The Relativistic Rocket

The Rindler Horizon and Unruh Temperature

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This is Bob and he is the captain of NASA's newest experiment called the Relativistic Rocket! Bob will be taking the maiden voyage on RR1 and is told to record everything that happens.

This is Carla , bob's twin Sister, and through a unexplainable phenomenon can communicate instantaneously with bob just by thinking and vice versa.

This is Relativistic rocket 1, RR1 , the prototype long distance short time traveler developed by NASA's biggest and best scientists. It Travels with a continuous Acceleration that happens to be *EXACTLY* the same as that felt on earth (1 g = 9.81 m/s^2)

First things First

- a = The acceleration of RR1 as measured at any instant by a non-accelerating reference frame traveling at the same instantaneous speed.
- T = Proper time measured by Bob.
- T' = Time measured by Carla on earth.
- d = The distance covered.
- v = Final speed
- γ = The time dilation or length contraction factor at any instant

Equations

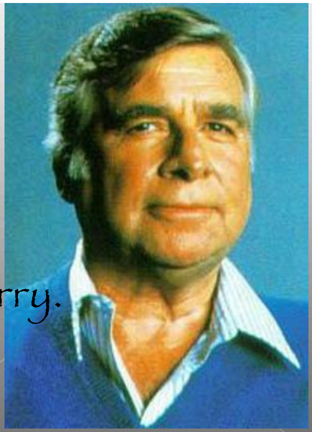
$$T' = \sqrt{\left(\frac{d}{c}\right)^2 + \left(\frac{2d}{a}\right)}$$

$$d = \left(\frac{c^2}{a}\right)\sqrt{\left[1 + \left(\frac{aT'}{c}\right)^2\right] - 1}$$

$$v = \left(\frac{aT'}{\sqrt{\left[1 + \left(\frac{aT'}{c}\right)^2\right]}}\right)$$

$$T = \left(\frac{c}{a}\right) Cosh^{-1}\left[\left(\frac{ad}{c^2}\right) + 1\right]$$

$$\gamma = \left(\frac{ad}{c^2}\right) + 1$$



Side note: The unit of the proper velocity was defined as the Roddenberry. Gene Roddenberry is the creator of Star trek. Coincidence, maybe, ...or someone just REALLY liked Star trek.

T	t	d	v	gamma
1	1.19 yrs	0.56 lys	.77	1.58
2	3.75	2.90	.97	3.99
5	83.7	82.7	.99993	86.2
8	1,840	1,839	.99999998	1,895
12	113,243	113,242	.9999999999996	116,641

Distance	Destination	Proper Time Felt
4.3 lyr	Alpha Centari	3.6 yrs
27	Vega	6.6
30,000	Center of the Galaxy	20
2,000,000	Andromeda Galaxy	28

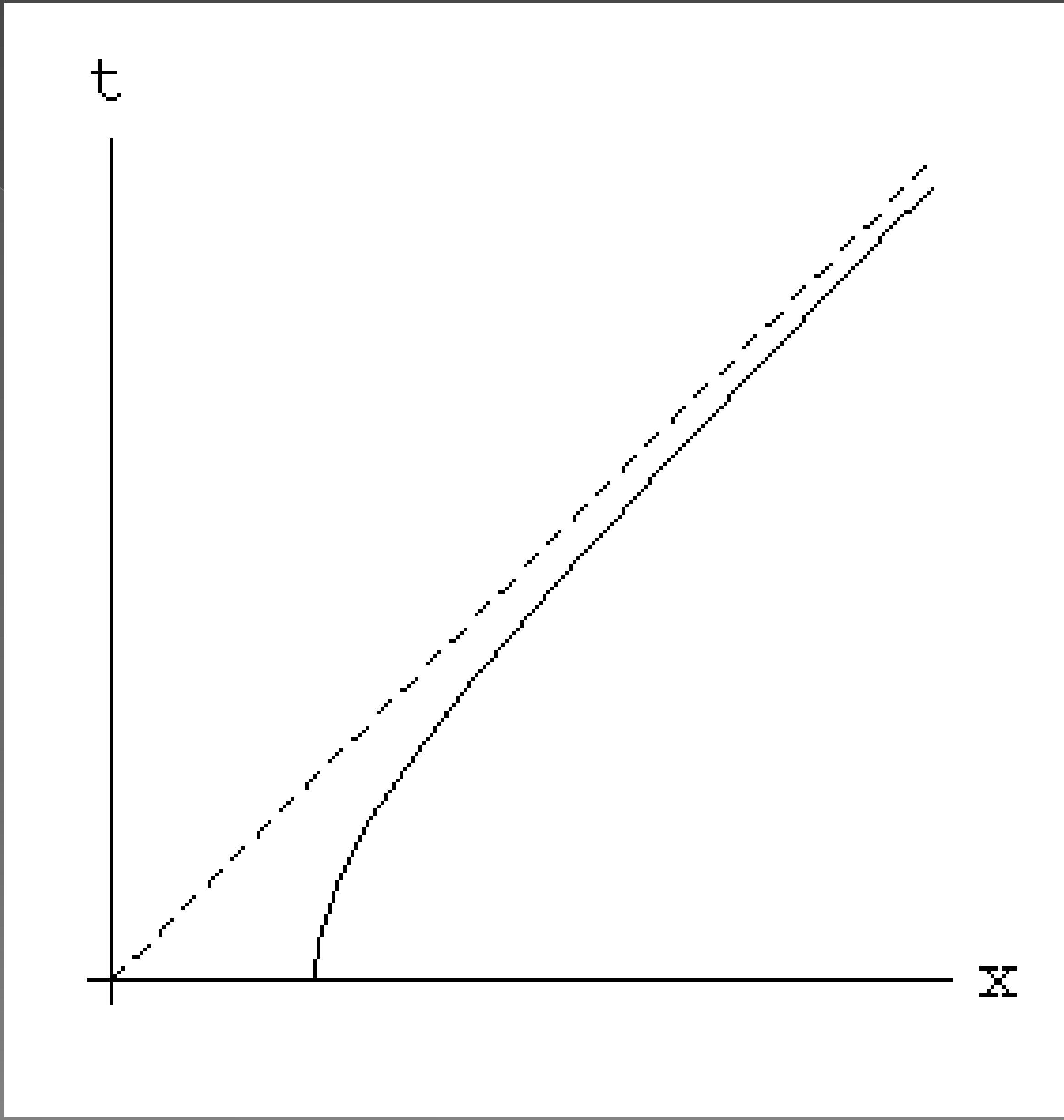
Behind the rocket!

As bob takes off he heads for a Amy who has a strobe that blinks at a constant rate r. This strobe is D lyr away. At blast off (t=T=0) the initial Distance is D away from the strobe but as the rocket travels it becomes D - d (d= distance traveled). The Distance you measure at time T (proper Time):

$$(D-d)/y = (D + c^2/a)/\text{Cosh}\ (aT/c) – c^2/a$$

Distance of Event Horizon

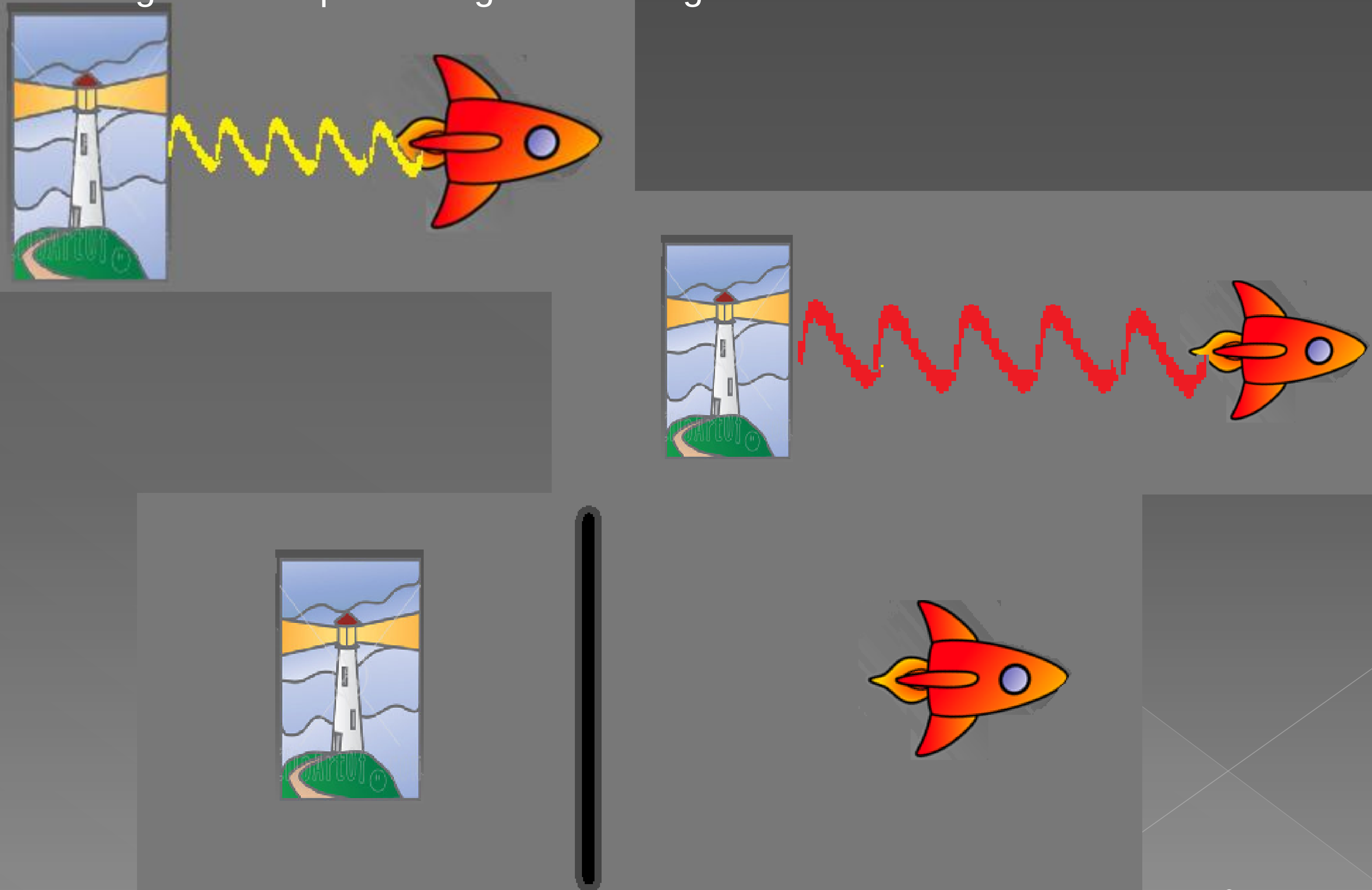
As you approach the star and pass it the distance D goes to zero and negative respectively. As t goes to infinity the distance that you can see asymptotes to a value of


t
x

What bob sees as Amy Goes past and approaches the $-c^2/a$

$-c^2/a$ Is the position of a Rindler horizon

Event Horizon - A spatial boundary around a black hole inside which gravity is strong enough to prevent all matter and radiation from escaping. The inability of even light to escape this region is what gives black holes their name.



In front of the Rocket

As Bob is moving through space he observes something very weird happens. The sensors in the front of the ship are reading heat.

$$Ŧ = \hbar a/2\pi ck$$

a is the local acceleration
k is the Boltzmann constant
h is the reduced Planck's constant

256 kelvin

Why? How?

Isn't Space Empty?

Empty Space is a normally perceived as being a vacuum void of energy but as special relativity tells us a vaccum is actually the lowest energy state possible. (a very different definition from "empty".) Even at this low energy state you still have some (even if its very small) energy that accumulates as you move through space. This presents its self as Heat on the front of the ship.

300 Hydrogen atoms

Photons

Cosmic Dust

Inside the rocket

As the ship moves through space bob notices that the clocks at the front of the ship are moving faster than those in the back.

Why?

Through Einstein's *Equivalence Principle*. Einstein postulated that any experiment done in a real gravitational field, provided that experiment has a fairly small spatial extent and doesn't take very long, will give a result indistinguishable from the same experiment done in an accelerating rocket.

If the ship experiences the same gravity as earth doesn't that mean that clocks in large buildings would act the same way?

Yes!

Mössbauer effect

- Tested By Pound and Rebka at Harvard's East Tower in 1959.
- Same principle as GPS Positioning systems.
- Tested using excited state Photon emissions.

Space travel is HARD

references

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