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 *l*y) in 40 yr

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

for M = M (electron)

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

ν = frequency

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

Ratio ~ 10^9 (and photon gets there in 4 yrs)

100 M watt transmitter - 1 yr

$ 40×10^6

Spacecraft to nearest star

~ $ 5×10^{16}

(some recent analysis questions this conclusion)

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)

$$N_l = \underbrace{R_* f_p n_e f_l L_l}_{\text{Birth Rate}} \qquad L_l > 3 \times 10^9 \text{ yr on Earth}$$

	Birth Rate	L_l	N_l
Happy Feller	50	3×10^9	1.5×10^{11}
Angela Angst	7.5×10^{-4}	3×10^9	2.3×10^6
Average Guy	2.2	3×10^9	6.7×10^9

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

Except

No Round Trips

Distances to Stars ~ Light Years

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

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

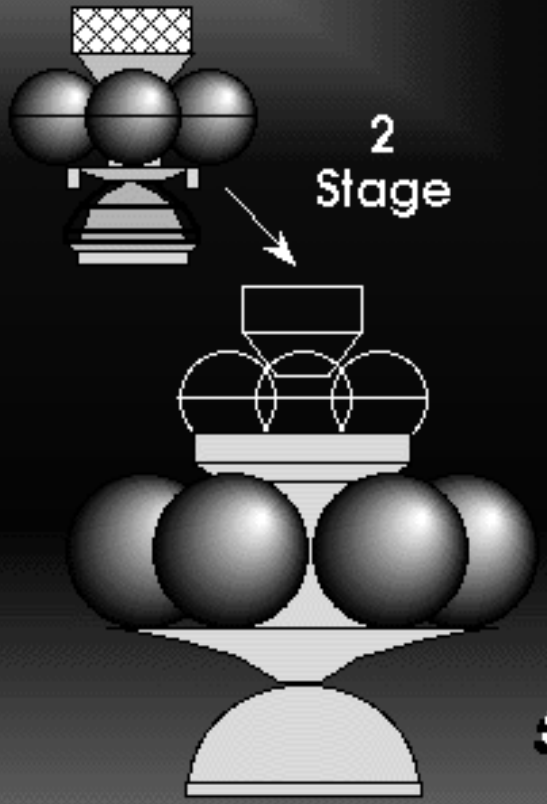
$v_e = 10^4$ km s^{-1}

R_M = 12 or 100 (payload)

s.i. = 10^6 sec

Nuclear Concepts

Project Daedalus
1973-1978
British Interplanetary Society



2 Stage

10^2 T payload

10^6 Isp
12% Light speed

Micro-Fusion explosions
~ 250/sec

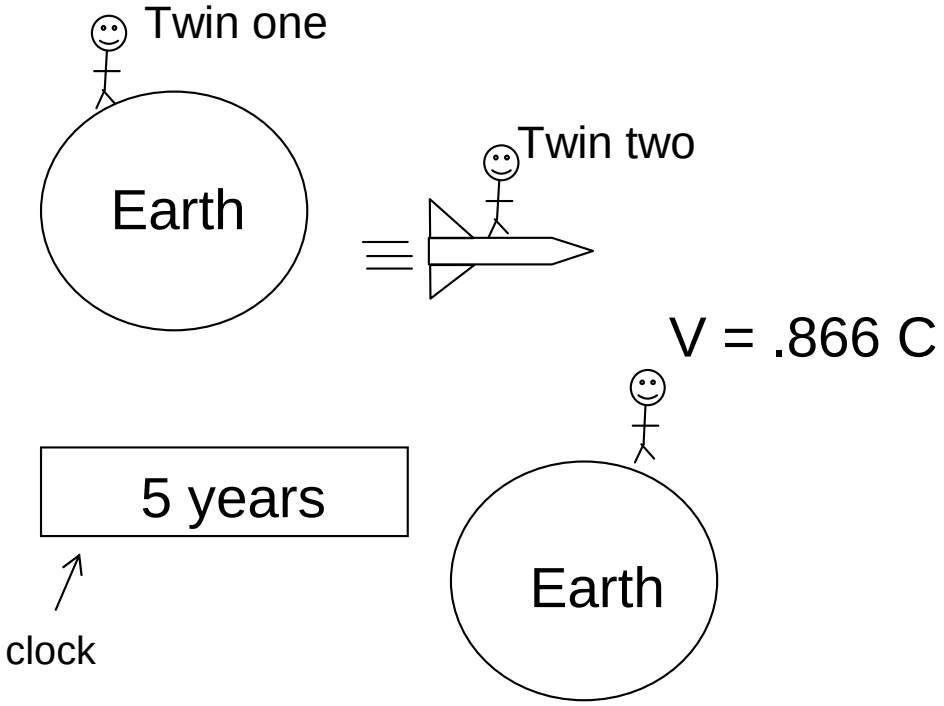
36 YEARS* Interstellar fly-by

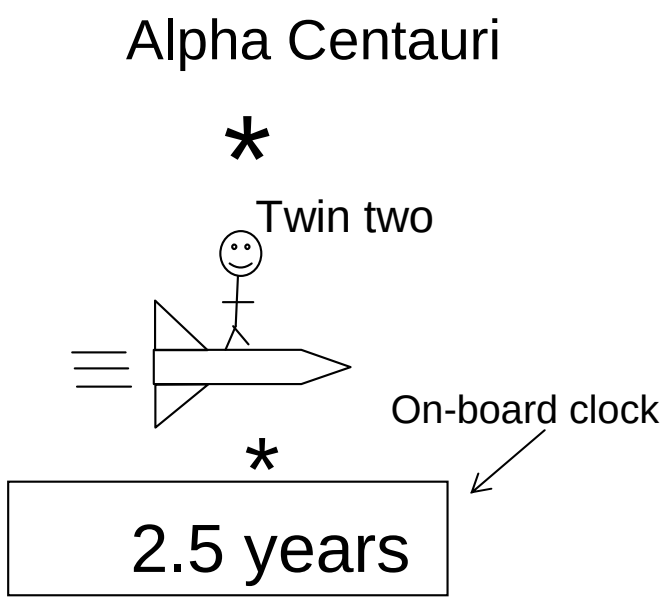
* Was 50 years to Barnard's star ≈5.9LY

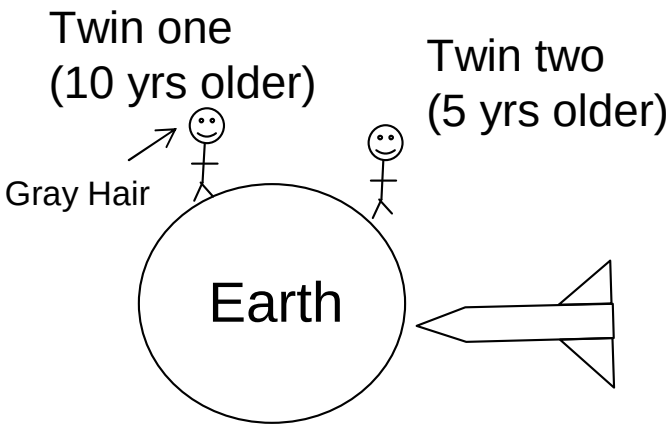
Faster Travel?

- 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

e.g. Twin Paradox







Time measured by Twin two

Time measured by Twin one → $t = \gamma t_0$

* $\gamma = \frac{1}{\sqrt{1 - (v/c)^2}}$

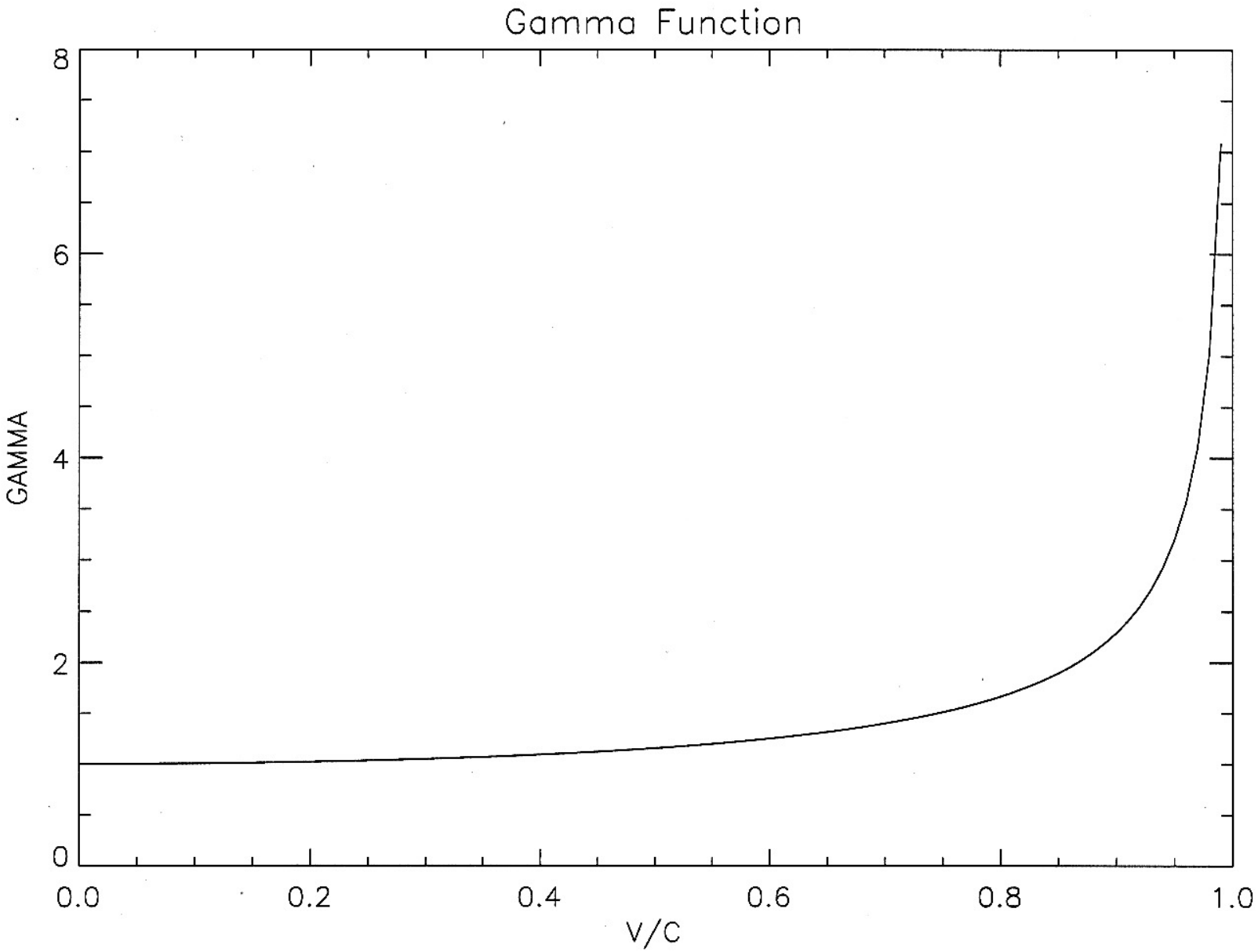

Gamma Function
GAMMA
0
2
4
6
8
0.0
0.2
0.4
0.6
0.8
1.0
V/C

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

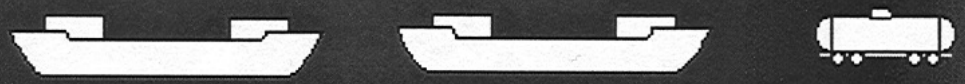
* Following an example given by Sebastian von Hoerner, we imagine a spacecraft that accelerates at 1 g; that is, the force of acceleration or deceleration equals the force of gravity at the Earth's surface. After one year, such a spacecraft would be moving at a velocity very close to the speed of light.

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
    - $R_M = 14 \times 14 = 196$
- To return you need all this fuel as payload
  - $R_M = 196 \times 196 \sim 40{,}000$
- And you need antimatter-matter for R_M=14

Rocket Limitation

Propellant Mass to send one canister past Centauri Cluster within 900 years

Chemical	Fission	Fusion	Ion/Antimatter
(500 sec)	(5,000 sec)	(10,000 sec)	(50,000 sec)
$\approx 10^{137}$ kg	$\approx 10^{17}$ kg	$\approx 10^{11}$ kg	$\approx 10^{5}$ kg
	A BILLION	A THOUSAND	TEN
Not enough mass in universe			

Conclusion: we need a

Propulsion Breakthrough ; NO PROPELLANT !

No Propellant?

- Bussard RamJet
  - Scoop up fuel as you go
  - Problems
    - Very diffuse (need huge scoop)
    - Hydrogen is low-grade fuel
    - You want rare $^{2}H + {}^{3}He$

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

Wormholes

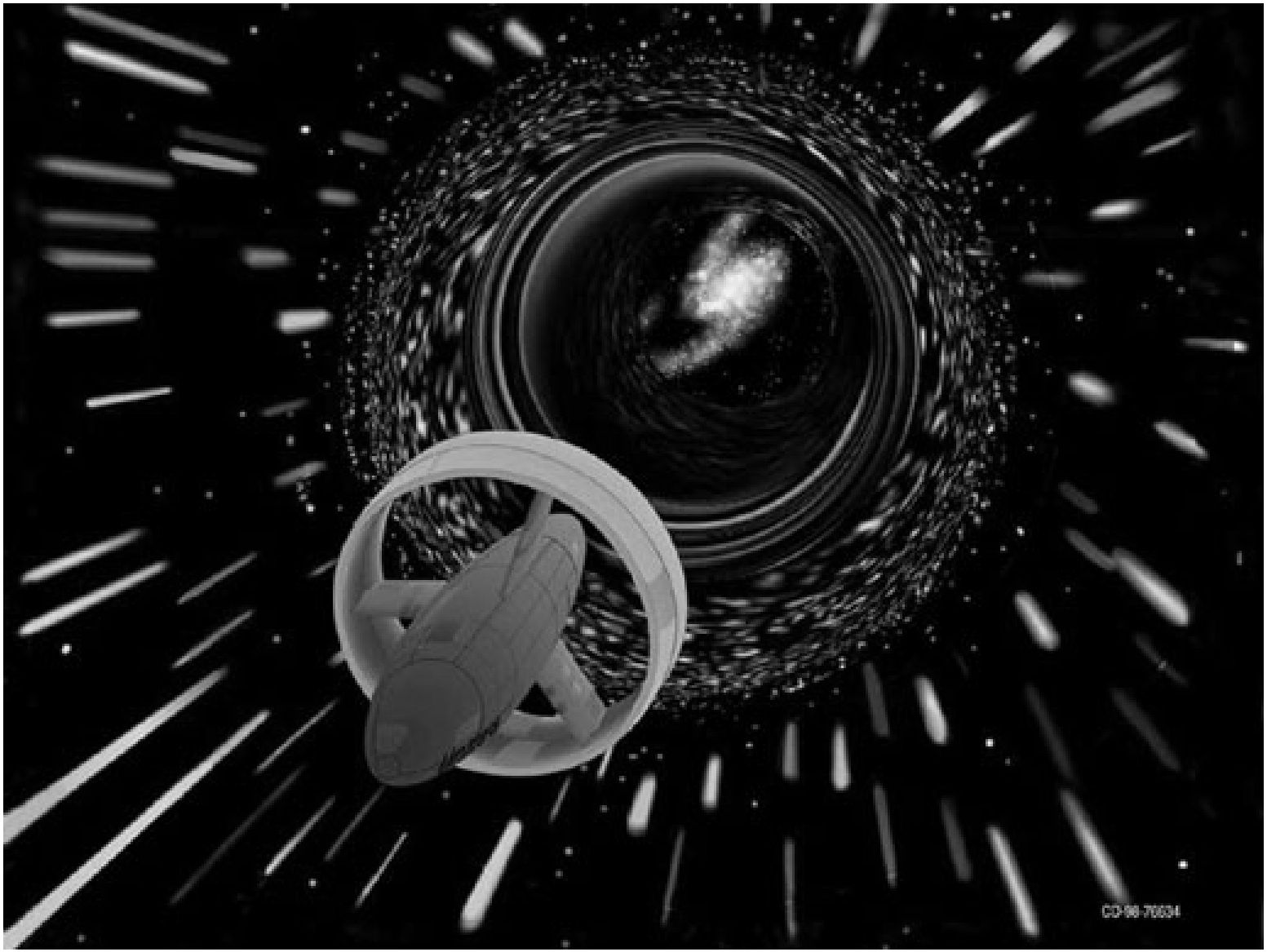
Unlikely to form when a star collapses

If it forms, it is unstable

Traveler probably cannot pass through

Loophole - stabilize it somehow?
Exotic Matter?

View entering a wormhole
artist’s conception



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

The Universe now seems to have a lot of "dark energy"

Source unknown

Acts like antigravity on large scales

Could we ever control this?

Alcubierre Warp

~ 1994 Miguel Alcubierre suggested use of "exotic matter" to surf a space-time distortion

Contract space in front, expand behind

Does exotic matter (negative mass) exist?
Can we control it?
Energy requirements

Originally thought to exceed that available in entire universe

Later calculations are less extreme

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)

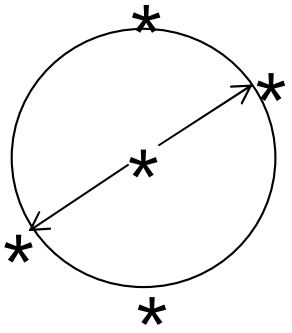
How long to colonize galaxy?

Colonization

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

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

e.g. $v = 0.1\ c$ $t_{reg} = 500$ yr



$$\Rightarrow v_{exp} = \frac{4 \text{ ly} \times 2}{540} \simeq 0.015\ c$$

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

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

t_{gal} << age of galaxy $\quad 5 \times 10^6$ yr

Colonization

With “reasonable” assumption,

$t_{\text{colonization}} << t_{\text{Galaxy}}$

How likely?

How many civilizations ever developed?

(Time available: 10×10^9 - $5 \times 10^9 \simeq 5 \times 10^9$)

Colonization

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

Happy Feller	50	$\times$	5×10^{9}	=	2.5×10^{11}
Angela Angst	7.5×10^{-8}	$\times$	5×10^{9}	=	375
Average Guy	0.93	$\times$	5×10^{9}	=	4.7×10^{9}

If even <u>one</u> 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?

Bracewell Probes

Unmanned

Orbit around another star

Wait for civilization to appear

Establish contact

Radio results to Earth

Is there a Bracewell Probe in Solar System?

Long-delayed echoes (1- 30 sec)

Duncan Lunan 1973

$\rightarrow$ Epsilon Boötes (Binary star)

$\rightarrow$ Contact attemped
now discounted

If use Daedalus technology (fusion)

$R_M = 150$ (need to decelerate)

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
which, on average, are much more interested
in UFOs.

Statistics of UFO belief

"UFOs are extraterrestrial visitors"

40 - 50% of people nationally

Previous class	Yes (before class)	Yes (after class)
UFOs exist?	68% (65%)	40 - 50%
If Yes, controlled by E.T.?	76% (50%)	45 - 55%

Expect this class to attract more believers, BUT

Austin also seems more credulous

Student polls 1983, 1995

~ 80% Believe in UFOs

Education:	High School or Less	Doctorate or Working on it
	62%	88%

50% believe Government covers up UFO evidence

What we Believe

	1983	1995
1. ETs are friendly	84%	53%

	1995	
2. ETs are friendly	males	females
	47%	58%

3. By ethnicity

	Asian-Am	African-Am	Hispanic	White
Believe in UFOs	35%	61%	77%	81%

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 $\rightarrow$ γ-rays

We have γ-ray detectors on satellites

1. Military - to watch for nuclear tests

   reported γ-ray bursts from space

   $\Downarrow$

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

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

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

(Assumes electron-positron annihilation for specific numbers)

Case Study: The Roswell Incident

1947 Rancher finds strange debris

Rumors of “flying saucer”

Attributed to weather balloon

1978 Marcel (Intelligence officer at AFB in 1947)

Talks to *Inquirer* $\rightarrow$ big UFO interest

Claims of Exotic Matter (originally balsa wood, tin foil, rubber, tape, paper)

Claims (& movies) of Alien Autopsy

Claims of a Government cover-up

Case Study: The Roswell Incident

~ 1994 -1995 Congressional inquiry → GAO

↓

USAF finally tells the story

<u>Project Mogul</u>

High altitude balloons to “listen” for nuclear bomb detonations (it did detect 1st Soviet bomb - 1949)

But winds → pushed balloons out of range → discontinued in 1950

One tracked to near where debris found - then contact lost

Photos of debris match description of Mogul balloons

Secrecy → Conspiracy theories