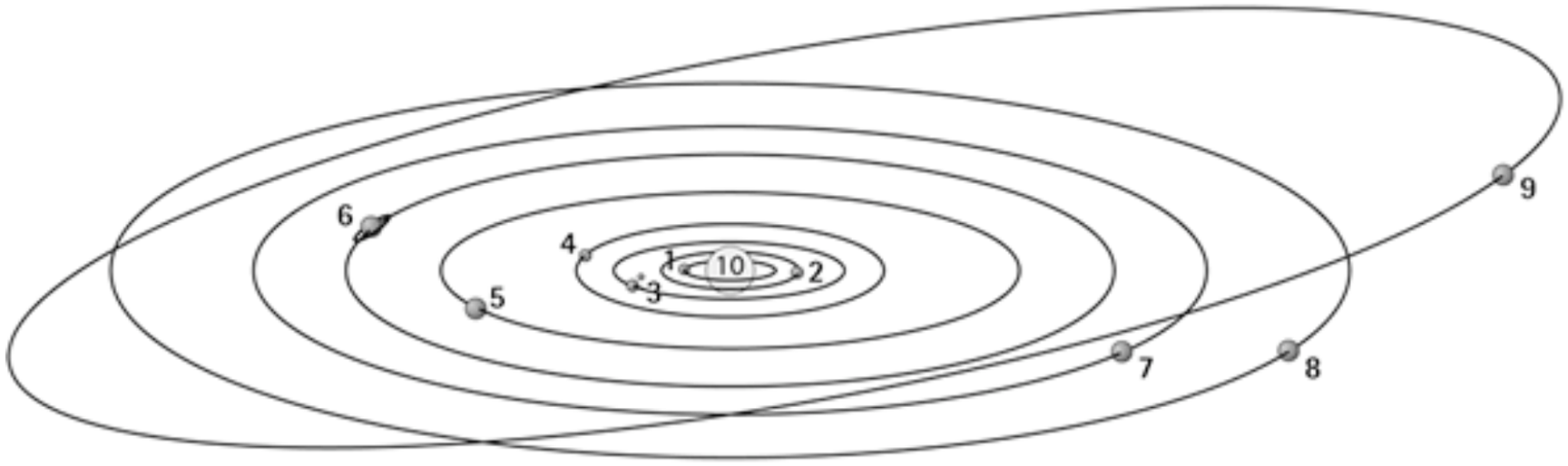
Outline

- A brief history of gravity
- The Runaway universe
- At the edge of the known

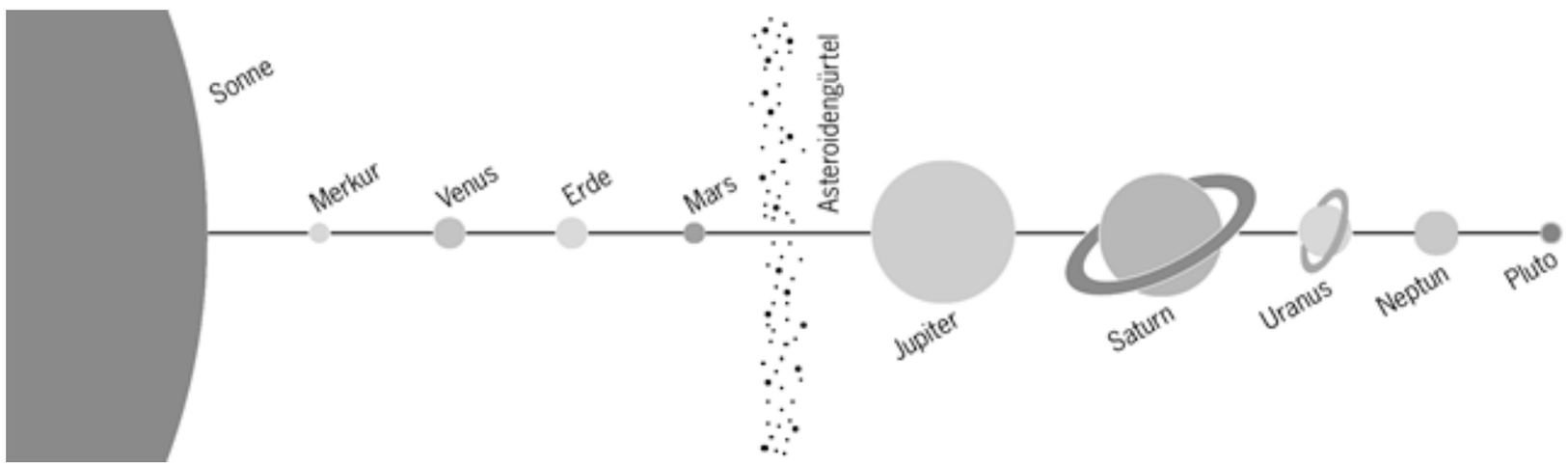
Galileo



Orbits of the planets



1 Merkur
2 Venus
3 Erde
4 Mars
5 Jupiter
6 Saturn
7 Uranus
8 Neptun
9 Pluto
10 Sonne



Mysterium Cosmographicum

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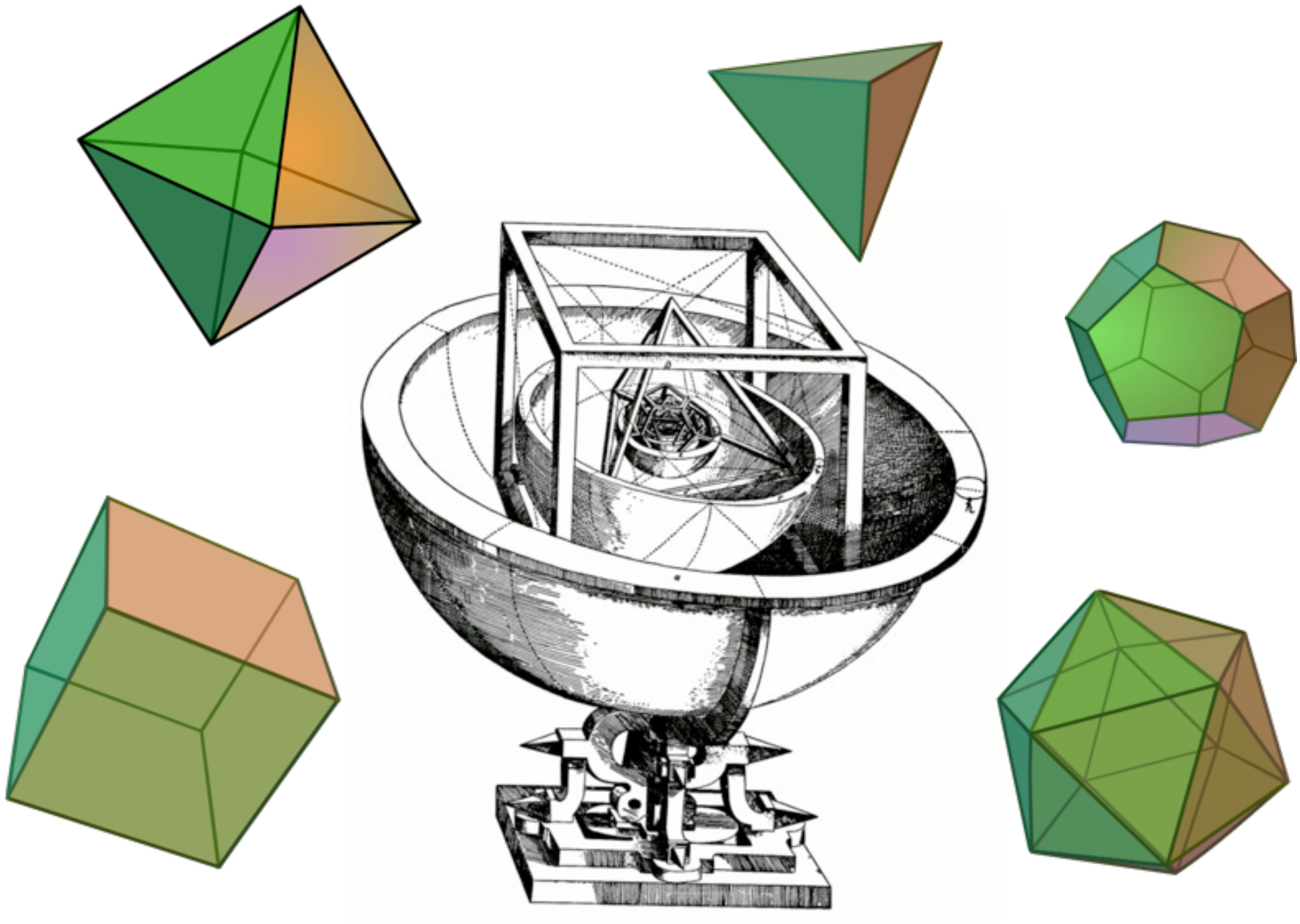
Mysterium Cosmographicum



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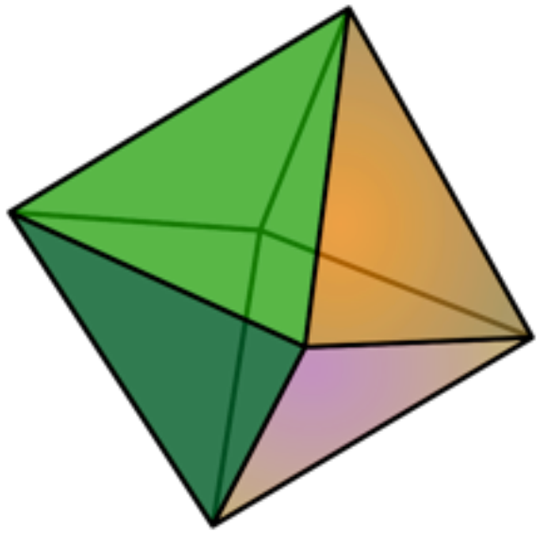
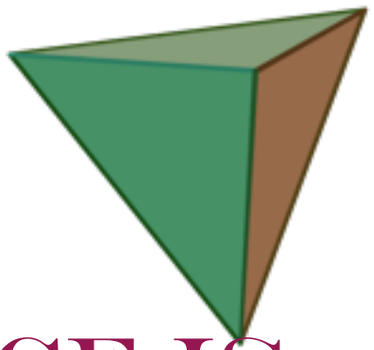
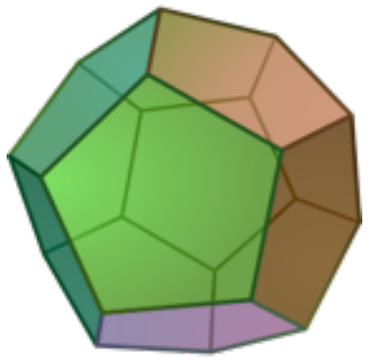
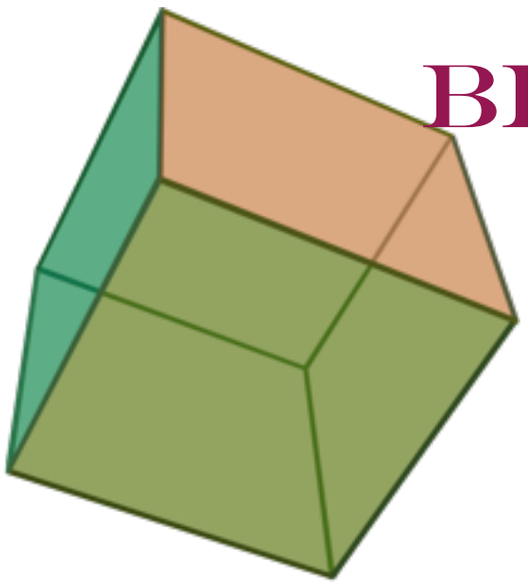
Mysterium Cosmographicum

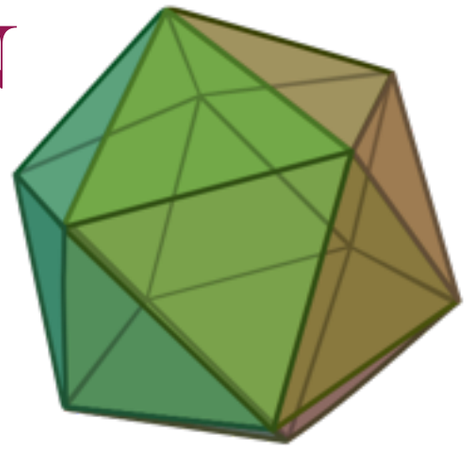




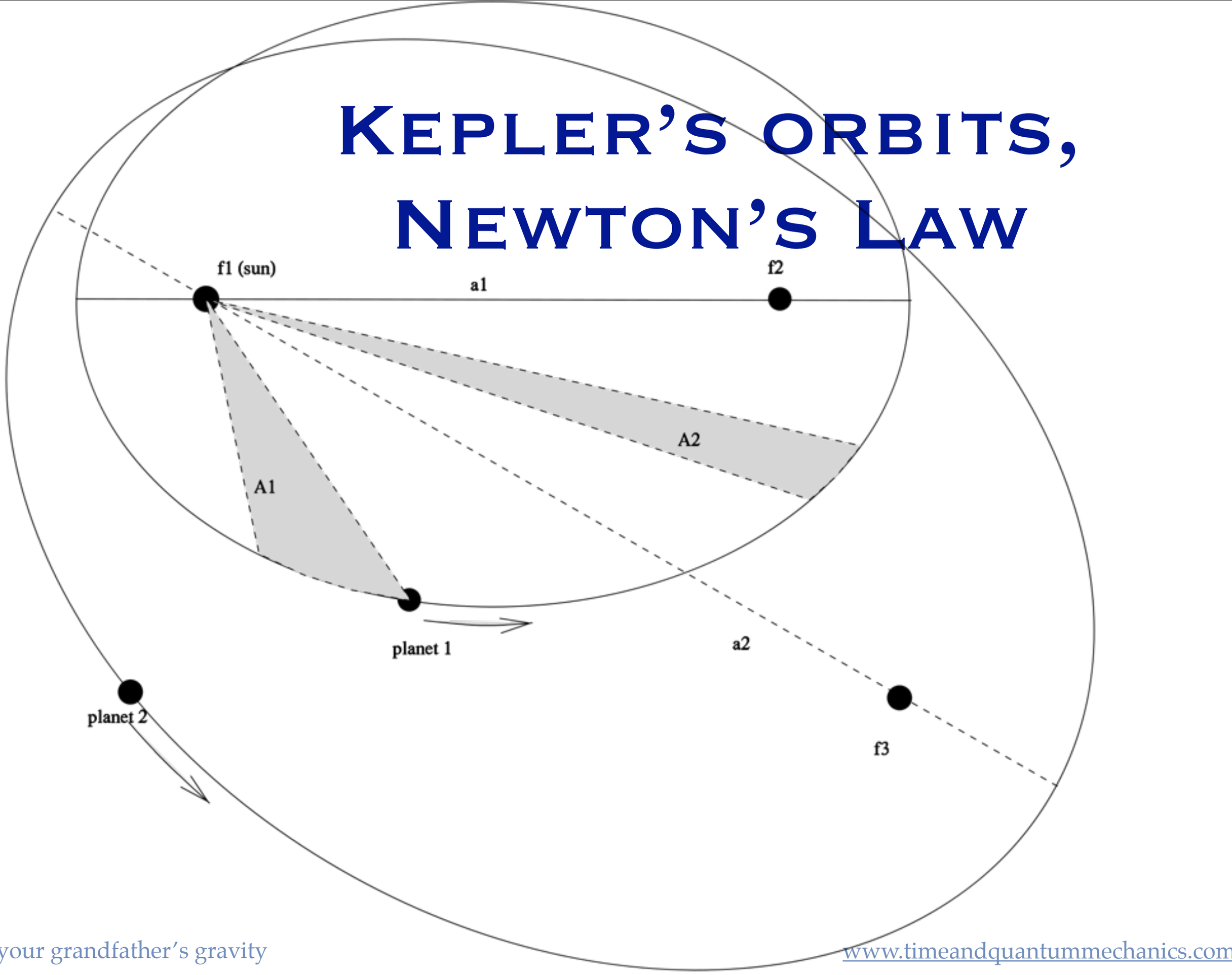


Science is organized common sense where many a beautiful theory is killed by an ugly fact. - Huxley





Kepler's orbits, Newton's Law



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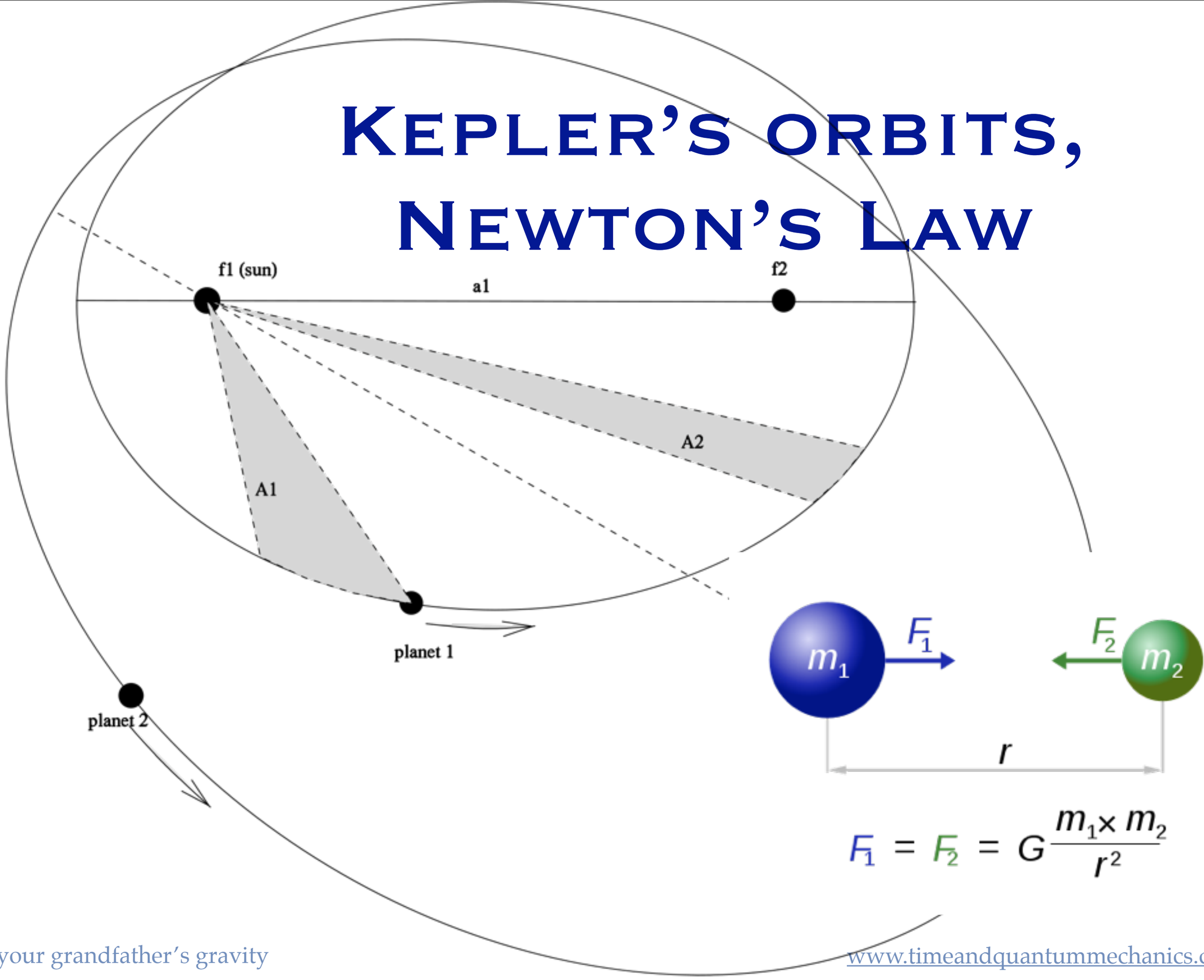
Kepler's orbits, Newton's Law



$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

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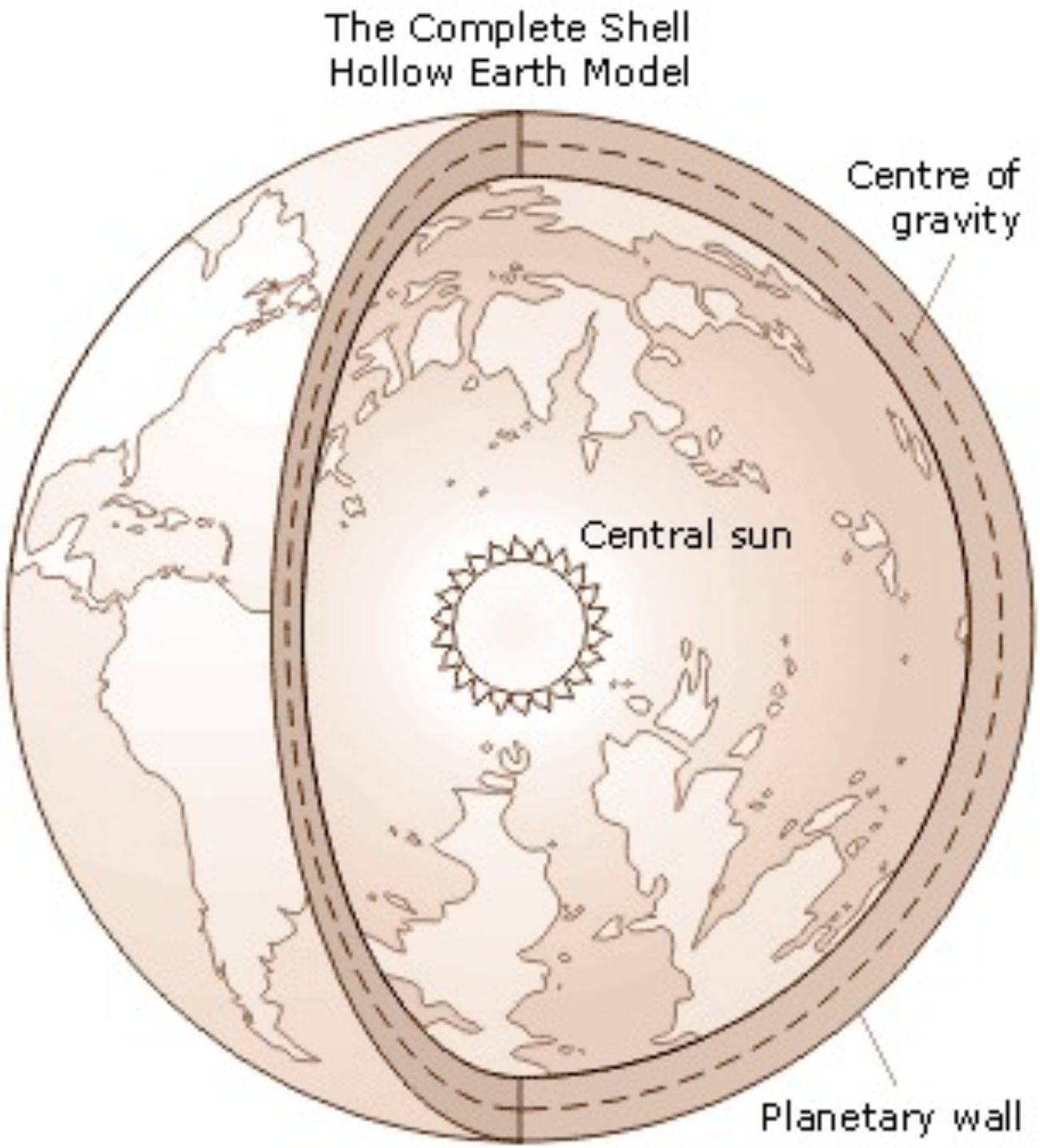
Hollow Earth



Cavendish

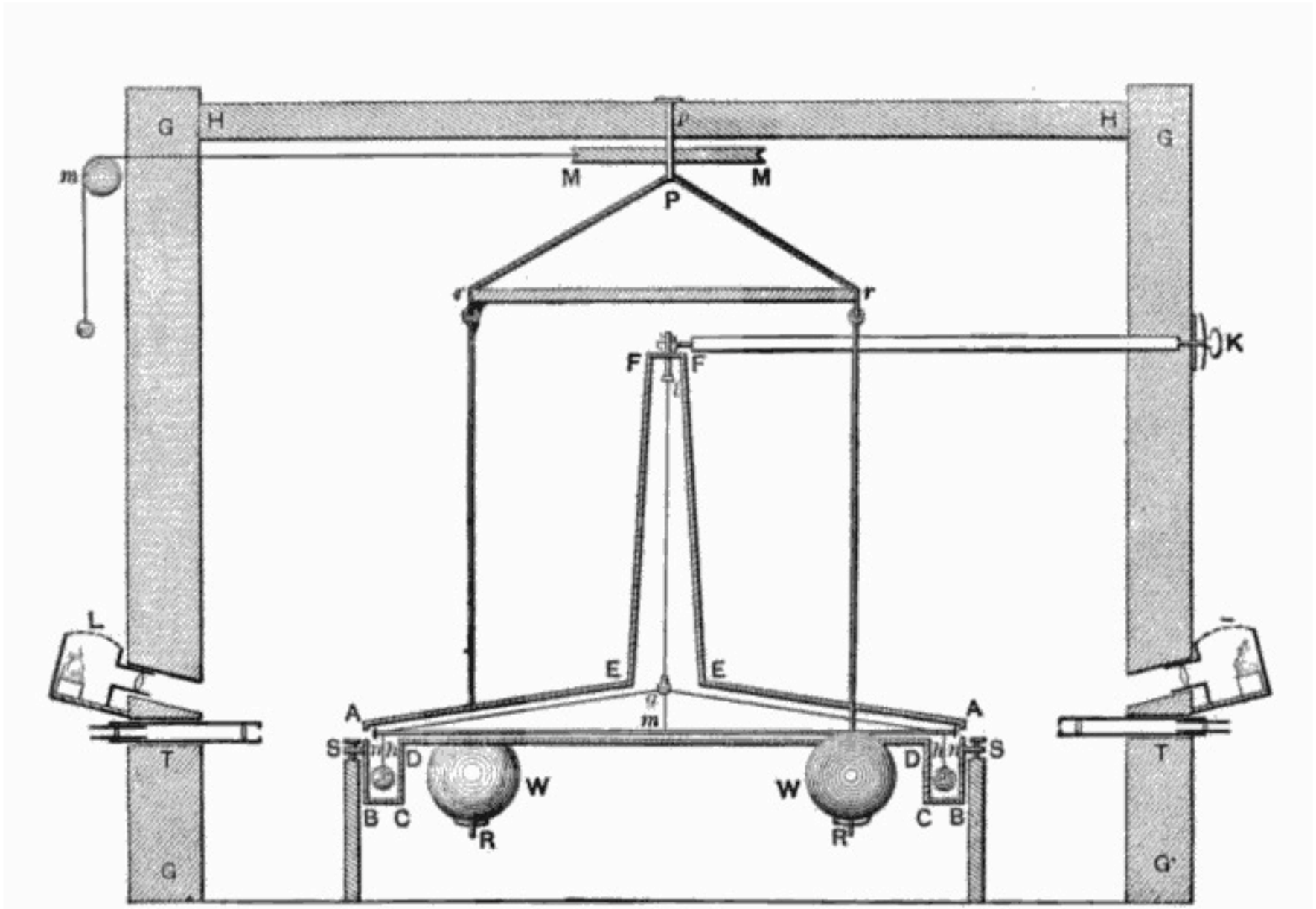
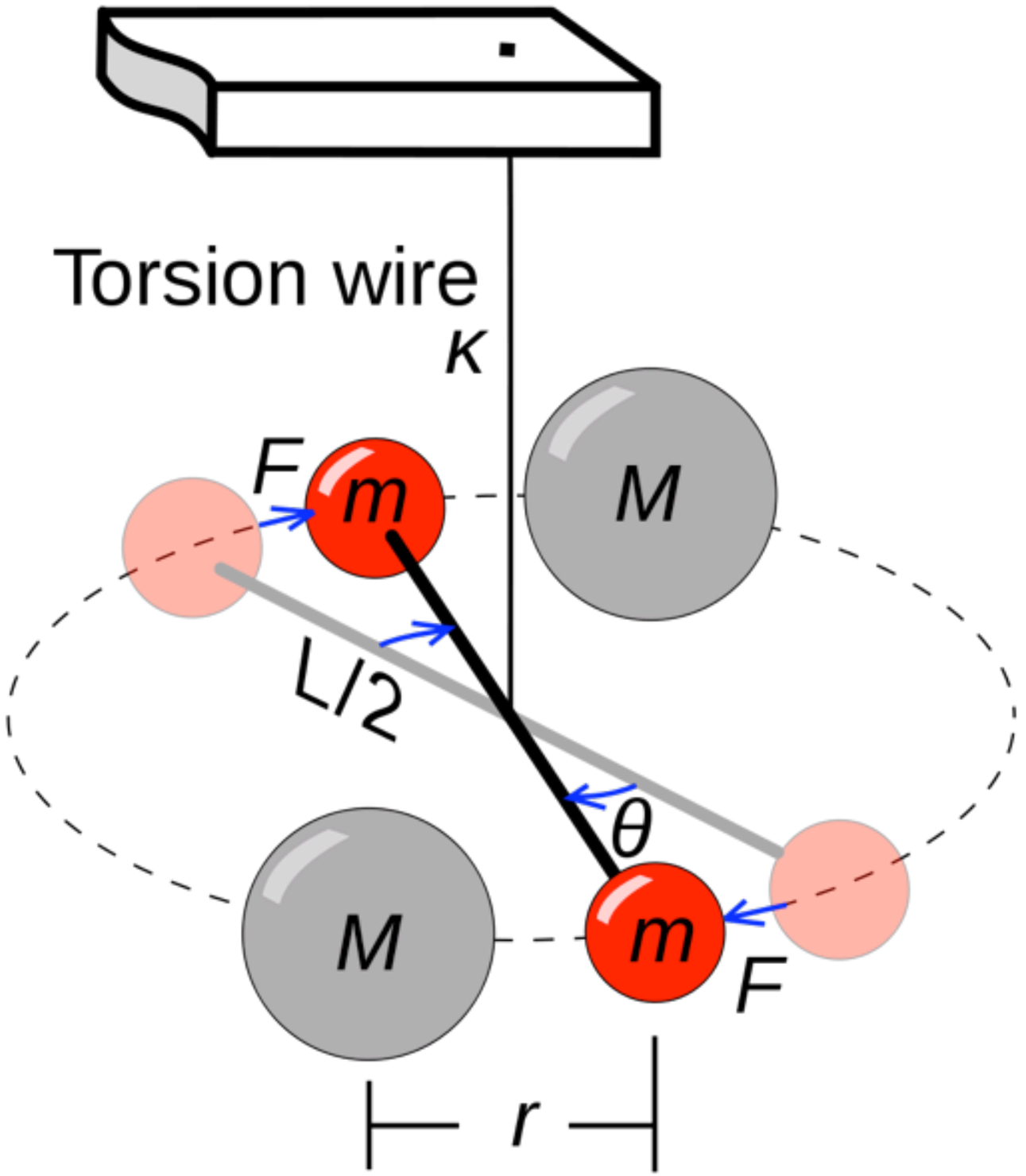


Fig. 1

Cavendish



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Equivalence principle

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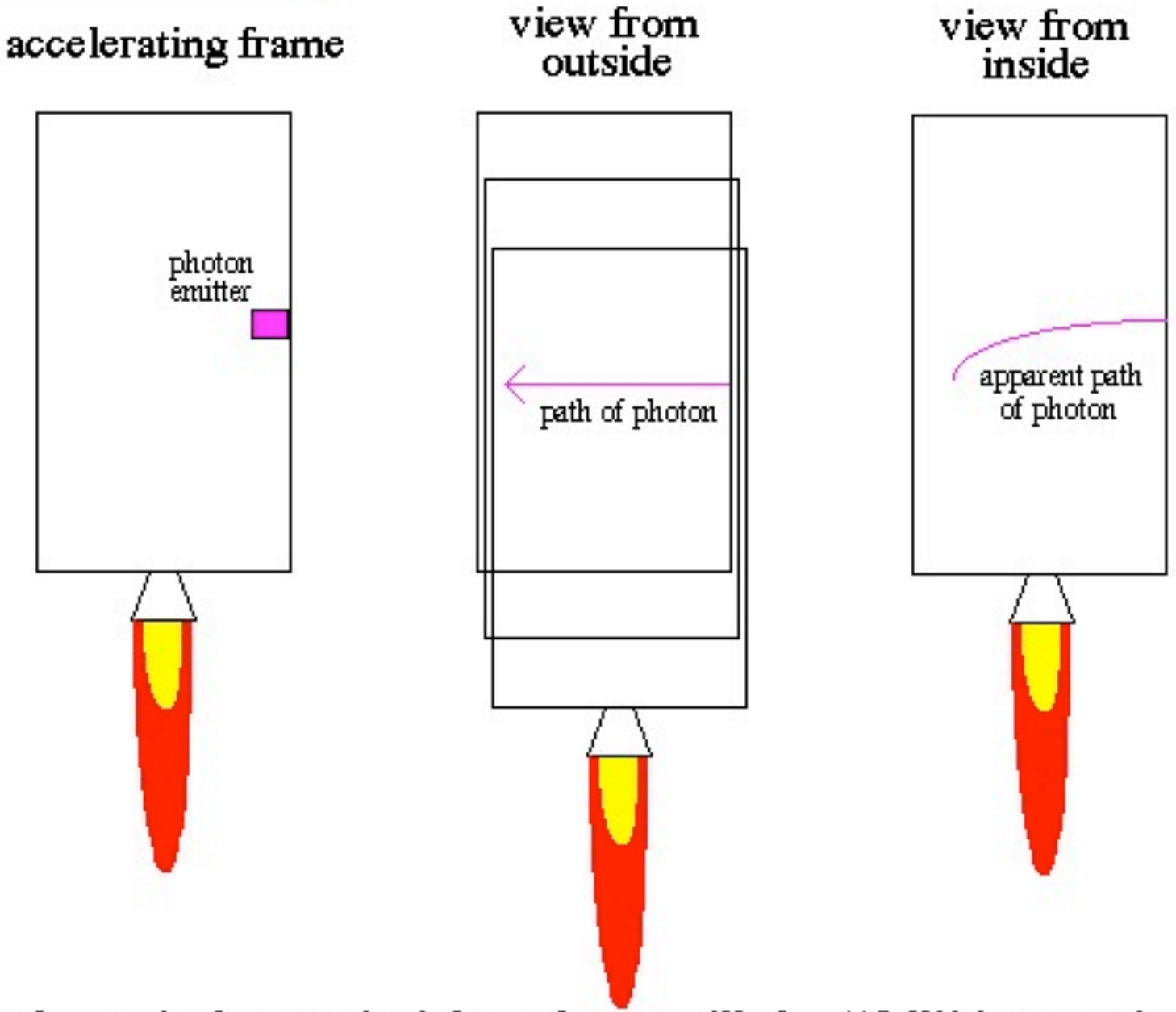
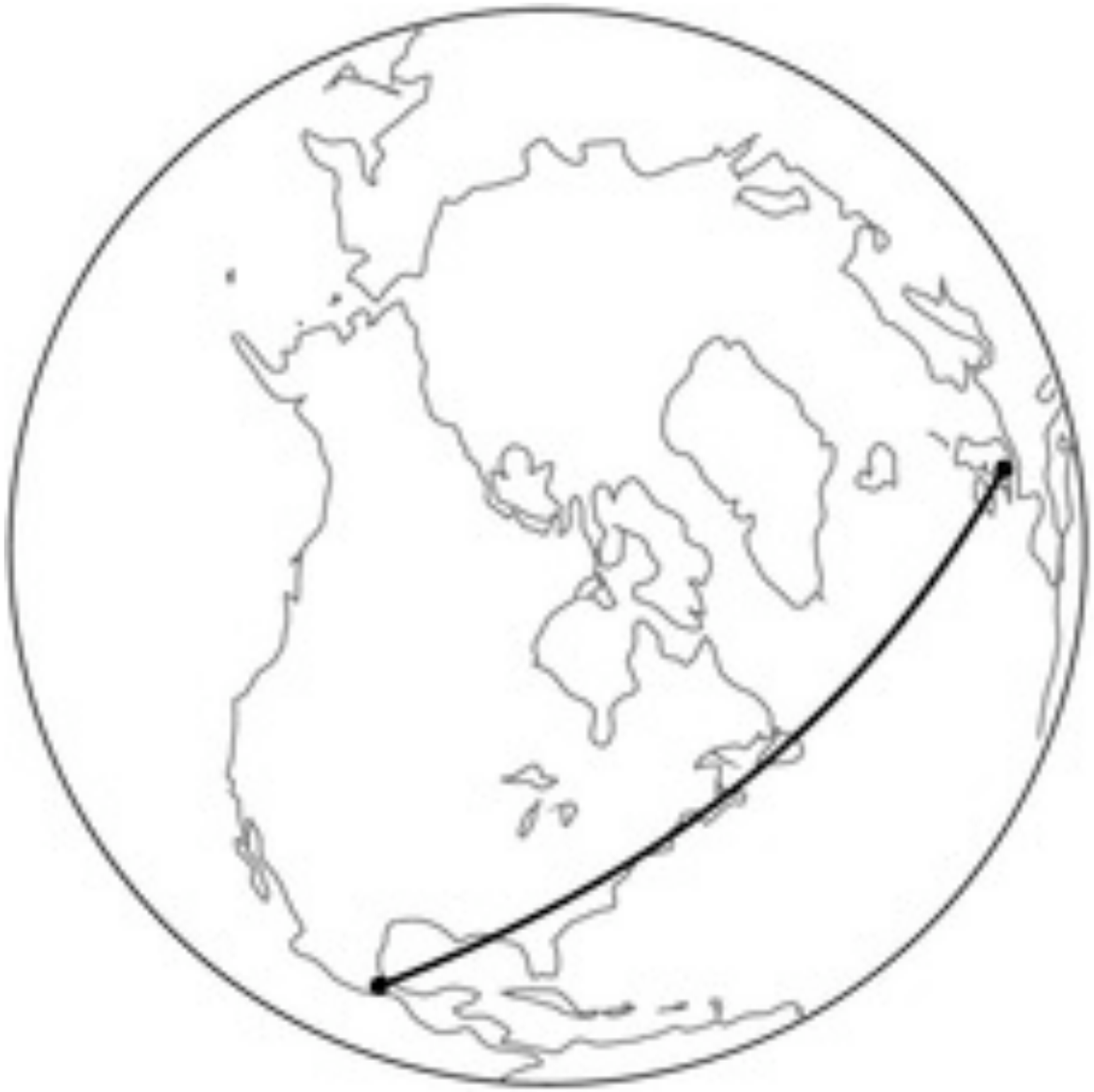
Gravity Bends Light

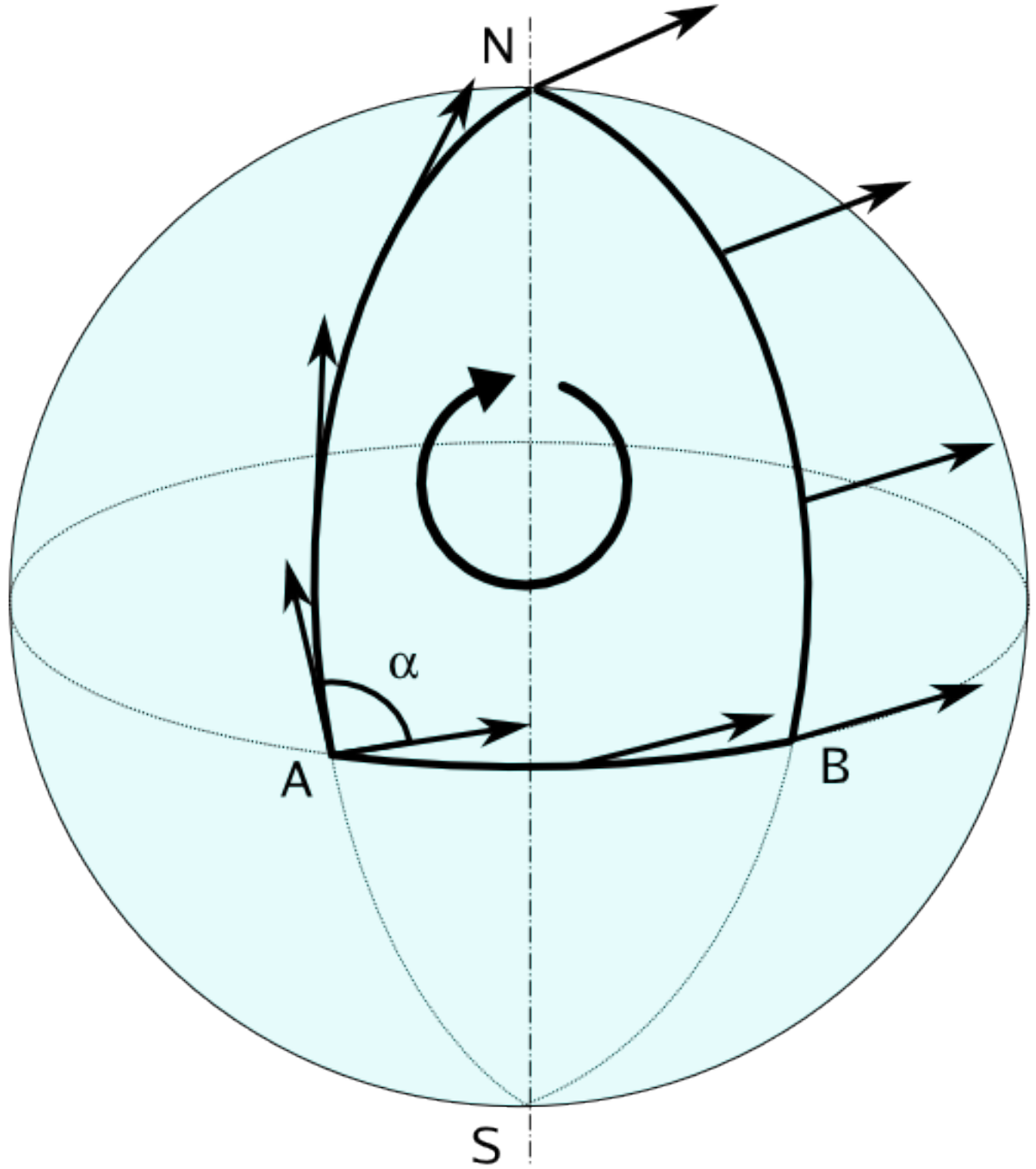


by the equivalence principle, a photon will also ‘‘fall’’ in a gravitational field

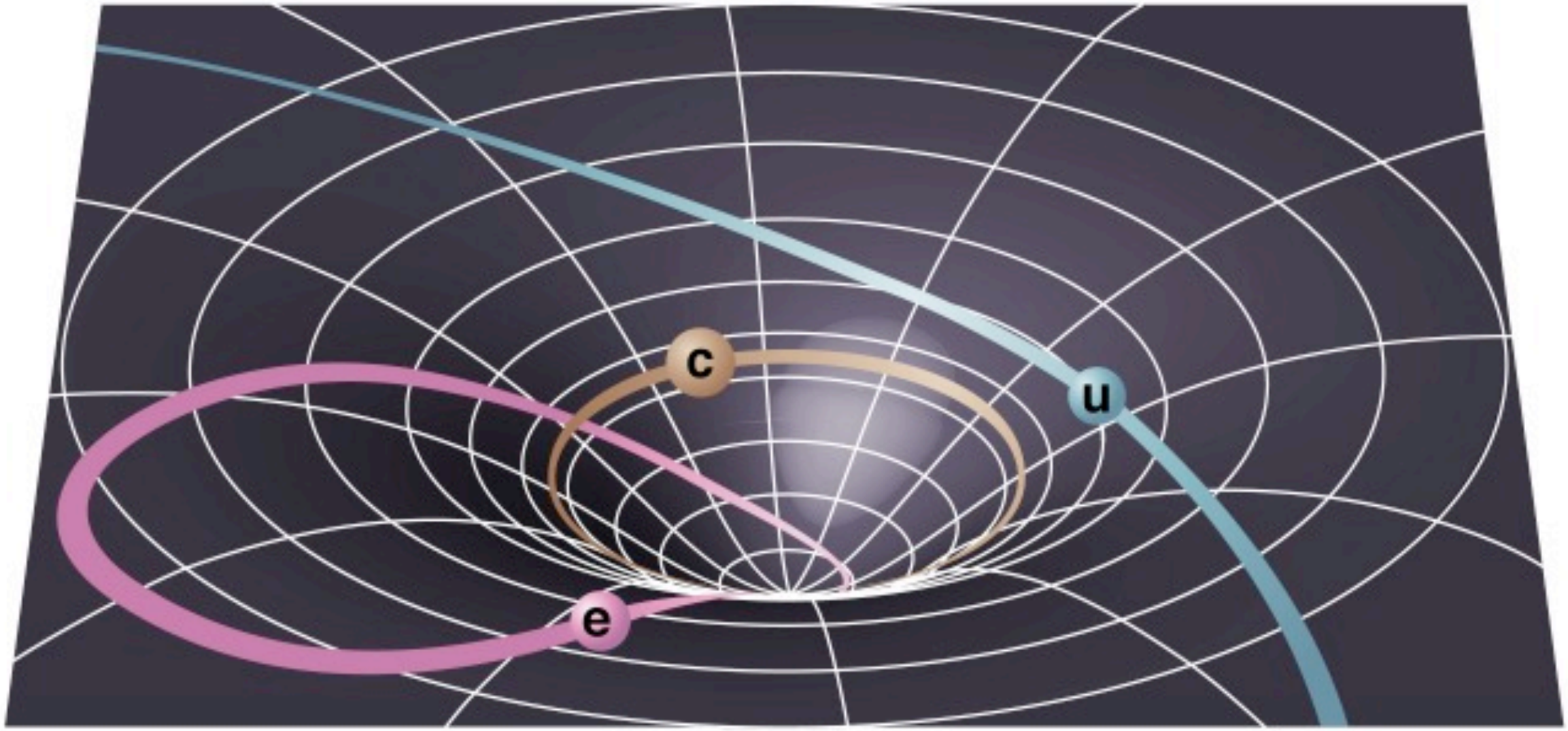
Of ants & apples



Parallel transport

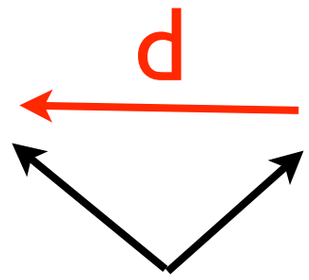


c circular orbit
e elliptical orbit
u unbound orbit

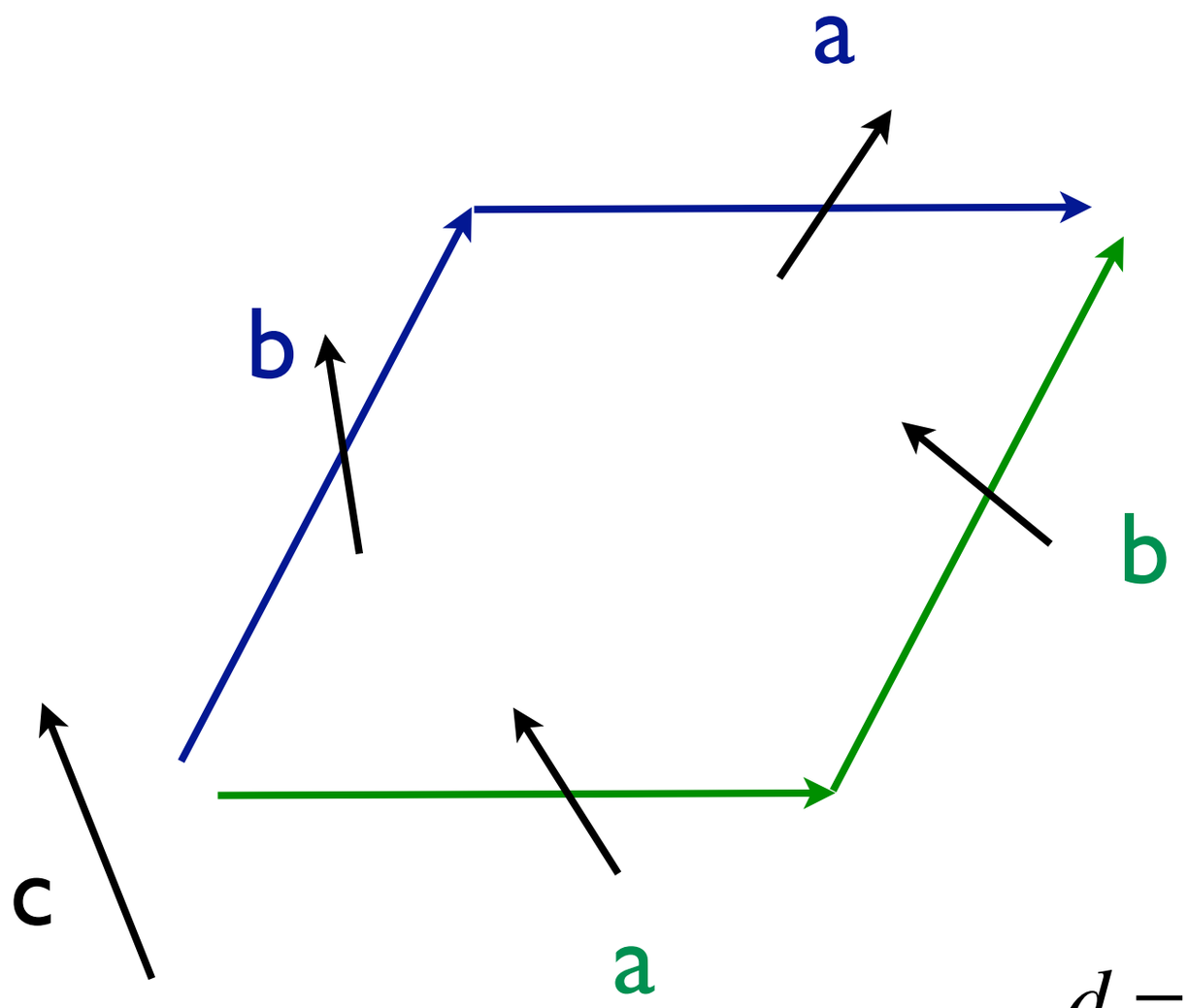


Copyright © Addison Wesley

Riemann Curvature Tensor



Effect of curvature



$$d = \left(\nabla(b)\nabla(a) - \nabla(a)\nabla(b)\right)c$$

Einstein's field equation

Einstein's field equation

$$x^d = R^d_{abc} x^c$$

Einstein's field equation

$$x^d = R^d_{abc} x^c$$

$$T^{(fluid)}_{\mu\nu} = \begin{pmatrix} \rho & 0 & 0 & 0 \\ 0 & p & 0 & 0 \\ 0 & 0 & p & 0 \\ 0 & 0 & 0 & p \end{pmatrix}$$

Einstein's field equation

$$x^d = R^d_{abc} x^c$$

$$T^{(fluid)}_{\mu\nu} = \begin{pmatrix} \rho & 0 & 0 & 0 \\ 0 & p & 0 & 0 \\ 0 & 0 & p & 0 \\ 0 & 0 & 0 & p \end{pmatrix}$$

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = \frac{8\pi G}{c^2} T_{\mu\nu}$$

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Einstein's field equation

$$x^d = R^d_{abc} x^c$$

$$T^{(fluid)}_{\mu\nu} = \begin{pmatrix} \rho & 0 & 0 & 0 \\ 0 & p & 0 & 0 \\ 0 & 0 & p & 0 \\ 0 & 0 & 0 & p \end{pmatrix}$$

$$R_{\mu\nu} - \frac{1}{2} g_{\mu\nu} R = \frac{8\pi G}{c^2} T_{\mu\nu} \qquad - g_{\mu\nu}\Lambda$$

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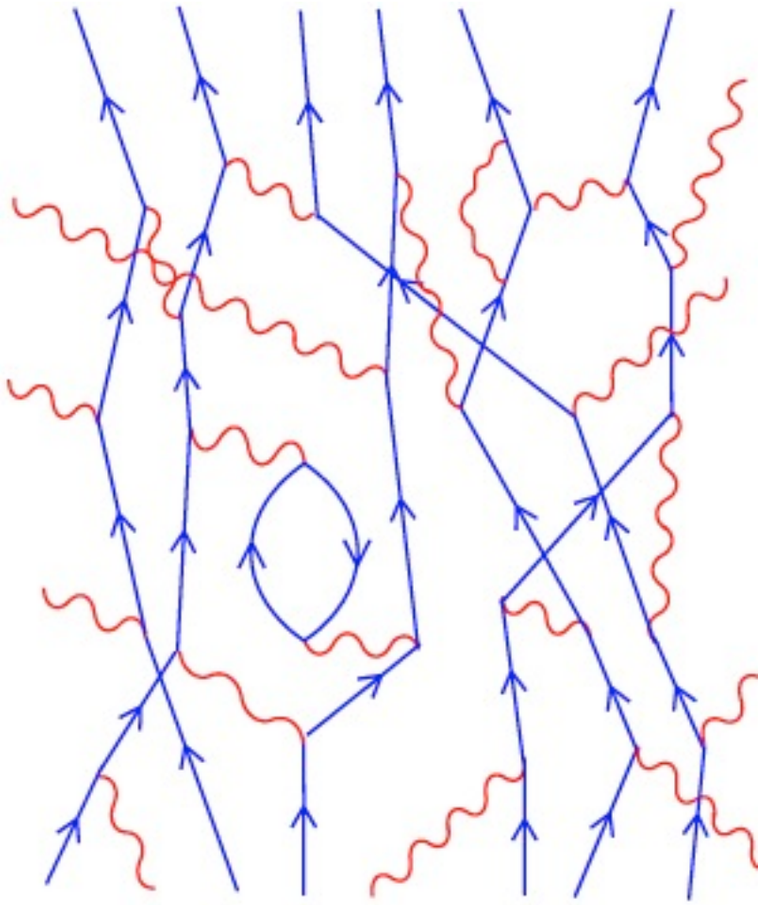
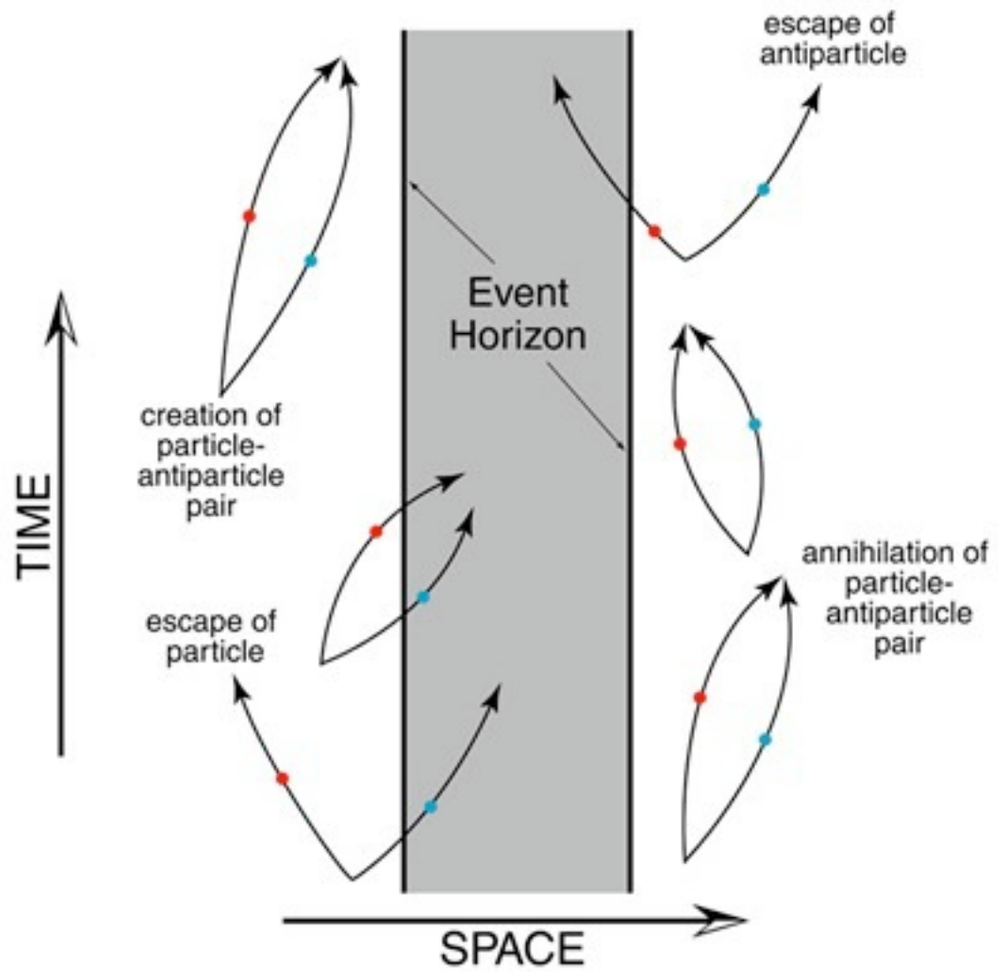
Quantum gravity



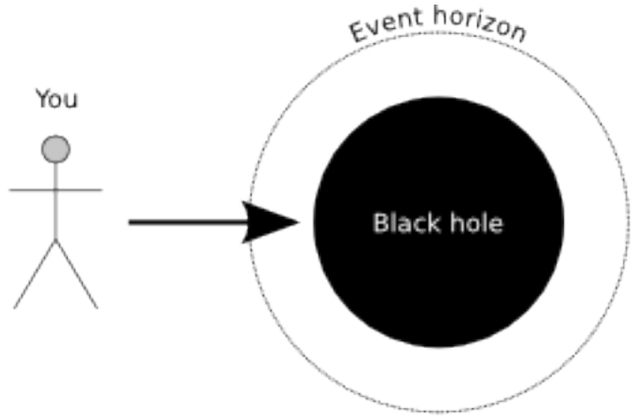
The Plenum in Particle QED

- Gravity is itself a source of gravity
- Quantum mechanics predicts almost infinite cosmological constant

Hawking Radiation



Black hole information paradox



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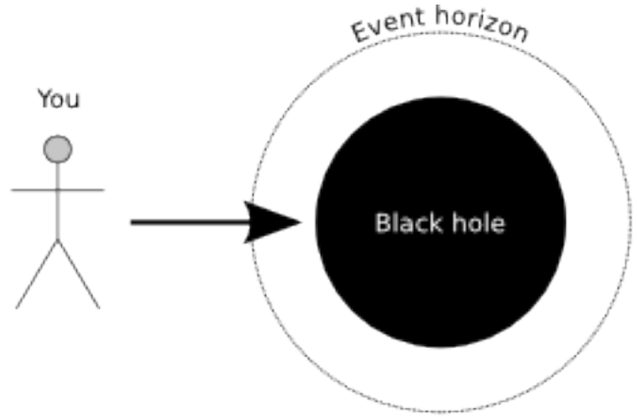
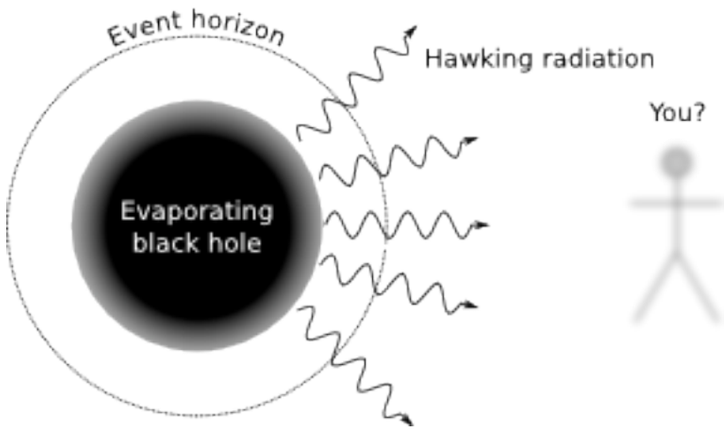
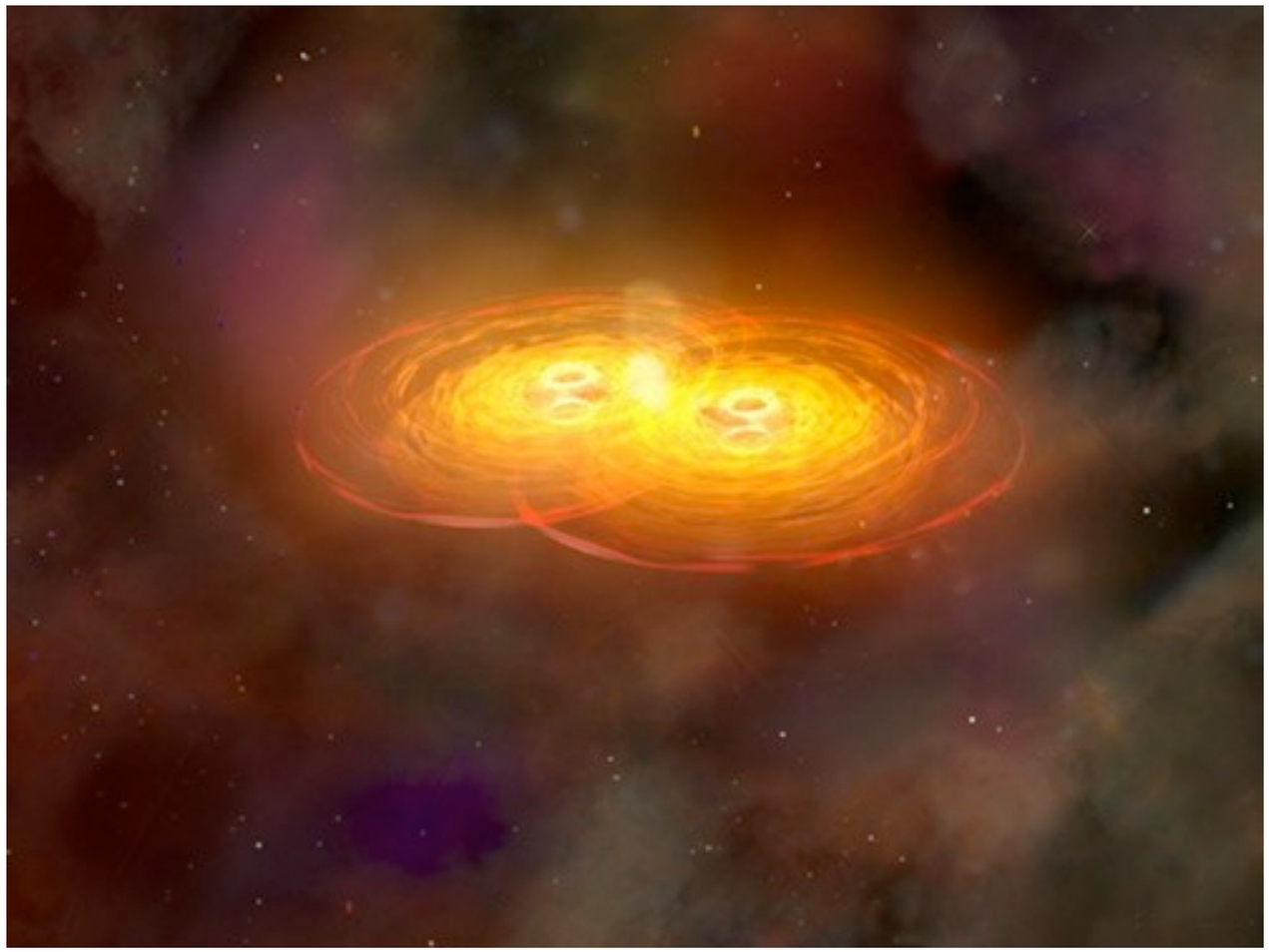


Much, much later...



Thermodynamics & gravity



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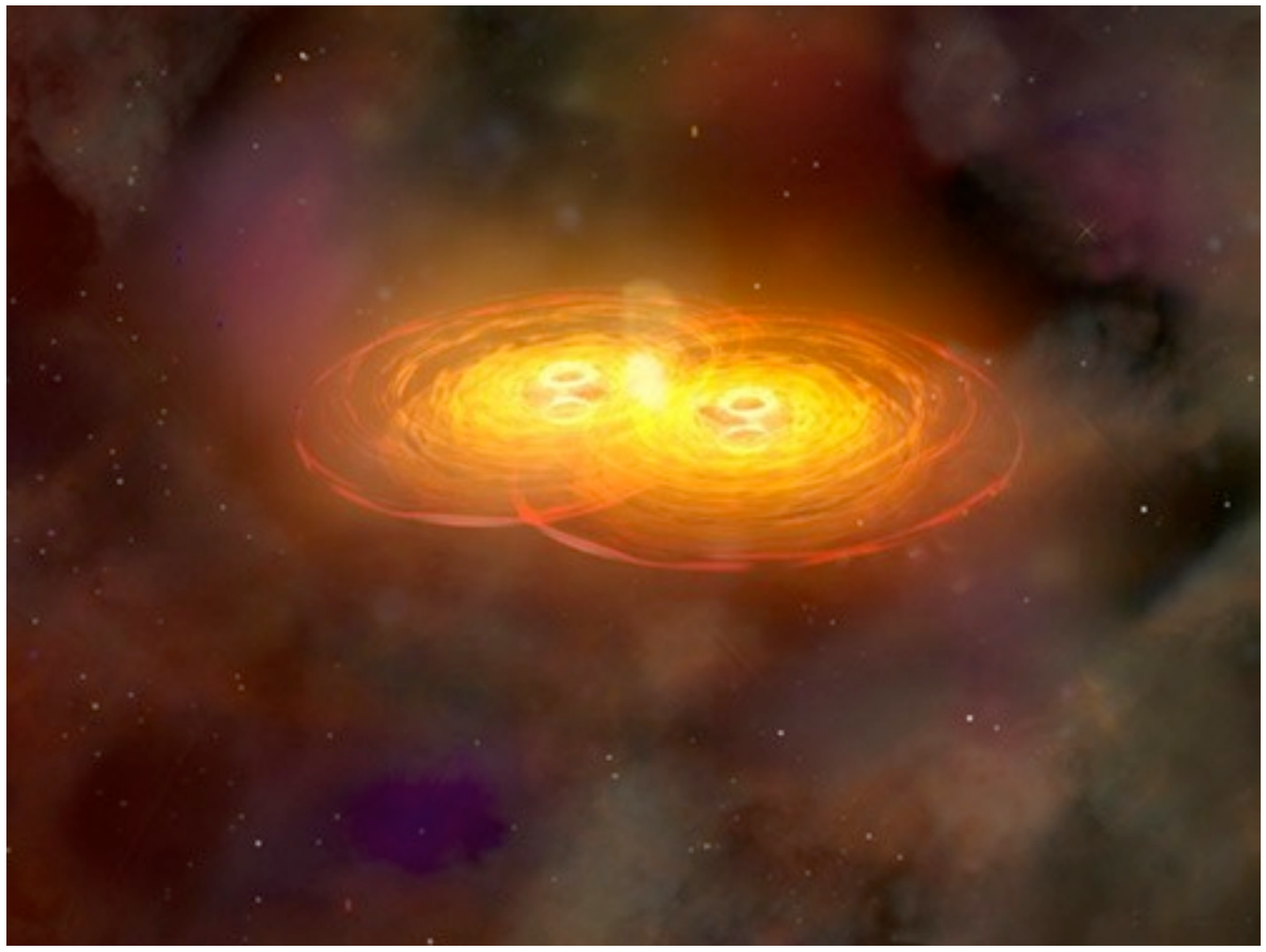
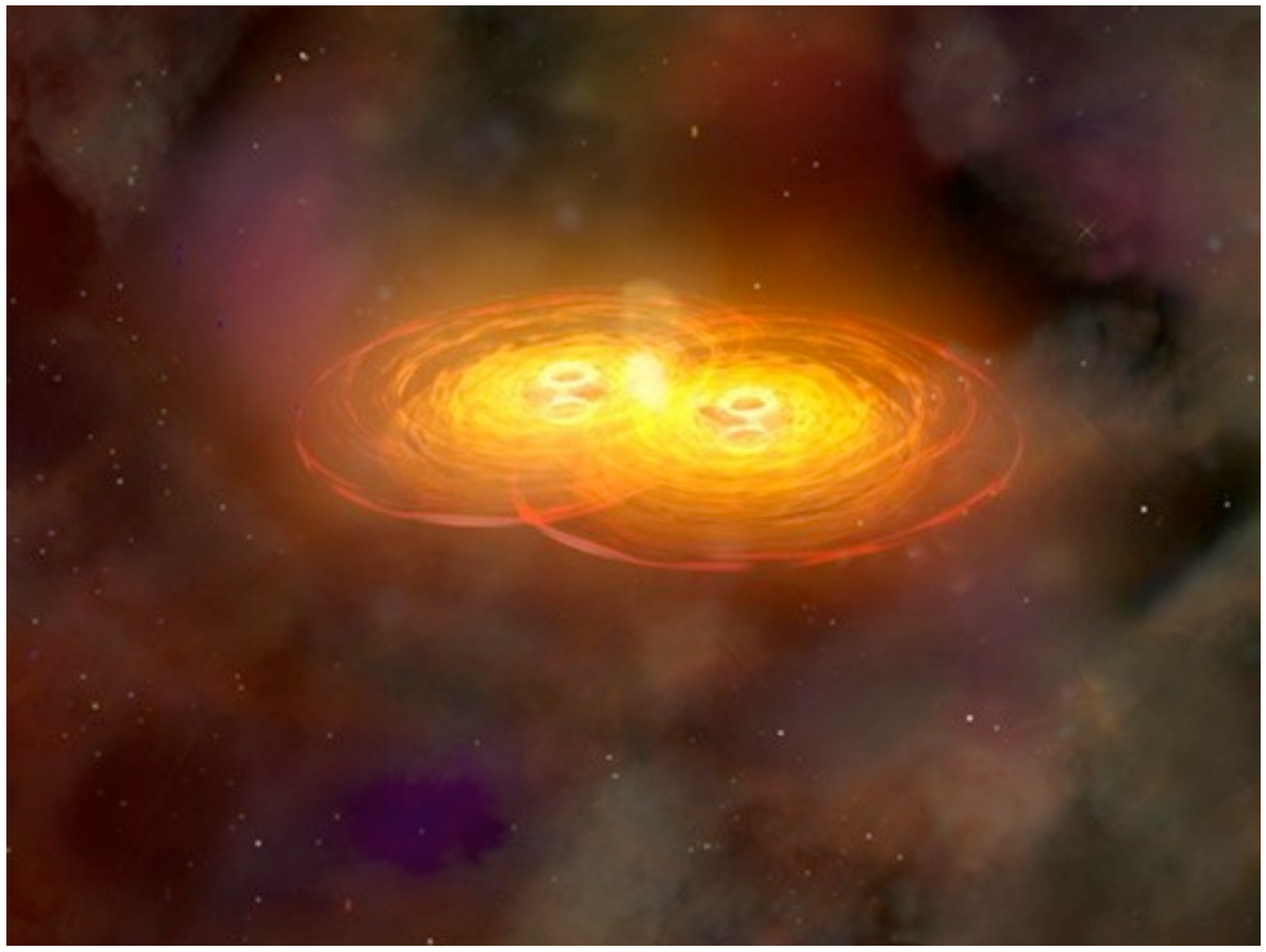
Thermodynamics & gravity

- Surface gravity ~ Temperature



Thermodynamics & gravity

- Surface gravity ~ Temperature
- Area ~ entropy



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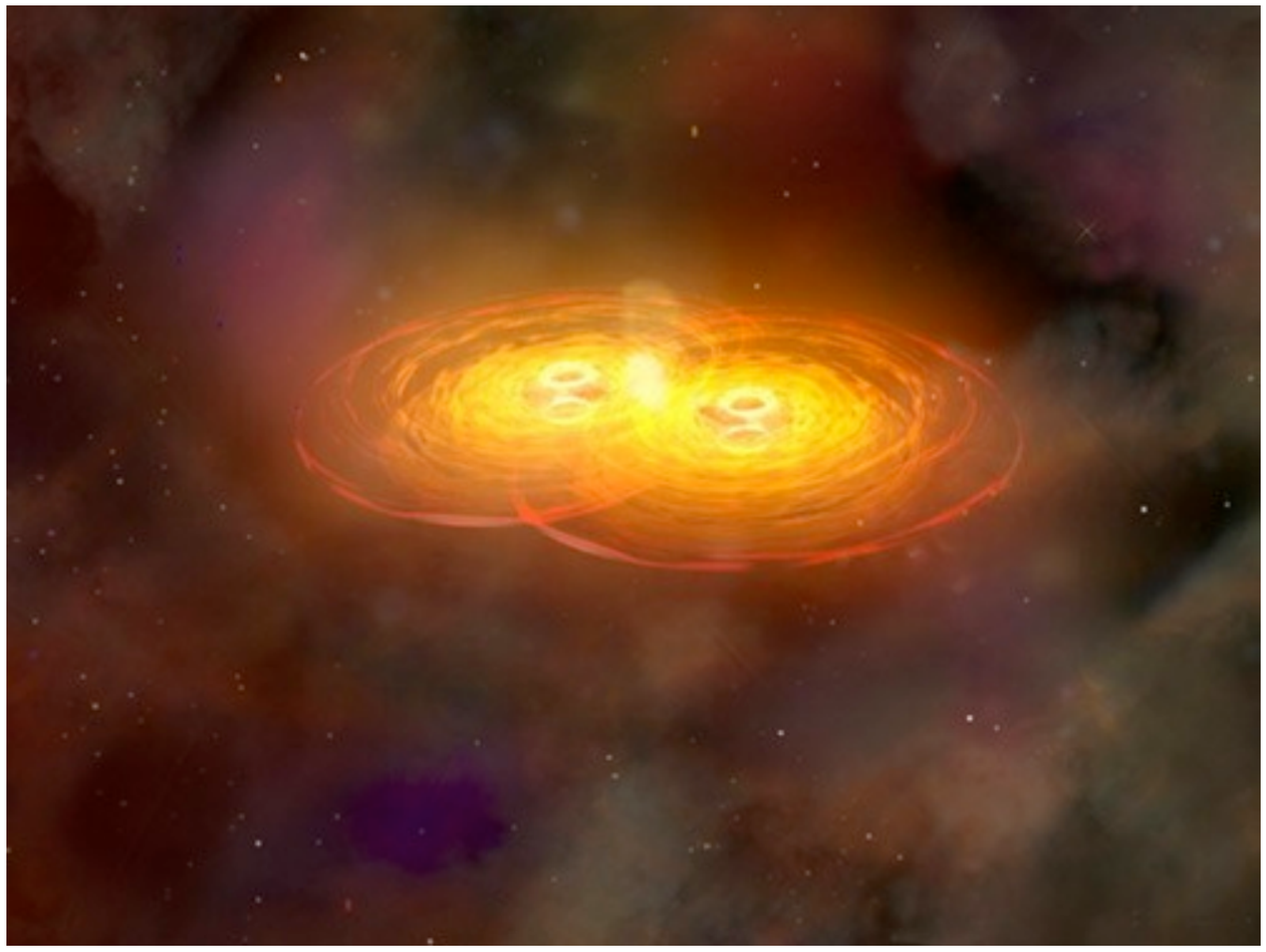
Thermodynamics & gravity

- Surface gravity ~ Temperature
- Area ~ entropy
- Mass ~ energy



Thermodynamics & gravity

- Surface gravity ~ Temperature
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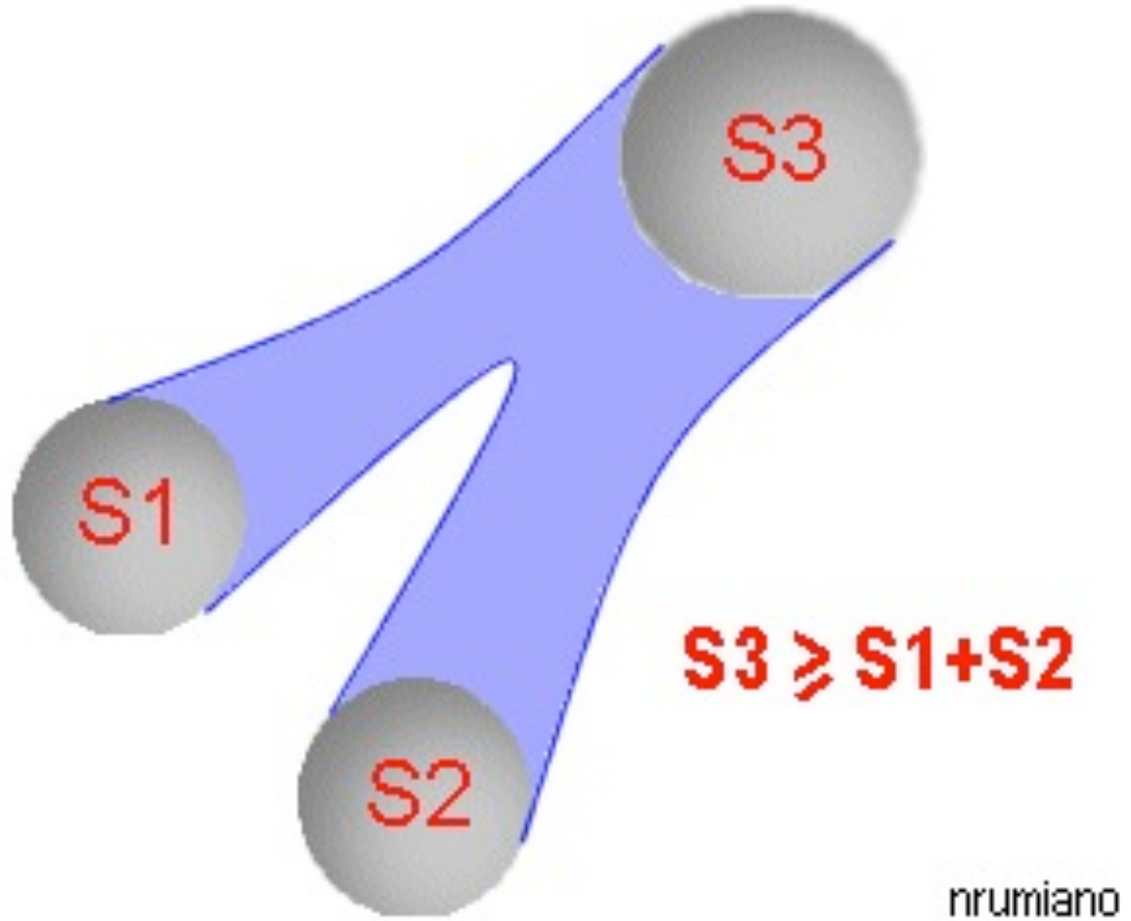
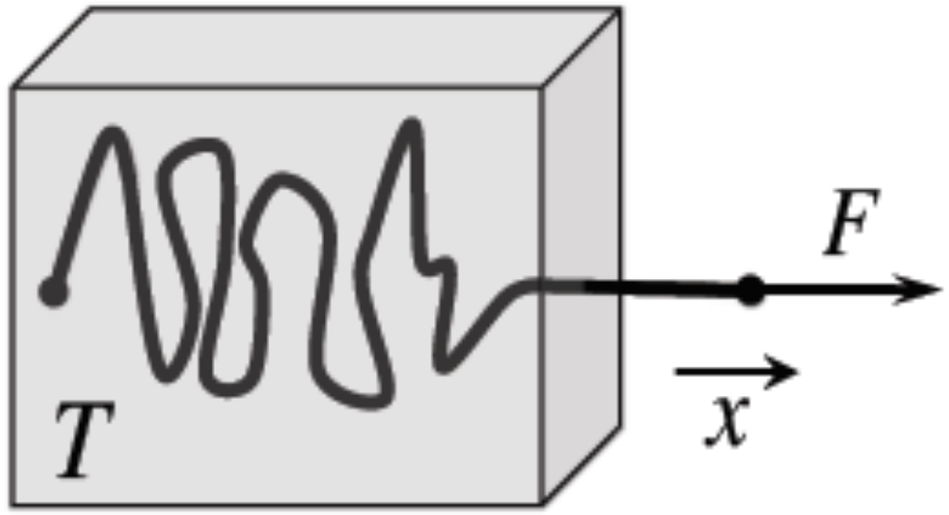
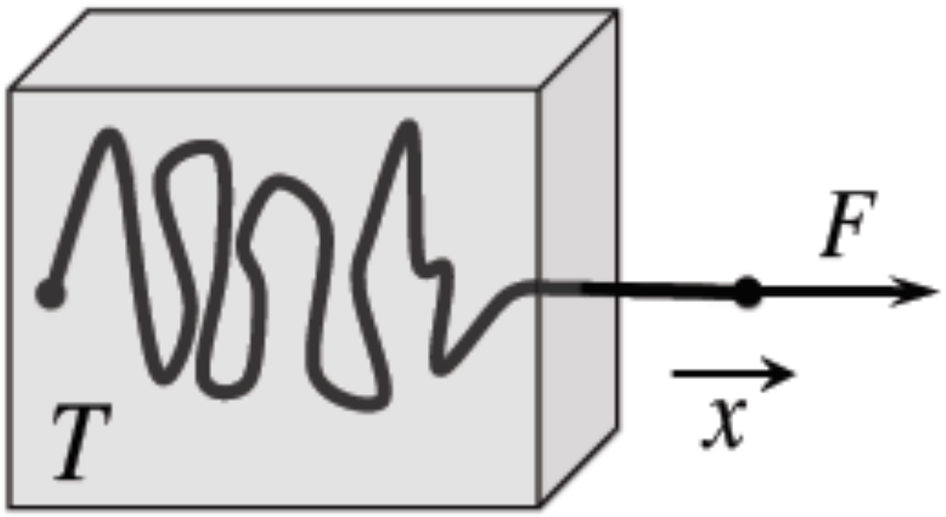
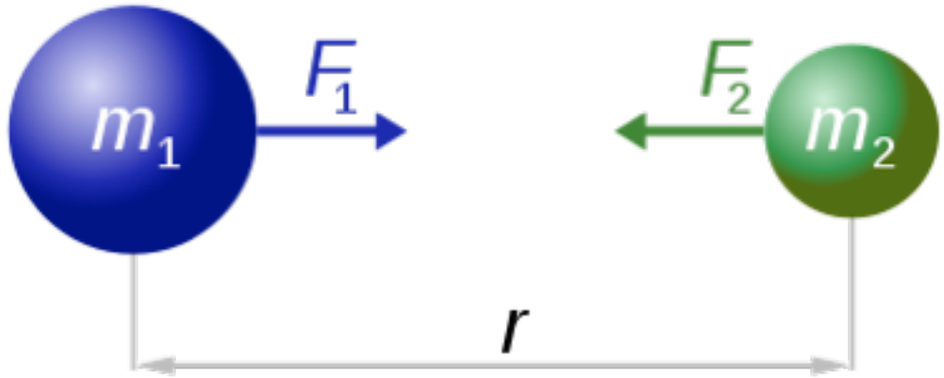


Entropic gravity



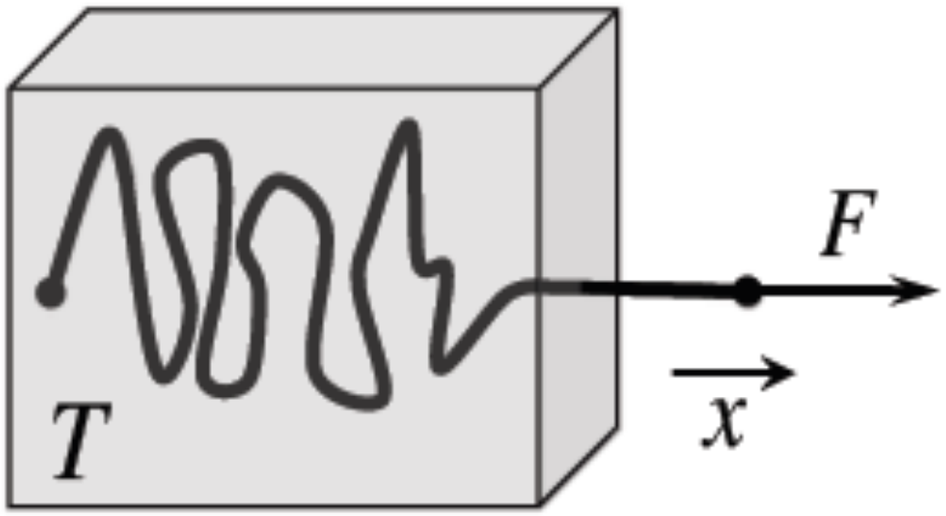
Entropic gravity

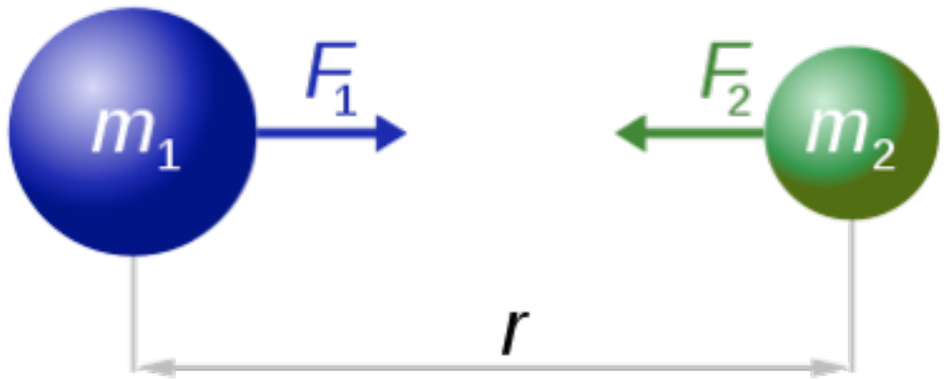




$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

Entropic gravity

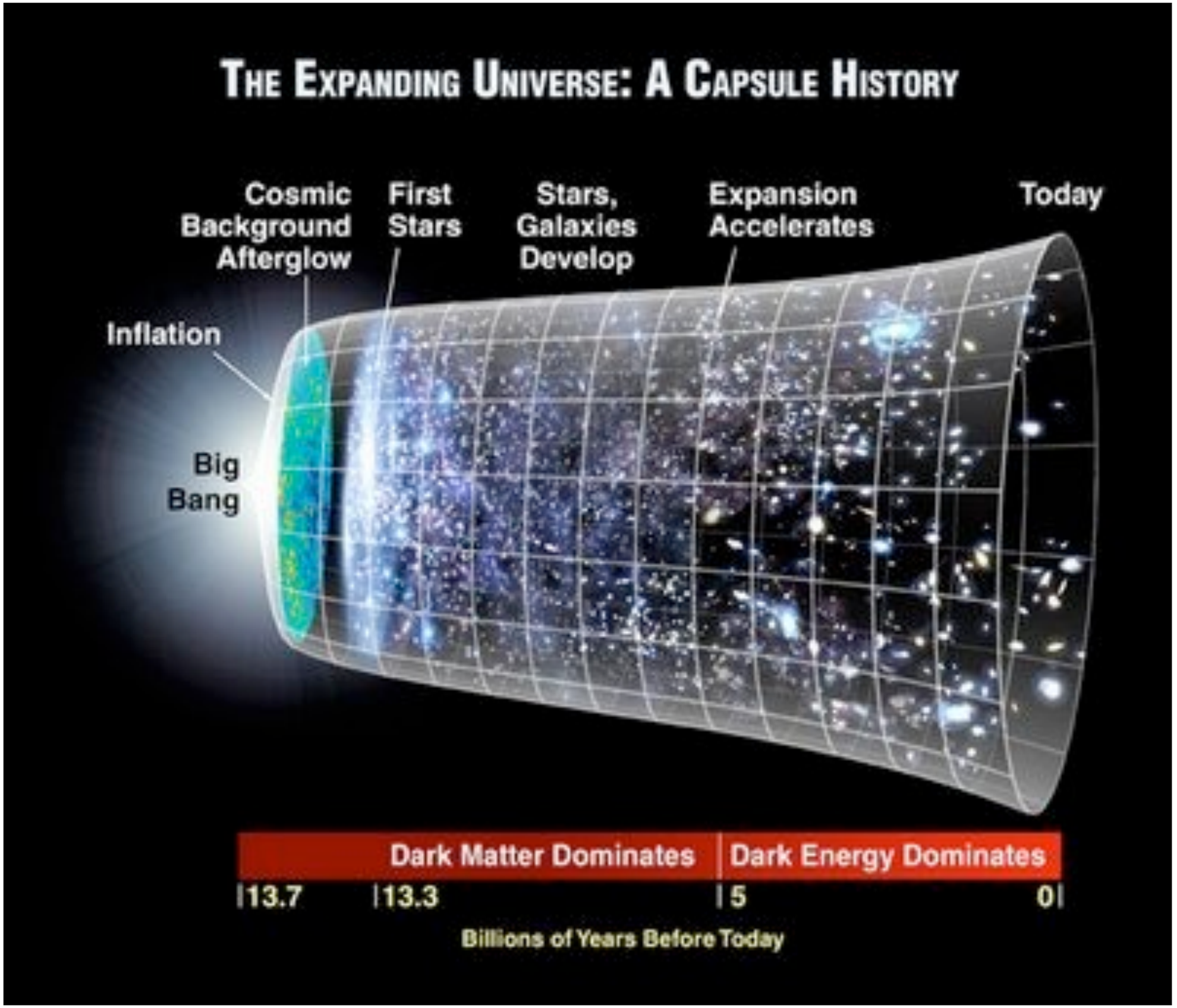




$$F_1 = F_2 = G\frac{m_1 \times m_2}{r^2}$$

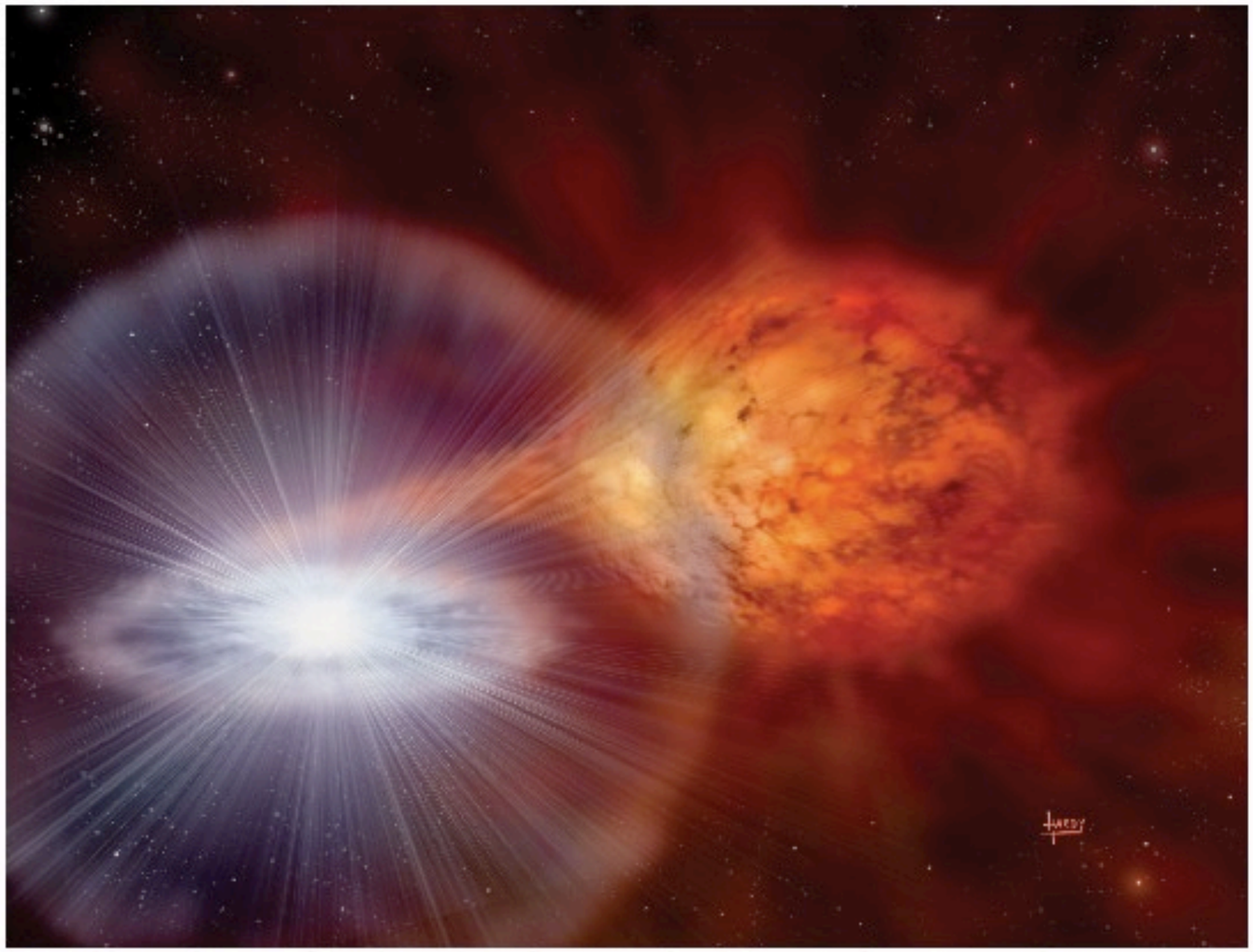
FOR ME GRAVITY DOESN'T EXIST," — VERLINDE

NASA / WMAP Science Team



NASA / WMAP Science Team

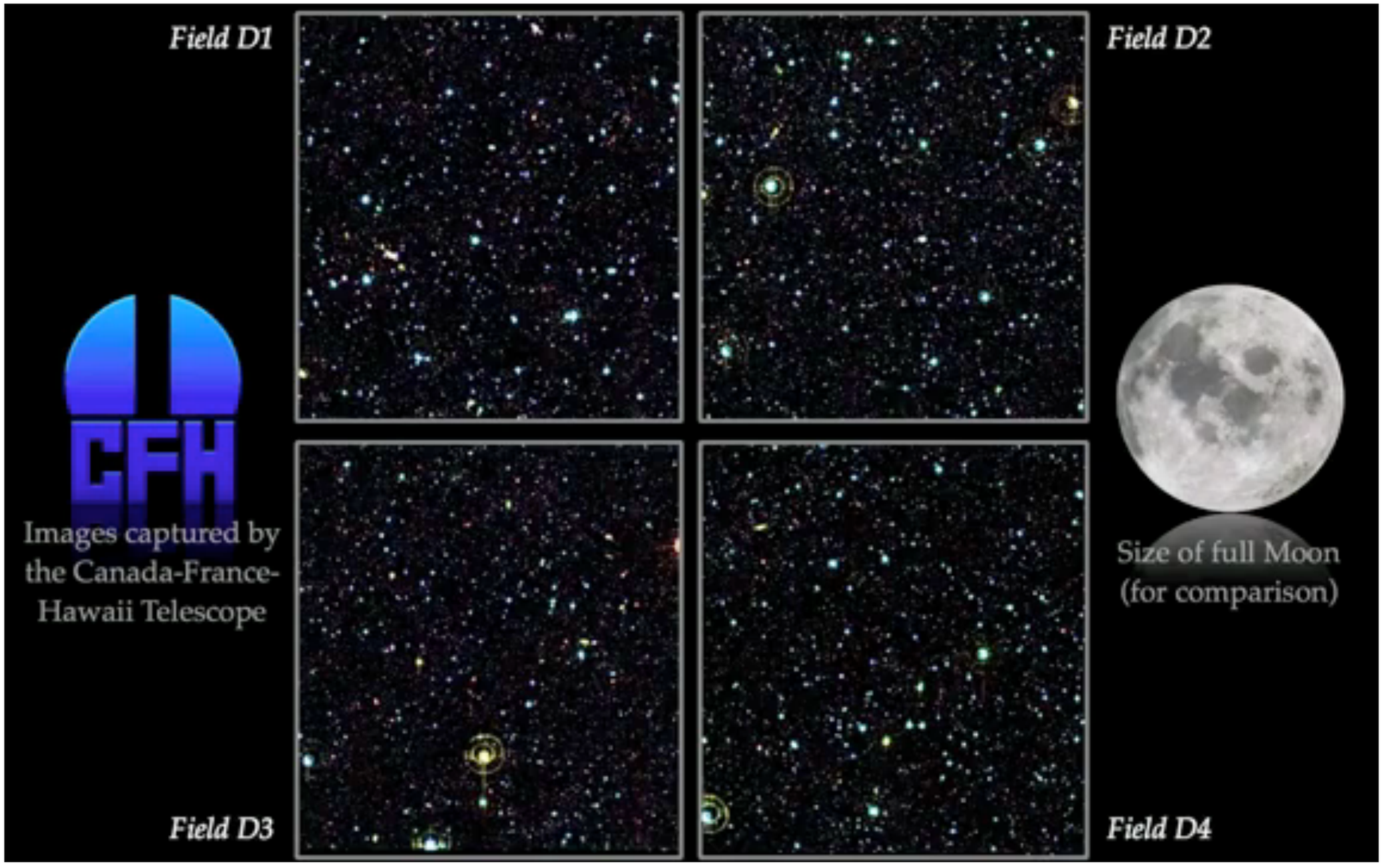
Type Ia supernova



Artist's rendition of a white dwarf accumulating mass from a nearby companion star. This type of progenitor system would be considered singly-degenerate.

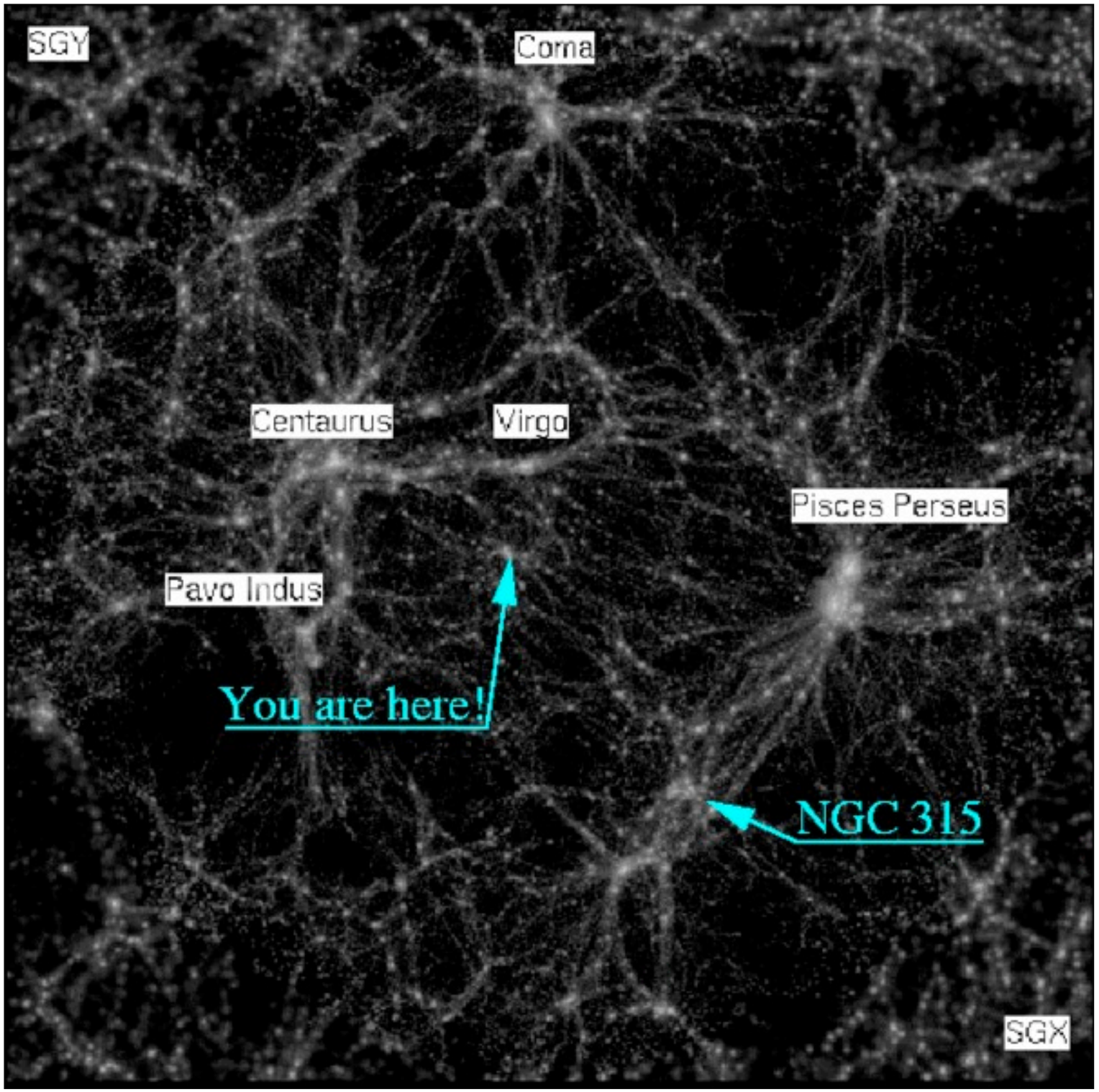
Image courtesy of David A. Hardy, © David A. Hardy/www.astroart.org.

The music of the spheres

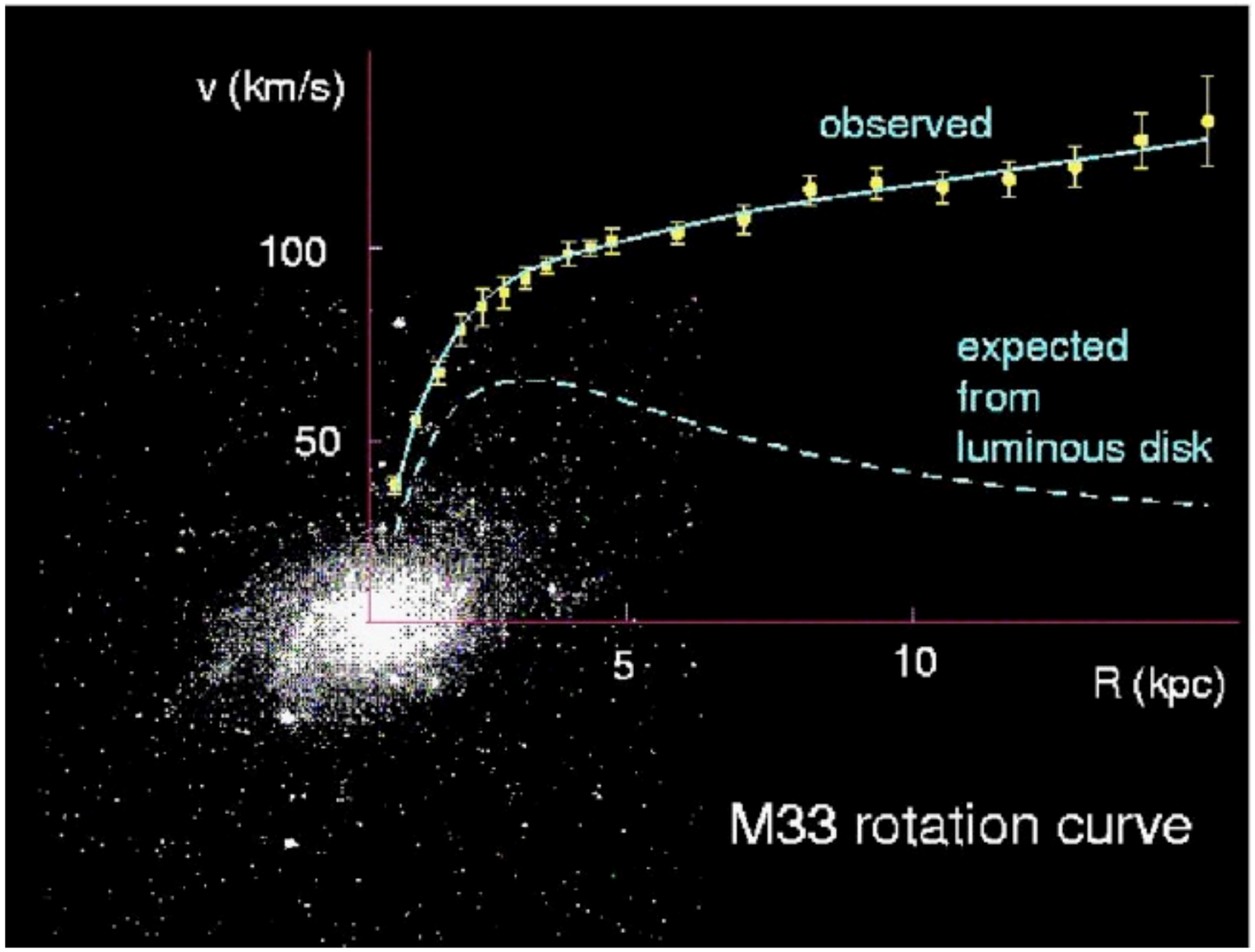


http://www.astro.uvic.ca/~alexhp/new/supernova_sonata.html

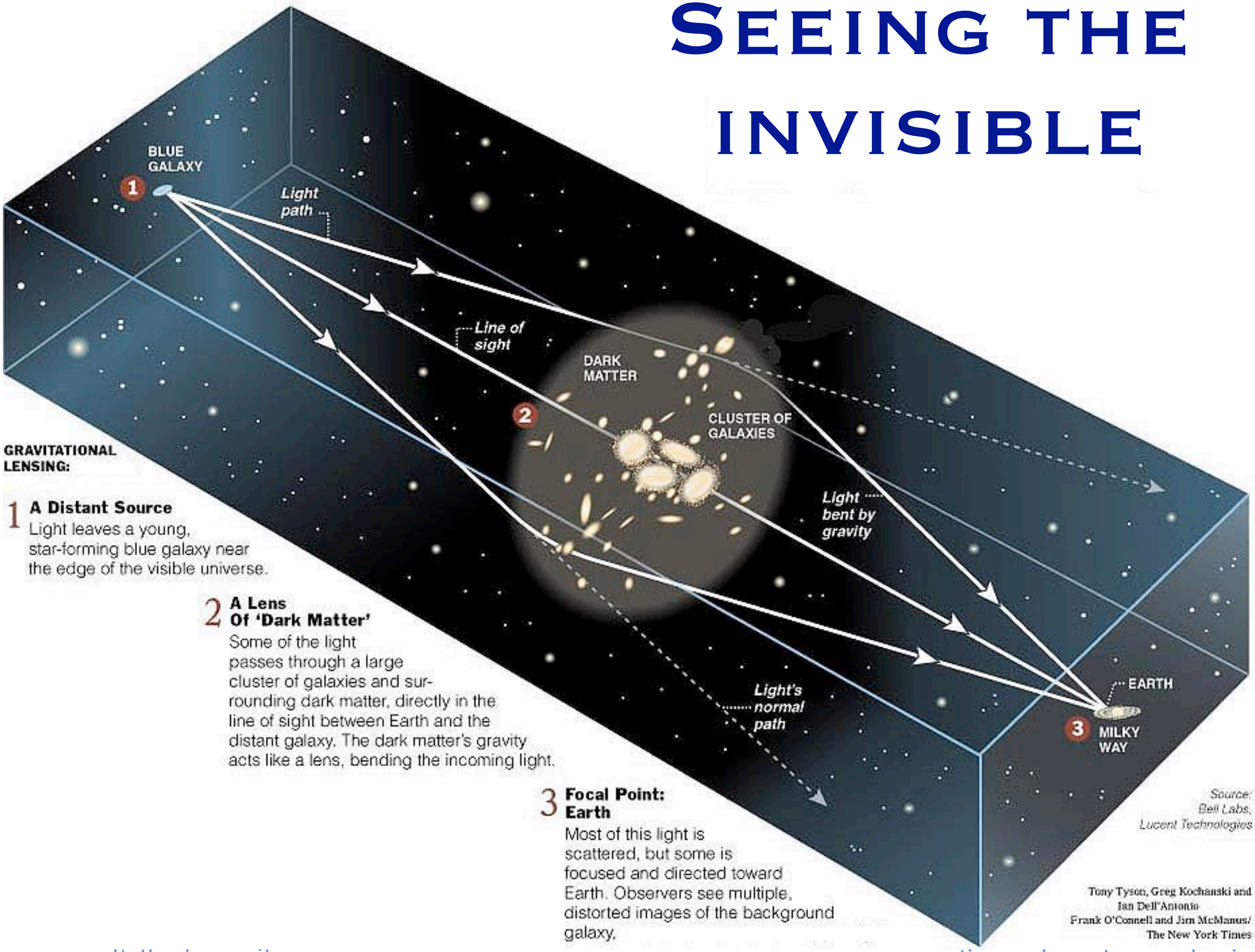
Baryonic Matter (us)



Rapidly spinning galaxies



Seeing the invisible



GRAVITATIONAL LENSING:

1 A Distant Source
Light leaves a young, star-forming blue galaxy near the edge of the visible universe.

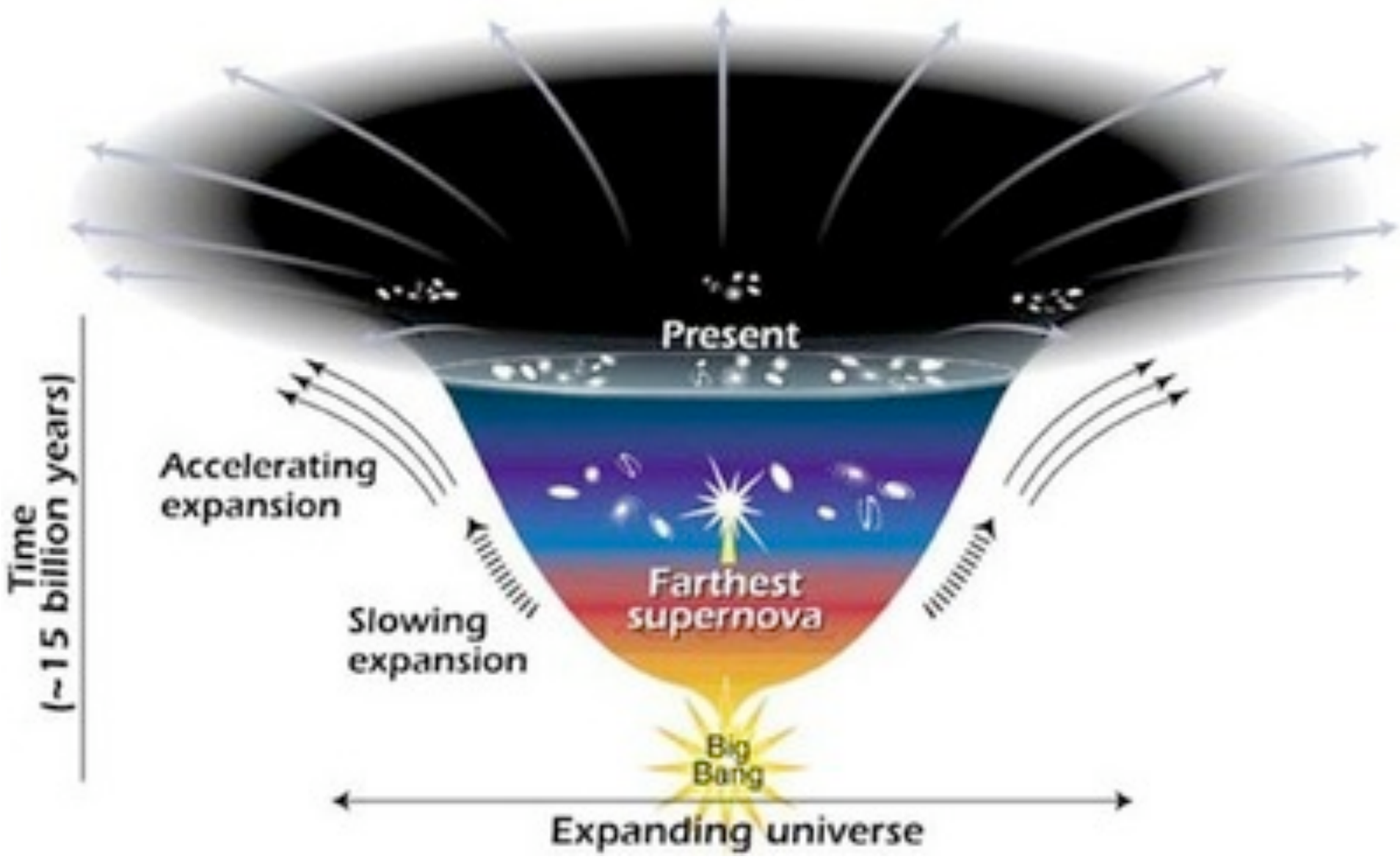
2 A Lens Of 'Dark Matter'
Some of the light passes through a large cluster of galaxies and surrounding dark matter, directly in the line of sight between Earth and the distant galaxy. The dark matter's gravity acts like a lens, bending the incoming light.

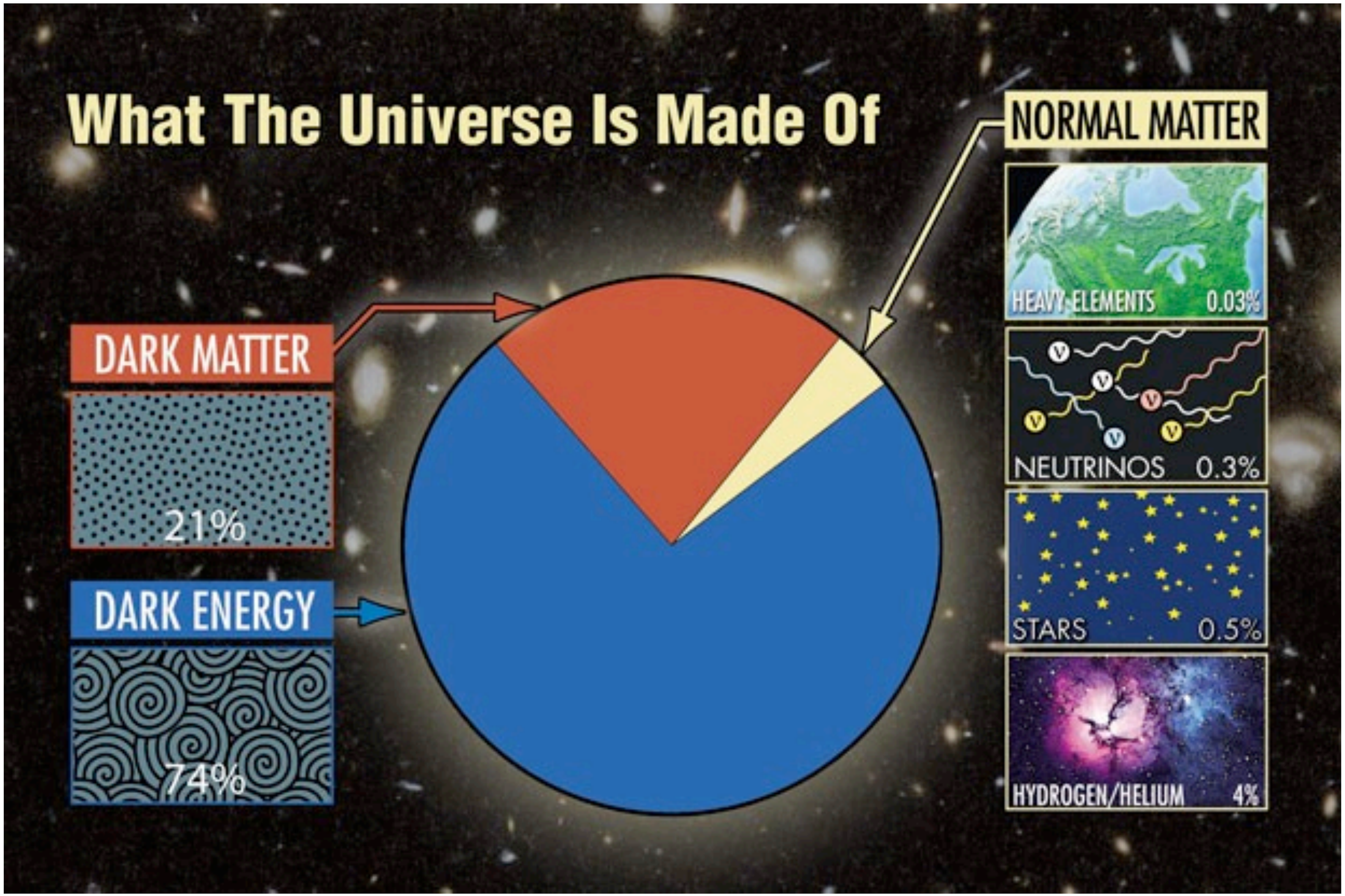
3 Focal Point: Earth
Most of this light is scattered, but some is focused and directed toward Earth. Observers see multiple, distorted images of the background galaxy.

Source: Bell Labs, Lucent Technologies

Tony Tyson, Greg Kochanski and Ian Dell'Antonio
Frank O'Connell and Jim McManus/ The New York Times

Dark energy


Present
Accelerating expansion
Time (~15 billion years)
Farthest supernova
Slowing expansion
Big Bang
Expanding universe


What The Universe Is Made Of
NORMAL MATTER
HEAVY ELEMENTS 0.03%
NEUTRINOS 0.3%
STARS 0.5%
HYDROGEN/HELIUM 4%
DARK MATTER
21%
DARK ENERGY
74%

The edge of the known

The edge of the known

- Astronomy

The edge of the known

- Astronomy
  - Neutrinos

The edge of the known

- Astronomy
  - Neutrinos
  - Cosmic rays

The edge of the known

- Astronomy
  - Neutrinos
  - Cosmic rays
  - Gravity waves

The edge of the known

- Astronomy
  - Neutrinos
  - Cosmic rays
  - Gravity waves
  - Wimps

The edge of the known

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  - Strings

The edge of the known

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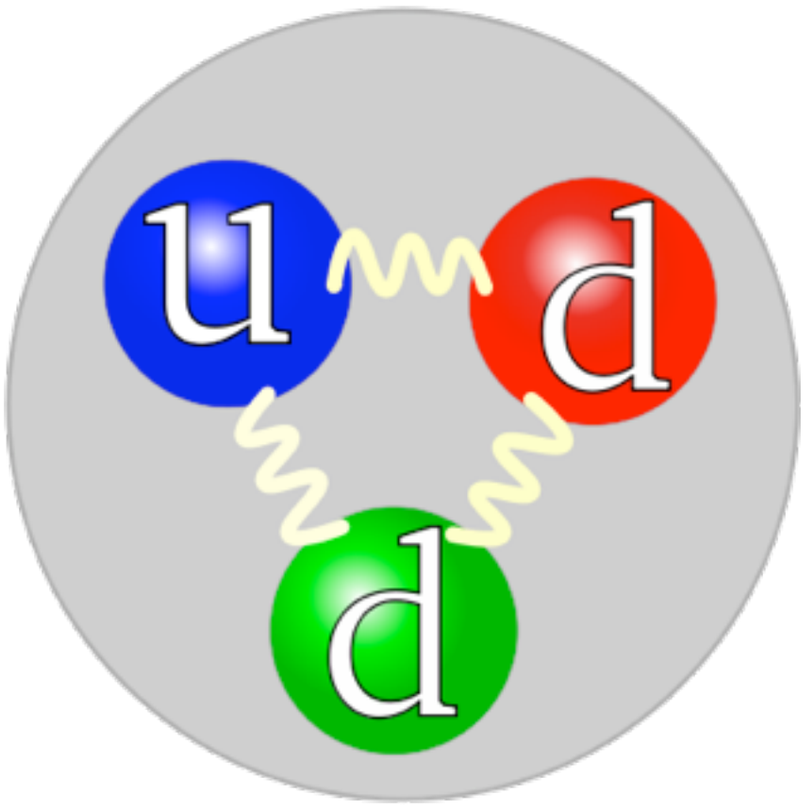
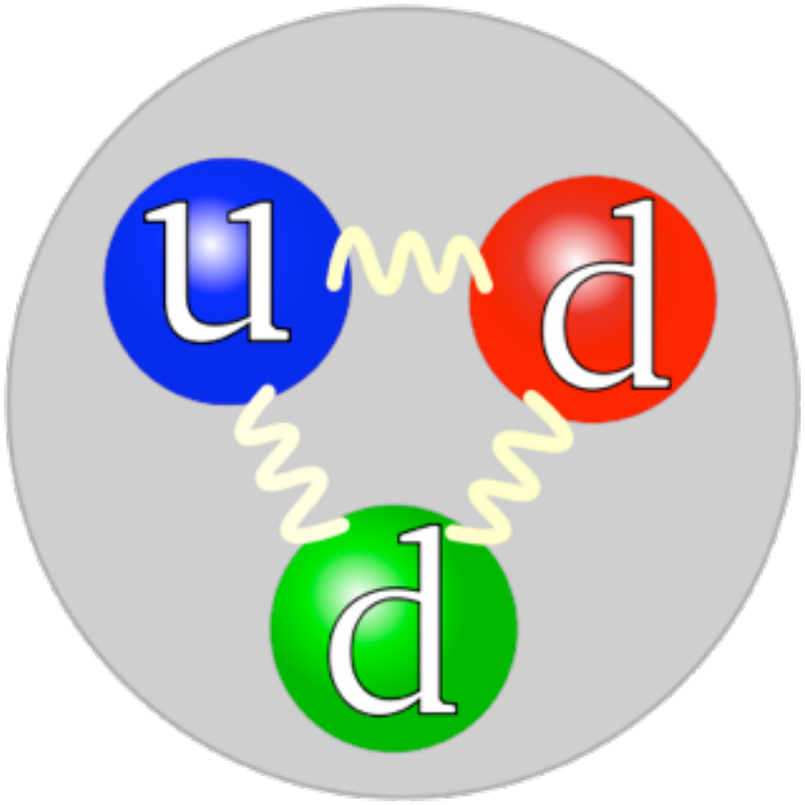
  - Wimps
- CERN/LHC
  - Higgs Boson
  - Wimps
  - Strings
  - Baby Black Holes

Neutrinos

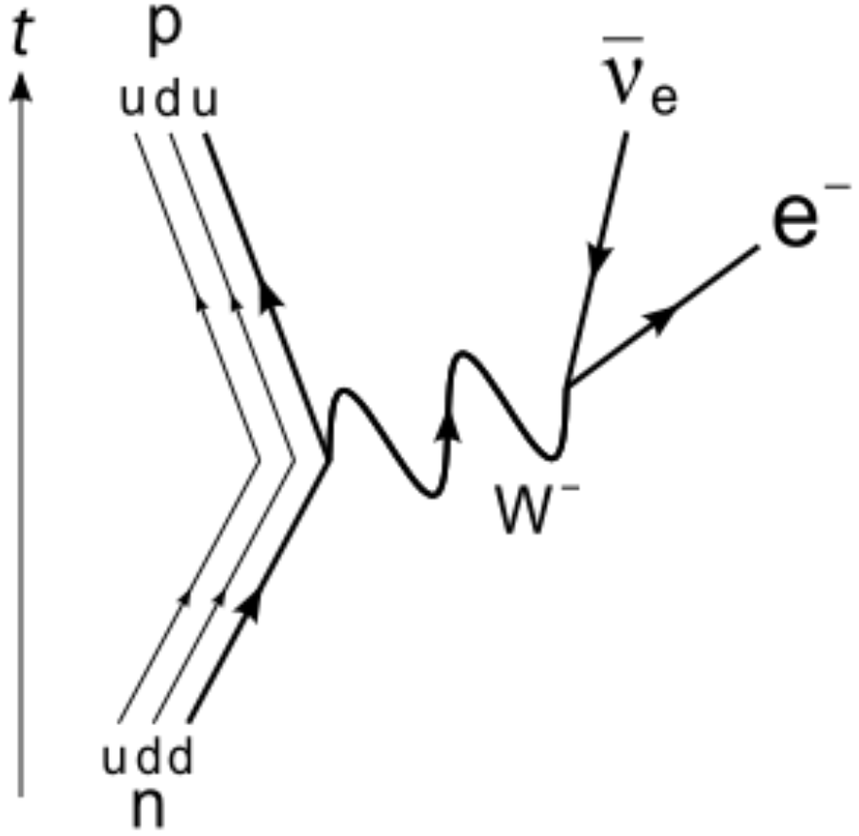


NEUTRON

Neutrinos

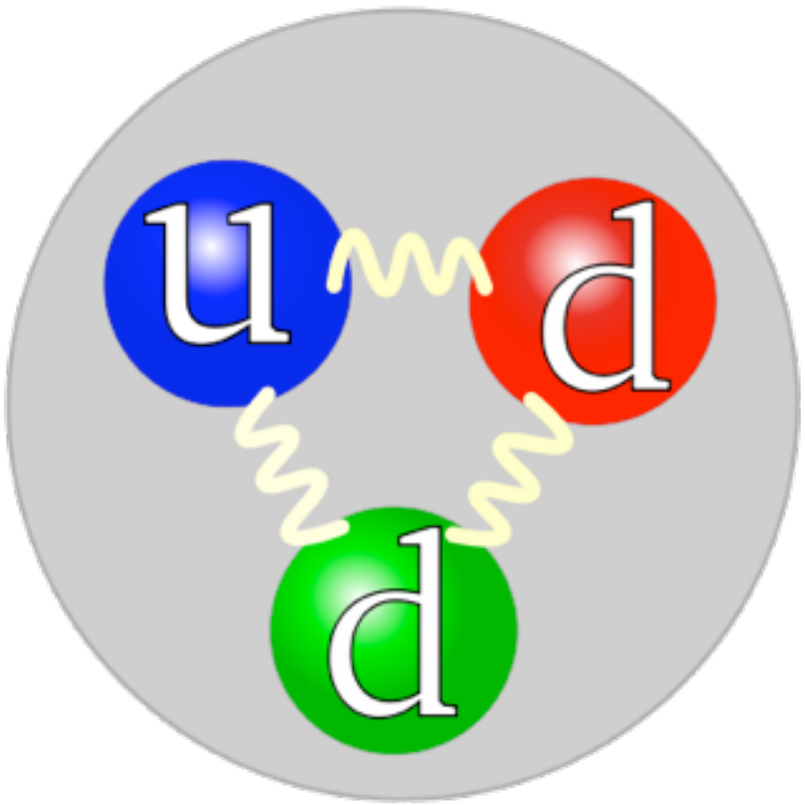


NEUTRON

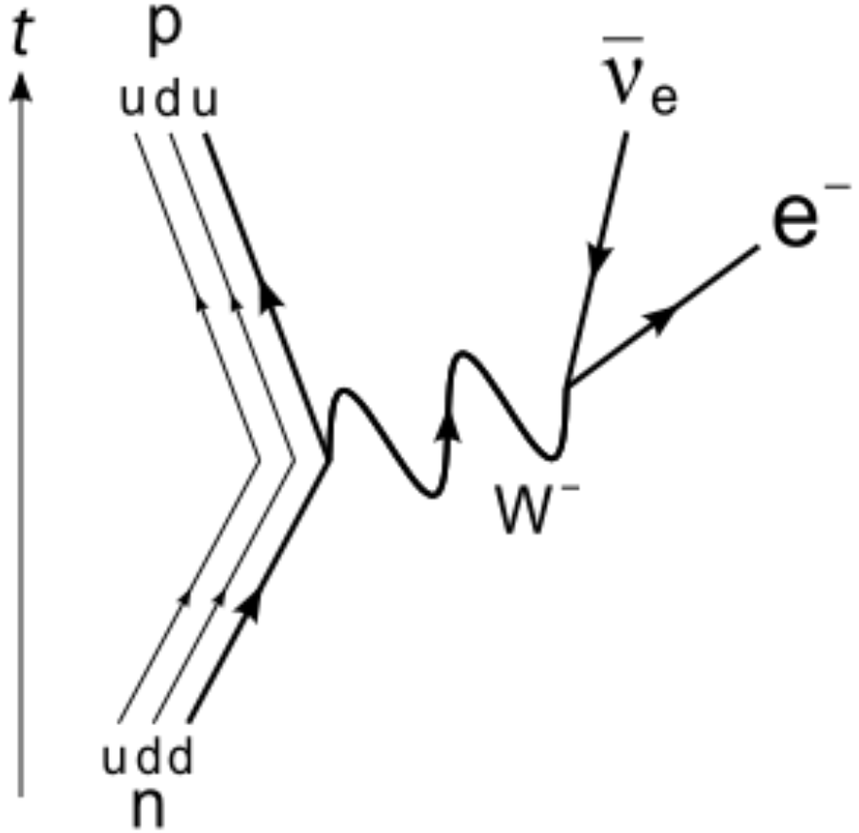


NEUTRON DECAY

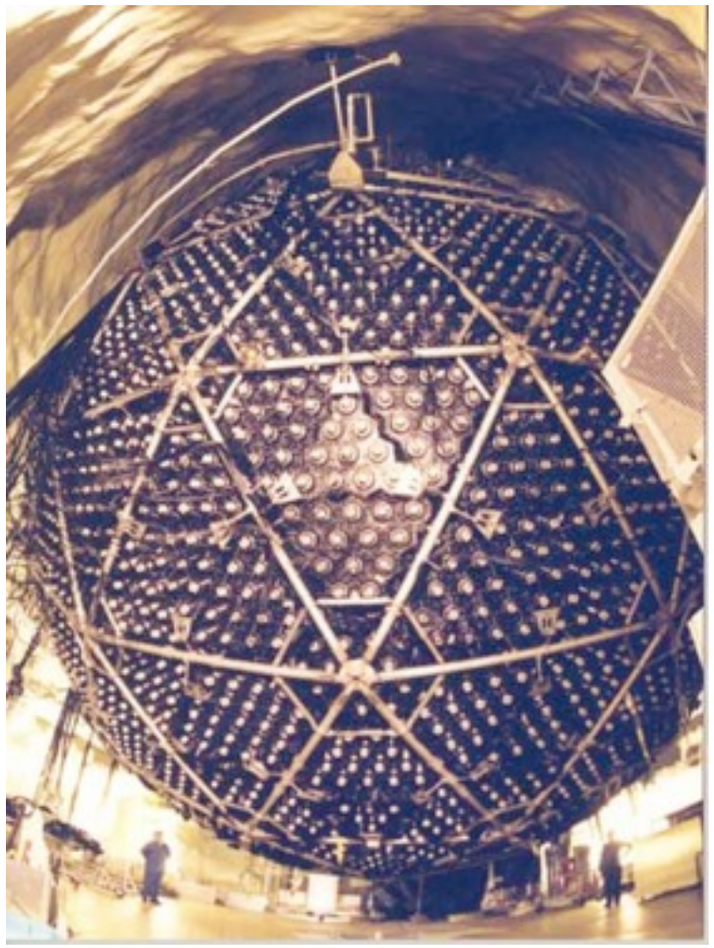
Neutrinos



Neutron

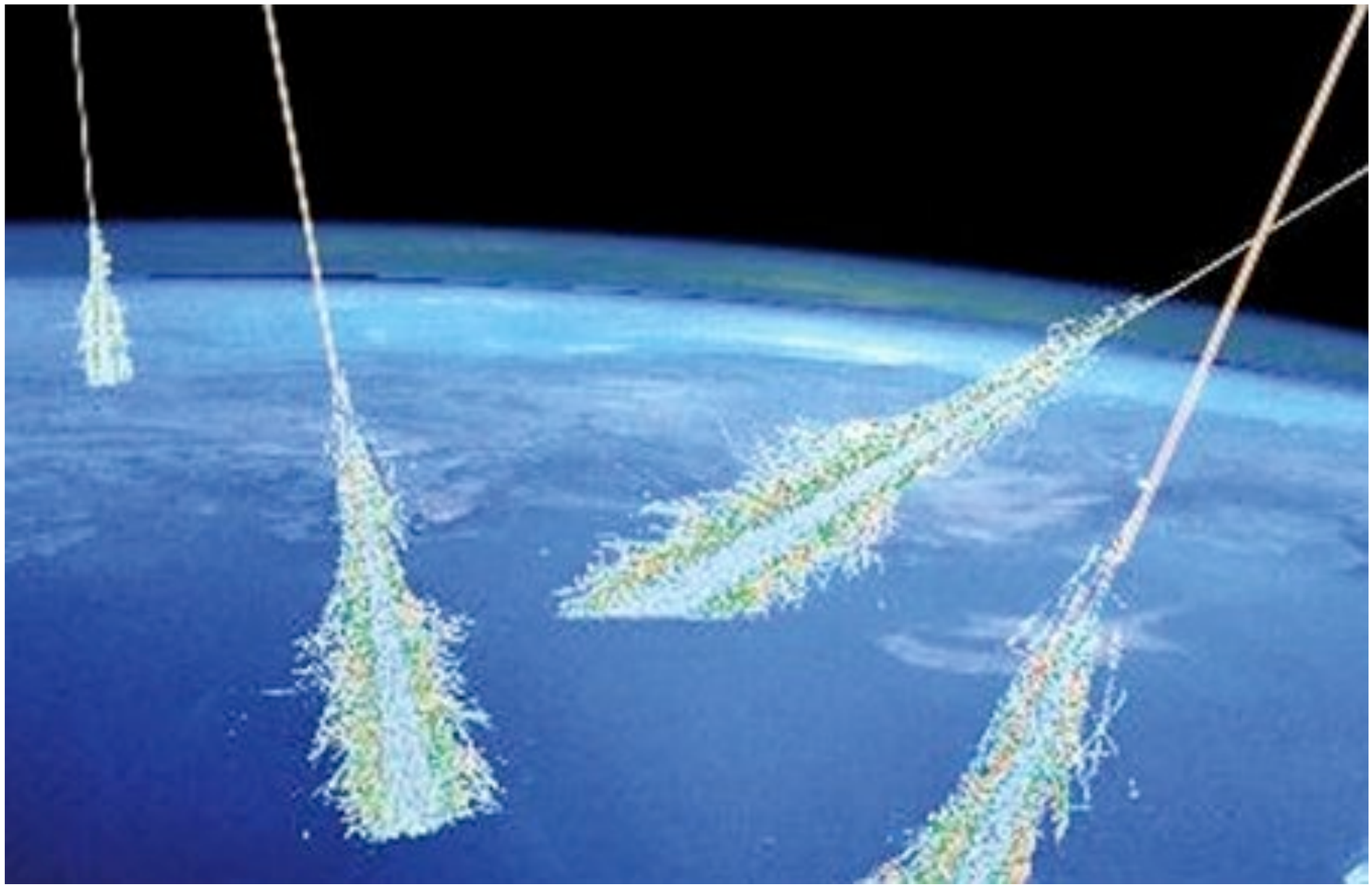


Neutron Decay

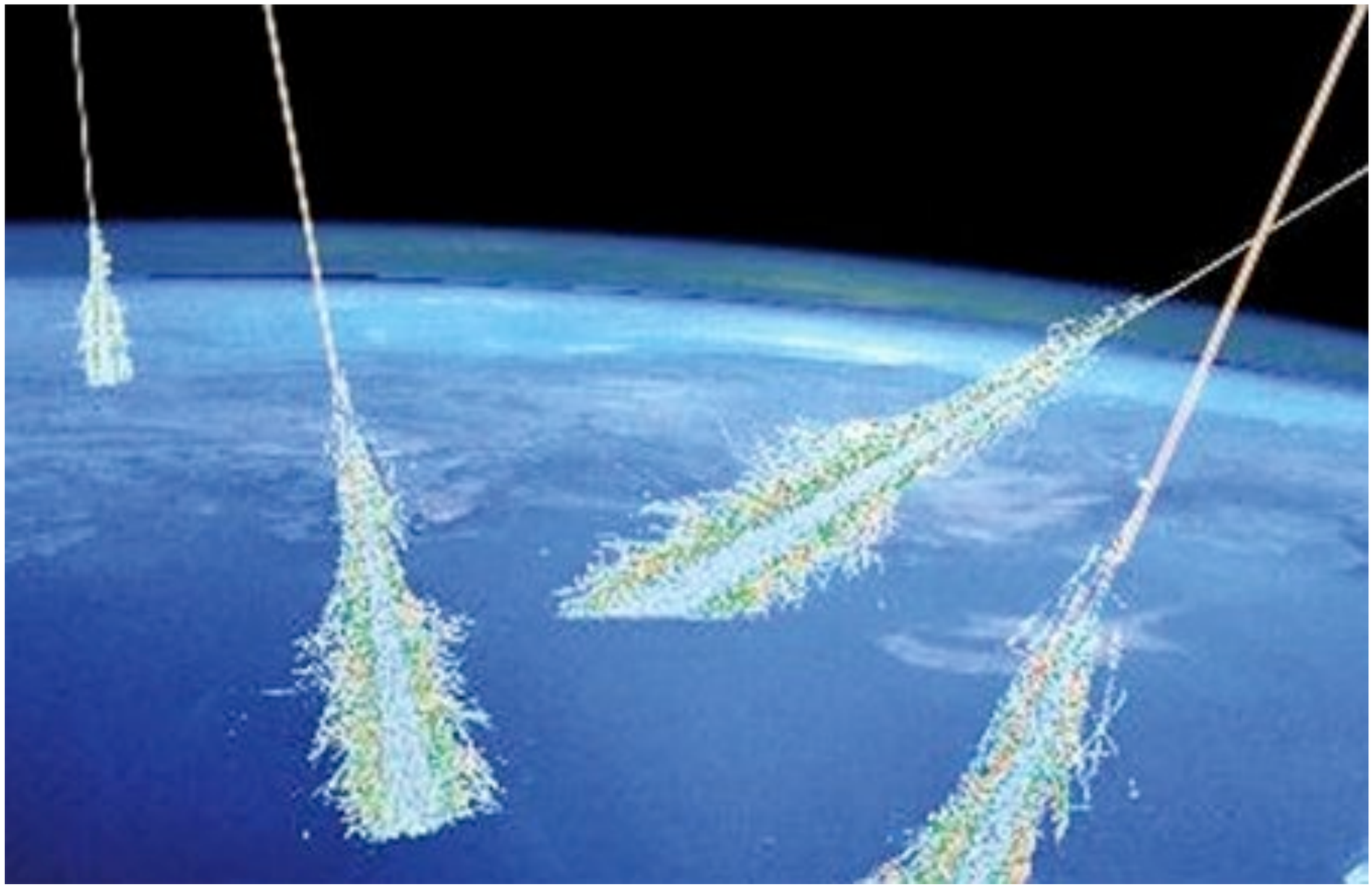


Sudbery Neutrino Detector

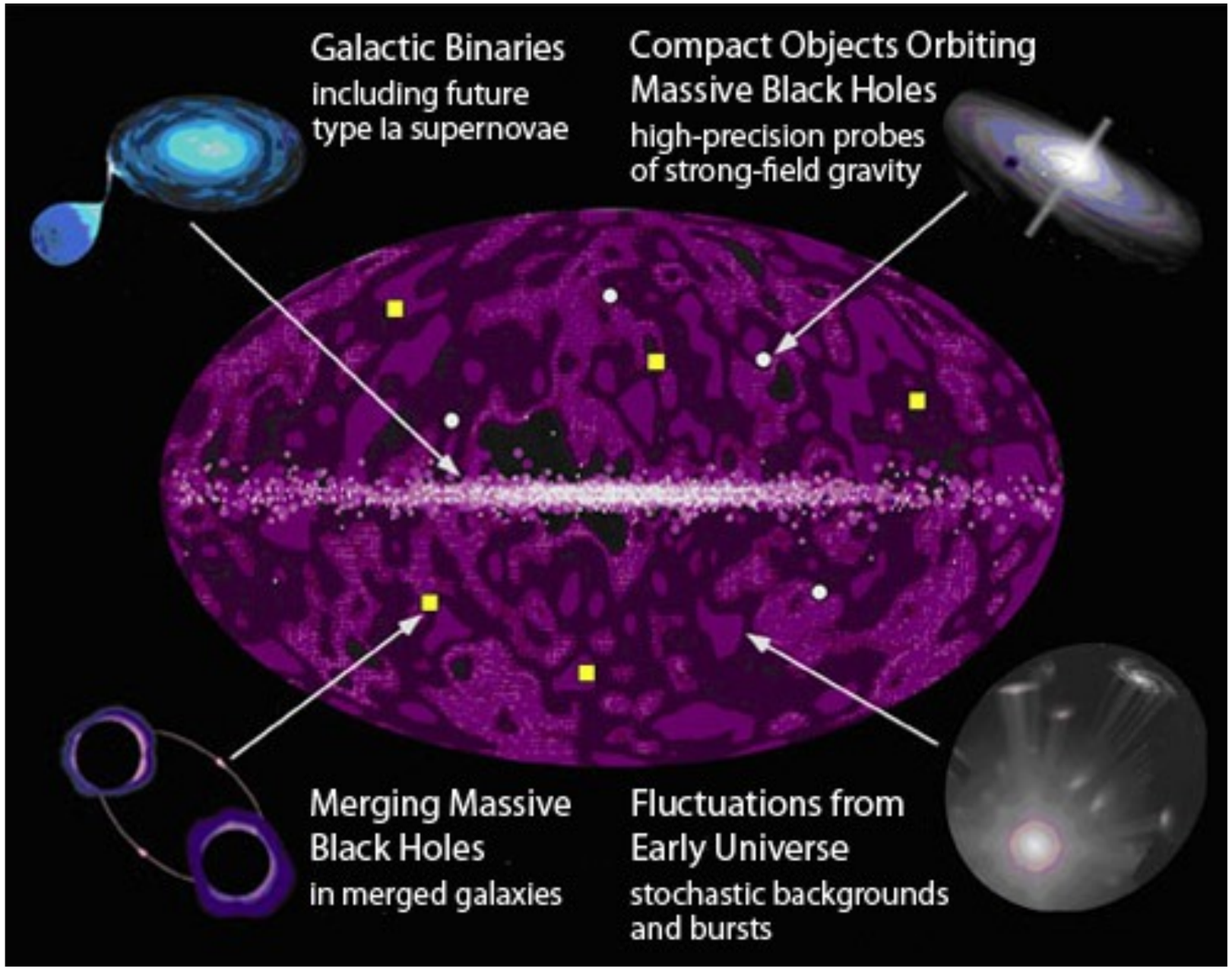
Cosmic Rays



Cosmic Rays



Gravity Waves



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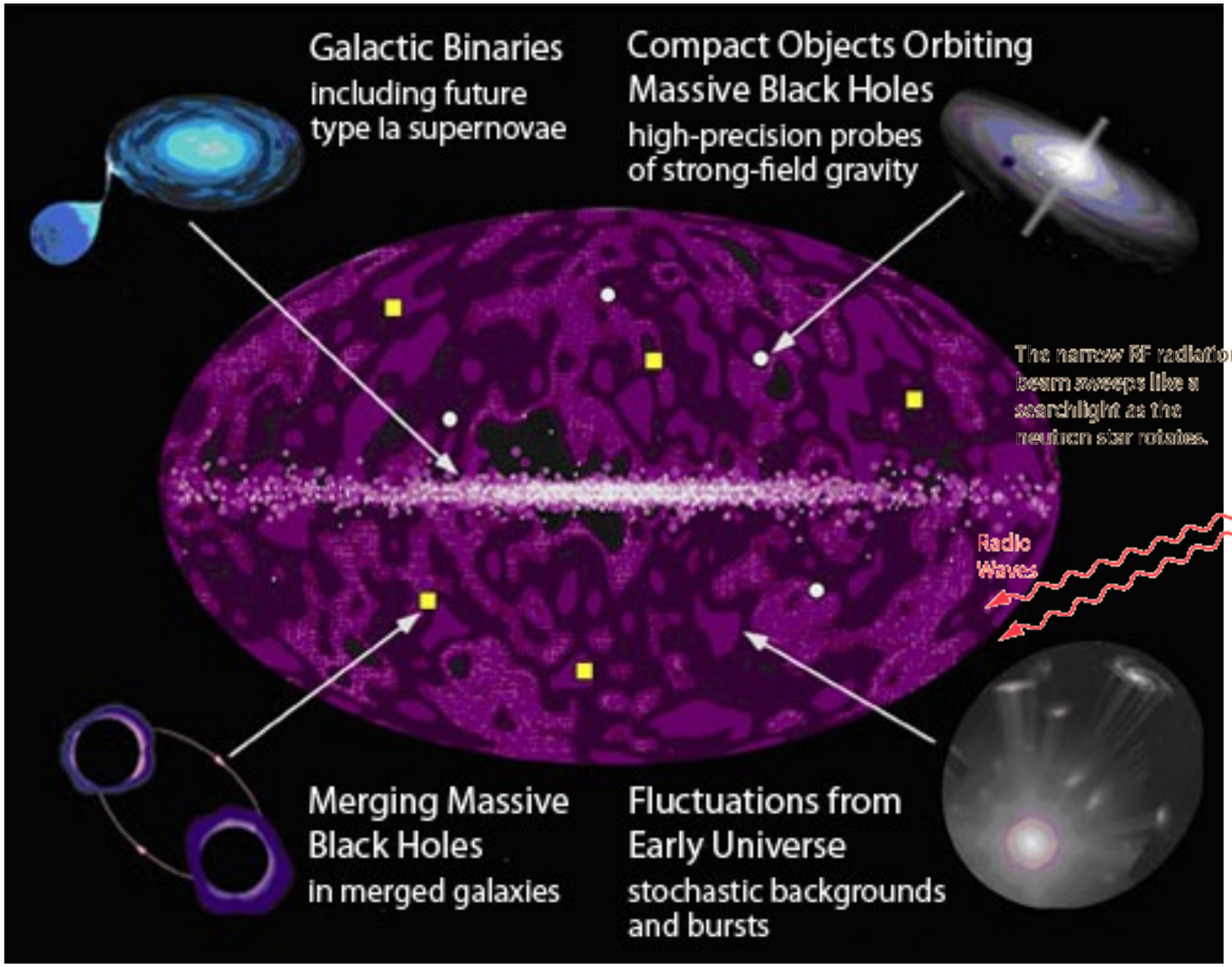
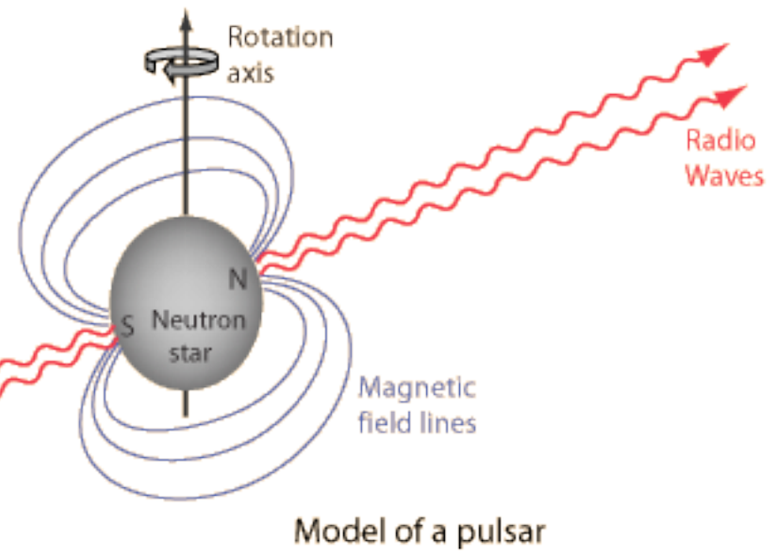
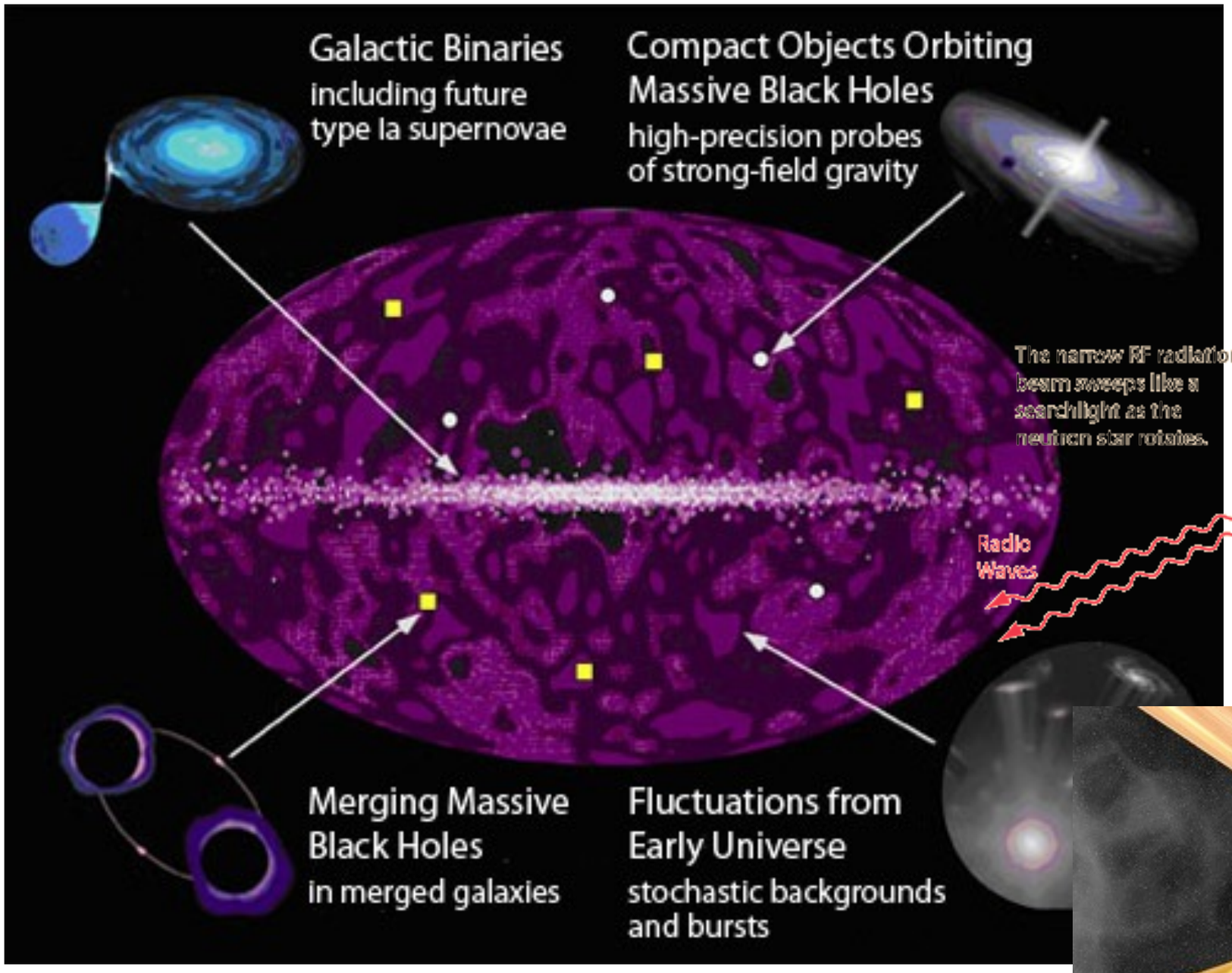
Gravity Waves

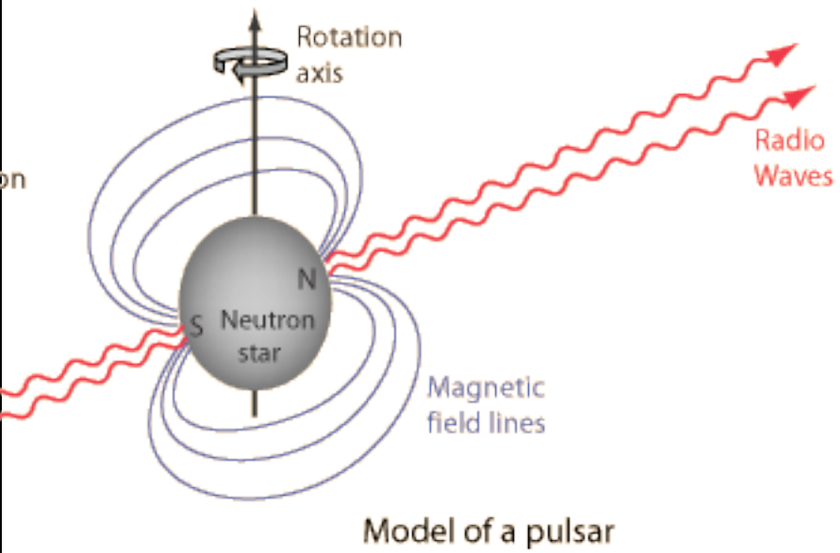




Model of a pulsar

Gravity Waves





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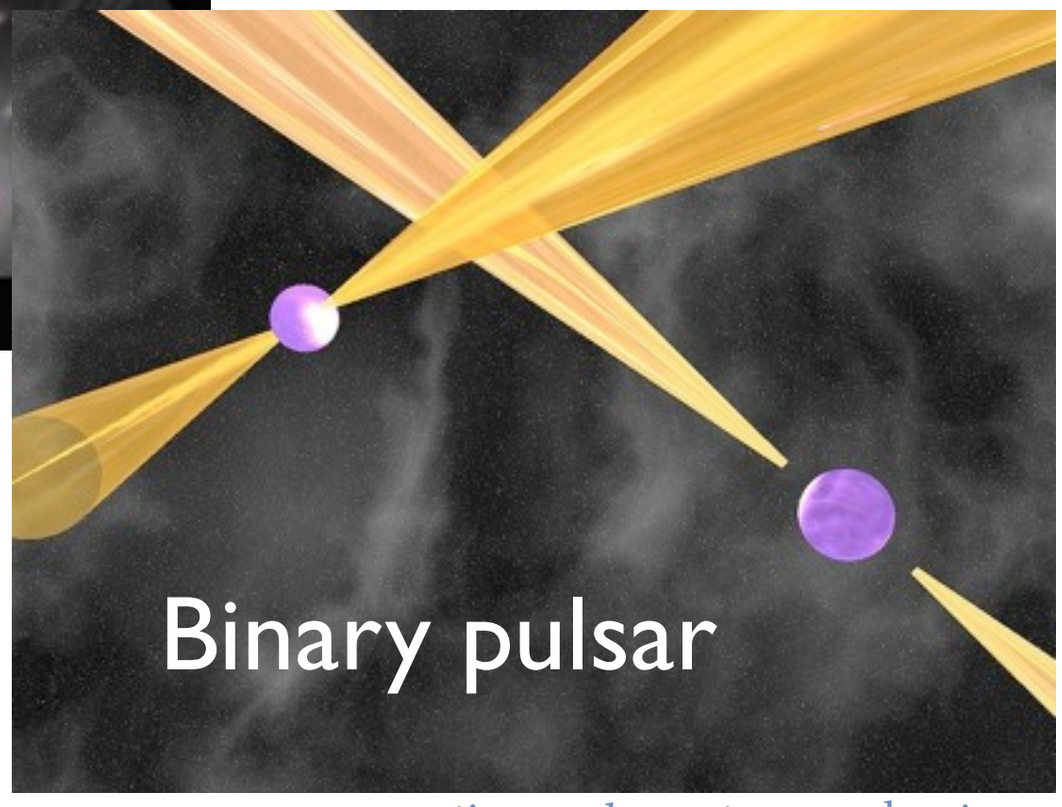
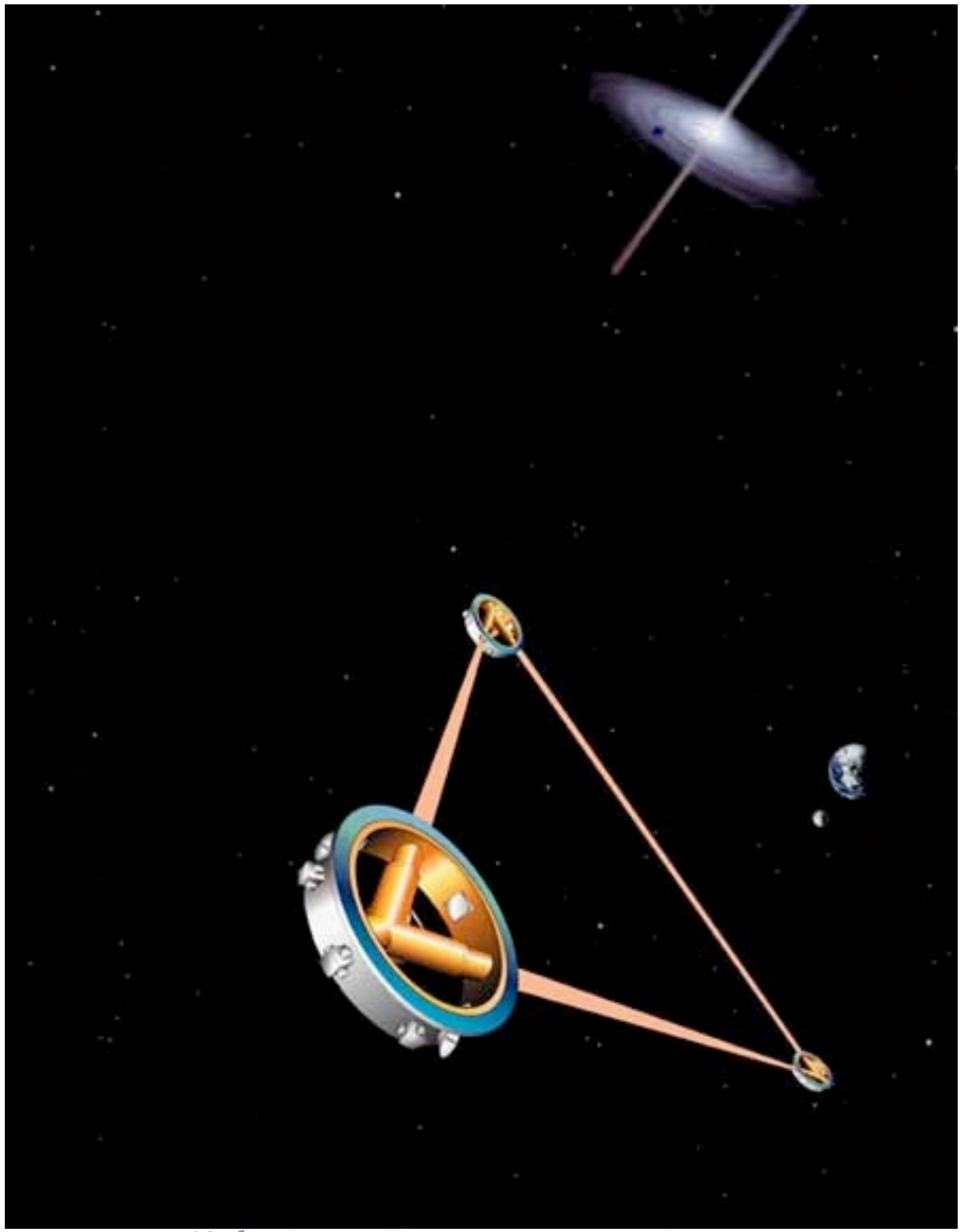


Gravity Waves



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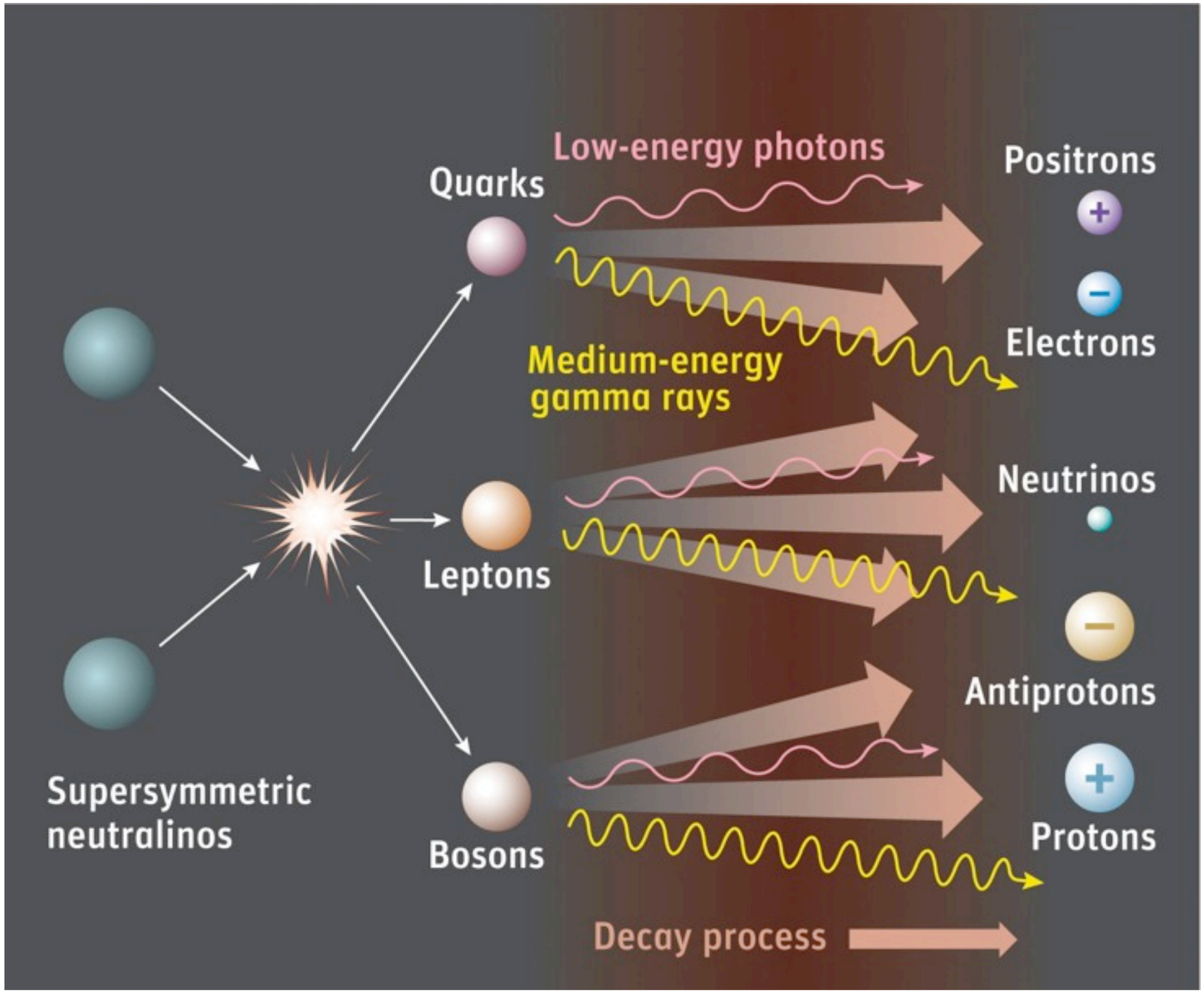
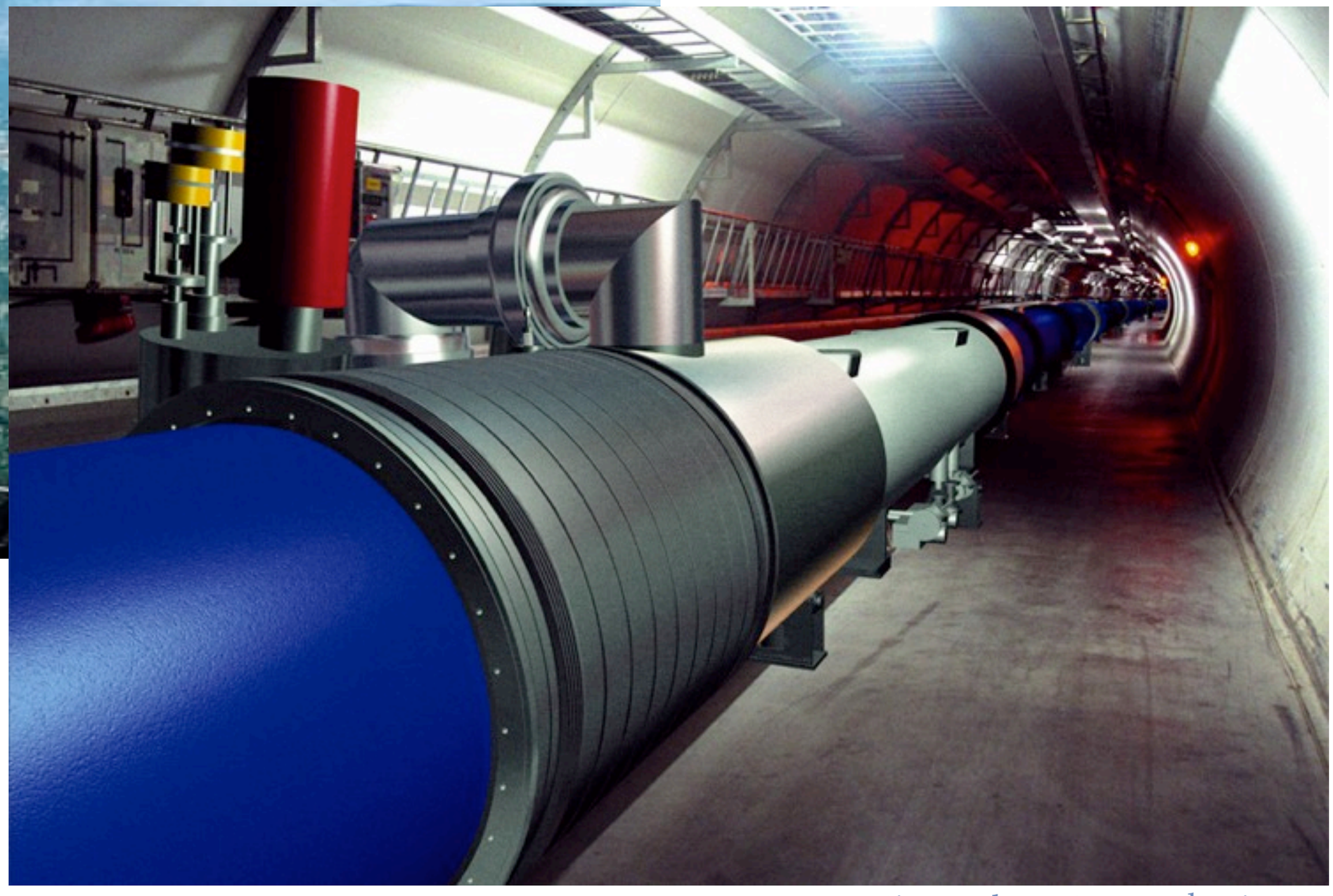
WIMPS

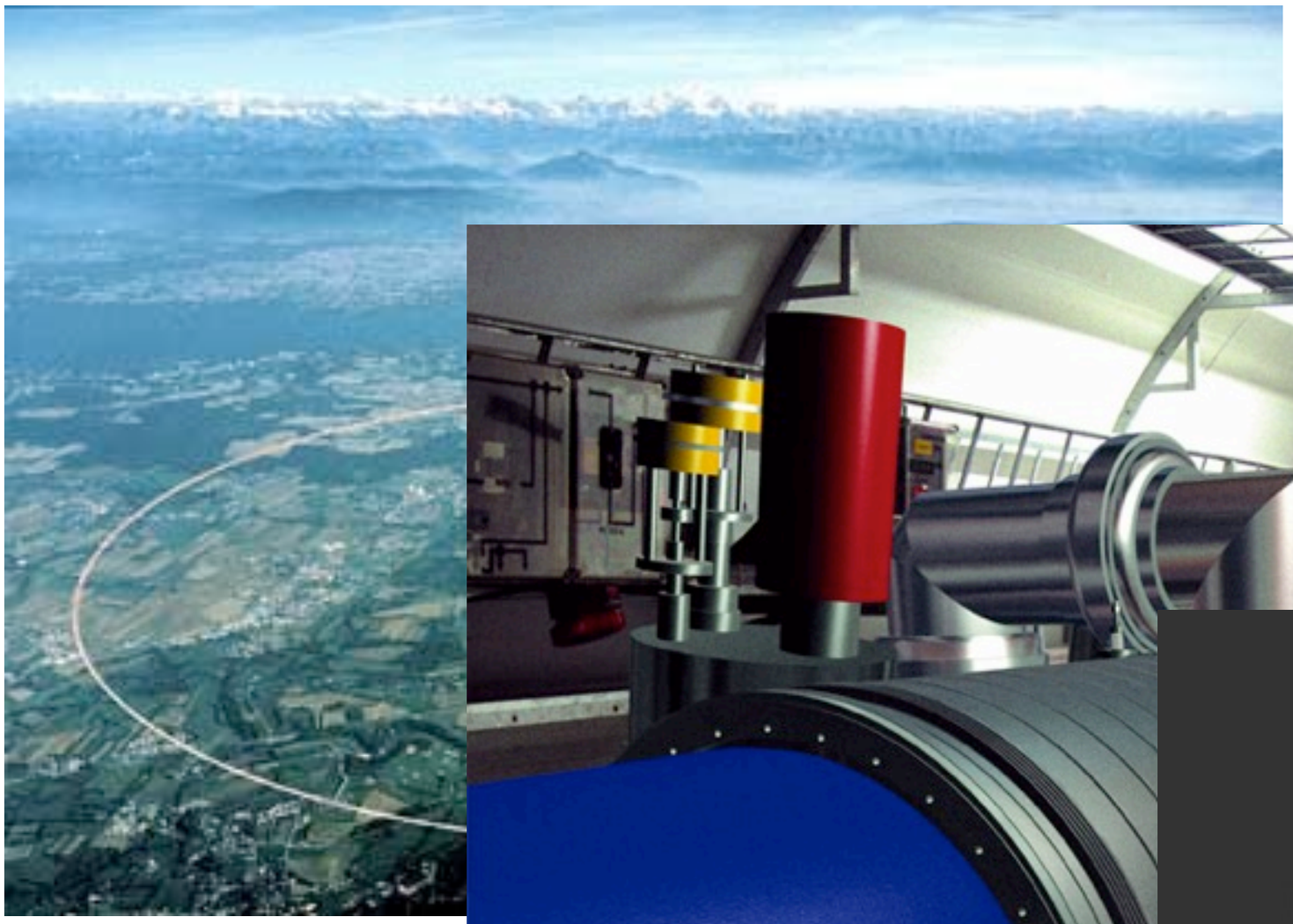

Low-energy photons
Quarks
Positrons
Electrons
Medium-energy
gamma rays
Neutrinos
Leptons
Antiprotons
Supersymmetric
neutralinos
Bosons
Protons
Decay process

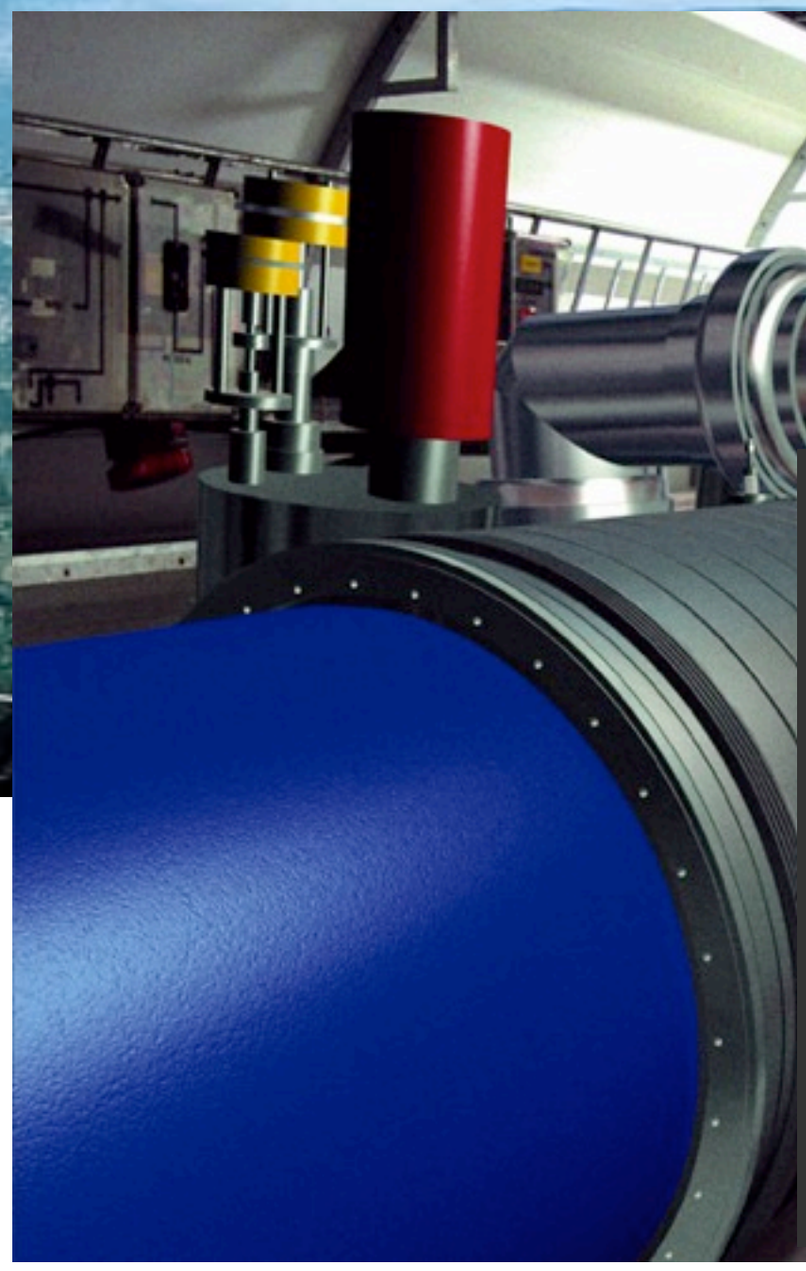
CERN

CERN



CERN





ALICE
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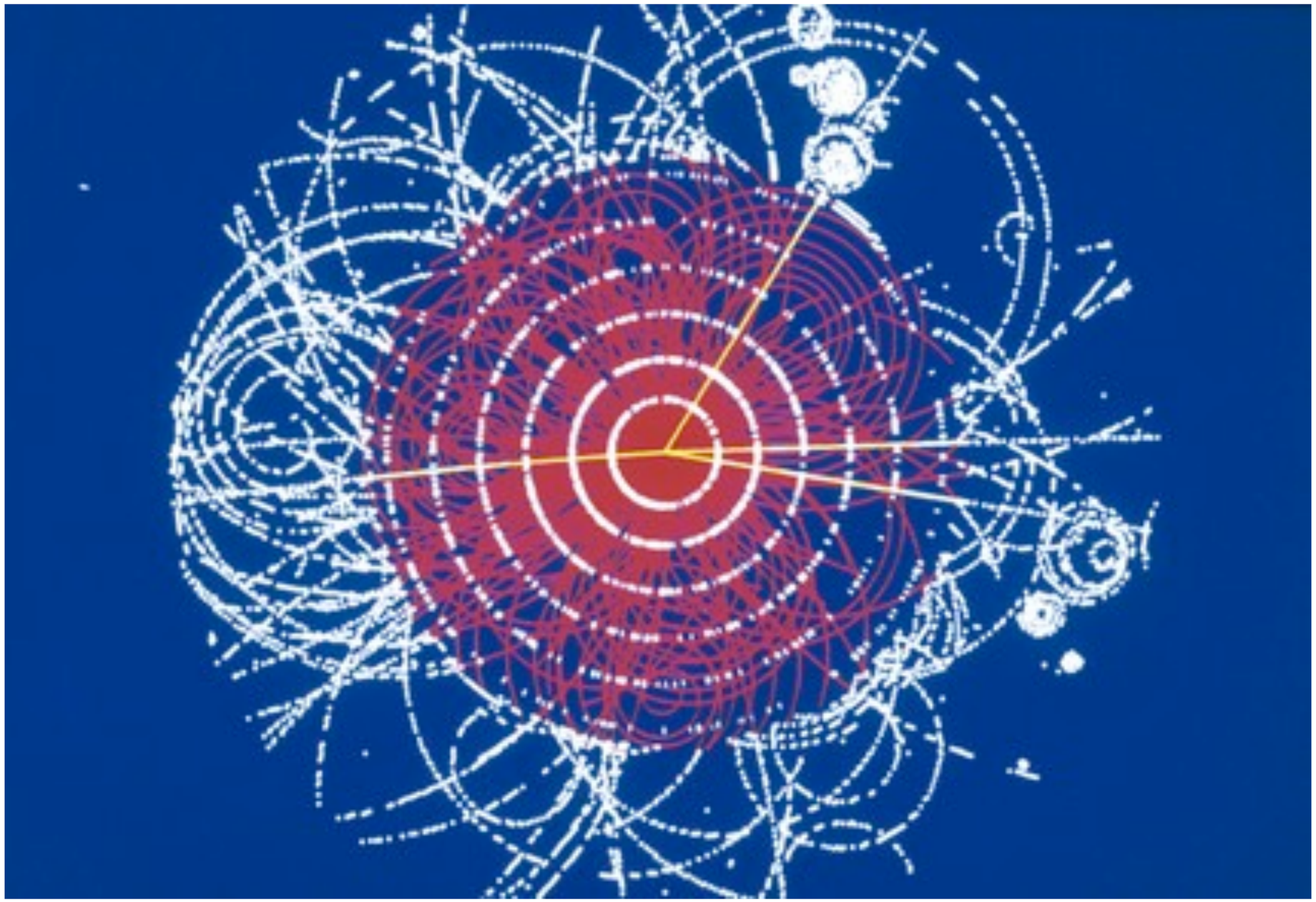
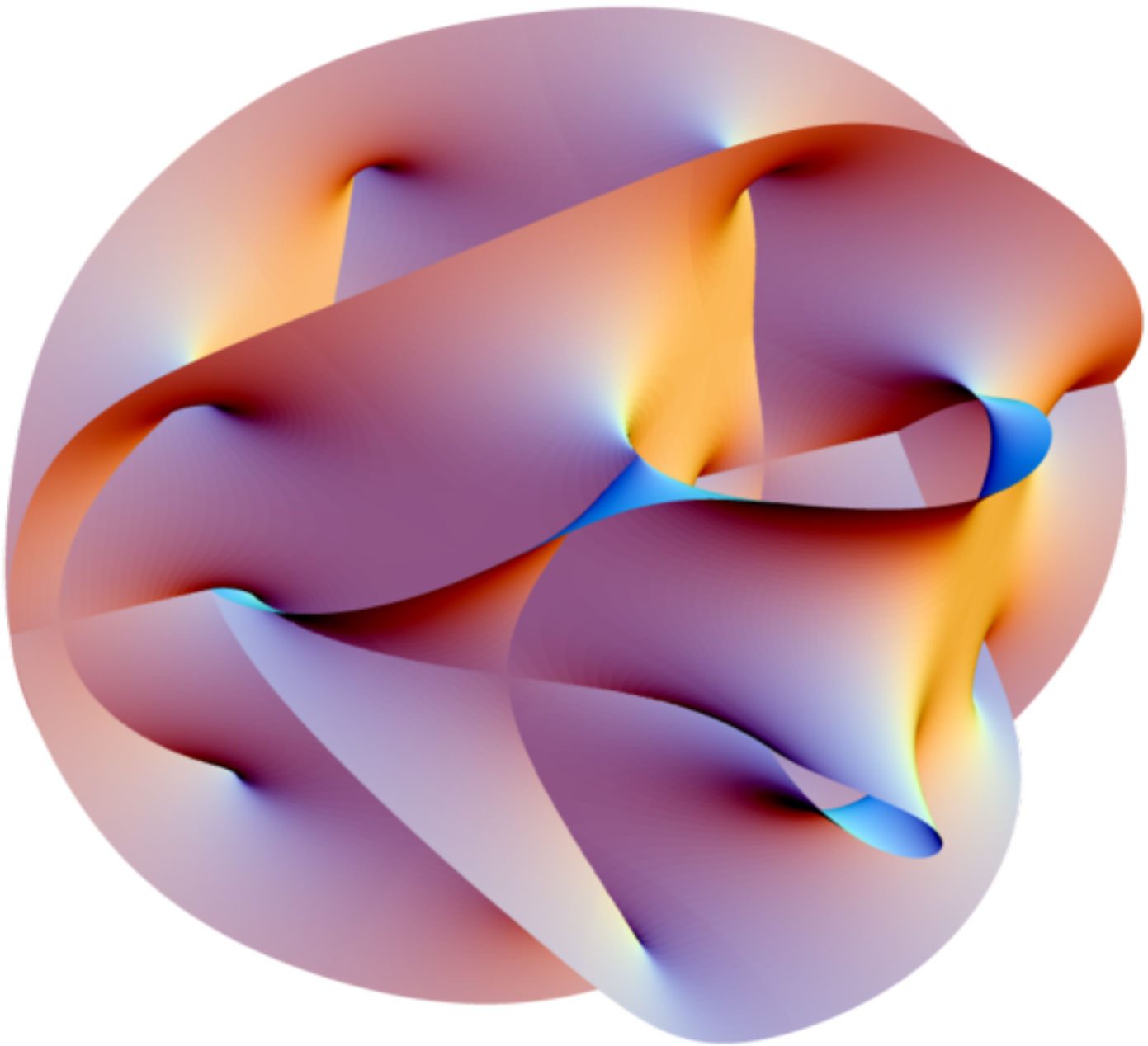
Higgs Bosons



String theory & Calabi-Yau spaces



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Research is the process of going up alleys to see if they are blind

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- Quark gluon plasmas

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May 27th, 2011
Daily Galaxy

"Black Holes are the Engines that Create New Universes" (Today's Most Popular)

"Our own Universe may be the interior of a black hole existing in another universe." In a remarkable paper about the nature of space and the origin of time, Nikodem Poplawski, a physicist at Indiana University, suggests that a small change to the theory of gravity implies that our Universe inherited its arrow of time from the black hole in which it was born.

Poplawski says that the idea that black holes are the cosmic mothers of new universes is a natural consequence of a simple new assumption about the nature of spacetime. Poplawski points out that the standard derivation of general relativity takes no account of the intrinsic momentum of spin half particles. However there is another version of the theory, called the Einstein-Cartan-Kibble-Sciama theory of gravity, which does.

This theory predicts that particles with half integer spin should interact, generating a tiny repulsive force called torsion. In ordinary circumstances, torsion is too small to have any effect. But when densities become much higher than those in nuclear matter, it becomes significant. In particular, says Poplawski, torsion prevents the formation of singularities inside a black hole.

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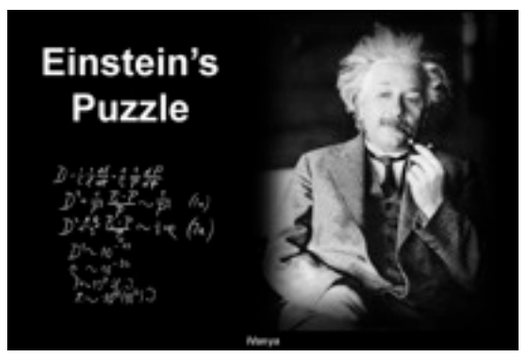

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- Halpern: Collider; Lincoln: large hadron collider
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