SEND OFF TO SPACE DEBRIS USING LASER TECHNIQUES!

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ABSTRACT

This is a proposal of well framed ideas to manage the ever increasing problems of space debris. Firstly the convention flight and rocket techniques are used in combination to put the apparatus to the space station. The experiment is controlled from the space station to clear out space debris. The experiment is developed based on the ablation of ultra-short laser pulses and plasma beam on different metals and other poly-materials while also discussing on the generation of high-density and high-temperature plasmas by focusing high peak power laser radiation onto solid targets in space. The experiment will be given of the main experimental techniques, namely optical emission and absorption spectroscopy, mass spectrometry, time-of-flight and charge collection measurements, devised to characterize laser-produced plasmas. The fundamental theoretical and numerical approaches developed to analyze laser-target interaction, plasma formation, as well as its expansion will also be reviewed while focusing mainly on metal target ablation and keeping in mind the continuous qualitative change in the velocity spectrum of expanding ions with increasing laser pulse length, ranging from approximately isothermal behavior from short pulse to ablative behavior from longer pulses.

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INTRODUCTION

LASER's are widely used in the modern world with its ever increasing applications. The LASER ablation techniques are also well known but limited in terms of its applications; the pulsed LASER techniques are now employed. Currently, being in research and developmental stage this new study ensures the mitigation of space debris cost effective and simple. The threat of space debris is growing exponentially for every payload which faces the sky. The space environment is polluted by the debris with ever increasing threat of colliding with international space station and damaging it, if not killing astronauts on board which will quite possibly halt future manned missions to space. The radical solution which has been an outcome of data which can employed to eliminate space debris from space either with human intervention or artificial intelligence.

The paper is being one of the applications of the femto-second technologies, the advantage being that there is no formation of molten materials which in turn might cause secondary problems. In this paper, we apply the investigated results of the ablation of metal targets and theoretically by (300 fs-20 fs depending on the thickness and the metal in question) Ti-sapphire LASER at 20mJ with average power up to 80 Watts at about 800nm-1120nm and other key advancements in the field[1][2][3][8].

Step 1 – REACHING SPACE!

The payload being the LASER ABLATION INSTRUMENT is carried in a hybrid space vehicle with self propulsion payload. The payload will be launched to a height of 70000 m after which the payload with self-propulsion device coupled with conventional orbital maneuvers will reach the destined orbit or ISS in this particular case.

The new flight – rocket system named are designed with capabilities to fly at higher altitude under extremely flight-unfriendly conditions. The launch, fuel costs are expected decrease by a maximum of 30 % (approximations) to the conventional launch with liquid/solid fuels. The flight carriers the rocket system to an altitude of about 45000 m above sea level and then the rocket which is a special type of sounding rocket gets activated and launches the system into the desired

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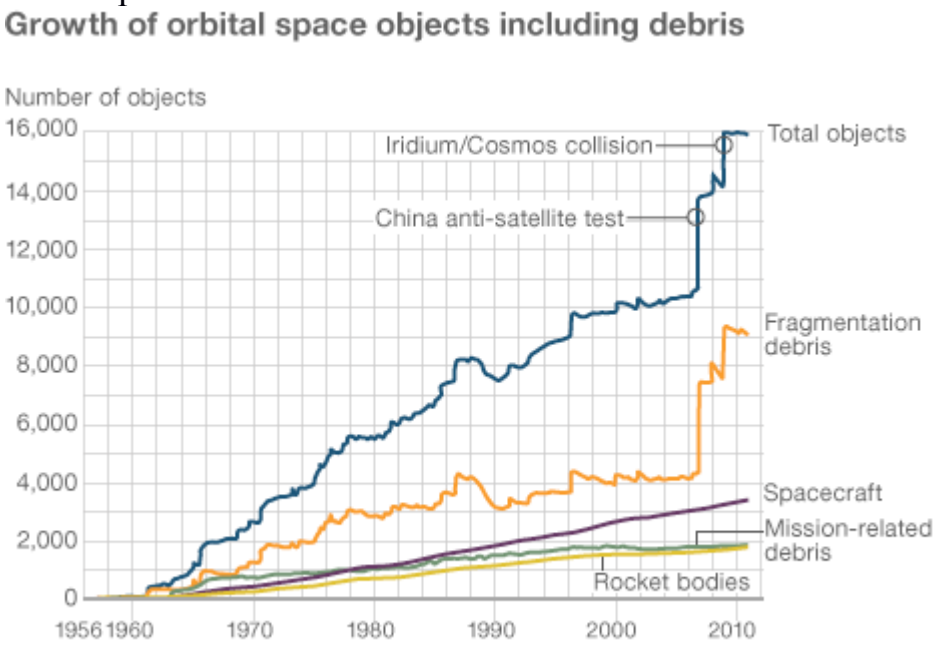
orbit or to ISS. The flight along with most of the rocket body is recovered on earth minimizing space junk and cost.

SCIENTIFIC OBJECTIVES

Upon careful study of affects of laser ablation, fundamental interactions of laser interactions and femto second laser applications and also the proceedings of UN space debris mitigation 2009, [5] [6] [7] following conclusions were made:-

1. The problem of space debris requires immediate attention and presently there is no factual solution at hand which can be employed safely, cost-effectively.
2. The present solutions are not applicable for space debris of all sizes and shape.



Step 2:- THE DEVICE -- P-MAN payload!

The device is a Ti-sapphire LASER which operates at 5mJ with average peak energy of 80 Watts while operating at a minimum of 800nm (upto 1100nm) at about 60fs maximum efficiency with divergence angle θ of about 0.16mrad. The radius r_0 is about 0.254mm.

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Table 1:- standard P-man payload

Scientific payload element	Mass [kg]
Standard laser instrument package	22
Robotic tech and detection device	3
Power source such as RTG/panels	20
Total	45

The mass of the standard P-MAN package may seem quite low however the mission requirements are nothing more than what is listed above. Also considering in this study, a 10% mass reduction from current values is possible with miniaturization.

Standard laser instrument package:-

The experimental setup consists of a target, spectrometer arrangement from which the analysis is made and a photo detector. The imaginary circular thread is of course to better understand the position of detectors and others experimental setups. The laser light is incident on the targeted space debris and the ablation takes place which results in the liberation of high density material from its surface at right angles to the same. The liberated material is later condensed in the material condenser however the material condenser is feasible if it operates for space debris of size >3m.

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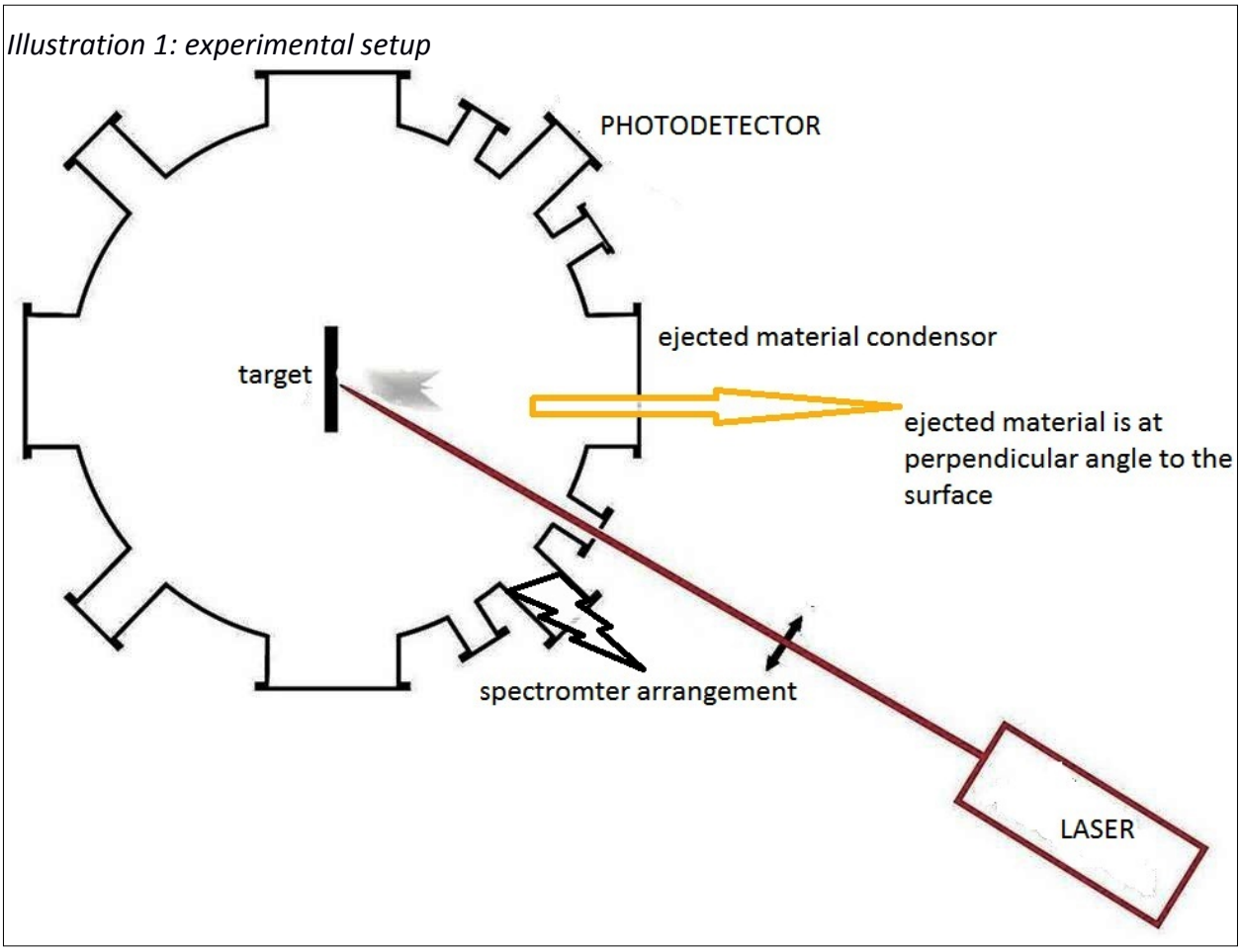
Illustration 1: experimental setup



Imaginary circular thread

The detectors were mounted behind a 1mm pinhole which was located at about 200cm from the output end of the laser. The laser used was a Ti-sapphire 20mW, 800nm of wavelength. The intensity of the light is proportional to the current produced by the photo detector.

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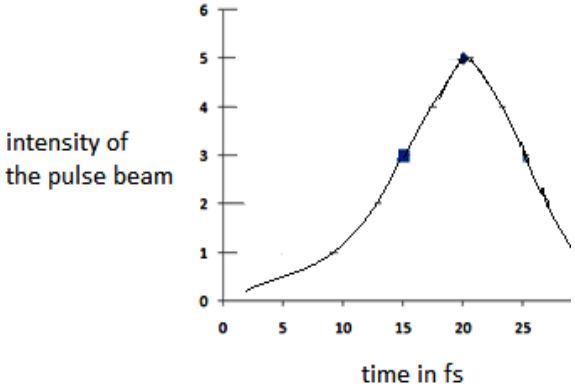
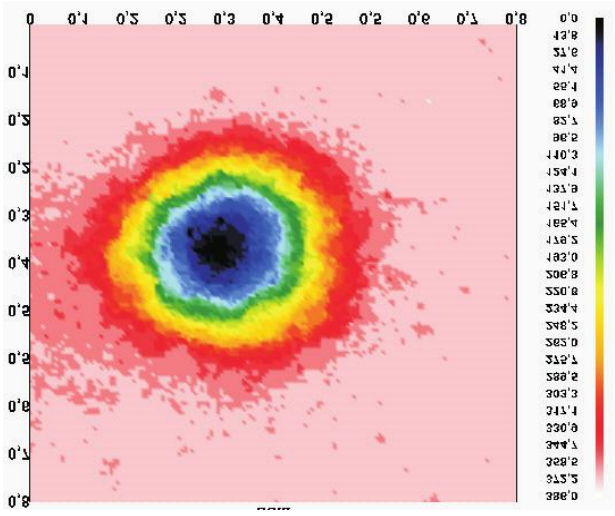
Illustration 1



The below is a contribution of experimental study (study was conducted on decreasing energy pulse) on the influence of the laser power density and energy flux. As the targets for the laser irradiation there were used various C, W and Al (as beryllium analogue) samples. We are able to conclude from the results that the energy density to the volume of the crater induced due to the ablation is linear and also that the direction of the ejected particles were perpendicular to the surface of the material which verifies [8].

Illustration2:[8] the crater depth with respect to the intensity of incident energy.



To study the behavior of metals subjected to ablation especially ultra-short pulsed laser beams and plasma beams leads us directly to the liberation of matter at high energy density irradiation. Hence the review of current advanced results of static and dynamic experiments has been studied.

Conclusion: - Laser ablation using ultra short- pico/femto second technology is one of the most successful ways of clearing out space debris relative to the already submitted ideas and projects. The above proposal can be immediately put in action,

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it requires very little human interference and it's economical and feasible. Thus character of the produced plasma will cause no secondary damage hence making it safer while the plasma can intern be used as an agent in the re-entry of selected space debris back to earth (space debris >10m) while others can be vaporized without need to receive it back on earth.

Discussion:-

1. Continuous qualitative change in the velocity of expanding ions liberated upon ablation which is to be examined in space in order to efficiently condense the liberated matter. The condenser comprises of varying electric fields which can be ideal in condensing them while keeping the energy and size minimal.
2. Precise orbit and angle of incidence of laser beam on the debris is most important because of the vast distances in space and any error may result in secondary damage either from the liberated material or the laser light itself hence care needs to be taken.
3. Space debris of size >10m must be made to fall back into the earth's atmosphere due to the limitations of the technology to completely ablate it. However even if it's ablated the chances are that the gases will cause further damage to future missions or the existing ones.

References:-

1. http://arxiv.org/ftp/arxiv/papers/1311/1311.0610.pdf
2. J. Opt. Soc. Am. B/ Vol. 14, No. 10/October 1997
3. American Physical Society 10.1103/PhysRevLett.99.195002s
4. Olowosejeje, Samuel Ayokunle. "Transition of Space Technologies and the Spin-Off Technologies Realised: An Incentive for Continued Investment in Space Exploration." Information and Knowledge Management. Vol. 3. No. 11. 2013.
5. T. Popmintchev, M.-C. Chen, D. Popmintchev, P. Arpin, S. Brown, S. Ališauskas, G. Andriukaitis, T. Balčiunas, O. D. Mücke, A. Pugzlys, A. Baltuška, B. Shim, S. E. Schrauth, A. Gaeta, C. Hernández-García, L.Plaja, A. Becker, A. Jaron-Becker, M. M. Murnane, and H. C. Kapteyn, "Bright Coherent Ultrahigh Harmonics in the keV X-ray Regime from Mid-Infrared Femtosecond Lasers," Science **336**, 1287–1291(2012)
6. Gy. Farkas and Cs. To´th, in *Fundamentals of Laser Interactions,* edited by F. Ehlotzky, Lecture Notes in Physics Vol. 339 ~Springer, Berlin, 1989!, p. 289.
7. UN_Report_on_Space_Debris99.
8. Dependence of power density and energy fluence on ablation rates and LIBS observation thresholds for laser-irradiated ITER relevant materials by P. Gasior, M. Kubkowska, J Wolowski a Institute of Plasma Physics and Laser Microfusion, Warsaw, Poland.

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