Warping About the Universe and Ship Detection by GLAST

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GLAST for Lunch

The physics for traveling anywhere in the Universe in less than a human lifetime.

1) Elevator from Earth to Space

    Design
    Materials
    Mass of elevator
    Electric cost / Kg to climb out of Earth's potential

2) Special Relativity - One Gravity Acceleration trips

    1 g x 1 year = 1.0 Lorentz Boost
    Warp (from Star Trek)
    Galactic and Inter-Galactic trips
    Radiation dangers to traveler (p,e,γ)

3) The Ship

    Initial mass
    Relativistic exhaust
    Matter/anti-matter, BH?
    Radiation shield
    Septum Torroid
    Braking
    Ship design

4) Signatures of present travelers

    Going away ships
    Approaching ships
        Already seen?

Elevator From Earth to Space

(Movie)

- Cable attached to the Earth's surface at the equator (ship in ocean).
- Cable extends beyond geosync orbit to a counter weight.
- Climb cable using electricity ($2/Kg) vs (Shuttle=$20,000/Kg).
- Climber can return material to Earth (no reentry and heat shields)
- Can climb beyond geosync, let go, and be flung into space.
- New materials (carbon nanotubes) make it possible….

  If nanotubes can be woven, matrixed, or grown into a cable.
- Cable is tapered to make it less massive.
- Engineering challenges
  - Space debris, airplanes, lightning, sabotage cutting cable
  - Oxidation of the cable
  - Powering the climber
  - Damping oscillations of the cable…………etc.

http://www.elevator2010.org/site/primer.html
Elevator primer, movie, NASA prizes for Teather and Climber progress

http://www.isr.us/spaceelevatorconference/2004presentations.html
NASA and Los Alamos sponsored conference.

http://en.wikipedia.org/wiki/Space_elevator
Encyclopedia article

http://www.islandone.org/LEOBiblio/CLARK1.HTM
Arthur C. Clarke, some history,

http://www.liftport.com/index.php
Companies are forming….invest now!!

Many of us first read about the Space Elevator in Arthur C. Clark's "Fountains of Paradise" (1978)

Tapered Elevator Cable

$A = [m^2]$ Cross section area of cable

$S = [N/m^2]$ Stress in cable (same all along cable by adjusting area)

$\rho = [Kg/m^3]$ Density of cable

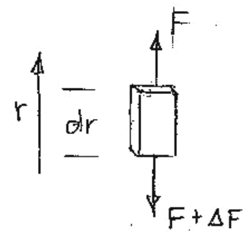
$g = 9.8\ m/sec^2$ = Acceleration at surface of Earth

$r_e = 6.4 \times 10^6\ m$ = Radius of Earth

$\omega = \frac{2\pi}{86{,}400}\ rad/sec$ = Angular velocity of Earth's rotation

SdA

$$dF = \rho A\, dr \left(g \frac{r_e^2}{r^2} - \omega^2 r \right)$$



$$d(\ln A) = \frac{\rho}{S} \left(g \frac{r_e^2}{r^2} - \omega^2 r \right) dr$$

$$\boxed{\frac{A(r)}{A(r_e)} = e^{\frac{\rho}{S} \int_{r_e}^{r} \left(\frac{g r_e^2}{r^2} - \omega^2 r \right) dr}}$$

Notice $\frac{\rho}{S}$ should be as small as possible so $\frac{A(r)}{A(r_e)}$ doesn't blow up

	ρ $[Kg/m^3] \times 10^3$	S $[N/m^2] \times 10^9$	$\frac{(\rho/S)}{(\rho/S)_{Carbon\ Nano\ Tube}}$
Carbon Nano Tube	~ 2.2	69.	1.0
Kevlar 49	1.44	4.	11.
Titanium (alloy)	4.54	.8	178.
Aluminum (2014-T6)	2.70	.4	212.
Steel (High Strength)	7.87	.7	352.

eg: $\text{Area Ratio}_{Steel} = \left(\text{Area Ratio}_{Carbon\ Nano} \right)^{352}$!!

Space Elevator

$rearth := 6.4 \cdot 10^{6}$ [meters] Radius of the Earth

$g := 9.8$ [m/sec2] Acceleration of gravity at the Earth's surface

$\omega := \dfrac{2 \cdot \pi}{86400}$ [rad/sec] Angular velocity of the Earth

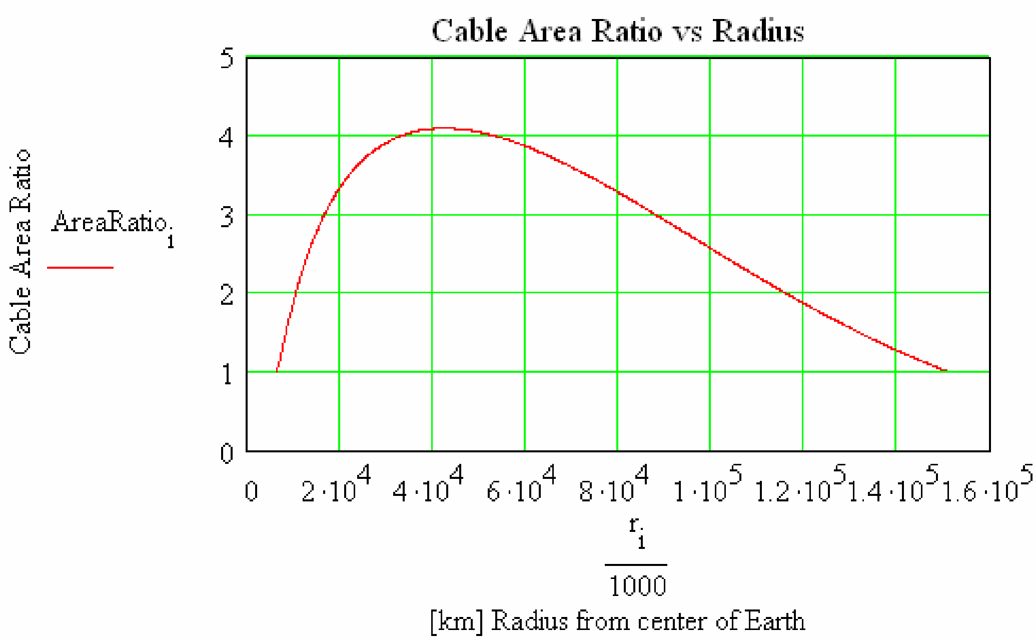
$\rho := 2. \cdot 10^{3}$ [kg/m3] Density of the cable material (Carbon Nano Tubes)

$s := 69. \cdot 10^{9}$ [Newtons/m2] Stress allowed in cable (~1,000,000 psi) (Carbon Nano Tubes)

$GM := g \cdot rearth^{2}$ $\qquad \alpha := \dfrac{\rho}{s}$ $\qquad imax := 1360$ $\qquad i := 0 .. imax$ $\qquad \Delta r := 106 \cdot 10^{3}$

$r_i := rearth + \Delta r \cdot i$

$$LnRatio(r) := \alpha \cdot \int_{rearth}^{r} \left(\frac{GM}{r^{2}} - \omega^{2} \cdot r \right) dr \qquad AreaRatio_i := e^{LnRatio(r_i)}$$



$igeosync := 339$

$AreaRatio_{igeosync} = 4.091$ [ ] Max ratio at Geosync

$\dfrac{r_{igeosync}}{1000} = 4.233 \cdot 10^{4}$ [Km] Geosyn radius

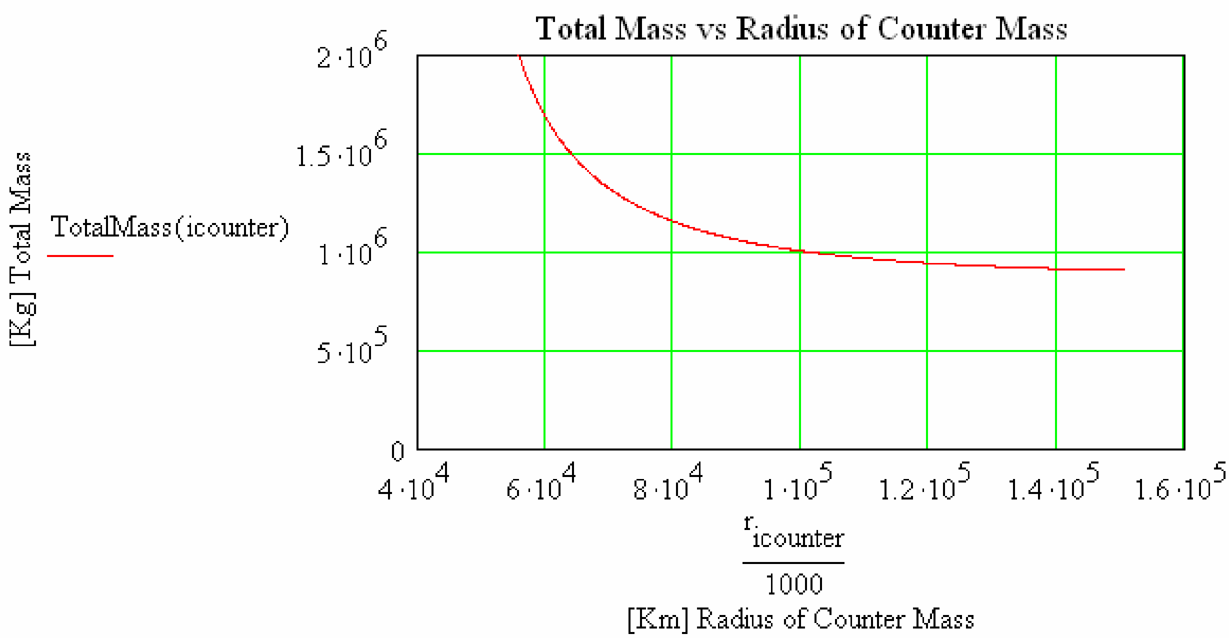
Assume the cable is $(1\ \text{mm})^2$ at the Earth. Assume the cable continues past Geosync to $r_{icounter}$. Hang a counter weight here. The centrifugal force on the counter weight balances the remaining downward load of the cable.

Calculate the total mass as a function of where the counter weight is hung.

$\text{Abottom} := \left(10^{-3}\right)^2$ [m^2] Cable area at the Earth end

$$\text{TotalMass}(\text{icounter}) := \left| \begin{array}{l} \text{CableMass} \leftarrow \rho \cdot \text{Abottom} \cdot \Delta r \cdot \displaystyle\sum_{i=0}^{\text{icounter}} \text{AreaRatio}_i \\ \text{CounterMass} \leftarrow \dfrac{s \cdot \text{Abottom} \cdot \text{AreaRatio}_{\text{icounter}}}{\omega^2 \cdot r_{\text{icounter}} - \dfrac{GM}{\left(r_{\text{icounter}}\right)^2}} \\ \text{Total} \leftarrow \text{CableMass} + \text{CounterMass} \\ \text{Total} \end{array} \right.$$

$\text{icounter} := 400 .. \text{imax}$



Therefore, the minimum total mass that must initially be rocketed to orbit is ~1000 tons.

Elevator Costs

1) Electric cost to lift 1 Kg out of Earth's potential

$$\frac{V}{m} = \frac{GM_E}{r_E}$$

$$= g r_E = (9.8 \ m/sec^2)(6.4 \times 10^6 m) = 6.3 \times 10^7 \ \frac{joules}{Kg}$$

$$= 17.5 \ \frac{Kw\text{-}hrs}{Kg}$$

$$\sim \$2/Kg \ @ \ \$.11/Kw\text{-}hr$$

2) Rocket cost for the initial 10^3 tons to orbit

$$= (10^6 \ Kg)(2 \times 10^4 \ \$/Kg)$$

$$= \$ \ 20 \times 10^9$$

The cable then lifts its own construction materials and grows $\times 100$ to 10^6 tons

$$= \$2/Kg \times 10^9 \ Kg$$

$$= \$ \ 2 \times 10^9$$

3) Research, design, climber, base station, top station, ...

$$= \$ \ ? \times 10^9$$

Special Relativity

1) Boost in X direction by λ ("Lorentz Boost Parameter")

$$\begin{pmatrix} Pc \\ 0 \\ 0 \\ E \end{pmatrix}_{New} = \begin{pmatrix} \cosh\lambda & 0 & 0 & \sinh\lambda \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ \sinh\lambda & 0 & 0 & \cosh\lambda \end{pmatrix} \begin{pmatrix} Pc \\ 0 \\ 0 \\ E \end{pmatrix}_{old}$$

$$\frac{v}{c} = \beta = \tanh\lambda$$
$$\gamma = \cosh\lambda$$
$$\beta\gamma = \sinh\lambda$$

2) Spaceship (as viewed by traveller) aquires Δv in the next $\Delta\tau$

Acceleration

$$a = \frac{\Delta v}{\Delta\tau} = c\,\frac{\Delta\beta}{\Delta\tau} = c\,\frac{\Delta\lambda}{\Delta\tau}$$

since $\Delta\beta = \tanh\Delta\lambda \sim \Delta\lambda$ for $\Delta\lambda \ll 1$

$$\Delta\lambda = \frac{a}{c}\,\Delta\tau$$

$\lambda = \frac{a}{c}\,\tau$ since successive boosts $\Delta\lambda$ in the same direction are additive, a = constant acceleration, τ = time in spaceship

For $a = 1$ Earth gravity

$$\lambda = \frac{(9.8\ m/sec^2)(\pi \times 10^7\ sec/YR)}{3.0 \times 10^8\ m/sec} \times \tau\,[YRS]$$

$$\boxed{\lambda = 1.0\,[1/YR] \times \tau\,[YRS]}$$

A constant 1 gravity acceleration gives the traveller a Lorentz boost of 1.0 per year

3) Distance X travelled as seen by an observer on Earth

$$dx = c\beta\, dt \quad \leftarrow \text{Earth time}$$
$$= c \tanh\lambda\ dt$$
$$= c \tanh\lambda \cosh\lambda\ d\tau \quad \leftarrow \text{Ship time}$$
$$= c \sinh\lambda\ d\tau$$

$$X(\tau) = \int^{\tau} \sinh\left(\frac{a}{c}\tau\right) d\tau = \frac{c^2}{a}\left(\cosh\frac{a}{c}\tau - 1\right) \approx \boxed{1\ LYR\ \gamma(\tau)}$$

$$\frac{c}{a}\cdot c = \frac{3\times10^8\ m/sec}{9.8\ m/sec^2} \sim 3\times10^7\,sec \cdot c$$
$$= 1.0\ LYRS$$

<u>Some Typical Trips</u>

Trip	Accell time [Years]	γ at half way	Decell time [Years]	Traveller Time [Years]	Distance Travelled [Lyrs]
Nearest star	1	1.5	1	2	1
Across the Galaxy	10	10^4	10	20	2×10^4
To Andromeda	14.5	10^6	14.5	29	2×10^6
Way Out	21.5	10^9	21.5	43	2×10^9

Notice:

1) Humans are built (strength and lifetime) to travel anywhere in the Universe (albeit.… never to see friends and family again).

2) Star Trek had something correct !

   Warp <10   all episodes within the Galaxy

   Warp ~15   the episode where the Enterprise was hijacked and modified to fly to Andromeda

Therefore:

Lorentz Boost Parameter = Warp (which is easier to say) !!!

Radiation Danger to Traveller

$\rho_c \sim 1 \text{ Gev}/\text{cm}^3$

$\Omega_b \sim .02 \quad \longrightarrow \quad .02 \text{ proton}/\text{cm}^3$

Away from stars $\longrightarrow$ $.001?$ proton/cm^3 $=$ 1 proton/m^3

) A traveller sees the space in front of him Lorentz contracted. Striking the front of the ship is a flux

$$f\left[\frac{\text{protons}}{\text{sec m}^2}\right] = \underbrace{\underbrace{1\left[\frac{\text{protons}}{\text{m}^3}\right]\cdot\gamma}_{\text{Lorentz contracted density seen by Traveller}} \cdot c\left[\frac{\text{m}}{\text{sec}}\right]}_{\#\text{ of protons}/\text{m}^2\text{ sec}}$$

$$f = 3\times10^8\,\gamma\left[\frac{\text{protons}}{\text{m}^2\text{sec}}\right] \text{ of relativistic protons}$$

$$\text{Rad Dose} = \gamma\,\cancel{3}\times10^4\left[\frac{\text{protons}}{\text{cm}^2\text{ sec}}\right]\times\cancel{2}\,\frac{\text{Mev}}{\text{cm}}\times\frac{1}{1\,\text{g}/\text{cm}^3}\times\frac{100\text{ rads}}{\cancel{6}\times10^9\,\frac{\text{Mev}}{\text{g}}}$$

$$= \gamma\cdot10^{-3}\left[\frac{\text{rads}}{\text{sec}}\right]$$

$$= \gamma\quad 2600\ \text{rad}/\text{month}$$

300 rads in $\lesssim$1 month is ½ Kill

$\therefore$ Traveller must be shielded

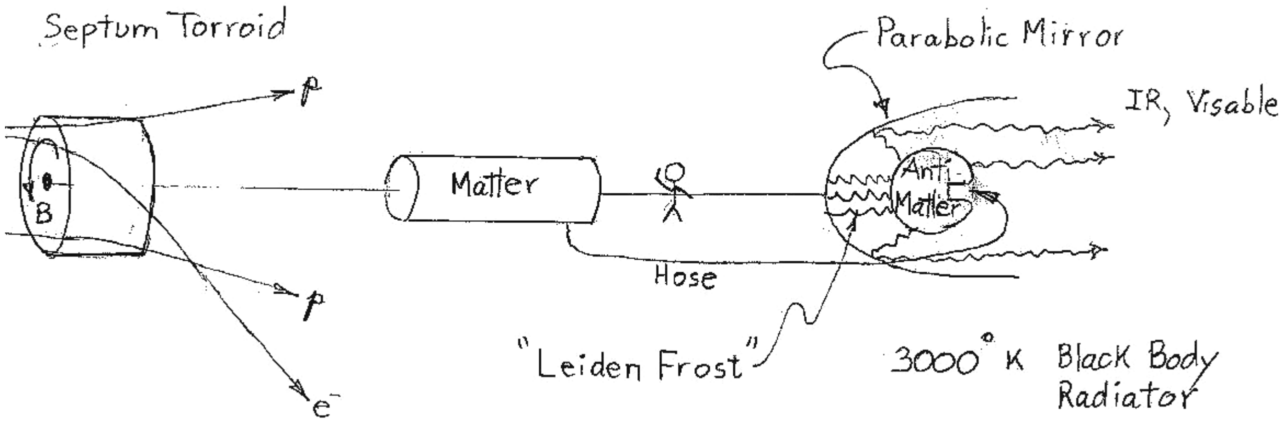
$$\left[\frac{\text{Energy}}{\text{m}^2\text{ sec}}\right] = 3\times10^8\,\gamma\left[\frac{\text{protons}}{\text{m}^2\text{ sec}}\right]\times1\left[\frac{\text{Gev}}{\text{proton}}\right]\times\underbrace{\gamma}_{\text{Lorentz energy increase}}\times1.6\times10^{-10}\left[\frac{\text{joules}}{\text{Gev}}\right]$$

$$= .048\ \frac{\text{Watts}}{\text{m}^2}\cdot\gamma^2$$

($=$ 4.8 Mwatts for $\gamma = 10^4$ Trip across the Galaxy!)

This can't be absorbed but must be deflected.

The Ship



1) Photon exhaust

   Relativistic $P = E$

   $\lesssim 3$ ev so mirror can reflect them

   $\lesssim 3000°$ K so Anti Ball is solid and IR-Visable γ

2) Matter – Antimatter direct to photons

   No electricity, electronics, Klystrons, etc to make a propulsion beam and generate waste isotropic heat

   $\alpha = 1$ 100% efficient mass → momentum

3) Power W per Kg to accelerate at 1 gravity

$$9.8 \frac{m}{sec^2} = \frac{W/c}{1 \text{ Kg}}$$

$$W = (1 \text{ Kg})(9.8 \text{ m/sec}^2)(3 \times 10^8 \text{ m/sec}) = \boxed{3 \times 10^9 \text{ Watts}}$$

... many practical design problems

Initial Mass

$$m_{ship}\,\Delta v_{ship} = \Delta P_{propellant}$$

$$m_{ship}\,c\,\Delta\lambda = \alpha\,c\,\Delta m_{ship}$$

$$\Delta\lambda = \alpha\,\frac{\Delta m_{ship}}{m_{ship}}$$

$$d\lambda = \alpha\,d\left(\ln m_{ship}\right)$$

$$\lambda = \alpha \ln\left(\frac{m_{initial}}{m_{payload}}\right)$$

$$\boxed{m_{initial} = m_{payload}\,e^{\frac{1}{\alpha}\lambda}}$$

Fuel	α
Mat-Antimat	1
Nuclear Fussion	.04
Chemical	4×10^{-5}

$$\alpha = \frac{p}{m_{proton}} = \sqrt{\frac{2T_{kin}}{m_{proton}}}$$

Notice:

1) Must have $\alpha \sim 1$ or it takes a lot more initial mass.

2) If you accel to λ, then use propellent to decel to $\lambda = 0$,

$$m_{initial} = m_{payload}\,e^{2\lambda}$$

a lot more initial mass !!

$\therefore$ Use propellent to accelerate to λ, but interact with the interstellar rest media to brake to rest.
= "Media Braking"

Media Braking

$\rho_c = 1 \text{ Gev/cm}^3$ $\qquad$ 1 proton/m^3 $\qquad$ $\Omega_x \equiv \frac{\rho_x}{\rho_c}$

$$\Omega_{\substack{\text{protons} \\ (\text{interstellar})}} \sim \frac{.02}{20} \approx 10^{-3}$$

$$\Omega_{\substack{\gamma \\ (\text{CMBR + starlight})}} \sim 5 \times 10^{-5}$$

$$\Omega_{\substack{\text{elec} \\ (\text{interstellar})}} = \frac{\Omega_p}{2000} \approx 5 \times 10^{-7}$$

1) Use the Septum Torroid to turn the interstellar protons 180°

$$\frac{\text{Force}}{\text{Area}} = 2 \times \text{Energy Density} \times \underbrace{\gamma}_{\substack{\text{Density Increase} \\ \text{due to length} \\ \text{Contraction}}} \times \underbrace{\gamma}_{\substack{\text{Energy} \\ \text{increase}}}$$

$$= 2 \times n \left[\frac{\text{protons}}{m^3}\right] \times \left(1 \frac{\text{Gev}}{\text{proton}} \cdot 1.6 \times 10^{-10} \frac{\text{joules}}{\text{GeV}}\right) \times \gamma^2$$

$$= 3 \times 10^{-10} \gamma^2 n \left[\frac{N}{m^2}\right]$$ Not much. Need a big area!

* Steer into hydrogen clouds to increase braking.

2) Reflect γ energy density with a mirror. $\rho_\gamma = \frac{1}{200} \rho_{proton}$

a) 200 times more area than for protons

b) Only short fractions of trip can be spent near stars where the γ energy density is greater

Ship Signatures

Going away – exhaust redshifted

$$\lambda_{earth} = \lambda_{emitted} / \gamma^2$$

$$= 5000 \times 10^{-8} \text{ cm} / (10^4)^2$$

$= 5000$ cm (Radio) ……… (Not for GLAST)

Approaching (and media braking)

GLAST sees Comptoned γs from the turned around electrons.

GLAST sees reflected γs if braking using mirror on γ density.

Cosmic Ray Ground Arrays see the turned around protons.

λ_{ship}	γ_{ship} $=\cosh(\gamma_{ship})$	Photon Braking $= (1\text{eV})\cosh(2\gamma_{ship})$ [GeV]	Electron Braking $= m_e \cosh(2\gamma_{ship})$ [GeV]	Proton Braking $= m_p \cosh(2\gamma_{ship})$ [GeV]
4	2.7×10^1	.000001	.05	1.5×10^3
5	7.4×10^1	.00001	5	1.1×10^4
6	2.0×10^2	.00008	40	8.1×10^4
7	5.5×10^2	.0006	300	6.0×10^5
8	1.5×10^3	.004	2.2×10^3	4.4×10^6
9	4.1×10^3	.03	1.5×10^4	3.3×10^7
10	1.1×10^4	.2	1.2×10^5	2.4×10^8
11	3.0×10^4	2	9.0×10^5	1.8×10^9
12	8.1×10^4	13	6.6×10^6	1.3×10^{10}
13	2.2 x 105	98	4.9×10^7	9.8×10^{10}

Yellow=Mirror on ship can reflect CMBR (3×10^{-4} eV) photons
Blue=GLAST energy photons
Red= End of the Ultra High Energy Cosmic Ray spectra

Ship Signature for GLAST

Calculate the energy flux of γ radiation we would see at Earth from the cosmic photon density Compton scattering on the Ships' braking radiation.

Assume:

1) All ships have the same λ
2) $E_{\gamma\,\text{Compton}} \sim E_{e\,\text{Braking}}$
3) Viewed from Earth, the most probable ship warp is the maximum λ (Since the 1 yr spent there by the traveller $\Rightarrow \cosh(\lambda_{max})$ years on Earth)
4) $\rho = \left[\frac{Kg}{m^3}\right]$ Density of ships
5) $\mathcal{L}_p = 1.5\times10^9 \left[\frac{Watts}{Kg}\right]$ Braking power (in protons) to decellerate 1 kg at 1 grav

$\mathcal{L}_e = \frac{1}{2000}\mathcal{L}_p = 10^6 \left[\frac{Watts}{Kg}\right]$ Braking power in electrons

Fraction of Braking Jets ($\Delta\Omega$ is the jet solid angle in the Earth frame) that point at Earth

$\left[\frac{W}{m^2 Kg}\right]$ seen on Earth

$$\left[\frac{Watts}{m^2}\right]_{Earth} = \int_0^R \left(\frac{\Delta\Omega}{4\pi}\right)\left(\frac{\mathcal{L}_e\cdot\gamma\cdot 2\gamma}{r^2\Delta\Omega}\right)\rho\, 4\pi r^2 dr$$

Lorentz boost of energy

In Earth frame, the time between photons is shorter!!

$$\boxed{\left[\frac{Watts}{m^2}\right]_{Earth} = 2\mathcal{L}_e\gamma^2\rho R}$$

Earth frame $\begin{cases}\Delta t_{Arrive} = \text{Arrival time difference}\\ \Delta t_{Emit} = \text{Emission time difference}\end{cases}$

$\Delta x_{Arrive} = \Delta t_{Emit}\cdot(c - c\beta_{ship})$ Ship gets closer between emissions

$\Delta t_{Arrive} = \Delta t_{Emit}(1-\beta_{ship})$

$\Delta t_{Arrive} = \Delta t_{Emit\,ship}\cdot\cosh\lambda(1-\tanh\lambda)$

$= \Delta t_{Emit\,ship}(\cosh\lambda - \sinh\lambda)$

$\Delta t_{Arrive} = \Delta t_{Emit}\left(e^{-\lambda}\right) \sim \frac{1}{2\gamma}$

$$f = 2\mathcal{L}_e \gamma^2 \rho R$$

The ship boost = λ_{ship}. Viewed from the ship, $\lambda = -\lambda_{ship}$ electron comes in and is turned around to a $\lambda = +\lambda_{ship}$ electron. Boosting back to the Earth frame, the electron then has $\lambda = 2\lambda_{ship}$.

(= One bounce First Order Fermi Acceleration)

$$E_\gamma \sim E_e = m_e \cosh(2\lambda_{ship}) \sim m_e \tfrac{1}{2} e^{2\lambda_{ship}} = m_e\, 2\left(\tfrac{1}{2}e^{\lambda_{ship}}\right)^2 = m_e\, 2\gamma_{ship}^2$$

Comptoned off electron

$$E_\gamma \sim m_e\, 2\gamma_{ship}^2 \qquad \overset{\text{GLAST}}{E_\gamma > 100 \text{ MeV}} \Rightarrow \lambda_{ship} >$$

$$n\left[\frac{\#\text{photons}}{m^2 \text{ sec sterad}}\right]_{\text{Earth}} = \frac{f\left[\frac{\text{Watts}}{m^2 \text{ sec}}\right]}{E_\gamma} \frac{1}{4\pi}$$

$$\boxed{n = \frac{\mathcal{L}_e \rho R}{4\pi m_e}}$$

Independent of γ_{ship}! (as long as $\gamma >$ few so approximations true)

Extragalactic diffuse background measured by EGRET

$$= 1.5 \times 10^{-5} \frac{\text{photons} > 100 \text{ MeV}}{\text{cm}^2 \text{ sec sterad}}$$

$$= .15 \frac{\text{photons} > 100 \text{ MeV}}{\text{m}^2 \text{ sterad}}$$

$$\rho = \frac{4\pi\, n\, m_e}{\mathcal{L}_e\, R} = \frac{\left(4\pi \times .15 \frac{1}{m^2\, sec}\right)\left(.5 \times 10^6 ev \times 1.6 \times 10^{-19}\, joules/ev\right)}{\left(10^6 \frac{joules}{sec \cdot Kg}\right)\left(10^9\, LYRS \times \pi \times 10^7 \frac{sec}{LYR} \times 3 \times 10^8\, m/sec\right)}$$

$$\cong 1.6 \times 10^{-44} \frac{Kg}{m^3}$$

$$= \left(1.6 \times 10^{-44} \frac{Kg}{m^3}\right)\left(10^{16} \frac{m}{LYR} \times 10^6 \frac{LYR}{MLYR}\right)^3 \left(1 \frac{MLYR^3}{galaxy}\right)$$

$$\rho = 1.6 \times 10^{22}\ Kg/galaxy$$

$\therefore$ $2 \times 10^{19} \frac{tons}{galaxy}$ of payload, media braking from $\lambda_{ship} > 6$ would account for the total number of extragalactic diffuse photons measured by EGRET.

How could GLAST separate braking photons from normal astrophysical source?

Spectral Shape?

If all ships had the same λ, there would be a peak at $E_\gamma = m_e (\cosh \lambda)^2$

Ship Detection by UHE Cosmic Rays (Protons)
(AGASA, Flys Eye, Auger, ...)

Same ship density ρ formula

$$\rho = \left(\frac{4\pi \; m_p}{R \; \mathcal{L}_p}\right) n$$

Same as for using e since $\frac{\mathcal{L}_p}{m_p} = \frac{\mathcal{L}_e}{m_e}$

$$\underset{\text{using protons}}{\rho_{ship}} = \underset{\text{Using GLAST}}{\rho_{ship}} \cdot \frac{n_{protons}}{n_\gamma}$$

Area of AGASA bump

$$= \left(2 \times 10^{19} \frac{tons}{galaxy}\right)\left(\frac{10^{-14} \text{ Protons} > 10^{19} \text{eV}/\text{m}^2 \text{ sec ster}}{.15 \text{ Gammas} > 100 \text{ MeV}/\text{m}^2 \text{ sec ster}}\right)$$

$$\boxed{\underset{\text{using protons}}{\rho_{ship}} \sim 10^6 \text{ tons/galaxy}}$$

$\sim (100\,m)^3$ of H_2O

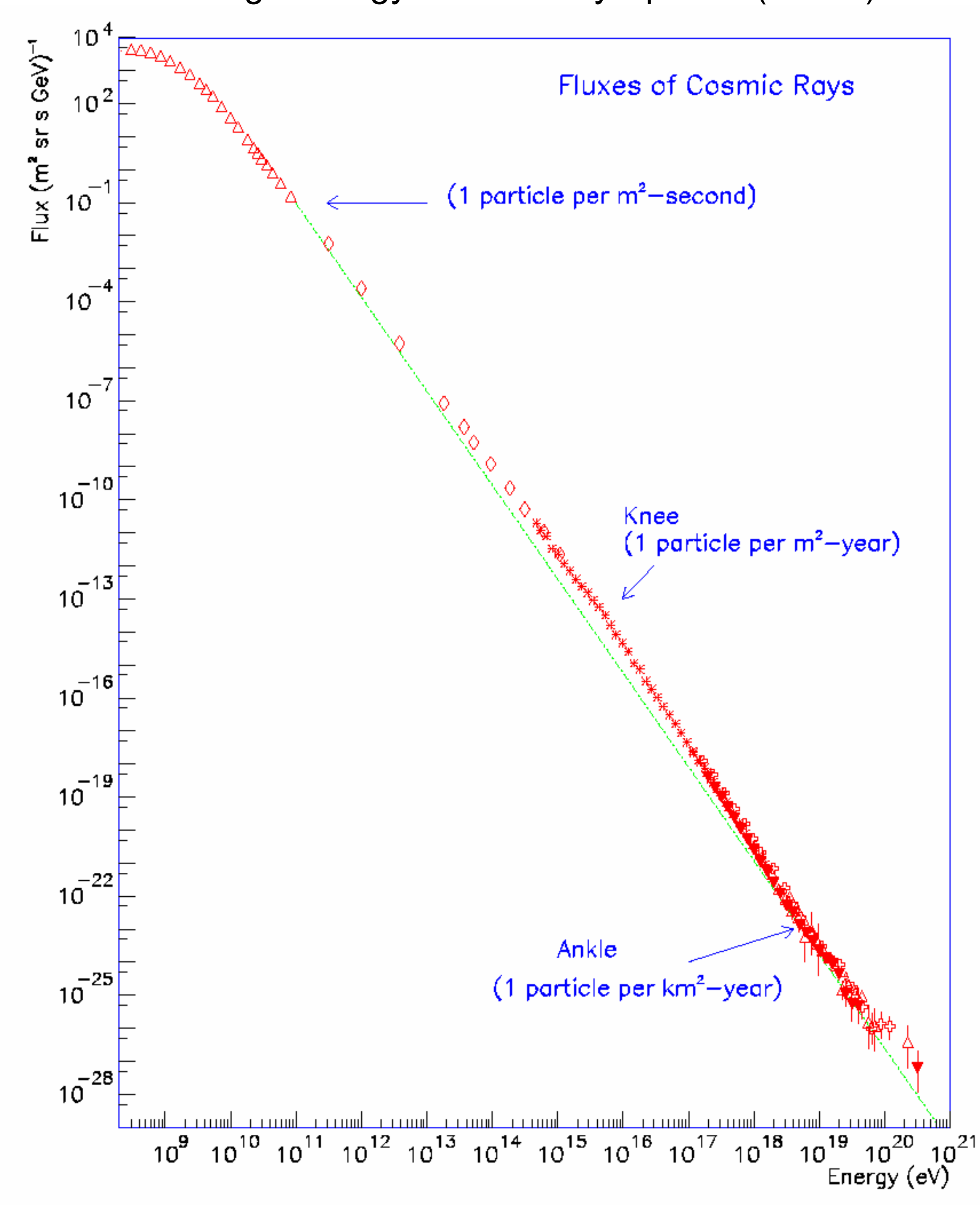
$\sim$ Oil Super Tanker

$\Downarrow$

$\sim$ 1 ship/galaxy explain's AGASA bump !!

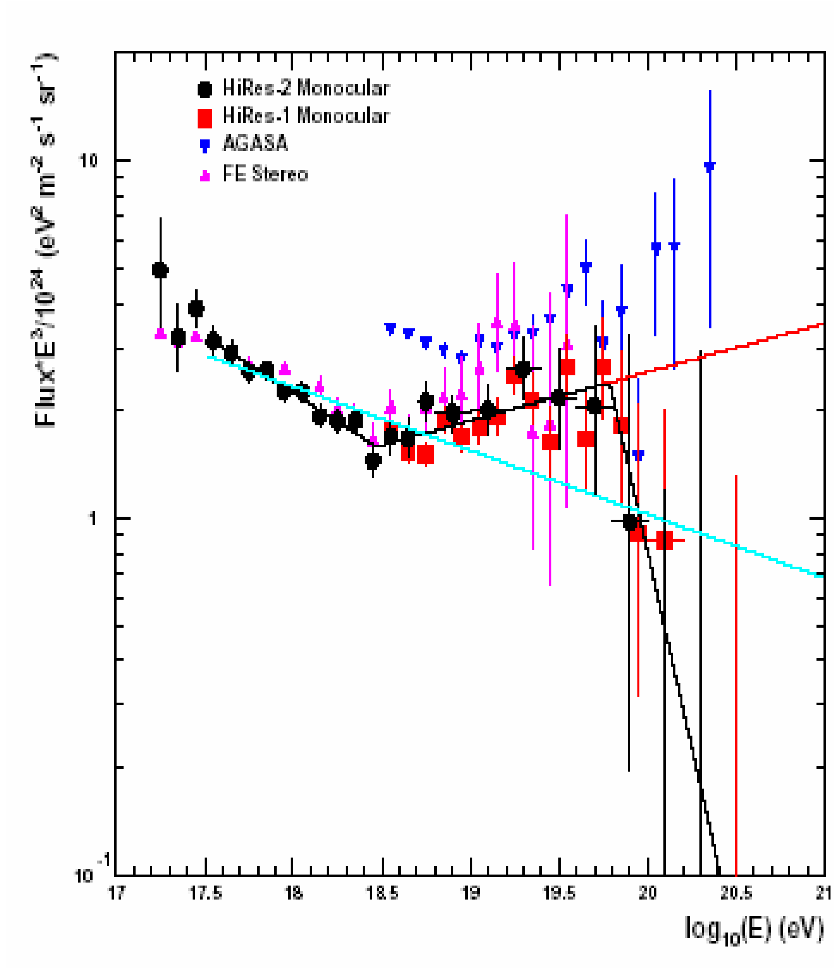
$\lambda_{ship} = 12$ (Galaxy size trip) $\Rightarrow 1.3 \times 10^{19}$ eV protons

Ultra High Energy Cosmic Ray Spectra (HiRes)



http://xxx.lanl.gov/PS_cache/astro-ph/pdf/0501/0501317.pdf

Ultra High Energy Cosmic Ray Spectra



λ_{ship}= 10 11 12 13 14

http://xxx.lanl.gov/PS_cache/astro-ph/pdf/0501/0501317.pdf

Summary

1) Civilizations must first get material off their planets cheaply. The Space Elevator does this. A cable material with a large enough [strength/density] is now at hand. When it can be fabricated into cables, the Space Elevator is buildable.

2) A constant acceleration of one Earth gravity for one year gives a Lorentz Boost (=Warp) of 1.0

3) A 1g trip for ~1/2 human lifetime takes you billions of light years.

4) GLAST can set a limit on the density of other civilizations' ships in transit by looking for the ships' braking radiation.

5) Ultra High Energy Cosmic Ray Ground Arrays may have already detected the media braking radiation from Warp ≥ 12 ships at a density of 10^6 tons payload (~1 ship) / galaxy.

   If more than 1 same energy proton is detected from the same spot on the sky, the ship is nearby.

Fortunately….

If they are nearby and heading for us, it will take them >80,000 years to slow down.