# Travel

# Recall Argument Against Travel

Communication is much cheaper than travel

Energy needed for Mass (M) at speed (v)

$E = 1/2 \ Mv^2$      if v much less than c

e.g., travel to nearest star (4 ℓy) in 40 yr

  $\Rightarrow \ v = 0.1 \ c$      $\Rightarrow$      $E = 4.1 \times 10^{-9}$ ergs

                         for M = M (electron)

Photon       $E = h\nu$                      $h = 6.6 \times 10^{-27}$

                                             $\nu$ = frequency

$= 6.6 \times 10^{-18}$ ergs              if $\nu = 10^9$ Hz

Ratio $\sim 10^9$  (and photon gets there in 4 yrs)


100 M watt transmitter - 1 yr

$ 40 \times 10^6$


Spacecraft to nearest star

$\sim$  $ 5 \times 10^{16}$

# Why Consider Travel?

# Reasons for Interstellar Travel

Reasons:

1. Communication if searches fail

2. Exploration of other planetary systems

   Planetary Science

   Exobiology (many bacterial planets)

$$N_\ell = \underbrace{R_* f_p n_e f_\ell L_\ell} \quad L_\ell > 3 \times 10^9 \text{ yr on Earth}$$

|  | Birth Rate | $L_\ell$ | $N_\ell$ |
|---|---|---|---|
| Happy Feller | 20 | $3 \times 10^9$ | $6 \times 10^{10}$ |
| Angela Angst | $5 \times 10^{-4}$ | $3 \times 10^9$ | $1.5 \times 10^6$ |
| Average Guy | 2.2 | $3 \times 10^9$ | $6.6 \times 10^9$ |

# Other Reasons

- Colonization
  - Species Immortality
  - Could survive the end of life on Earth
- The explorer's urge
  - "to boldly go …"

# Pattern of Solar System Exploration

1. Ground-based observations (telescopes)
2. Fly-by missions, Radio back results
3. Orbit or land, Radio back results
4. Mission with human beings
   Return to Earth (Moon Only)
5. Permanent Base (Not Yet)

Expect similar for Interstellar exploration,
**Except**
No Round Trips
Distances to Stars ~ Light Years

$$\text{Time} = \frac{\text{Distance (Ly)}}{\text{Speed (Ly/y)}} \simeq \frac{4 \text{ Ly}}{0.1 \text{ c}} = 40 \text{ yr}$$

Round trip = 80 y

# Project Daedalus

Design study for Fly-by
Barnard's Star 6 ly away

Inertial confinement fusion
(Ignite pellets of hydrogen w/lasers, particles)

Terrestrial fusion: $^2H + {}^3H \longrightarrow {}^4He + n$

deuterium tritium     causes problems

Daedalus:     $^2H + {}^3He \longrightarrow {}^4He + p$

charged, control with mag. Field

$\Delta E = 4 \times 10^{-3}\, mc^2$

Problem:  $^3He$ rare  $\Rightarrow$  Mine Jupiter?

Design:      v = 0.12c          travel for 50 yrs

500 ton payload          54,000 tons at takeoff
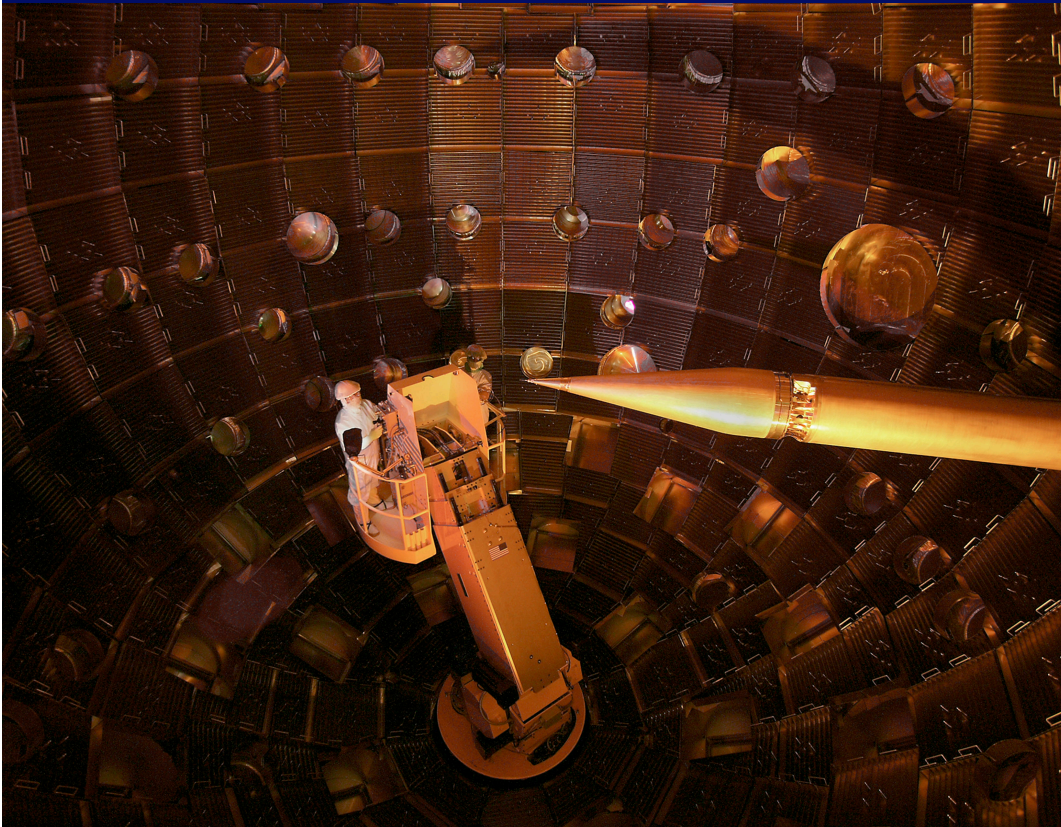                         50,000 tons of fuel


$v_e = 10^4$ km s$^{-1}$          $R_M$ = 12 or 100
                         (payload)

s.i. = $10^6$ sec

# Current Status of Laser Fusion



National Ignition Facility
Livermore National Lab
192 lasers focused on a tiny pellet of deuterium and tritium.
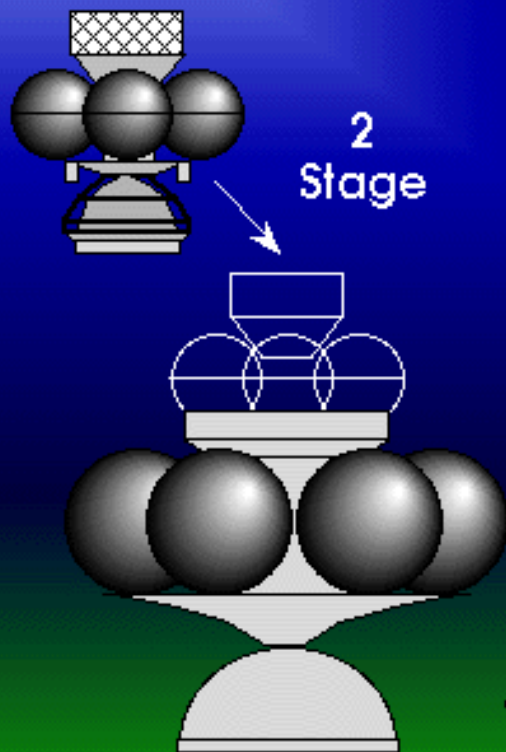Goal is controlled fusion.

Experiments with new lasers released more energy that was put in (Oct. 2013). A long way from being useful still…

https://lasers.llnl.gov/

# Faster Travel?

- If we could travel close to speed of light
- Time Slows down
- Could travel more light years than years on the space ship clock
- Though not on the clock on the home planet

# The Twin Paradox

Twin one

Twin two

Earth

V = .866 C

5 years

clock

Earth

Alpha Centauri

*

Twin two

On-board clock

*

2.5 years

Twin one
(10 yrs older)

Twin two
(5 yrs older)

Gray Hair

Earth

Time measured by Twin two
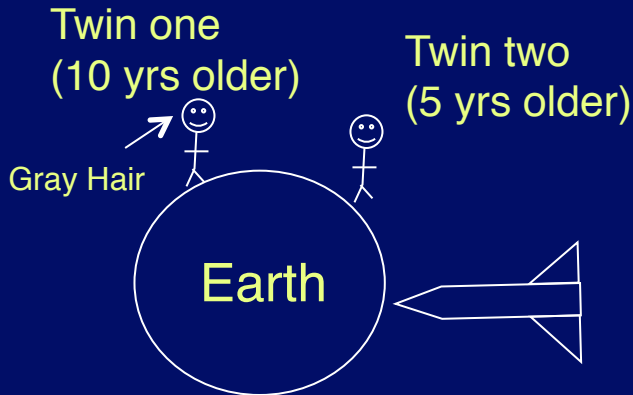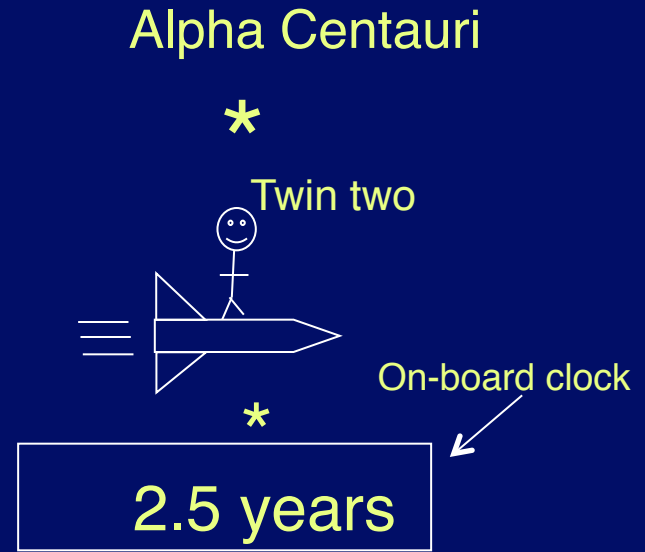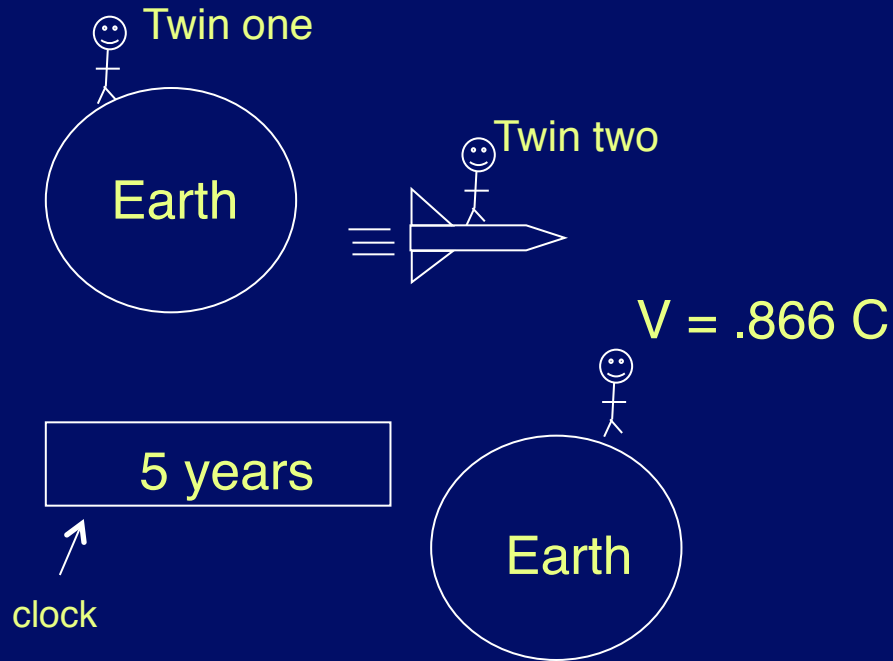
Time measured by
Twin one

$t = \gamma\, t_0$

$* \quad \gamma = \dfrac{1}{\sqrt{1 - (v/c)^2}}$
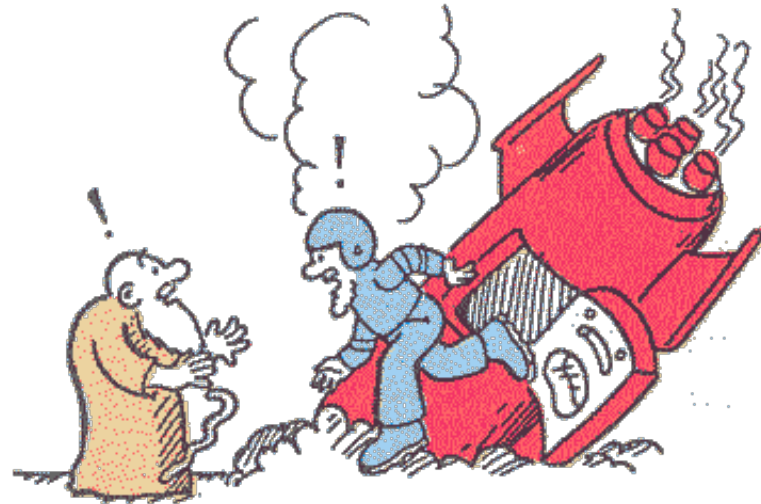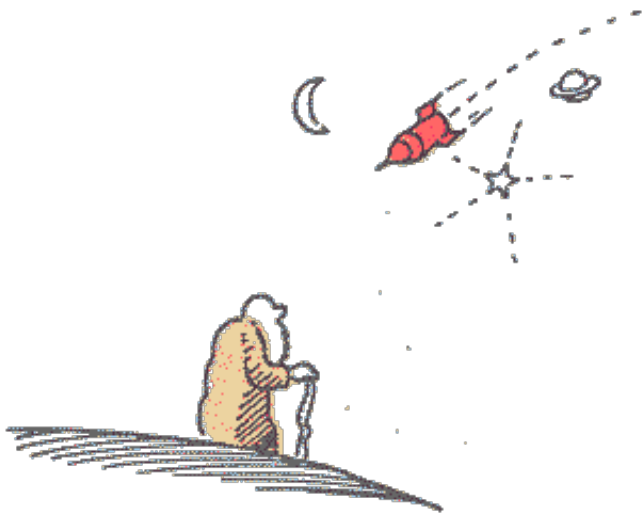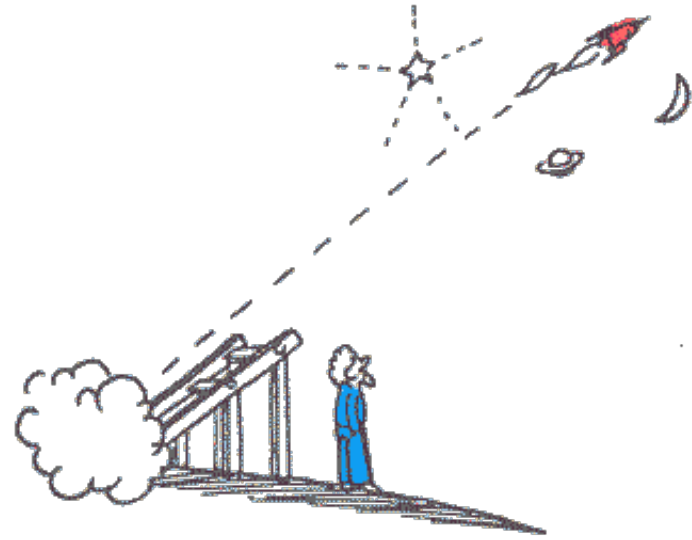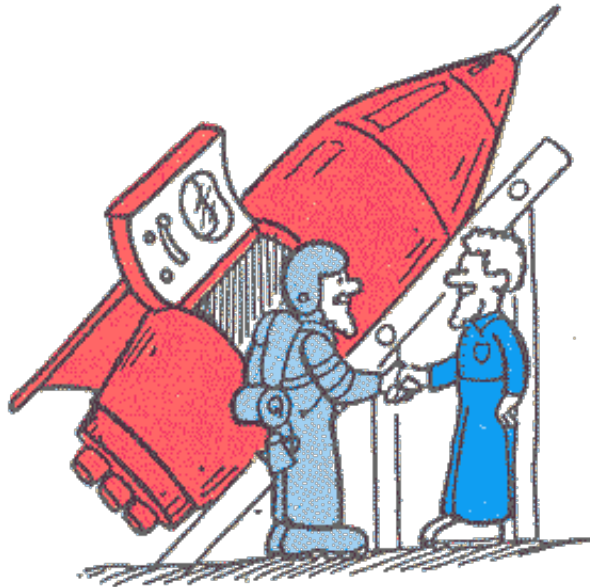
Gamma Function
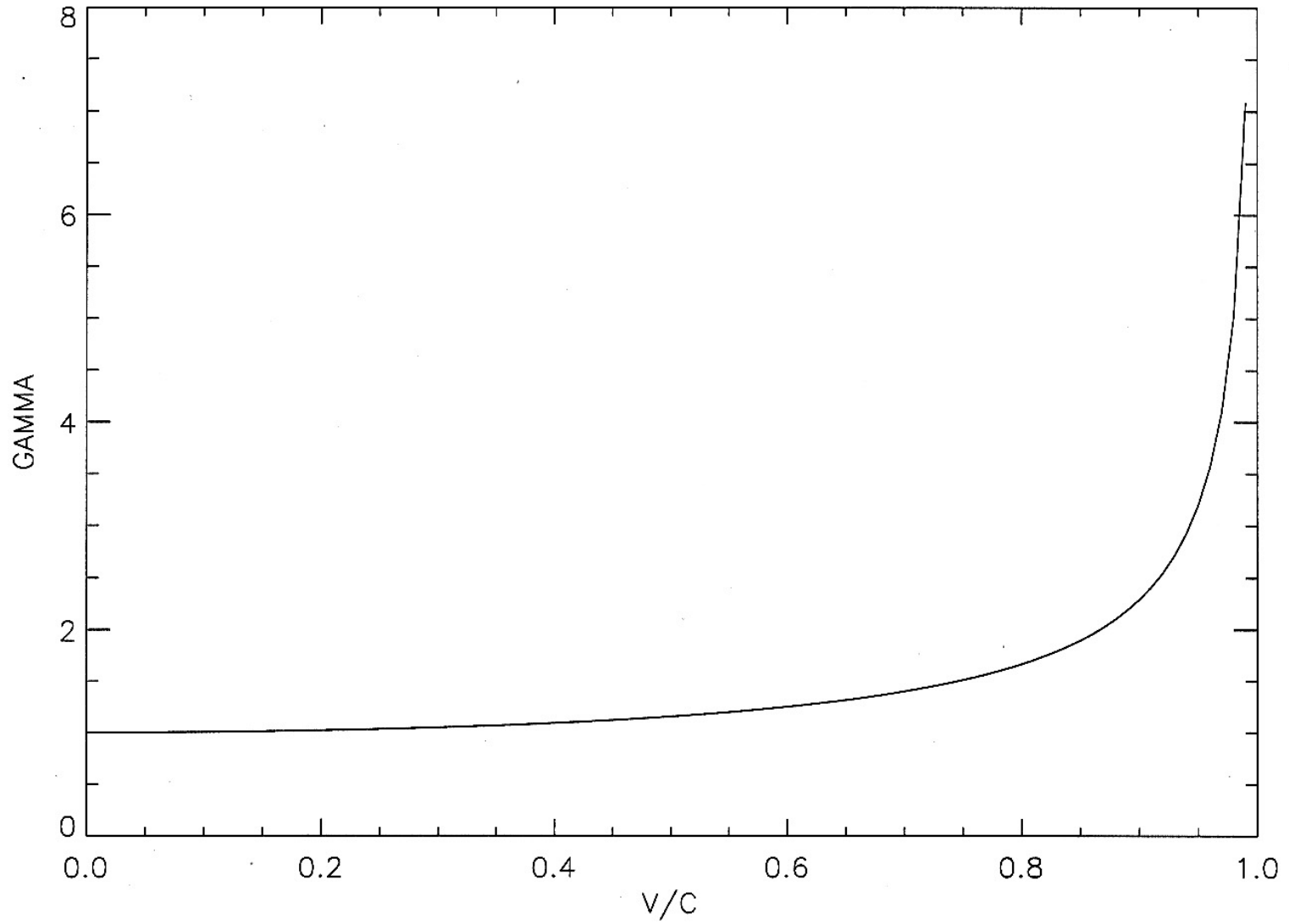
**TABLE 18.2**   Round-Trip Times for Journeys at an Acceleration of 1 g[*]

| Time as Measured by Spacecraft Crew (years) | Time as Measured on Earth (years) | Greatest Distance Reached (light years) | Farthest Object Reached |
|---|---|---|---|
| 1 | 1 | 0.06 | Comets |
| 10 | 24 | 9 | Sirius |
| 20 | 270 | 140 | Hyades |
| 30 | 3100 | 1,500 | Orion Nebula |
| 40 | 36,000 | 17,500 | Globular cluster |
| 50 | 420,000 | 170,000 | Large Magellanic Cloud |
| 60 | 5,000,000 | 2 million | Andromeda galaxy |

[*] Following an example given by Sebastian von Hoerner, we imagine a spacecraft that accelerates at 1 g; that is, the force of acceleration or deceleration equals the force of gravity at the Earth's surface. After one year, such a spacecraft would be moving at a velocity very close to the speed of light.

# Problems with fast travel

- Mass ratio ($R_M$) increases rapidly with v
  - $M = M_o \, \gamma$
  - at v = 0.99c, best possible fuel: $R_M$ = 14
- You have to take fuel to slow down
  - Fuel is payload on the way out
    - $R_M$ = 14 x 14 = 196
- To return you need all this fuel as payload
  - $R_M$ = 196 x 196 ~ 40,000
- And you need antimatter-matter for $R_M$=14

# Future Fantasies?

Consider now some things that are outside physics as we know it, but **might** be possible.

# Wormholes

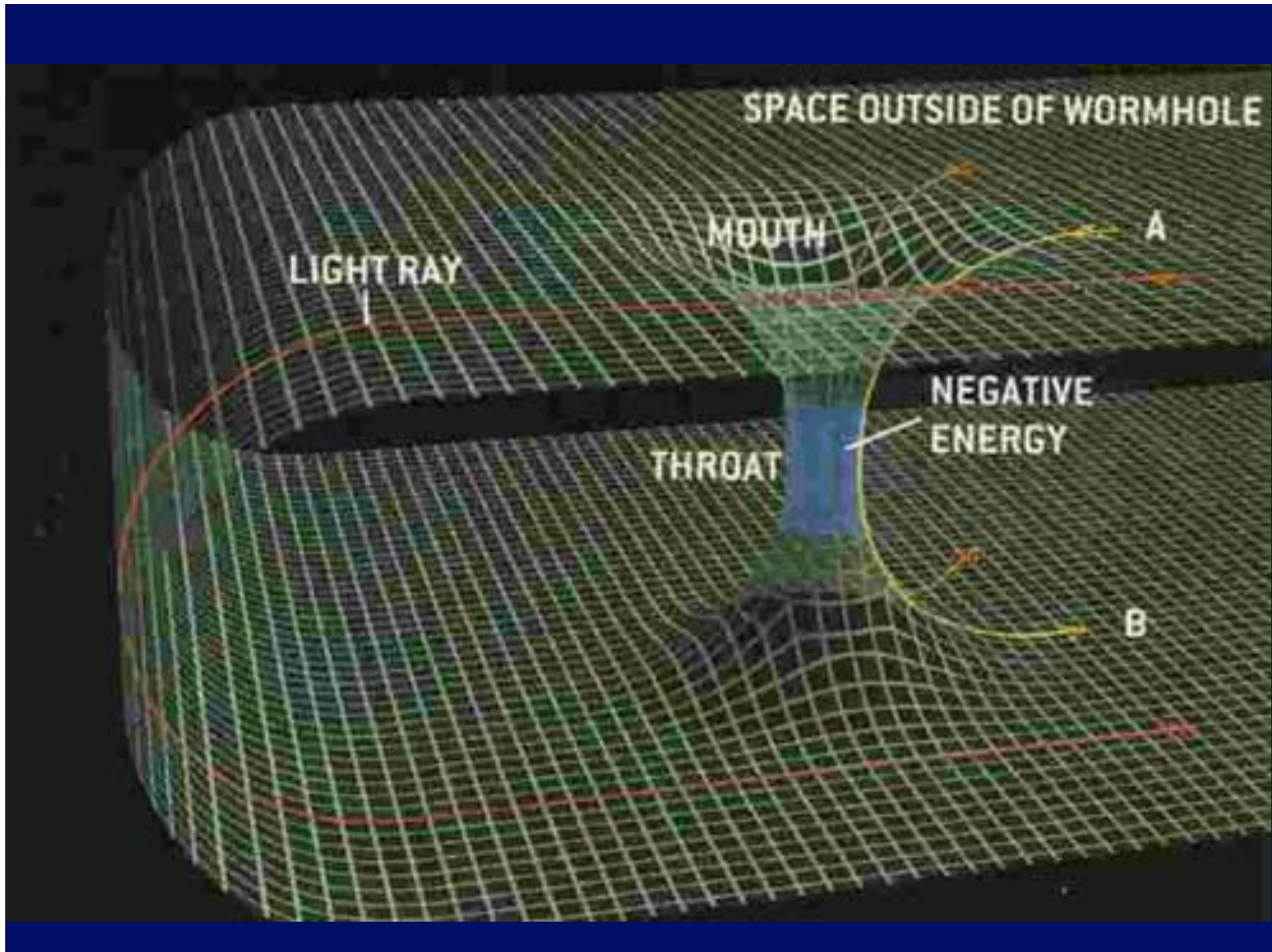General relativity:                    A. Einstein

Matter warps space-time

This warp is gravity

e.g. Black holes pinch off a piece of the

Universe - even light cannot escape

Rotating black hole  $\longrightarrow$  wormhole (maybe)

# Wormholes: Problems…

Unlikely to form when a star collapses

If it forms, it is unstable

Traveler probably cannot pass through

Loophole - stabilize it somehow?
Exotic Matter?

# Warp Drives

Faster than light travel?

Not possible for ordinary matter, physics

$M = \gamma\, M_0 \Rightarrow \quad M \rightarrow \infty$ as $v \rightarrow c$

Loophole:

c is a speed limit for motion **in** space-time

not **of** space-time

e.g., The space-time of the universe expanded

faster than c during **very** early **inflationary**

expansion

# Back to Reality

- Hard to decide if very advanced civilizations might develop such schemes
- Use only laws of physics as constraint - apply to all civilizations, no matter how advanced their technology

# Colonization

Assume Daedalus technology      (v = 0.1 c)

$$t = \frac{d_*}{v} \sim \frac{4 \text{ ly}}{0.1} = 40 \text{ yrs}$$

Multi-generational travel
(space colony + propulsion)

How long to colonize galaxy?

# Colonization

$$t_{gal} = \frac{r_{gal}}{v_{exp}}$$

$$v_{exp} = \frac{2d_*}{t} \qquad\qquad t = \frac{d_*}{v} + t_{reg}$$

e.g.    $v = 0.1\ c$      $t_{reg} = 500$ yr
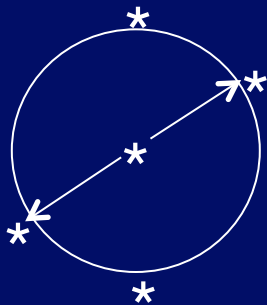
$$\Rightarrow\ v_{exp} = \frac{4\text{ ly x 2}}{540} \simeq 0.015\ c$$

If $r_{gal} = 80 \times 10^3$ ly        $t_{gal} = \dfrac{80 \times 10^3}{1.5 \times 10^{-2}}$

$$\sim\ 50 \times 10^5$$

$$5 \times 10^6 \text{ yr}$$

# Colonization

Time available:  Age of galaxy minus time for first advanced civilization to arise:

$10 \times 10^9 - 5 \times 10^9 \simeq 5 \times 10^9$

$t_{colonization} << t_{Galaxy}$

How likely?

How many civilizations ever developed?

# Colonization

$$\text{Birthrate} \times \text{age of Galaxy} = N_{(ever)}$$

| | | | | |
|---|---|---|---|---|
| Happy Feller | 20 | $\times$ | $5 \times 10^9$ | $= 2 \times 10^{11}$ |
| Angela Angst | $5 \times 10^{-8}$ | $\times$ | $5 \times 10^9$ | $= 250$ |
| Average Guy | 0.94 | $\times$ | $5 \times 10^9$ | $= 4.7 \times 10^9$ |

If even **one** of these decided to colonize, it should already have happened!

Possible consequences:
1. Galactic community
2. Solar-system has been visited
3. Solar-system being monitored
4. Solar-system leakage radiation detected?

# Hart Hypothesis

Fact:   There are no intelligent  beings from outer
Space on the Earth now.

Only 5 possible explanations:
1.   Space travel is not feasible
2.   Civilizations **chose** not to colonize
3.   Not enough time to colonize galaxy
4.   The Earth was visited but they did not colonize
5.   There are no other advanced civilizations

# "Answers" to the Hart Hypothesis

1.  Colonization may be much slower
    $10^6$ yr regeneration $\rightarrow$ $t_{colon}$ > $10^{10}$ yrs

2.  Nomads/explorers make trips, not colonists!

3.  May be harder to adapt to life on a new planet than "we" think.
    We need 20 essential amino acids

4.  Optimist's time scale for colonization > t for biological evolution
    Maybe >>

5.  Possible development of "ecological ethic"
    Do not interfere

6.  They <u>are</u> here!   UFO's

# Have We Been Visited?

# Visits in the Past?

- In historical times?
- Erich von Daniken is most famous promoter
  - Pyramids, precision stone work
  - Drawings on Nazca plain
  - Easter island statues
  - Note western bias
    - No need for aliens to help with Stonehenge

# Ongoing visits?

- Flying saucers (after WWII)
- Neutral term: Unidentified Flying Objects (UFOS)
- Evidence is primarily anecdotal

# Reliability

e.g. Night advertising aircraft

< 10% correctly described these

$\Rightarrow$    Unreliable witnesses $\Rightarrow$ some ordinary
objects will fall into UFO category

# Statistics of UFO cases

90% of UFOs eventually identified  (IFO)

No difference between UFOs and IFOs
in time of day, duration, age or gender of
witness, occupation, or UFO interest

Both UFO and IFO incidents involve people
who, on average, are much more interested
in UFOs.

# Attitudes of Scientific Community

Generally much more skeptical

Repeated studies found no evidence of alien connection

2 studies suggested UFOs worthy of further research

1. Allen Hynek
   → Categories

2. Stanford Panel 1997

   Peter Sturrock, von Eshleman, Thomas Holzer

"Deserves Scientific Study" but no evidence of

"involvement of an extraterrestrial intelligence"

# Categories of UFOs

1. Nocturnal lights

   Clear weather, usually 8-11 PM

2. Daylight Disks

   Usually disks, some cigar shaped

3. Radar-visuals

   Detected by radar as well

4. Close encounters

   First Kind - UFO seen closer than 500 feet

   Second Kind - Physical effects - burnt vegetation, electrical problems

   Third Kind - Observation or encounter with Aliens

   A. Hynek

# Detection of Alien Spacecraft

Matter-antimatter annhilation $\rightarrow$ $\gamma$-rays

We have $\gamma$-ray detectors on satellites

1. Military - to watch for nuclear tests

   reported $\gamma$-ray bursts from space

   $\Downarrow$

2. NASA satellite:  Gamma-ray observatory (GRO)
   was in orbit from 1991 to 2000

   could detect annihilation $0.02 \; \dfrac{\text{grams}}{\text{sec}} \left( \dfrac{R}{1AU} \right)^2$

$\Rightarrow$ No spacecraft decelerating within 1 AU with mass
   of ship exceeding 90 grams since 1991.

   $\left[ \text{Assumes electron-positron annihilation for specific numbers} \right]$

Photo by M. Dunham