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Solar Electric Propulsion Sail

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Abstract: *The solar expedition missions have been minimized mainly due to the performance of the space capsules, also because of the planned amount of fuel a space shuttle must carry without discharging in order to advance to an unfamiliar region. Traditionally, a solar electric propulsion sail is extremely deformable to drive a space rocket through outer space. Photon or electric sails are propounding medium of propulsion by utilizing the cosmic radiation endeavored because of sun's rays on massive mirrors. It is a fusion of photo-voltaic cells and ions for the propelling and is also capable of enabling very fine maneuvering of the spacecraft by means of large sail-surface deformations. Solar electric propulsion sailutilizes the natural beams of sunlight to advancethe vehicles into and out of space, just the way wind helps to propel the sailboats over the water. NASA team claimed working on the start ofgrowth of technology on the assignment recognized as the solar sail demonstrator which proved thatmaking use of giant, weightless and unfurling objects float in universe would enhance the abilities of travelling deeper in space. The reliance on reflective and captive material for construction of electric sail. Factors such as wave length and temperature could make way for the finer operation.*

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I. Introduction

Solar electric propulsion sail avails sun's beam to catapult through the vast dimensions of space by the reflection of solar radiations comingfrom massive, mirror-alike instrumentsmade of flimsy, highly reflective substances. The solar electric sail can be utilized for flights to the major planets, to meet with asteroids and comet, to realize a special desired motion in the neighbourhood of the Sun or near the Earth. Theusage of materials by NASA mainly is a temperature-resistant substance known as CP-1 that is proved to be 100 times less in weight than the regular sheet of stationary; alsothe material should be an aluminized. The study of the synergy of two elements of solar light, the radiation of the electromagnet and energyfrom the low and high electrons helium and photon ions coming from the Solar systemalong with the materials add to the working of the sail .The weightless nature of electric sail unfolding outside the earth by utilizingthe pressure from sunlight itself for providing propellant, transportation, hovering and exploration capabilities to the sail. Solar electric propulsion sailconsumes light from sun to propel itself through vast region in space, just the way airblows the sail boat across river. Technology uses solar radiation from sunlight which reflect due to gigantic, large mirror kindof things in the shape of sails made out of lightweight, reflective things about 40 to 100 times thinner,than a regular paper used for writing. The continuous emission of solar pressure provides sufficient thrust for arranging the manoeuvres, usually for drifting only at a stationary point in the expanded lands which in turn would need much more propulsion for the normal space rocket, because the sun provides all the required propeller energy, solar electric sails requires no on-board propulsion, hence helps in reducing the mass load on the vehicle.

II. Mission goals & objective

Primarily, a solar electric sail spacecraft requires three key components continuous, force exerted by sunlight,a large ultrathin mirror, used for different launching vehicle. Solar electric propulsion sail is significant for the missions that require space capsule to workabsolutelyon large variety of manoeuvres, so thatthe change in orientation and also orbital elements, revolvingat a stationary place. Missions that need constant transportation vehicles to attain the need of thrustfor scientific objectives. For the working of the solar electric sail by providing the space shuttleswith lightweight materialwhich is highly reflective having the capacity to take extreme conditions and also temperatures.

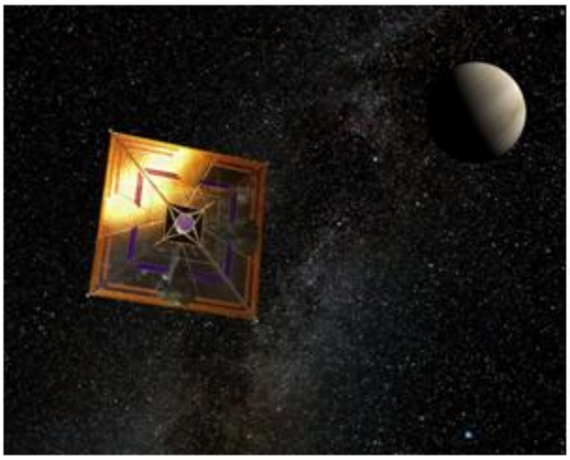

Fig [1]: Represents the solar electric sail.

This technology would help us to eradicate some of the problems caused during orbital launch. Debris in the planet would alsocome in the way for conduction where station keeping operations would come to a halt and this would stop the examination at vast latitudes and longitudes much above the earth for mainly the communication purpose and observation at the universe.

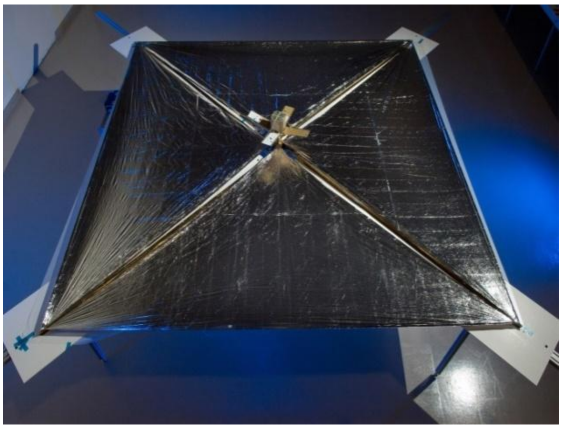

Fig [2]: The scaled model of previous version of solar sail.

The main ideology of the modern solar electric propulsion sail would be to have an ideal sail which is totally flat and is 100% specular in terms of reflecting. The sail actually should contain an overall productivity of at least 90%, 8.17 μN/m because of the curvature, re-radiation .The absorbancefrom the back n rear, and the non-specular effects most importantly that the sunlight has electromagnetic radiation that could beexerted only when there is a certain pressure ,force on article as it comes to contact .

If the solar electric sail is successful then it would unlock the path to number of versatile missions that could lead right into land of deep space using advancements like flying an advanced space weather warning system that could warn us before of the consequences more accurately also an alert satellite operator that could be used on earth for warning us much before the geomagnetic storms are hitdue to mass coronal ejections that are produced due to the sun. Ultimately, solar electrictechnology will lead to the interstellar trips and make possible the shuttling among the planets. That would be muchlessoverpriced than before and hence lead to more realistic conventional means of rockets.

III. Past Of The Solar Sail

The main ideologyofa solar electric propulsion sail is that it has been there from approximately more than 100 years, it all started with the Tsiolkovsky and Tsander in the1900. Professionals at JPL completed the very first mission work and study in the end of 1970s for aassigned work along with Halley's Comet. Traditionally many just simply believe that that spacemachine utilizing the solar sails arepropelled due to strong sun rays much alike the way a sailing boat or a simple sailing ship are shoved using the strong breeze across the water bodies .But solar radiation exerts a pressure on the electric sail is caused by themirroring of sunlight as a small amount of itis soaked up.Johannes Kepler noticed that comet tailsare directed opposite from the light and he alsoproposed that the sun is the main cause of the effect. While writing the letternote to Galileo in 1610, he said that "Provide ships or sails adapted to the heavenly breezes, and there will be some who will brave even that void".NASA had given a name to their innovatory solar sail spacecraft as - the Sunjammer mainly to honour the author C. Clarke's story known as 'The Sunjammer', in the 1964 where he had made up the phrase 'solar sailing'. In the 1973 the main ultimatum was that of packing such a massive structure in space odyssey which wasdaunting.Heliogyro solar electric sail is having about 12 rotating blades which were of about approximately four miles extended. While the space ship offers totally the most advanced ways to release the payloads, its cost was gobbling up an exorbitantly huge amount of NASA's estimation plan.

NASA's space propulsion technology was one such project that had been promoting thegrowth of two major prototypes that would be solar sail structures only for surface testing. Two squared shaped sail designs were developed. These comprised of 4 sections which were made of reflective membranes, a deployable unit for support of structure, control of attitude subsystem and necessary hardware to place the sail ready for launch. These different 20-m solar electric sail systems were manufactured and had successfully accomplishedtheir functioning of a vacuumchecked at the Glenn Research Centre's (GRC's) Space. Outside of NASA, solar electric sailing is ontrial in the space. Duringmid-summer of 2010, a Aerospace Exploration Agency belonging to the JAXA from japan had launched a solar based spacecraft and called it as IKAROS in tandem with another mission to Venus. The sailcraft IKAROS (14 m by 14 m) is the first in-flight demonstration of solar sailing (Tsuda, 2010). While the issues of solar radiation pressure (SRP) are tiny on this spacecraft comparing to other concepts for sail.

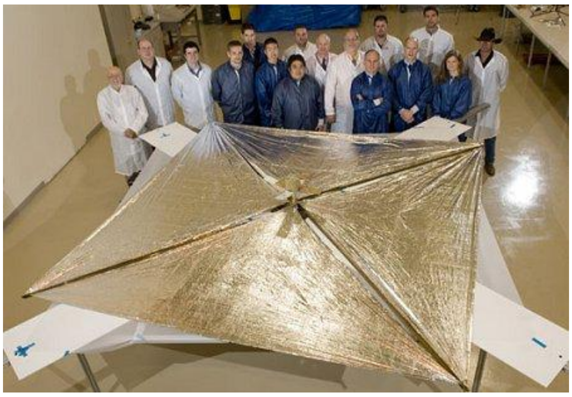

Fig [3]: The prototype sail in front of NASA team on Solar Electric Propulsion, courtesy-NASA.

Various program goal have been attained, including certifying solar radiation pressure (SRP) issues on the sail and performing in-flight supervision and navigation approach using the solar .

IV. Physical Principles

Solar radiation exerts a pressure on the electric sail because it throws back the radiation and therefore a very small proportion is taken inside.Momentum of the photon or thetotal amount flux is given by Einstein's relation.

$p = E/c$

The force exerted and also acceleratedgives advancement at zero generally for around $\theta = 60°$ instead of being 90° as one will expect with an unreal sail. If the energy is to be considered then, the energy engrossed in it will heat the sail, which re-diffuse this source of energy from the front and back surfaces, relying on the emissivity of these two places. Solar breeze, the flow of charged particles directed and sucked from the Sun, is likely going to exert a nominal amount of dynamic pressure of at least 2 to 4 nPa, three orders of magnitude fewer than solar pressure on the reflective part of sail.NASA scientists have devised that at one astronomical unit (AU), which is equal to 150 million km, sunlight can generate about 1.4 kW of power. When 1.4 kW is divided according to the speed of light, it grants the force applied by the sun, which is about 2 lb./km2.

Hence CP-1 is considered an ideal material for all the factors until now.

V. Mission concept & operation:

Conventionally, solar explorationhas been brinked by the conduction of the space shuttles and also by the quantity of fuel a spacecraft must bear to travel to an unexplored region. Hence in today's day the need of a solar electric propulsion sail is highly essential that is capable of the exploration of the space odyssey.Here photons from sun's radiation will rebound from the reflective material, and propel the sail along by substituting momentum to the sail. The perpetual pressure plying on the sail generate a regularthrust for the spacecraft. The solar-sail spacecraft is consistentlyhastened and over time building a greater velocity than conventional. Before using the solar electric propulsion sail the checking of Attitude controls, assessment of sail stability, ability to trim, navigation sequence are some of the issues being looked into. The operation of the solar electric propulsion sail depends on force exerted by sunlight, a large ultrathin mirror, and a sovereign launch vehicle. Solar electric propulsion sail is significant for the missions that lack a space vehicle to achieve a large variety of gimmick, such as changing orbital elements or coordination, lingering at a fixed point. Missions that needconsistent vehicle thrust to attain science objectives are main factors comprising of the working of the sail. These possible factors were observed and improved so that the solar electric sail would be highly utilizable:-

- Diminished absorption: The planned diffractive layer would eradicate problems embedded in the metallic coating, which has heat and accommodates sail substrates.
- Restate of photons: Diffractive sails would reclaim transfered photons, transducing them to solar-electric power or diffracting the radiation twice for extra momentum. (Reflective sails reverse photons back into cosmos or absorb in the metallic coating).
- Upgraded orientation: Diffractive sails cultivate a more adequate position towards the sun, avowing highly efficient driving anddeveloping of electric solar power on implanted of photovoltaic cells. However, this assimilationreduces the eaves of solar power upon the sail.

In case the solar electric sail goes farfrom the sun, NASA has an alternative, an on-board laser is designated to control and arrange the necessary propulsion for the sail.

VI. Space Vehicle description and design (future possibility)

The solar sail is one of the very few nominated space-propulsion ideas that has huge potential, because it takes asset of sunlight and does not need the chemical fuel that spacecraft heavily dependent on for propulsion. We are Introducing a new possible theory which would be of the more complex folding mechanism for sail so that we get more surface area leading that would lead to betterment of the solar electric sail. One more factor that is to reducing the size of pre-expansion housing as new sail will be much more effectively applied in smaller housing hence benefits us with space for other essential components. Solar electric propulsion sails accelerate slowly till now but surely are capable of eventually reaching tremendous speeds that may eventually be applied to interstellar exploration and travel. NASA has found an aluminized, temperature-opposing material named CP-1 polyimide, which is assumed to be 100 times meagre than an average sheet of paper. About 47% of the solar radiation is in the feild of infrared and microwave spectrum which is generating the heating of the sail and, as a conclusion, its temperatureescalates. Hence CP-1 polyimide is considered an ideal material for all the factors until now.

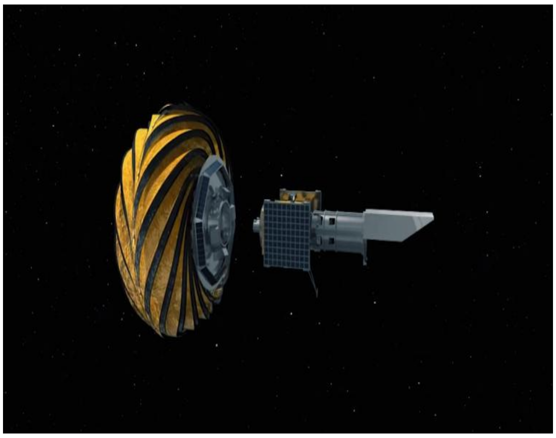

Fig [4]: Theinitial phase of sail separating from housing and then in the process of expansion, courtesy-SEEKER.

The main demerit of the other solar sail was mainly due the acceleration and also that they lose thrust the further you are from the Sun. They are large, delicate, and cannot be used on any craft intended to land on another body unless jettisoned or retracted. That increases very gradually, other than any conventional rocket, which could offer potentially quick acceleration. So, for a rapidexpedition to Mars, a solar electric sail being propelledoffers no benefit over a conventional chemical space craft engine. However, if you would like to carry a huge pay-load to Mars or if you are in a hurry, a solar electric propulsion sail spacecraft is perfect thing to travel in.In space the sail expand itself from ejecting from its housing due to moving mechanical components and gears to its full extend. The whole expansion could take within an hour and adjust itself facing the sun directly. The wrapping of the sail is done in complex manner keeping goal in mind of having the large sail in a comparatively very small housing.

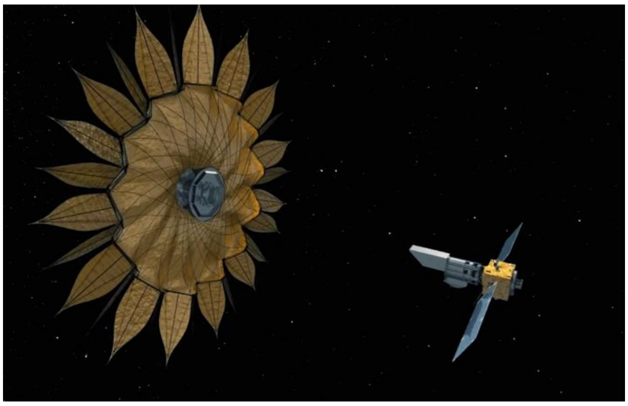

Fig [5]: The mid process of expanding of sail in space after entering in the orbit, courtesy-SEEKER.

The major benefit of this solar electric propulsion sail shuttle is its ability to travel inter-planets and between stars without carrying much fuel. This solar sail system has a symmetrical structure as for symmetric sails, some of the force and moment tensor coefficients go to zero or become equal to each other, thus the total amount of coefficients necessary to characterize the force or moment is reduced.

V. Conclusion

Ultimately, solar electric propulsion sail technology will advance us in making interstellar flights and transporting between planets cost-effective and therefore more useful than conventional chemical rockets. The major supremacy of a solar electric propulsion sail space shuttle is due to its capacity to travel effortlesslyin-between the planets and much more into the stars even in the absence of fuel, as these have simulatedand constant acceleration can achieve greater velocities than any other rockets present till date and so can span the distance in less time.

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