International Journal of Multidisciplinary Research and Development

IJMRD 2014; 1(7): 296300
www.allsubjectjournal.com
Received: 08-12-2014
Accepted: 22-12-2014
e-ISSN: 2349-4182
p-ISSN: 2349-5979

S. Thamilarasu
Assistant professor
Department of Mechanical engineering, SRM University, Vadapalani, Chennai, India.

P. Durai Raj
Assistant professor
Department of Mechanical engineering, SRM University, Vadapalani, Chennai, India.

K. Krishna das
UG research scholar
Department of Mechanical engineering, SRM University, Vadapalani, Chennai, India.

Correspondence:
S. Thamilarasu
Assistant professor
Department of Mechanical engineering, SRM University, Vadapalani, Chennai, India.

Laser driven space vehicles: An application of photons from sunlight

S. Thamilarasu, P. Durai Raj, K. Krishna das

Abstract
This paper is based on the conceptual idea of space cars, which are believed to be developed in the nearing future. The basic principle of driving these space cars is fuelling it with sunlight to drive it. Sunlight as we all know travels at the velocity of light and are also force carriers exhibiting wave-particle duality. This principle is used to calculate how much energy is required to drive the space vehicle at the needed velocity. Though this concept we will be able to make space vehicles to travel by just propagating white on and not wasting any scarce fuel resources available on the earth.

Keywords: laser, velocity, space vehicles.

1. Introduction
We are familiar with the fact that light travel at high velocities i.e., velocity of light (approx. 3×10^8 m/s). Then why not we think of driving vehicles in outer space at the velocity of light. But we very well know that it is not possible to achieve it on the earth because of various damping factors. If we are able to filter the sunlight of ultraviolet and other harmful radiations, we can easily drive rockets and other space vehicles without damaging them.

2. Light
Light usually refers to visible light, which is electromagnetic radiation that is visible to the human eye and is responsible for the sense of sight.[1] Visible light is usually defined as having a wavelength in the range of 400 nanometres (nm), or 400×10^{-9} m, to 700 nanometers – between the infrared, with longer wavelengths and the ultraviolet, with shorter wavelengths. [2][3] The main source of light on earth is the sun. Sunlight provides the energy that green plants use to create sugars, which release energy into the living things that digest them. This process of photosynthesis provides virtually all the energy used by living things. Historically, another important source of light for humans has been fire, from ancient campfires to modern kerosene lamps. With the invention of electricity, electric lighting has all but replaced firelight. Some species of animals generate their own light, called bioluminescence. For example, fireflies use light to locate mates, and vampire squids use it to hide themselves from prey. Primary properties of visible light are intensity, propagation direction, frequency or wavelength spectrum, and polarization, while its speed in a vacuum, 299,792,458 meters per second, is one of the fundamental constants of nature. Visible light, as with all types of electromagnetic radiation (EMR), is experimentally found to always move at this speed in vacuum. In physics, the term *light* sometimes refers to electromagnetic radiation of any wavelength, whether visible or not.[4][5] In this sense, gamma rays, X-rays, microwaves and radio waves are also light. Like all types of light, visible light is emitted and absorbed in tiny "packets" called photons, and exhibits properties of both waves and particles. This property is referred to as the wave–particle duality. The study of light, known as optics, is an important research area in modern physics.

3. The sun
The Sun is by far the largest object in the solar system. It contains more than 99.8% of the total mass of the Solar System (Jupiter contains most of the rest). It is often said that the Sun is an "ordinary" star. That's true in the sense that there are many others similar to it. But there are many more smaller stars than larger ones; the Sun is in the top 10% by mass. The median size of stars in our galaxy is probably less than half the mass of the Sun. The Sun is personified in many mythologies: the Greeks called it Helios and the Romans called it Sol. The Sun is, at present, about 70% hydrogen and 28% helium by mass everything else

("metals") amounts to less than 2%. This changes slowly over time as the Sun converts hydrogen to helium in its core. The outer layers of the Sun exhibit *differential rotation*: at the equator the surface rotates once every 25.4 days; near the poles it's as much as 36 days. This odd behavior is due to the fact that the Sun is not a solid body like the Earth. Similar effects are seen in the gas planets. The differential rotation extends considerably down into the interior of the Sun but the core of the Sun rotates as a solid body. Conditions at the Sun's core (approximately the inner 25% of its radius) are extreme. The temperature is 15.6 million Kelvin and the pressure is 250 billion atmospheres. At the center of the core the Sun's density is more than 150 times that of water. The Sun's power (about 386 billion billion mega Watts) is produced by nuclear fusion reactions. Each second about 700,000,000 tons of hydrogen are converted to about 695,000,000 tons of helium and 5,000,000 tons (=3.86e33 ergs) of energy in the form of gamma rays. As it travels out toward the surface, the energy is continuously absorbed and re-emitted at lower and lower temperatures so that by the time it reaches the surface, it is primarily visible light. For the last 20% of the way to the surface the energy is carried more by convection than by radiation. The surface of the Sun, called the photosphere, is at a temperature of about 5800 K. Sunspots are "cool" regions, only 3800 K (they look dark only by comparison with the surrounding regions). Sunspots can be very large, as much as 50,000 km in diameter. Sunspots are caused by complicated and not very well understood interactions with the Sun's magnetic field. [6]

4. Photons

A photon is an elementary particle, the quantum of light and all other forms of electromagnetic radiation, and the force carrier for the electromagnetic, even when static via virtual photons. The effects of this force are easily observable at both the microscopic and macroscopic level, because the photon has zero rest mass; this allows long distance interactions. Like all elementary particles, photons are currently best explained by quantum mechanics and exhibit wave–particle duality, exhibiting properties of both waves and particles. For example, a single photon may be refracted by a lens or exhibit wave interference with itself, but also act as a particle giving a definite result when its position is measured. The modern photon concept was developed gradually by Albert Einstein to explain experimental observations that did not fit the classical wave model of light. In particular, the photon model accounted for the frequency dependence of light's energy, and explained the ability of matter and radiation to be in thermal equilibrium. It also accounted for anomalous observations, including the properties of black-body radiation, that other physicists, most notably Max Planck, had sought to explain using semi classical models, in which light is still described by Maxwell's equations, but the material objects that emit and absorb light do so in amounts of energy that are quantized (i.e., they change energy only by certain particular discrete amounts and cannot change energy in any arbitrary way). Although these semi classical models contributed to the development of quantum mechanics, many further experiments [7, 8] starting with Compton scattering of single photons by electrons, first observed in 1923, validated Einstein's hypothesis that light itself is quantized. In 1926 the optical physicist Frithiof Wolfers and the chemist Gilbert N. Lewis coined the name photon for these particles, and after 1927, when Arthur H. Compton won the Nobel Prize for his scattering studies, most scientists accepted the validity that quanta of light have an independent existence, and the term photon for light quanta was accepted. In the Standard Model of particle physics, photons are described as a necessary consequence of physical laws having a certain symmetry at every point in space-time. The intrinsic properties of photons, such as charge, mass and spin, are determined by the properties of this gauge symmetry. The photon concept has led to momentous advances in experimental and theoretical physics, such as lasers, Bose–Einstein condensation, quantum field theory, and the probabilistic interpretation of quantum mechanics. It has been applied to photochemistry, high-resolution microscopy, and measurements of molecular distances. Recently, photons have been studied as elements of quantum computers and for applications in optical imaging and optical communication such as quantum cryptography. [9]

5. The Concept

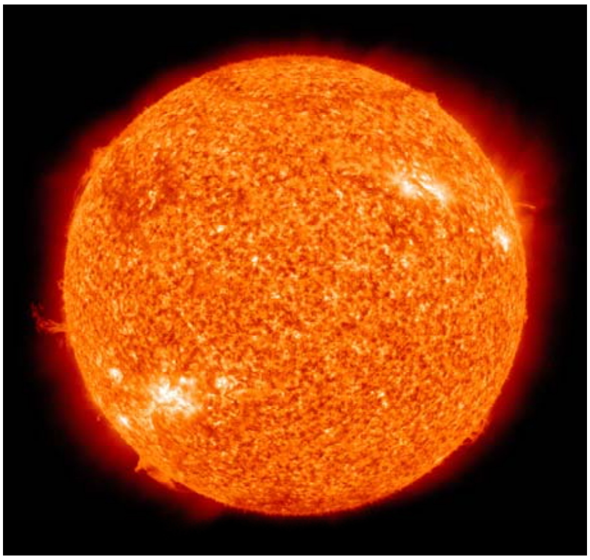
Photons travel at the velocity of light in other words photons are the fundamental units of light or energy packets. Though they are considered to not have any mass (according to quantum mechanics) they exert a force on any object they fall on. So, we are making use of this energy without any remarkable significant loss (due to energy conversion). All we need to take care is that we have to concentrate the light after filtering it with a artificially created ozone layer in the required place in the space to make the objects to travel in the required paths.

6. Calculation

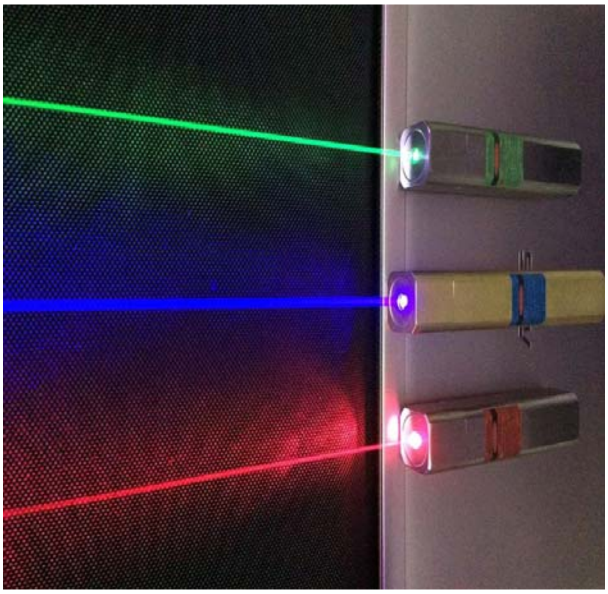
We know that, $c = \nu\ \lambda$ (which velocity of a wave)
and also $e = h\ \nu$ (which gives energy of a wave) we know power = 1.5 mW for a laser transition (laser pumped by sunlight)
$F = m\times a$,
We know mass is negligible for a photon,
So, $F = a\times 1$
$= (v-u)$.. [where, u=0 m/s]
$= (2.99\times108)$ Kg-m/s or N.
$e = (h\times c/\lambda)$
which gives,
$e = (h\times 2.99\times 108/633\times 10\text{-}9)$ ev
$= 7.085 \times 1026h$.
We know, Power(P) = energy(e)×number of photons(n)
Energy of a photon (e) $= 1.239/(\lambda \text{ in } \mu m)$
$= 1.239/0.633$
$= 1.9573$ ev.
Power of 1 photon = 3.13×10-19 J/s
Force to set a satellite into earth's orbit =
$F = (mv2/r)$ [let mass of satellite be 2000 Kg]
$= (2000\times 11.22/(120))$
= 2090.666 N of force is required to launch a satellite into earth's orbit above 220 km above the earth's surface from about 100 Km above the earth.
Therefore, momentum = force × velocity.
= 2090.666 × 8000 Nm
= 16725333.33 Nm.
Momentum of a photon = e/c
$= 7.085 \times 1026h/2.99\times 108$
= 15.696 Nm
No. of photons needed = 16725333.33/15.696
= 1066223 photons.

Therefore, 1066223 photons of 633 μm wavelength are needed to set a satellite of 2000 kg into geo-stationary orbit about 220 Km above the earth's surface. Which eventually means, we need laser transition for this to happen.

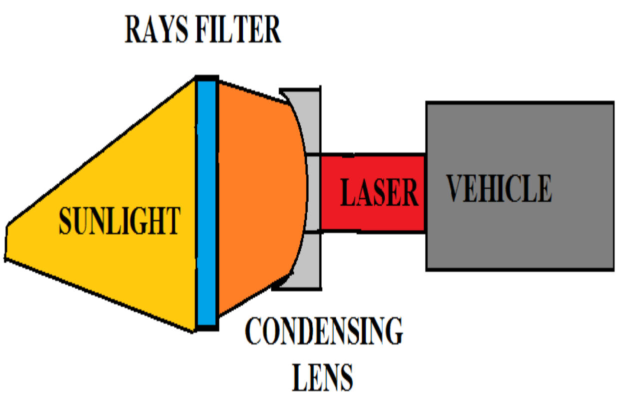
7. Diagram



The Sun [10]



Existing Laser Sources [11]



The Setup

8. Definitions

- **Damping factor** –Damping is an influence within or upon an oscillatory system that has the effect of reducing, restricting or preventing its oscillations. In physical systems, damping is produced by processes that dissipate the energy stored in the oscillation. Examples include Viscous drag in mechanical systems, resistance in electronic oscillators, and absorption and scattering of light in optical oscillators. Damping not based on energy loss can be important in other oscillating systems such as those that occur in biological systems. [12]

- **Dynamic**
  It a branch of physics (specifically classical mechanics) concerned with the study of forces and torques and their effect on motion, as opposed to kinematics, which studies the motion of objects without reference to its causes. Isaac Newton defined the fundamental physical laws which govern dynamics in physics, especially his second law of motion. [13]

- **Einstein's theory of relativity**
  The theory of relativity, or simply relativity in physics, usually encompasses two theories by Albert Einstein: special relativity and general relativity. Concepts introduced by the theories of relativity include : particular, space and time can dilate. Space-time: space and time should be considered together and in relation to each other. The speed of light is nonetheless invariant, the same for all observers. [14]

- **Flex**
  "To flex" as a verb means "to bend". [15]

- **Frame of reference**
  In physics, a frame of reference (or reference frame) may refer to a coordinate system used to represent and measure properties of objects, such as their position and orientation, at different moments of time. It may also refer to a set of axes used for such representation. In a weaker sense, a reference frame does not specify coordinates, but only defines the same 3-dimensionalspace for all moments of time such that the frame can distinguish objects at rest from those that are moving. [16]

- **Frequency**
  Frequency is the number of occurrences of a repeating event per unit time. It is also referred to as temporal frequency, which emphasizes the contrast to frequency and angular frequency. [17]

- **Friction**
  Friction is the force resisting the relative motion of solid surfaces, fluid layers, and material elements sliding against each other. There are several types of friction: like fluid friction, dry friction, and sliding friction. [18]

- **Galaxy**
  A galaxy is a massive, gravitationally bound system consisting of stars, stellar, an interstellar medium of gas and dust, and dark matter, an important but poorly understood component. [19]

- **Gravity**
  Gravitation, or gravity, is a natural phenomenon by which all physical bodies attract each other. It is most commonly recognized and experienced as the agent that gives weight to physical objects, and causes physical objects to fall toward the ground when dropped from a height [20].

- **Interstellar space**
  Interstellar space is the physical space within a galaxy not occupied by stars or their planetary systems. The contents of interstellar space are called the interstellar medium. The average density of matter in this region is about 106 particles per m^3 [21].

- **Law of conservation of momentum**
  In classical mechanics, linear momentum or translational momentum is the product of the mass and velocity of an object [22].

- **Monochromatic**
  Monochromatic colors are all the colors (tints, tones, and shades) of a single hue [23].

- **Newton's third law of motion**
  When one body exerts a force on a second body, the second body simultaneously exerts a force equal in magnitude and opposite in direction to that of the first body [24].

- **Orbit**
  In physics, an orbit is the gravitationally curved path of an object around a point in space, for example the orbit of a planet around the center of a star system, such as the Solar System. Orbits of planets are typically elliptical [25].

- **Photons**
  A photon is an elementary particle, the quantum of light and all other forms of electromagnetic, and the force carrier for the electromagnetic force, even when static via virtual photons [26].

- **Polarized light**
  A polarized light is a ray of light that have been polarized. Polarization is a property of waves that can oscillate with more than one orientation. Electromagnetic waves, such as light, and gravitational waves exhibit polarization whereas this is not a concern with sound waves in a gas or liquid which have only one possible polarization, namely the direction in which the wave is travelling [27].

- **Trajectories**
  A trajectory is the path that a moving object follows through space as a function of time. The object might be a projectile or a satellite, for example. It thus includes the meaning of orbit—the path of a planet, an asteroid or a comet as it travels around a central mass. A trajectory can be described mathematically either by the geometry of the path, or as the position of the object over time [28].

- **Wavelength**
  In physics, the wavelength of a sinusoidal wave is the spatial period of the wave—the distance over which the wave's shape repeats. It is usually determined by considering the distance between consecutive corresponding points of the same phase, such as crests, troughs, or zero crossings, and is a characteristic of both traveling waves and standing waves, as well as other spatial wave patterns [29].

9. Advantages of the System

The advantages of this system are:

- There is no need for any external source to produce the laser.
- Eliminates the need for fuel usage for satellites.
- No remarkable loss of useful harmless energy as there is less transformation.
- Vehicles able to orbit at high velocities at a greater radius too.

10. Demerits of This System

- Cost of installation is high.
- Must be done with a lot precaution.
- Creating an artificial filter to filter the radiations is difficult.
- Can be done only in space stations not on earth.

11. Conclusion

Thus we have come across a new methodology to produce laser and its real time application which may provide a breakthrough in the field of astrophysics and set up the trend for this technology to develop to great extent with a lot of scope in this field and also related fields. Thereby we have produced or synthesized laser transition from mere white light (sunlight) and discussed its possible applications in this paper.

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