E7

レーザーパルスによる宇宙空間力積発生データーベース構築に向けて

Towards Database Development of In-Space Impulse Performance Generated by Laser Pulses

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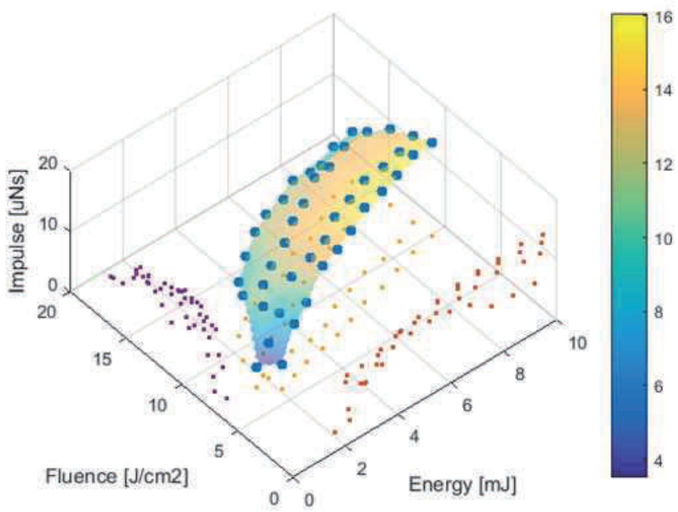
宇宙空間での遠隔的な力積発生法として、現在唯一実用可能なのは、レーザーアブレーションの利用によるものである。我々は、実験室にて、ターゲット条件（材質、形状、表面状態など）とレーザーパルス照射条件（波長、エネルギー、照射面積、繰返しパルス数、繰返しパルス周波数等）を変化させて、力積特性評価実験を行っている。図は、アルミに対して波長 1 μ m のレーザーパルスを 200 回繰返して照射したときの力積特性をまとめたもので、従来フルーエンス（照射レーザーエネルギー密度）のみの関数とされていた力積特性が、パルスエネルギーそのものも独立変数として評価されるべきであることを示唆した結果である。発表では、関連研究の総括と最新の結果について、述べる。

We are conducting in-space remote impulse measurements with various materials and their conditions and laser pulse conditions. The figure suggests that there are two independent control parameters to characterize the impulse performance.



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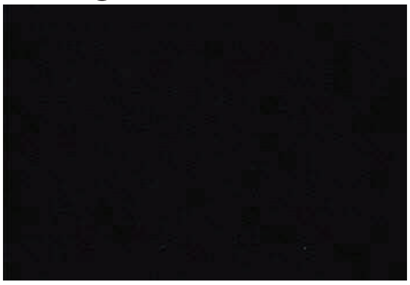
(PI: Dr. Toshikazu Ebisuzaki).

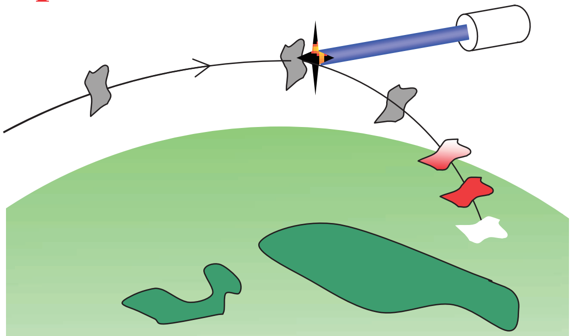
Laser Propulsion: Cheap & Fast Solution for Remote Impulse Generation

Launch by laser power

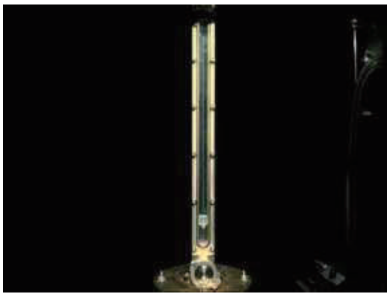
In gas-filled tube



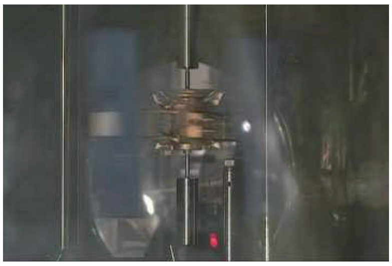
Space debris deorbit



Ablator on tube wall



Detumbling



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Impulse Generation by Laser-Pulse Ablation with Influential Parameters

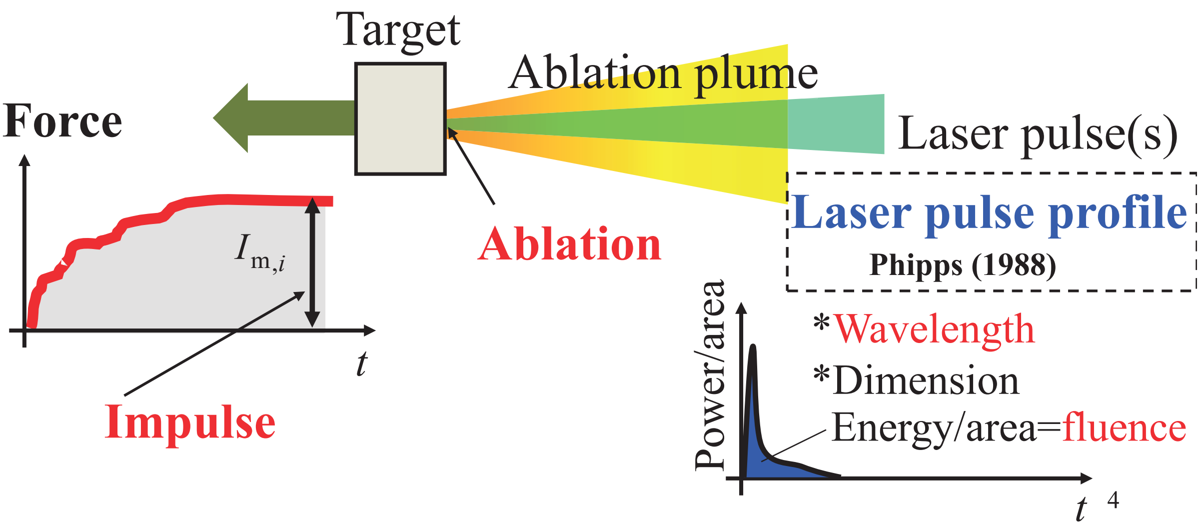
Target characteristics

- -Material
- -Geometry
- -Dimension

Phipps (1988)
Pakhomov et al. (2002)
Tsuruta et al. (2015)

Ambient gas

Lin et al. (2004)
Watanabe et al. (2006)



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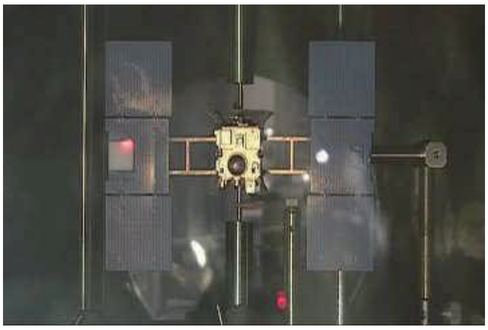
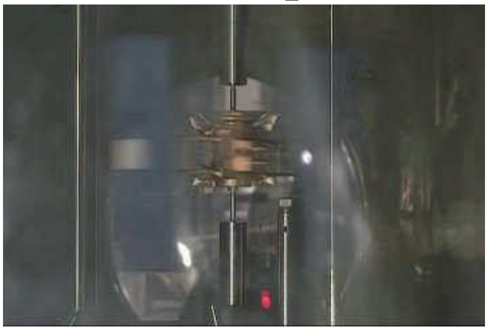
Satellite Detumbling
-Our Demonstration-

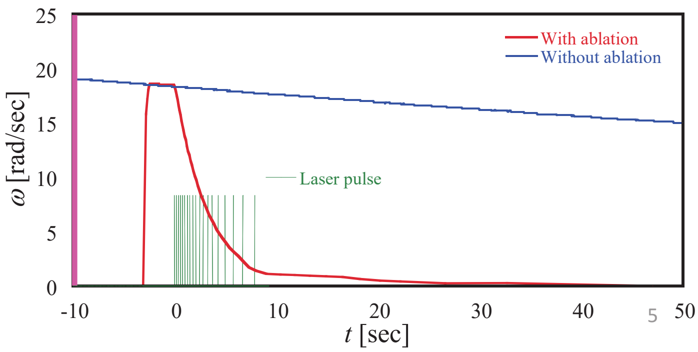
w/ laser pulses



w/o laser pulse



Ambient pressure = 1×10^{-2} Pa,
Ablator: POM,
Moment of inertia=1.22×10^{-4} kgm^2
TEA CO2 Laser
-wavelength = 10.6 mm
-pulse duration = 140 ns
-pulse energy = 5.3 J/pulse



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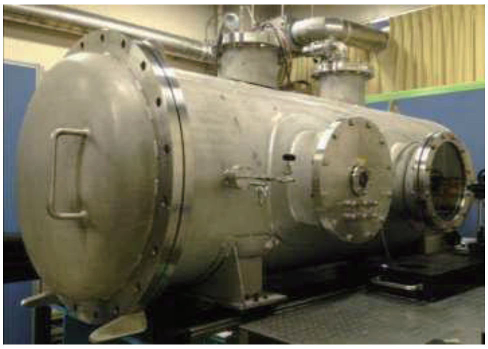
Lasers for Investigation

	Nd:YAG	TEA CO_2	Nd:YLF	Nd:YVO_4	(Nd:YAG)
Manufacturer	Litron	SLCR-Lasertechnik	Edgewave	Edgewave	QUANTA system
Wavelength, nm	532 1064	10600	1047	1064	1064
Max. Pulse Energy, mJ	150 95(250)	9000	12	7	450
Pulsewidth, nsec	10	140	5-15	5-15	7
Beam Diameter, mm	5	55	3	25	9
Max. Repetition Rate, Hz	1	50	10000	100000	1

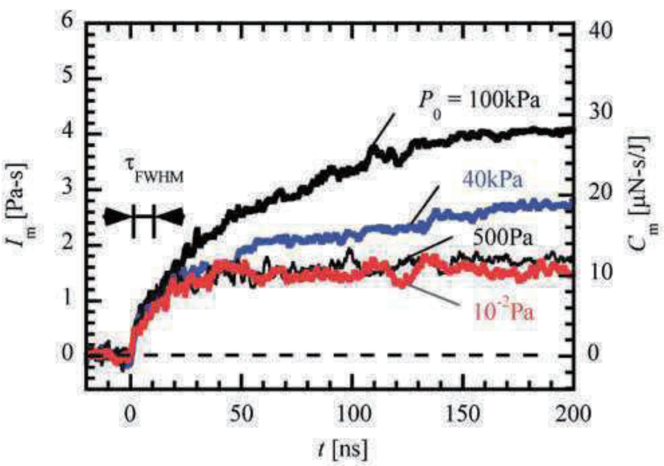
Vacuum Chambers



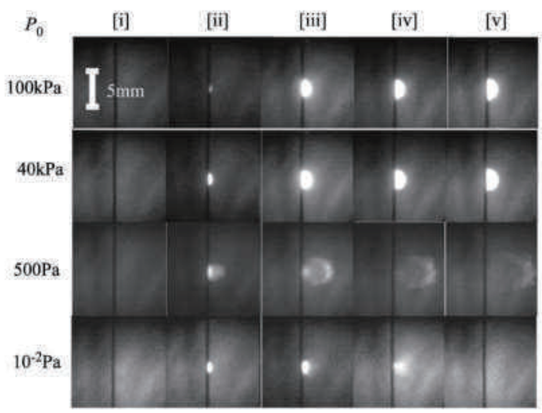
Diameter：0.7m
Length：2.2m
Pressure：10^{-2}Pa
TMP exhaust ability：2000l/s

Diameter：2m
Length：4m
Pressure：10^{-3}Pa
TMP exhaust ability：3200l/s

Time-Resolved Ablation Thrust Measurement Using VISAR

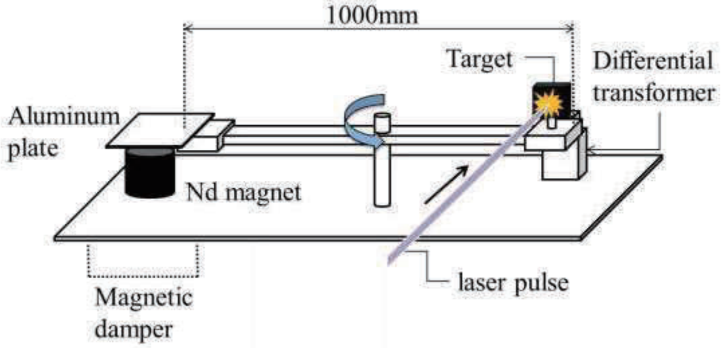


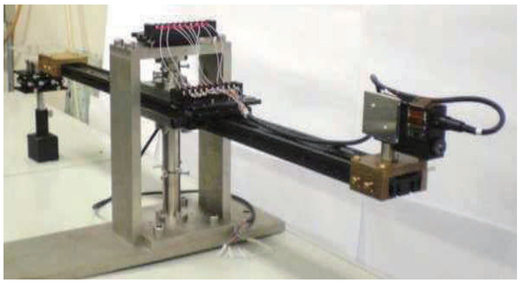
Ablator : Aluminum
Laser : Nd:YAG
Fluence : 14.5 J/cm^2

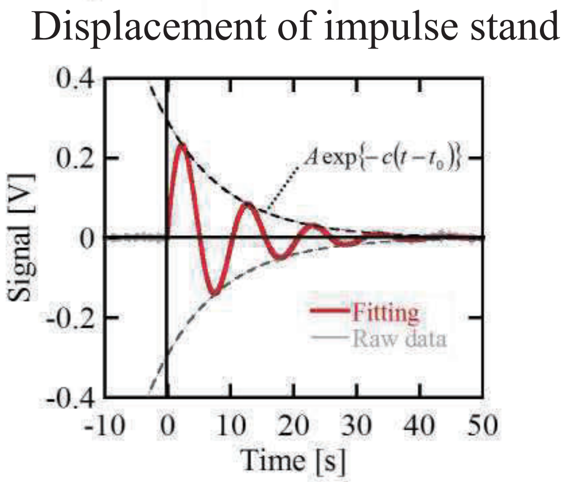


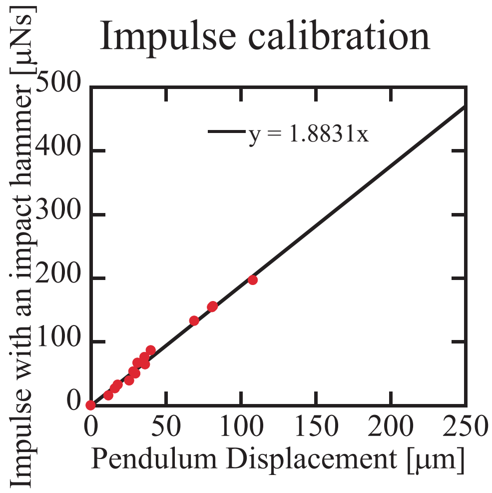
(K. Anju et al. J. Propulsion & Power, 2008)

Torsion-Type Impulse Stand









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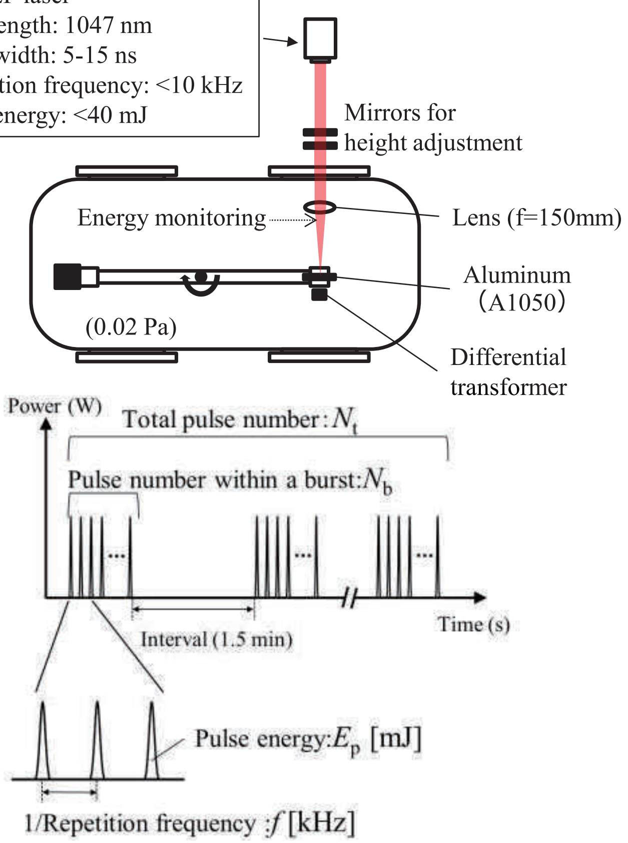
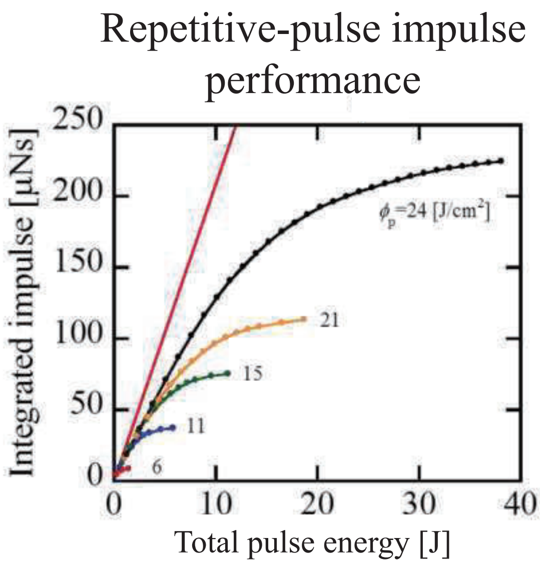
Impulse by Repetitive Laser Pulses

Nd:YLF laser
Wavelength: 1047 nm
Pulse width: 5-15 ns
Repetition frequency: <10 kHz
Pulse energy: <40 mJ





Ablator : Aluminum
Laser : Nd:YLF
Repetitive frequency : 1 kHz

(H. Tsuruta et al. J. Propulsion & Power, 2014)

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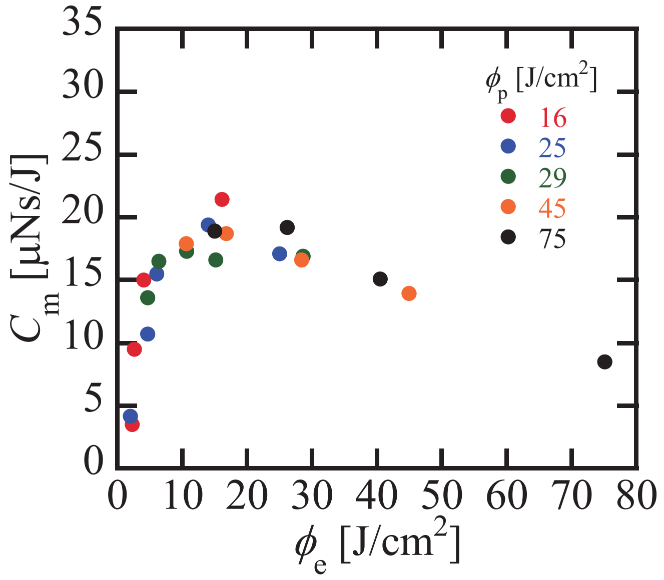
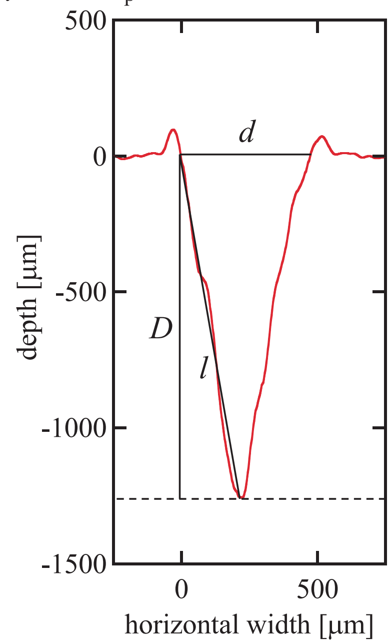
C_m Dependence on Effective Fluence ϕ_e



Nd:YAG laser
Ambient pressure : 2 × 10^{-2} Pa
laser spot diameter: 7.5 × 10^2 μm

Example of crater profile cross-section, N_t = 100, ϕ_p = 25 J/cm^2.



Effective fluence $\phi_e = \phi_p \dfrac{1}{\sqrt{4\alpha^2+1}}$ $\alpha = \dfrac{D}{d}$

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Summary

We have facilities for experimentally evaluation of laser pulse ablation impulse, which should be applied to in-space motion control of debris.