

P02

超高速衝突による飛翔体直径がイジェクタサイズ 分布に与える影響

Influence of Projectile Diameter on Size Distribution of Ejecta
Resulting from Hypervelocity Impacts

○平岩 泰幸, 石田 魁人, 御代川直人, 西田 政弘 (名工大),
林浩一 (鳥羽商船高専), 長谷川直 (JAXA/ISAS)

○Yasuyuki Hiraiwa, Kaito Ishida, Naoto Miyokawa, Masahiro Nishida (Nagoya Institute of Technology),
Koichi Hayashi (National Institute of Technology, Toba College) and Sunao Hasegawa (JAXA/ISAS)

スペースデブリの衝突によって発生する破片(イジェクタ)は二次デブリとなる可能性が高いため, イジェクタの構成や生成メカニズムを知ることは重要である. そこで本研究グループは, アルミニウム合金球をアルミニウム合金厚板に垂直衝突させ, 実験チャンバーから回収したイジェクタについて累積個数分布により求めた結果を用いて, その相似性, 主に飛翔体直径の観点から考察した. 異なる衝突速度および飛翔体直径の結果から, 飛翔体直径が増加するにつれてイジェクタの大きさおよび個数が増加し, 衝突速度が同じ条件下において, 図1に示すように, 飛翔体の直径で規格化すると, イジェクタのサイズ分布は一致した.

Fragments (ejecta) caused by collision of the space debris have the potential to become the secondary debris. It is important to know the composition and the formation mechanism of ejecta. Scaling law of ejecta size, in particular, the effect of projectile diameters was discussed using cumulative number distributions of ejecta size collected from test chamber when aluminum alloy spheres strike perpendicularly aluminum alloy thick plates. From the results of different impact velocities and projectile diameters, the size and number of ejecta increased as projectile diameter. Under the condition of a certain impact velocity, when ejecta length was normalized by projectile diameter, the size distributions of the ejecta were consistent with each other.

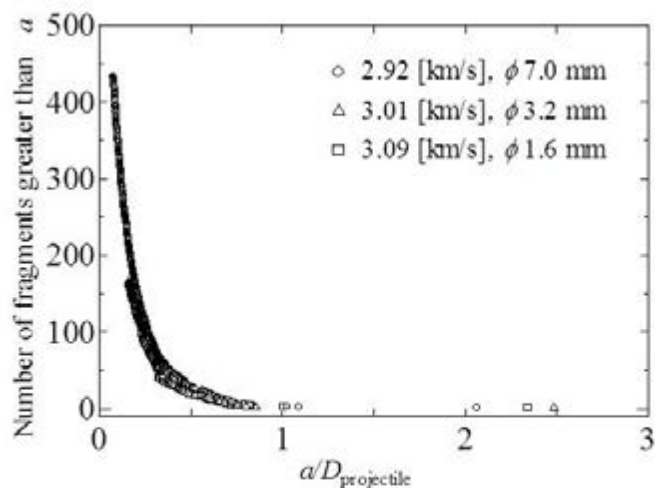


Fig. 1 Cumulative number distribution of normalized ejecta length

超高速衝突による飛翔体直径がイジェクタサイズ分布に与える影響

Influence of Projectile Diameter on Size Distribution of Ejecta Resulting from Hypervelocity Impacts

Yasuyuki Hiraiwa¹, Kaito Ishida¹, Naoto Miyokawa¹, Masahiro Nishida¹,

Koichi Hayashi², Sunao Hasegawa³

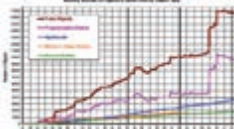
¹ Nagoya Institute of Technology

² National Institute of Technology, Toba College

³ Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency



1. Background



Increase of space debris
NASA Orbital Debris Program Office (Orbital Debris Quarterly News, 18-1 (2010))

Average velocity of space debris
: approximately 10 km/s

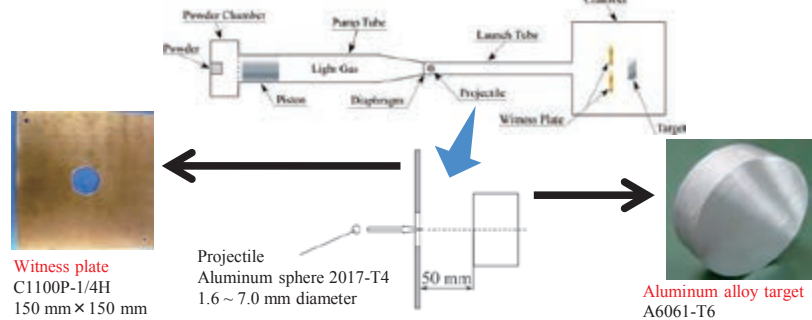
Reason for the failure of satellite ADEOS-II

Kawakita, S. Spacecraft design standard
The collision experiments in debris protection design (WG04a Japanese),
Space Environment Symposium Proceedings, (2007), pp.131-134.



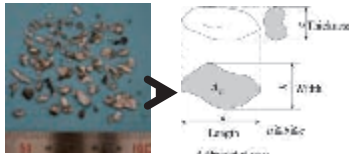
2. Experimental Methods

Schematic diagram of a two-stage light gas gun



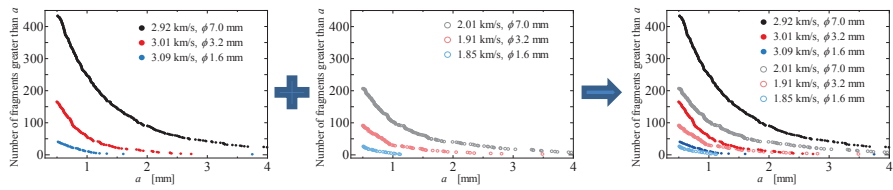
3. Results and Discussion

3.1 Definition of ejecta size

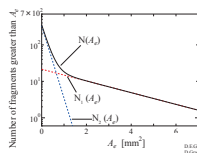


We measured only the ejecta with a length over 0.5 mm.

3.2 Cumulative number distribution of ejecta size



3.3 Bilinear distribution of ejecta size



Bilinear distribution

$$N(A) = N_1(A) + N_2(A)$$

$$N_1(A) = a_1(e)^{a_2 A}, N_2(A) = a_3(e)^{a_4 A}$$

3.4 Normalizing the horizontal axis in projectile diameter

Evaluation by the coefficient of determination : R^2

$$R^2 = 1 - \{\sum_i (y_i - f_i)^2\} / \{\sum_i (y_i - \bar{y})^2\}$$

$a/D^{1.0}$				
3.0 km/s	7.0 mm	3.2 mm	1.6 mm	Total sum
7.0 mm		0.807	0.659	1.466
3.2 mm	0.642		0.911	1.553
1.6 mm	0.124	0.877		1.001
Total sum	0.767	1.684	1.570	4.020

$a/D^{1.1}$				
3.0 km/s	7.0 mm	3.2 mm	1.6 mm	Total sum
7.0 mm		0.928	0.944	1.873
3.2 mm	0.887		0.917	1.804
1.6 mm	0.925	0.929		1.853
Total sum	1.812	1.857	1.861	5.530

$a/D^{1.2}$				
3.0 km/s	7.0 mm	3.2 mm	1.6 mm	Total sum
7.0 mm		0.967	0.828	1.795
3.2 mm	0.957		0.681	1.638
1.6 mm	0.886	0.838		1.723
Total sum	1.843	1.804	1.509	5.156

$a/D^{1.3}$				
2.0 km/s	7.0 mm	3.2 mm	1.6 mm	Total sum
7.0 mm		0.349	0.651	1.000
3.2 mm	0.620		0.924	1.544
1.6 mm	0.826	0.935		1.761
Total sum	1.446	1.285	1.575	4.305

3.5 Normalizing the vertical axis in projectile diameter

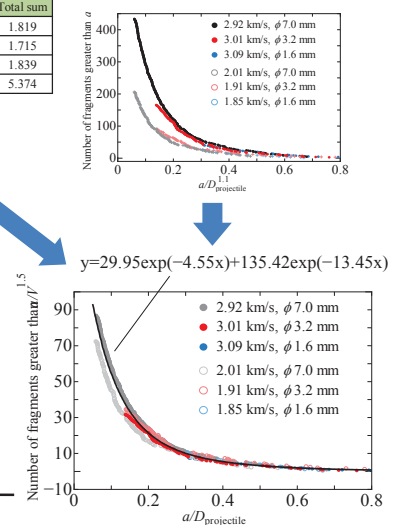
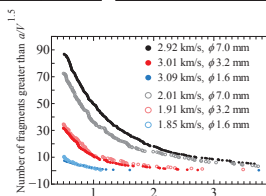
Evaluation by the coefficient of determination : R^2

$$R^2 = 1 - \{\sum_i (y_i - f_i)^2\} / \{\sum_i (y_i - \bar{y})^2\}$$

$N(a)/V^{1.4}$		
3 km/s	2 km/s	Total sum
7.0 mm	0.741	1.337
3.2 mm	0.977	1.975
1.6 mm	0.858	1.777
	0.919	

$N(a)/V^{1.5}$		
3 km/s	2 km/s	Total sum
7.0 mm	0.793	1.494
3.2 mm	0.959	1.955
1.6 mm	0.804	1.704
	0.900	

$N(a)/V^{1.6}$		
3 km/s	2 km/s	Total sum
7.0 mm	0.843	1.630
3.2 mm	0.927	1.920
1.6 mm	0.687	1.539
	0.852	



4. Conclusions

1. The cumulative number of the size of ejecta was proportional to the projectile impact velocity to the power of 1.5 in the vertical axis.
2. The cumulative number of the size of ejecta was proportional to the projectile diameter to the power of 1.1 in the horizontal axis.
3. The cumulative number distribution the size of ejecta was fitted by a bilinear exponential distribution model.

Acknowledgments

This work was supported by the Space Plasma Laboratory, ISAS, JAXA as a collaborative program with the hypervelocity impact experiment.
This work was supported in part by a Grant-in-Aid for Scientific Research, KAKENHI (C), from the Japan Society for the Promotion of Science (JSPS).