SOLAR-GRAVITATIONAL SPACECARFT USED FOR TRAVELING IN THE SOLAR SYSTEM

Constantin Sandu[1], Dan Brasoveanu[2], Valentin Silivestru[1], Bogdan Filipescu[3], Radu Constantin Sandu[4]*

[1]COMOTI, Bucharest, Romania
[2]Systems Engineering Group Inc. (SEG),MD, USA
[3]Teletrans. Craiova, Romania
[4]S.C. Structural Management Solutions S.R.L., Bucharest, Romania
[*]Corresponding author: E-mail : constantin.sandu@comoti.ro

ABSTRACT

In some previous papers, the authors presented the theory and design of the Electromagnetic Gravitational Spacecraft. According to this theory, the Electromagnetic Gravitational Spacecraft no longer uses the Theorem of Momentum Conservation for propulsion like rockets or other space vehicles. The gravitational spacecraft is propelled by an artificial flux of gravitational radiation produced on the board of spacecraft, which permeates and attracts the spacecraft body. This flux of gravitational radiation is produced through multiple reflections of electromagnetic waves between multiple reflective layers embedded within the spacecraft hull. The generation of gravitational radiation in this way is a consequence of Einstein's General Theory of Relativity. This discovery was published as a theorem in a modern physics journal.
In the case of Solar Gravitational Spacecraft the solar light is used for generating gravitational waves through multiple reflections between two or multiple reflective layers which are important components of the spacecraft. The solar light is inserted in the direction perpendicular to the reflective layers by a double parabolic mirror system which strongly concentrates the solar light.
The paper presents only the main design and working principle of this type of spacecraft. While the absence of propellant is a great advantage, this type of spacecraft will not be soon preferred for future travels within the solar system because much research work is necessary for improving the reflection coefficient of mirrors, the cooling of reflective layers, and the design of a system which continuously feeds the spacecraft with concentrated solar light when it navigates at great distance from the Sun.

KEYWORDS: solar, gravitational spacecraft, space travel

NOMENCLATURE

a, acceleration, [m/s^2]
c, speed of light, [m/s]
d, distance, [m]
E, energy of a packet of photons, [J]
E, electric field, [dyne/SC in CGS]
E_e, irradiance in proximity of Earth, [W/m^2]
F, force, [N]
g_{ik}, metric (or fundamental) tensor
G, universal constant of gravitation [Nm^2/kg^2]
h, Planck's constant, [J·s]
H, magnetic field intensity, [Oe in CGS]
M, mass, [kg]
P, power, [W]
r, radius, [m]
R, reflectivity, dimensionless
R, Ricci's scalar curvature
R, Riemann's curvature tensor
s, length in the 4-dimensional space [m]

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t, time, [s]
T, the invariant of the energy-impulse tensor
T_{ik}, energy-impulse tensor
Greek
δ, Kroneker symbol
λ, wave length, [m]
Φ, gravitational potential, [N·m/kg]

1. INTRODUCTION

It is very clear that the propulsion systems which rely on the Theorem of Momentum Conservation cannot represent the future for space propulsion because the amount of propellant which can be carried on board is limited.
The authors demonstrated in previous AIAA papers [1...10] that our civilization should replace the current present propulsion systems with a new type of propulsion system which no longer uses the Theorem of Momentum Conservation and relies on a Gravitational Principle instead. According to the Gravitational Principle, a spacecraft can move in space without propellant being attracted by its hull which generates artificial gravitational waves spanning the spacecraft body. Such a spacecraft uses no propellant. The Gravitational Principle is based on the 'Theorem of Conversion of Electromagnetic Energy into Gravitational Energy published by authors in the Journal of Advances in Physics [11]. This theorem shows that in some circumstances the electromagnetic waves (radiation) are converted into gravitational waves (radiation). The present paper demonstrates the transformation of solar light into gravitational radiation usable for propulsion of solar-gravitational spacecraft.

2. DESCRIPTION OF ELECTROMAGNETIC GRAVITATIONAL PROPULSION PRINCIPLES

For a clear understanding of the Solar-Gravitational Spacecraft, a short presentation of the principles of Electromagnetic Gravitational Spacecraft is necessary.
The Electromagnetic Gravitational Spacecraft relies on 4 design principles [1]:
1)-Usage of energy in wave form only. This means that both power and propulsion are generated and transferred in wave form (excluding chemical energy and ion acceleration by magnetic and electric fields);
2)-The principle of radiant hull – the ship hull is integrated into the propulsion system and emits an attractive radiation that permeates the entire body of ship. This means that the spacecraft moves in space due to attraction not due to pushing as in the case of present spacecraft;
3)-The use of artificial gravitation generated onboard the spacecraft, according to the Theorem indicated at point 4.
4)-The Theorem of Conversion of Electromagnetic Waves (radiation) into Gravitational Waves (radiation) for generation of gravitational radiation onboard the spacecraft. This theorem mainly affirms that electromagnetic waves (radiation) which are reflecting between two or more parallel and highly reflective surfaces is transformed into gravitational waves (radiation), which are directed the line perpendicular to the reflective surfaces. The power of gravitational waves radiated in this way is proportional with the square of the reflecting electromagnetic energy, E^2, and the square of frequency of this energy, ν^2. This theorem was demonstrated in previous papers by the authors [2, 5 and 11].

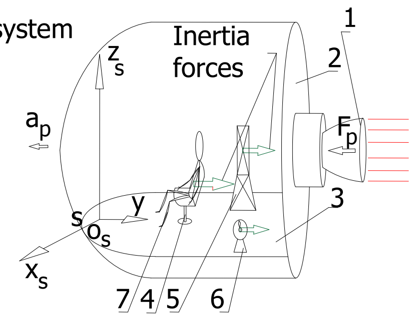

Figure 1: Spacecraft using the Theorem of Momentum Conservation for propulsion

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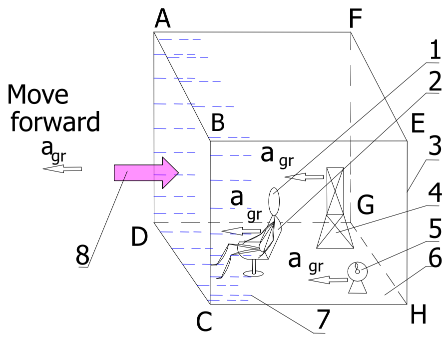
For understanding the main differences between the two propulsion principles, the classic principle of propulsion is presented in fig.1 and the Gravitational Principle of propulsion is presented in fig. 2 for the case of a cubical gravitational spacecraft. [1]
In the classic spacecraft shown in fig.1, the crew-member 7, apparatus 6 and an inner object 5 are subject to inertia forces.
In the cubical gravitational spacecraft shown in fig.2, electromagnetic energy 8 injected among the reflective multilayer surfaces of hull area ABCD generates artificial gravitational radiation according to the Theorem of Conversion of Electromagnetic Radiation (Waves) into Gravitational Radiation (Waves).

1. Crew-member
2. Seat
3. Spacecraft's hull
4. Inner object
5. Apparatus
6. Floor
7. Uniform gravitational radiation emitted by the ABCD section of hull



8. Electromagnetic energy E in form of waves(radiation) injected between the reflective layers of hull section ABCD for generating gravitational waves (radiation)

Figure 2: Cubic spacecraft using the Gravitational Principle of propulsion

This gravitational radiation is directed along the line normal to the face ABCD toward the spacecraft body. This radiation simultaneously attracts forward the spacecraft body and all the onboard crew-members, apparatus, inner objects etc with acceleration a_{gr}. In other words, the crew-member, its seat, the whole spacecraft are attracted by the same gravitational force in the same direction and for this reason the crew-member feels no inertia forces during spacecraft acceleration. In a gravitational spacecraft, the crew does not sense a difference between the gravitational radiation emitted by a far star (planet) and the artificial gravitational radiation emitted by a part of spacecraft hull (in fig.2 the emitting part of spacecraft is face ABCD).
If face ADGF is activated through injection of electromagnetic energy in its center, it also begins to radiate gravitational waves toward the spacecraft body. If the face ABCD is inactivated, the spacecraft begins to move suddenly in the direction normal to the ADGF surface. If the face ADGF is activated and face ABCD is not inactivated then the spacecraft moves in the direction EA (HD).The main components of gravitational spacecraft are presented in fig.3 showing gravitational spacecraft with a tetrahedron shape]

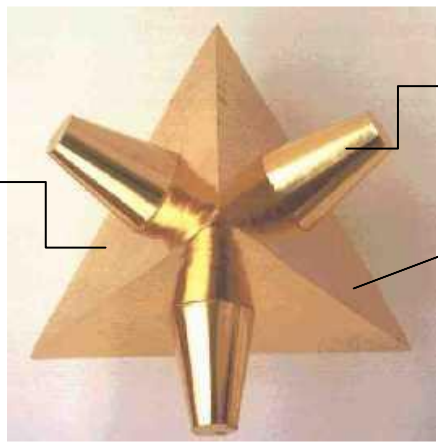


Figure 3: The components of a gravitational spacecraft having a tetrahedron shape

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While precedent papers [1...10] defined and detailed all the design principles of gravitational spacecraft, a solution for a designing a generator of powerful electromagnetic waves was not found yet. The following sections of this paper show that this kind of spacecraft can be fed with concentrated solar light.

3. A BRIEF PRESENTATION OF THE THEOREM OF CONVERSION OF ELECTROMAGNETIC RADIATION (WAVES) INTO GRAVITATIONAL RADIATION (WAVES)

This theorem is important for understanding the operation of Electromagnetic Gravitational Spacecraft and Solar-Gravitational Spacecraft.
For this reason, although previously demonstrated in [11] the main steps of this demonstration are repeated below.
Einstein field equations are:

$$R_{ik} - \frac{1}{2} \cdot g_{ik} \cdot R = -\frac{8\pi G}{c^4} \cdot T_{ik} \tag{1}$$

In the above equations i and k take values from 0 to 3. The values 1, 2 and 3 indicate space coordinates (for example x_1=x, x_2=y, x_3=z when Cartesian coordinates are used and x_1=r, i.e., radius, x_2=θ, x_3=φ when spherical coordinates are used). The value 0of index is reserved for the temporal coordinate, which is $x_0 = c \cdot t$, where 'c' is the speed of light in vacuum and 't' is time.

R_{ik}, g_{ik} and T_{ik} are tensors. R_{ik} is the curvature tensor of second order (or Riemann's tensor); g_{ik} is the tensor that defines the space metric; R is Ricci's scalar curvature of space and G is the universal constant from Newton's Law of gravitation. T_{ik} is the energy-momentum tensor of matter (also known as the stress-energy tensor).
For electromagnetic waves, which propagate freely through space, the components of the energy-momentum tensor are given below.

$$T_{00} = \frac{1}{8\pi}(E^2 + H^2), T_{0i} = -\frac{1}{4\pi}(\vec{E} \times \vec{H})_i \tag{2}$$
$$T_{ik} = -\frac{1}{4\pi}(E_i E_k + H_i H_k) + \frac{1}{8\pi}\delta_{ik}(E^2 + H^2)$$

where i, k=1, 2, 3, $\delta_{ik} = 1$ for i=k and $\delta_{ik} = 0$ for i≠k.
It is known that 'contraction', (i.e., the multiplication of covariant field Eq. (1) with the metric tensor expressed in counter-variant form, which is labelled g^{ik}, followed by a summation), provides a new form of Einstein's field equations which is given below.

$$R = \frac{8\pi G}{c^4} T \tag{3}$$

where R is the invariant of curvature R_{ik} (also known as Ricci's scalar curvature).
Notes: Equation (4) was derived taking into account that:
1) The definition of the counter-variant metric tensor g^{ik} is based on the covariant metric tensor:
$\sum_{k=0}^{3} g_{jk} \cdot g^{ik} = \delta_j^i$, $\delta_j^i = 1$ when i=j and $\delta_j^i = 0$ when i≠j.
2) $g^{ik} \cdot R_{ik} = R$.
3) $g^{ik} \cdot T_{ik} = T$.
In the case of note 3), due to the fact that g^{ik}=-1 when i=k=1, 2, 3,g^{ik}=1 when i=k=0 and g^{ik}=0 when i≠k and taking into account the values of electromagnetic stress-energy tensor given by expressions (2), the result is:

$$T = \sum_{i=0}^{3} g^{ii} T_{ii} = (-1) \cdot T_{11} + (-1) \cdot T_{22} + (-1) \cdot T_{33} + 1 \cdot T_{00} = 0$$

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(4)

Eq. (4) shows that the invariant T of the energy-momentum tensor T_{ik} is null for a free electromagnetic field. Based on Eq. (4), the scalar curvature R is null.
This result is of a tremendous importance because it shows that **electromagnetic waves propagating freely through space do not generate gravitational fields**.
The situation is similar for the case when electromagnetic waves are confined inside a sphere, where the scalar curvature R is null (fig.4).
However, outside the sphere, the gravitational field must exist because, if the total energy of electromagnetic waves confined inside the sphere is E, then according to Einstein's formula, the relativistic mass of photons is:

$$M = \frac{E}{c^2} \tag{5}$$

and according to Newton, such a mass must produce a gravitational field with potential:

$$\Phi = -\frac{G \cdot M}{r} \tag{6}$$

where G is Newton's gravitational constant and r is the distance from sphere's center ($r > r_0$, r_0=sphere's radius).

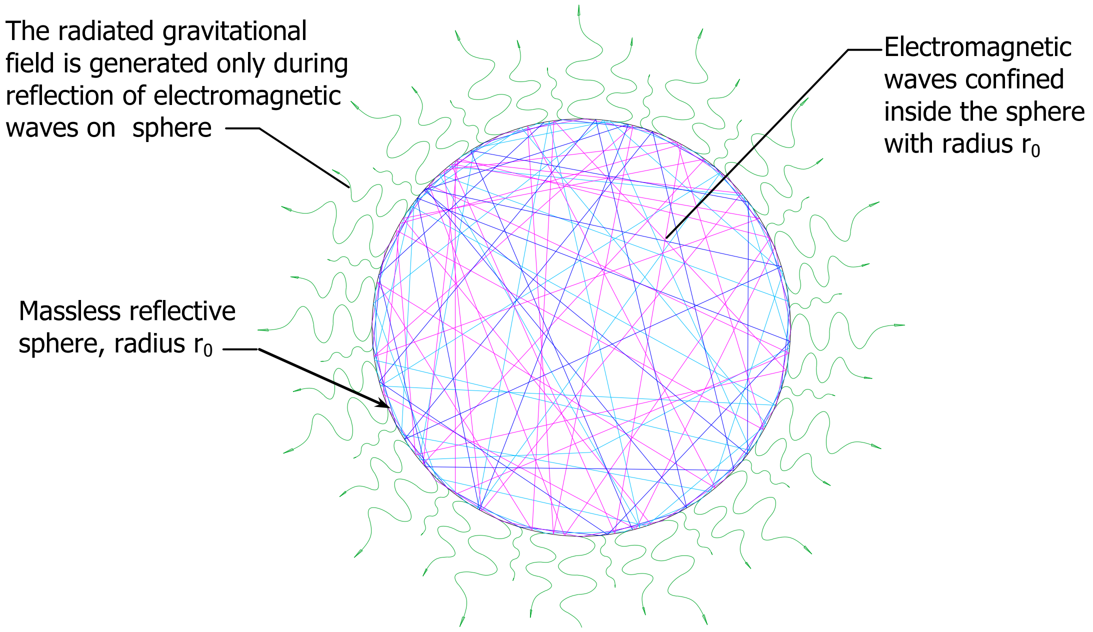

Fig.4: The scalar curvature R of an electromagnetic field confined within a massless sphere (radius r_0) is zero while outside the sphere the gravitational field should exist

In Einstein's view, the mass M of electromagnetic waves confined inside sphere modifies the continuum space-time curvature, this being characterized by Schwarzschild's metric given below.

$$ds^2 = \frac{r-\alpha}{r+\alpha} c^2 dt^2 - \frac{r+\alpha}{r-\alpha} dr^2 - (r+\alpha)^2 \cdot d\theta^2 - [(r+\alpha)\cdot \sin\theta]^2 \cdot d\varphi^2 \tag{7}$$

where r, θ, φ are spherical coordinates, t is time, $\alpha = GMc^{-2}$.
Thus, we arrive to an implausible situation:
On one hand, according to equation (4) the gravitational field **should not exis**t inside the sphere because the invariant T of stress-momentum tensor T_{ik} is null and on the other hand, the gravitational field **should exist** outside the sphere both in Newton's and Einstein's interpretation

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because the potential Φ is not zero according to equation (6) and the space element ds is not zero, too, according to Schwarzschild's metric (7).
This contradiction can be solved only by admitting that gravitons are generated during reflection of electromagnetic waves on sphere's wall.
Thus, a previous paper [11] finally demonstrated the 'Theorem of Conversion of Electromagnetic Radiation (Waves) into Gravitational Radiation (Waves):

'During normal reflection of an electromagnetic wave on a reflective surface, electromagnetic energy is partially converted into gravitational energy. The frequency of the emitted gravitational wave is equal to the frequency of incident wave. The energy of emitted gravitational wave is proportional to the cube of frequency of electromagnetic wave. The direction of gravitational wave is opposite to that of the incident electromagnetic wave'.

4. USE OF 'THEOREM OF CONVERSION OF ELECTROMAGNETIC RADIATION (WAVES) INTO GRAVITATIONAL RADIATION (WAVES)' FOR PROPULSION OF GRAVITATIONAL SPACECRAFT

Assume two packs of electromagnetic waves 1, 2 having the same energy E and the same frequency are continuously reflected between two parallel reflective surfaces A, B. The two surfaces are separated by a gap, $d = \lambda$ (λ is the wave length supposed constant and equal in value for the two packets of electromagnetic energy, E) (fig. 5). During normal reflection of the two packs of electromagnetic energy E by surfaces A, B, a continuous flux of gravitational power is generated.

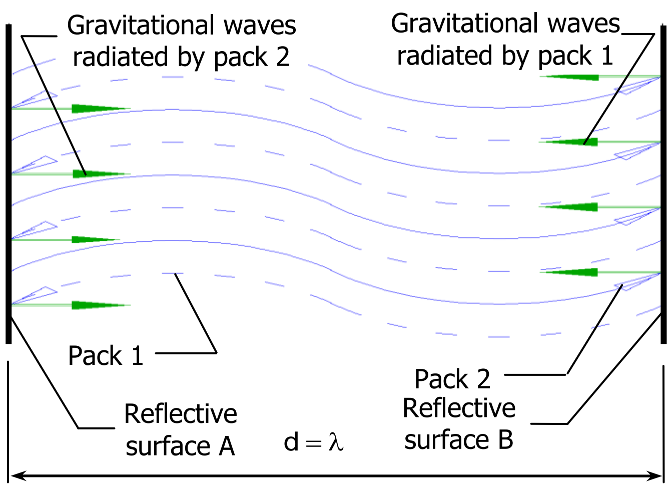

Figure 5: Two packs of electromagnetic energy which continuously radiate gravitational waves through multiple reflections

The radiated flux of gravitational power P_g is: [11]

$$P_g = \frac{512 \cdot G}{5 \cdot c^5} \cdot E^2 \cdot \nu^2 \qquad (8)$$

where ν is the frequency of the two packs of electromagnetic energy, E, c is the speed of light and G is Newton's gravitational constant.
In formula (8) one can see that although G/c^5 is very small, $E^2 \cdot \nu^2$ can have great values if the reflecting electromagnetic energy E is sufficiently large and frequency of electromagnetic energy is high enough.
Two or more reflective surfaces as presented in fig. 5 compose the hull of gravitational spacecraft. For example, in fig.2 the hull of spacecraft has cubic faces. Any face is composed of two or more reflective surfaces. When electromagnetic energy E is injected between the reflective surfaces of hull

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(for example ABCD), it generates through multiple reflections gravitational radiations which pulls (attracts) the spacecraft body to the left. When the electromagnetic energy E is injected in face ABEF of hull, the spacecraft is pulled (attracted) upwards etc.

5. DESIGN OF THE SOLAR-GRAVITATIONAL SPACECRAFT

Unfortunately at present there is no current technology for generating packets of electromagnetic energy having high energy and frequency. In addition, reflective surfaces able to efficiently reflect electromagnetic energy have not been created yet. These are the main reasons for which the gravitational spacecraft has not been developed yet.

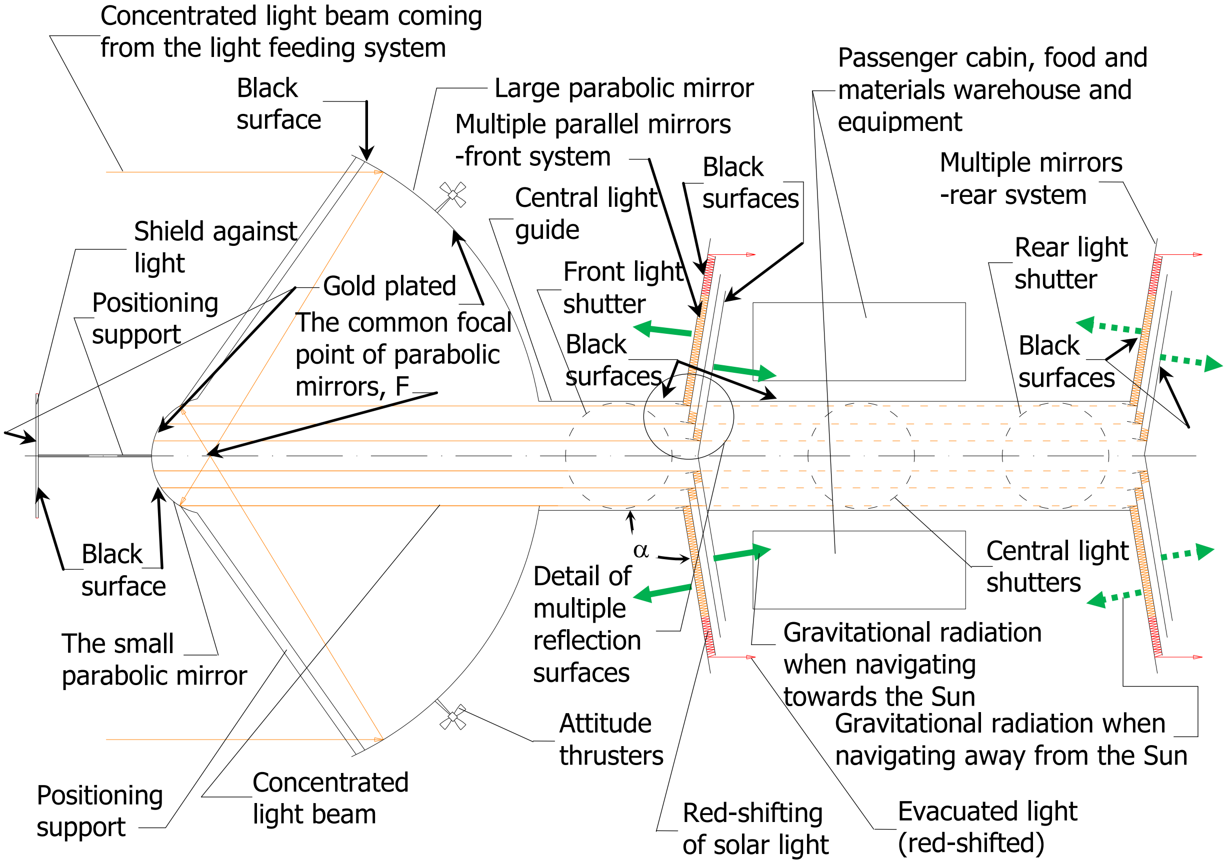

Figure 6: The simplified scheme of solar-gravitational spacecraft

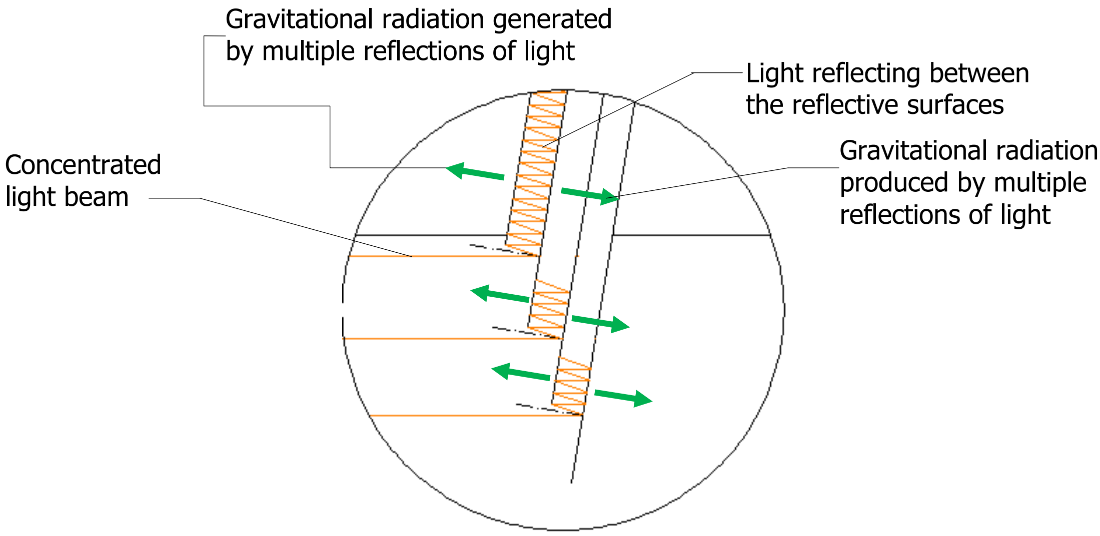

Figure 7: Detail of multiple reflection of light between the reflective surfaces

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In the case of solar-gravitational spacecraft which is schematically presented in figs.6, 7, the problem of high electromagnetic energy is solved using concentrated solar light.
The solar light rays are collected by the large parabolic mirror and reflected to the focal point of mirror F. The focal point F is the same for the small parabolic mirror which is placed face to face with the large parabolic mirror. After leaving the focal point F, the light rays are reflected by the small parabolic mirror in parallel light rays (concentrated light beam) through the central light guide. When the front light shutter is opened, the concentrated light beam enters the multiple parallel mirrors. The mirrors are placed at an angle $\alpha=90°+\delta$, were δ is a very small angle. When the light rays reflect between mirrors gravitational waves are generated while the frequency of light decreases (all the components of the white light coming from Sun are red-shifted). [11]
At the end of process the light is evacuated in space as a brilliant red light. In this situation, the spacecraft is accelerated to the direction of Sun because the gravitational radiation generated by the front system of multiple parallel mirrors is spanning the passenger cabin which has the most of mass of spacecraft (the parabolic mirrors have a negligible mass).
The shutter is a thin disc plated with gold on the both faces. If the front light shutter is closed, the light is sent back to the small parabolic mirror, to the large parabolic mirror and then to the Sun and gravitational radiation is not generated.
The front system of parallel mirrors is composed of two halves which move aside letting the concentrated light beam to reach the rear system of multiple parallel mirrors (the central and rear shutters are opened). The concentrated light beam begins to reflect between the rear system of mirrors generating gravitational radiation. In this situation the spacecraft is moving in opposite direction relatively to the Sun. When the central shutter is placed at 45° the concentrated beam is directed to the left, right, upper or lower systems of parallel mirrors (these systems are not represented). The gravitational radiation spans the cabin attracting the spacecraft to the left, right, upwards or downwards. The left, right, upper or lower systems of parallel mirrors have a smaller surface area than the front and rear systems of parallel mirrors. Their role is only to correct the trajectory of spacecraft while the front and rear systems of parallel mirrors is for accelerating or decelerating of spacecraft. In addition to the mentioned systems, the spacecraft has attitude classic thrusters for contingency situations when solar light is not available.
The large and small parabolic mirrors, plane mirrors and light guide are made of composite materials (graphite fibre or graphene base) and are gold plated on the reflective surfaces. The heat is radiated in space through radiation of black surfaces of the above mentioned components. The passenger cabin is plated with gold foil or Mylar for reflection of light.
For a better understanding of design, a mock-up of spacecraft is presented in figs 8a, 8b and 8c.

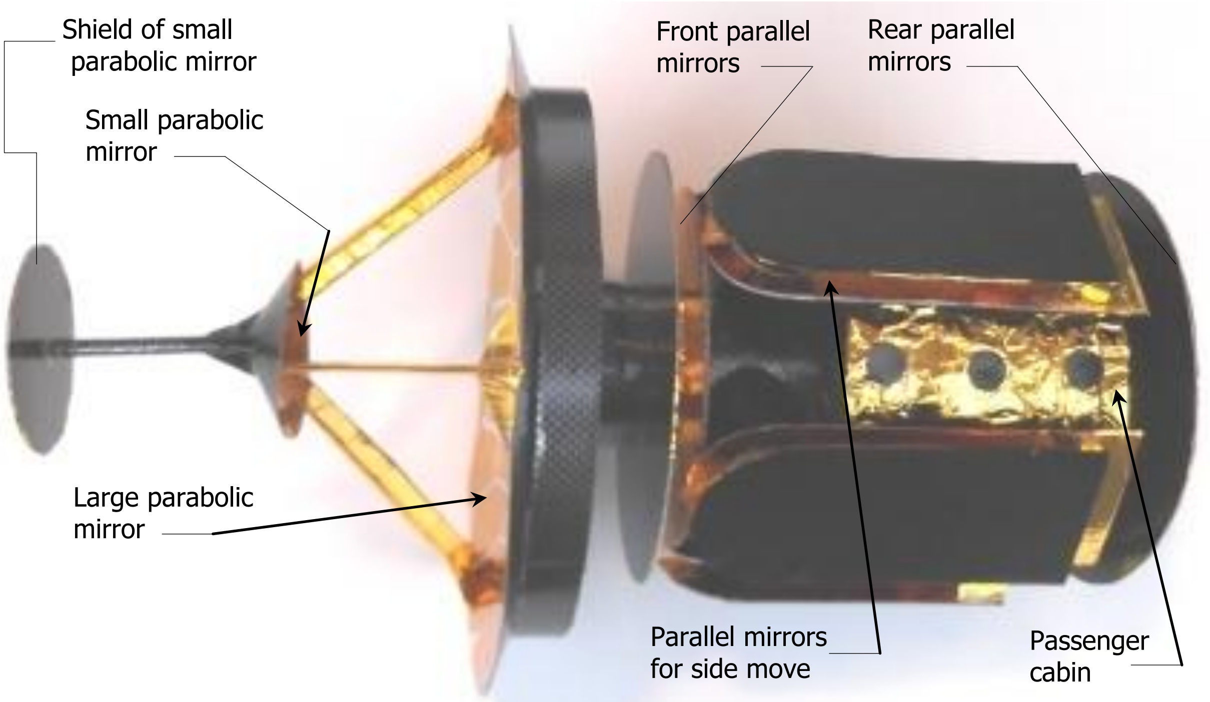

Fig.8a-Side view of a spacecraft (mock-up)

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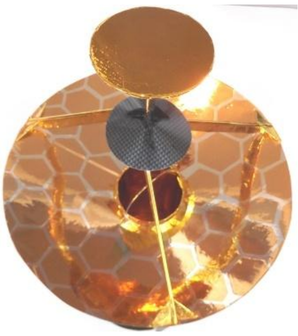

Fig.8b-View of small and large parabolic mirrors (mock-up)

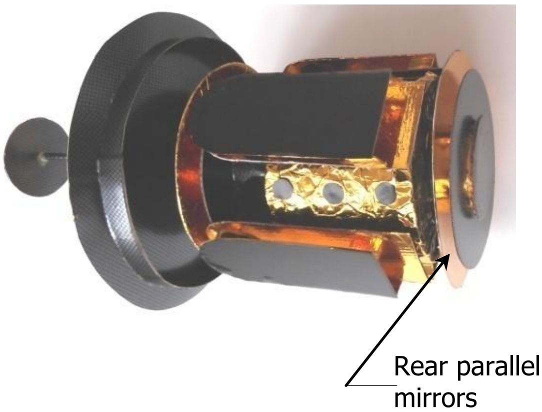

Fig.8c- Side view of spacecraft (mock-up)

6. CALCULATION OF GRAVITATIONAL RADIATED POWER

In ideal conditions (reflectivity coefficient of surfaces R=1), the gravitational power radiated by two parallel mirrors due to multiple reflection of two packets of photons having energy E each, is given in the table 1 for infrared, visible and ultraviolet light.

Table 1: Power of gravitational radiation produced through reflection of infrared to ultraviolet light

E, kJ ⇨ ν, Hz ⇩	**1** $\frac{dE}{dt}, kW$ ⇩	**10^3** $\frac{dE}{dt}, kW$ ⇩	**10^5** $\frac{dE}{dt}, kW$ ⇩	**10^7** $\frac{dE}{dt}, kW$ ⇩	**10^9** $\frac{dE}{dt}, kW$ ⇩	**10^{11}** $\frac{dE}{dt}, kW$ ⇩	**10^{13}** $\frac{dE}{dt}, kW$ ⇩
$3x10^{11}$ (infrared)	$2.5x10^{-25}$	$2.5x10^{-19}$	$2.5x10^{-15}$	$2.5x10^{-11}$	$2.5x10^{-7}$	$2.5x10^{-3}$	$2.5x10^{1}$
$3x10^{14}$ (infra red)	$2.5x10^{-19}$	$2.5x10^{-13}$	$2.5x10^{-9}$	$2.5x10^{-5}$	$2.5x10^{-1}$	$2.5x10^{3}$	$2.5x10^{7}$
$3.75x10^{14}$ (red)	$4x10^{-19}$	$4x10^{-13}$	$4x10^{-9}$	$2x10^{-5}$	$4x10^{-1}$	$4x10^{3}$	$4x10^{7}$
$5x10^{14}$ (yellow)	$0.7x10^{-18}$	$0.7x10^{-12}$	$0.7x10^{-8}$	$0.7x10^{-4}$	$0.7x10^{0}$	$0.7x10^{4}$	$0.7x10^{8}$
$5.75x10^{14}$ (light green)	$0.9x10^{-18}$	$0.9x10^{-12}$	$0.9x10^{-8}$	$0.9x10^{-4}$	$0.9x10^{0}$	$0.9x10^{4}$	$0.9x10^{8}$
$6x10^{14}$ (dark green)	$1x10^{-18}$	$1x10^{-12}$	$1x10^{-8}$	$1x10^{-4}$	$1x10^{0}$	$1x10^{4}$	$1x10^{8}$
$6.25x10^{14}$ (light blue)	$1.1x10^{-18}$	$1.1x10^{-12}$	$1.1x10^{-8}$	$1.1x10^{-4}$	$1.1x10^{0}$	$1.1x10^{4}$	$1.1x10^{8}$
$6.5x10^{14}$ (dark blue)	$1.2x10^{-18}$	$1.2x10^{-12}$	$1.2x10^{-8}$	$1.2x10^{-4}$	$1.2x10^{0}$	$1.2x10^{4}$	$1.2 x10^{8}$
$7x10^{14}$ (light violet)	$1.4x10^{-18}$	$1.4x10^{-12}$	$1.4x10^{-8}$	$1.4x10^{-4}$	$1.4x10^{0}$	$1.4x10^{4}$	$1.4x10^{8}$
$7.5x10^{14}$ (dark violet)	$1.6x10^{-18}$	$1.6x10^{-12}$	$1.6x10^{-8}$	$1.6x10^{-4}$	$1.6x10^{0}$	$1.6x10^{4}$	$1.6x10^{8}$
$3x10^{15}$ (ultra violet)	$1.6x10^{-17}$	$1.6x10^{-11}$	$1.6x10^{-7}$	$1.6x10^{-3}$	$1.6x10^{1}$	$1.6x10^{5}$	$1.6x10^{9}$
$3x10^{16}$ (ultra violet)	$2.5x10^{-15}$	$2.5x10^{-9}$	$2.5x10^{-5}$	$2.5x10^{-1}$	$2.5x10^{3}$	$2.5x10^{8}$	$2.5x10^{11}$

Table 1 shows that the radiated gravitational power can have high values if the energy E of the reflecting light packets is sufficiently high.

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Only half of this power is used for propulsion because the rest of power is lost in space.

7. NAVIGATION OF SOLAR GRAVITATIONAL SPACECRAFT INSIDE THE SOLAR SYSTEM AT GREAT DISTANCE FROM EARTH

The irradiance decreases with the square of distance from Sun. As a result, propulsion of such spacecraft becomes difficult at great distance from Sun. However, solar gravitational spacecraft can navigate even in this case if a feeding system with concentrated light is used (fig.9). [12]

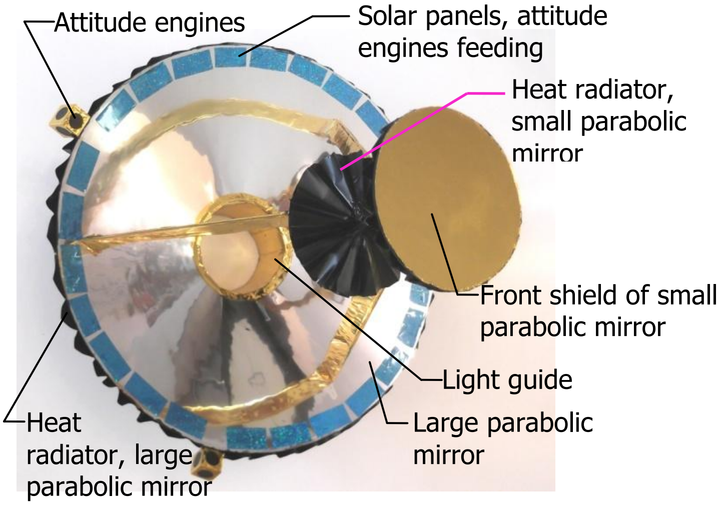

Figure 9-Feeding system with concentrated light for solar gravitational spacecraft (mock-up)

The feeding system is a large construction composed of a large parabolic mirror and a small parabolic mirror which have the same focal point. The system is built on an orbit around Earth and lifted to Earth's orbit around Sun. The large parabolic mirror which is directed toward the sun collects the sun-light which is transformed into a concentrated light beam by the small parabolic mirror. In this case the spacecraft navigates in the concentrated light beam emitted by the feeding system (fig.10).

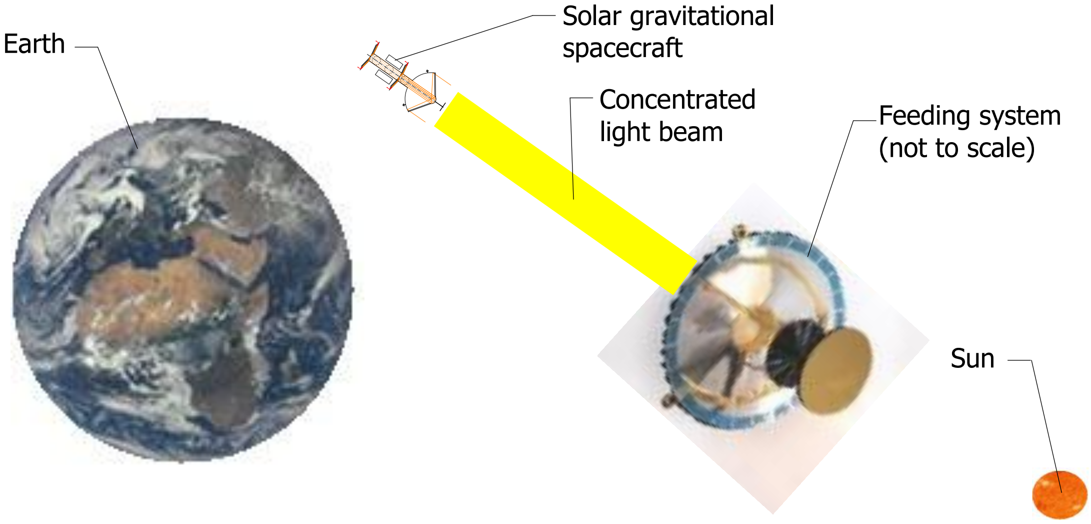

Figure 10: Navigation of solar gravitational spacecraft along the concentrated light beam emitted by the feeding system

The concentrated light beam is a spiral with approximately zero curvature i.e., it is almost a straight line. However, for continuous navigation in the concentrated light beam the solar gravitational

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spacecraft must make continuous corrections opening the central light shutters (fig.7) (the front and rear shutters are used only for acceleration and deceleration of spacecraft).

8. THE PROBLEM OF MIRROR REFLECTIVITY

While in space there is plenty of light to be collected and reflected for creating gravitational radiation, the low reflectivity of materials is a great problem which must be solved. Until this problem is solved, the packets of light having energy E cannot be maintained due to absorption of light during reflection. Today, the best reflective materials can reach a reflectivity R=0.98…0.99 while for creating pulses of high energy E, reflectivity must be very virtually 1.
New artificial materials or charging of reflective layers with electrons at high potential could offer the necessary reflectivity. This is a very difficult problem of solid physics and much research work is needed for finding a solution.

9. THE FUTURE OF SOLAR GRAVITATIONAL SPACECRAFT

The solar gravitational spacecraft is an intermediate step towards building the electromagnetic-gravitational spacecraft. Looking at equation (8) one can see that if electromagnetic energy with high frequency is employed, the working electromagnetic energy E can be greatly reduced.
In ideal conditions (reflectivity coefficient of surfaces R=1), the gravitational power radiated by two parallel mirrors due to multiple reflection of two packets of electromagnetic waves having energy E each, when frequencies in the X , gamma rays or higher are used, is given in the table 2.

Table 2: Power of gravitational radiation produced through reflection of X and gamma rays

E, kJ ⇨ ν **, Hz** ⇩	**1** $\frac{dE}{dt}, kW$ ⇩	$\mathbf{10^{3}}$ $\frac{dE}{dt}, kW$ ⇩	$\mathbf{10^{5}}$ $\frac{dE}{dt}, kW$ ⇩	$\mathbf{10^{7}}$ $\frac{dE}{dt}, kW$ ⇩	$\mathbf{10^{9}}$ $\frac{dE}{dt}, kW$ ⇩	$\mathbf{10^{11}}$ $\frac{dE}{dt}, kW$ ⇩	$\mathbf{10^{13}}$ $\frac{dE}{dt}, kW$ ⇩
$3x10^{15}$ (ultraviolet)	$1.6x10^{-17}$	$1.6x10^{-11}$	$1.6x10^{-7}$	$1.6x10^{-3}$	$1.6x10^{1}$	$1.6x10^{5}$	$1.6x10^{9}$
$3x10^{16}$ (ultraviolet)	$2.5x10^{-15}$	$2.5x10^{-9}$	$2.5x10^{-5}$	$2.5x10^{-1}$	$2.5x10^{3}$	$2.5x10^{8}$	$2.5x10^{11}$
$3x10^{17}$ (X-Ray)	$2.5x10^{-13}$	$2.5x10^{-7}$	$2.5x10^{-3}$	$2.5x10^{1}$	$2.5x10^{5}$	$2.5x10^{9}$	$2.5x10^{13}$
$3x10^{18}$ (X-Ray)	$2.5x10^{-11}$	$2.5x10^{-5}$	$2.5x10^{-1}$	$2.5x10^{3}$	$2.5x10^{7}$	$2.5x10^{11}$	$2.5x10^{15}$
$3x10^{20}$ (gamma ray)	$2.5x10^{-7}$	$2.5x10^{-1}$	$2.5x10^{3}$	$2.5x10^{7}$	$2.5x10^{11}$	$2.5x10^{15}$	$2.5x10^{19}$
$3x10^{22}$ (gamma ray)	$2.5x10^{-3}$	$2.5x10^{3}$	$2.5x10^{7}$	$2.5x10^{11}$	$2.5x10^{15}$	$2.5x10^{19}$	$2.5x10^{23}$
$3x10^{24}$ (very high ν)	$2.5x10^{1}$	$2.5x10^{7}$	$2.5x10^{9}$	$2.5x10^{15}$	$2.5x10^{19}$	$2.5x10^{23}$	$2.5x10^{27}$
$3x10^{26}$ (very high ν)	$2.5x10^{5}$	$2.5x10^{11}$	$2.5x10^{13}$	$2.5x10^{19}$	$2.5x10^{23}$	$2.5x10^{27}$	$2.5x10^{31}$
$3x10^{28}$ (very high ν)	$1.25x10^{9}$	$1.25x10^{15}$	$1.25x10^{17}$	$1.25x10^{23}$	$1.25x10^{27}$	$1.25x10^{31}$	$1.25x10^{35}$

Table 2 shows that the radiated gravitational power can have very high values if the frequency of electromagnetic waves is high even if E has smaller magnitude.
Only half of this power is used for propulsion because the rest is lost in space.
Again, the main problem is the reflectivity of mirrors.
Metallic mirrors can reflect only ultraviolet light but not X-rays, gamma rays and higher frequencies.
Another problem is that a technology yielding X, gamma or higher frequency rays using solar light is imperative.

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10. CONCLUSIONS

▪ The solar gravitational spacecraft uses gravitational attraction for propulsion instead of theorem of momentum conservation. For this reason, the solar gravitational spacecraft no longer uses propellant.
▪ The gravitational radiation is produced on board the solar gravitational spacecraft through multiple reflections of concentrated sun-light between two or more mirros. This process is endorsed today by advanced physics journals.
▪ The main problem which must be solved for building solar gravitational spacecraft is increasing the reflectivity of mirrors utp to virtually 1. For achieving this goal, much research work is necessary in the field of solid physics. The reflectivity of metallic mirrors can be increased developing special materials or by charging the mirror metal with electrons of at very high electric potentials.
▪ In the future, developing technology for producing of X, gamma or higher frequency rays using solar light must be accompanied with correspondent advancements for manufacturing high reflectivity mirrors for the respective rays.

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