Re: Solar powered lasers in space

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* *From*: BradGuth <bradguth@xxxxxxxxx>
* *Date*: Fri, 21 Sep 2007 18:31:51 −0000

On Sep 21, 8:21 am, Ian Parker <ianpark...@xxxxxxxxx> wrote:

> On 20 Sep, 22:35, Willie.Moo...@xxxxxxxxx wrote:
>
> > > I doubt that. If you are going to travel at 0.03c you want an
> > > ion
> > > drive that accelerates to 0.05c (say)
>
> > Why do you doubt it? What's the basis? You state a conclusion and provide absolutely no technical data to back it up. I find that maddening! lol. The way to look at this is propellant fraction, power level and thrust.
>
> > A 1 gee acceleration is convenient for interplanetary travel for a variety of reasons. First off, you have gravity aboard ship during the transit. Secondly, you get to where you're going pretty fast. You fly halfway to your destination, carry out a powered pitchover, and arrive at zero altitude and zero speed at your destination. With clever programming the gee forces slide linearly from your start to your finish so that you are acclimated to the destinations gravity by the time you get there.
>
> > So, lets look at a 1 gee spaceships performance. You may remember these from elementary physics
>
> > d = 1/2 a t^2
> > v = a t

So,

$t = v / a$

and so

$d = v^2 /(2a)$

Where d= distance travelled
a = acceleration
t = time
v = velocity

So, the velocity needed to attain the halfway point is

$v = \sqrt{d * a}$

And the total delta vee to achieve the trip is

$V = 2 * v$

and the time in hours needed to make the trip is

$t = V / 9.82 / 3600$

So, we can construct the following chart

m kps hours LSD
Earth to d sqrt(d*a) t u
Moon 3.86E+08 61.60 1.74 2.03%
Mars−close 7.50E+10 858.20 24.28 24.88%
Mars−far 3.75E+11 1,918.98 54.28 47.25%
Venus−close 4.50E+10 664.76 18.80 19.88%
Venus−far 2.55E+11 1,582.43 44.76 40.99%
Ceres−close 2.70E+11 1,628.31 46.06 41.89%
Ceres−far 5.70E+11 2,365.88 66.92 54.55%
Mercury−close 9.00E+10 940.11 26.59 26.90%
Mercury−far 2.10E+11 1,436.04 40.62 38.04%
Jovia 8.55E+11 2,897.60 81.96 61.93%

So sailing the inner solar system in a 1 gee spaceship would be like sailing the Pacific in a cruise ship. You'd have islands like the moon, that are only hours a way. You'd have nearby territories like Mars and Venus that are only a day or two away. Then you'd have the outer planets that are weeks away.

The factor u is the propellant fraction for a Laser Sustained Detonation (LSD) rocket operating with an exhaust velocity of 3000 km/sec (kps)

Now, lets look at the power levels needed to achieve that, and the propellant fractions. The first thing we realize is that to have reasonable propellant fractions we need exhaust speeds to match the flight speeds.

Vf = Ve * LN(1/(1−u))

so

u = 1 − 1/EXP(Vf/Ve)

So, Vf/Ve must be less than or equal to 1 to have reasonable u. 3,000 kps − is a specific impulse of 30,000 − which is damned difficult to achieve. And power to weight of the engine must be tremendous. So, an ion rocket with 5,000 sec Isp − won't cut it for this application. (it would do fine for 1/10th gee or 1/100th gee operation) some sort of laser sustained detonation of inert working fluids would be needed. This is nearly an exact analogue of nuclear pulse propulsion, but the energizing force comes from pulses of laser energy accurately directed at a thrust structure.

The power level to produce 1 kgf is

F = mdot * Ve
P = 1/2 mdot * Ve ^2

So,

mdot = 2 * P / Ve^2

and so

F = 2 * P / Ve

This is in newtons and 1 kgf = Newton / 9.82

so..

F(kgf) = P / (4.91 * Ve)

And with Ve = 3,000 kps = 3e6 m/sec we need 14.73 MW per kgf of thrust. That's 7.37 quadrilion watts of power. And this is the low

> power solution!!! haha.. The world has a few thousand super tankers. To operate a few thousand interplanetary freighters with this capacity requires tapping into 1e20 watts of power. Such capacity would tie humanity together across the interplanetary frontier.

> At 1MW per sq meter − the sun centered laser array would have to cover 1e8 sq km of area. A disk 11,283 km in diameter − about the size of the Earth − a very small fraction of the sun's total surface. Four disks 6,000 km in diameter equally spaced around the plane of the ecliptic would provide adequate power for a fleet of such spacecraft.

I am afraid I was simply thinking about energy. To go to 0.03c with minimal energy you need ion drive. If you have plenty of energy you indeed don't need to worry about that.

There is one other point. If you have polulated the ecliptic with lasers, you will (presumably) be able to phase lock them. You will have a telescope 300million kilometers in diameter. In earlier postings I have said how a number of problems are all tied together. Now let us see what sizes you can see 10 parsecs distance. Now a parsec is by definition 1sec of arc with observations separated by 6 months. Therefore 10 parsecs means that viewed from the target the telescope is subtending 1/10 sec of arc. 50 deg per radian 3600sec per degree. That is 1/180000 radian. This means we see objects some 7cm across. Clearly the gas in interstellar space + gravitational lensing will prevent us getting anywhere near that figure. We should have little difficulty though in seeing any planets.

We will know fairly quickly whether or not we are in a race, another possible explanation of the Fermi paradox.

> Humanity today consumes 10 TW of power − 1/10,000,000th the power level postulated here. Needless to day, any industrial activity we wanted to carry out on the planets or in free flying space colonies, could easily be provided as well. This might also form the basis of maintaining government control over this far flung array of humans, to keep them from using high tech to attack one another − and stopping the possibility of interplanetary war.

You are assuming that war is the result of competition for resources. I say it is saying your prayers the wrong way.

A laser light sail requires no propellant, but power levels go way up for both high thrusts, small sail size, and for ton of payload moved.

There are two ways to do this. One is to heat a body to very high temperatures and use the black body radiation for propulsion − this requires some sort of plasma containment system that can't be built. The other (if we are to have high gee forces) is to use a mirror to reflect nearly all the energy incident on it. In order to limit the size of the mirror.

To make logistics simple, it would be nice to have the mirrors operate like wings do on aircraft − exerting 100 kg/m2 or more. A disk like spacecraft that had multi−mode capabilities would be interesting. That is, a spherical payload encircled by a mirror disk, that might also operate as a radiator propulsor short term − for landing and operating out of sight of the sun...

A laser is monochromatic. This means you can use simple dielectric sails which do not heat up. A metal sail is hopeless at anything like a high energy.

Black body thrustor

Pr = 1/3 ar T^4

Where ar = radiation constant = 7.57e−16 J/m3/K4
T = temp K
Pr = radiation pressure (watts/m2)

To exert 100 kg/m2 requires a temperature of 45,000 K − and the power output of that square meter is j = sigma * T^4

Where j = watts/m2
T = temp K
sigma = stephan boltzman constant = c * ar / 4
= 5.67e−8

j = 5.67e−8 * 45,000^4 = 232.5e9 W/m2

So, 1/100th of a meter squared, would be a square 10cm on a side, would produce 1 kg of thrust, and consume 2.32 GW of power!!! Compare this to 14.7 MW of power needed for 1 kgf in the LSD rocket!! But the great advantage here is that no propellant is needed.

This is a black body radiator, some sort of cavity containing a magnetically stabilized plasma − that efficiently absorbs powerful laser energy. By encasing the cavity in a reflective parabolid that transmits the laser energy but reflects the bulk of the plasma radiation in a desired direction, the surface can absorb laser energy from one direction and emit radiation in another direction. By having a certain amount of plasma that stores a goodly amount of energy − thrust can be maintained for a period of time − without direct illumination. Excellent for landing and takeoffs, where laser energy may be a hazard (the plasma itself would be a hazard if the cavity developed any leaks! − and the exhaust itself would also be a hazard − it may be possible to use the plasma energy directly by venting it for landing and take off.

A mirror based system has the following relation;

Pressure = 2 U / c

Where U = power per unit area, c = speed of light, Pressure = N/m2

So, 100 kg /m2 = 982 N/m2 implies U = 3e8 m/sec * 982 N/m2 / 2 = 147.3 GW/m2 − which is less than that required for the radiation pressure mode − and actually, the radiation pressure mode above, doesn't include the momentum that is obtained from absorbing the light energy in the first place.. which can help or hinder the thrust effects depending on how the cavity is arrayed relative to the energy being beamed in.

Of course to keep temperatures under control requires VERY VERY highly reflective mirrors. Before the invention of GBO films I would say such things would be impossible. But the advent of GBO films that have reflectivities in excess of aluminized coatings − suggest that continued development along this path would allow mirrors that absorb less than 1 part per million of the incident energy. This means that the wings need only

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I would have to agree that any 0.03 c ion thrusted craft has great cruising potential, even if limited to 0.01 c. However, why bother to store ion worthy gas when it can be made next to forever on the fly? (sort of speak)

Hot radon gas is actually a fairly active resource or cache of impressive ions that are on the move as is. A sufficient payload of radium as contained within a breeder reactor is what offers such an ongoing decay of producing those highly interjetic atoms of radon, on the fly sort of speak.

A high pressure vessel of Pu239 pumped Radium(Ra226) as the breeder reactor on behalf of obtaining the most Radon (Rn222) or rather LRn222 per given kg of radium isn't hardly rocket science, although as Uncle Al having restipulated that essentially a nifty byproduct of such a hot reactor could rather easily become a nice volume or potential kgf/ kg worth of super heated steam ions, of which h2o at 1000 bar at the nuclear reactive boosted thermal temperature of perhaps 1000 K isn't exactly of no reaction usage, is it.

BTW, wars are mostly about global resources, and/or of what those

resources can deliver to those most interested in exploiting such valued resources of either mineral or energy. In other words, wherever there's little if anything of value to fight over, there's no point in our joining into whatever's the fight that's often faith−based as being the secondary or stealth/perpetrated reason(s) for that war. Mainstream religion has almost nothing to do with God, whereas instead it has to do with obtaining and/or orchestrating the most control over others, and of these days that takes loot, and/or the control over the loot of others.
− Brad Guth −

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