Velocity Distributions of Fragments and its Time Dependence

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Introduction: Oblique impact cratering experiments were done, and the fragment size and velocity were measured for fragments larger than 1mm in diameter, and slower than 200m/sec. A high speed CCD video camera was used to see the fragments in flight, and secondary collisions with a window of the target chamber. The purpose of this paper is to provide a database of fragments velocity, which is essential to deeper understanding of the surface evolution of small aster-oids.

Experimental Procedure: A two-stage light-gas gun was employed, and impact velocities are around 4km/sec. A high-speed CCD video camera of 4500frames/sec and 9000frames/sec enabled us to track fragments in flight, and to measure the locations and the times of the secondary collisions. A target box with a slit of15mm width was employed to limit the ejection in the plane including the trajectory of the projectile.

Results: An example of the time dependence of the ejection pattern is shown in figure 1. In this run a target box with a slit was employed. Ejection is divided into 4 stages according to the ejection pattern. The first stage (order of μsec) corresponds to ejection of very fine and fast fragments like jetting and the earliest conical ejecta cloud, and these particles could not be traced individually. Their typical size is less than 1mm in diameter, and velocity is over 1km/sec. The ejecta in the second stage (0-3msec) consists of 0.1 to 1mm fragments ejected conically at a few hundreds m/s, and at an ejection angle higher than about 60degree from the target surface. The 3D velocity derived from the secondary collisions also shows that the ejection at the second stage is conical. In the third stage (1-10msec), larger spall fragments, about 1cm in diameter, ejected in a cone narrower than that of the second stages. And a cluster of small and slow fragments (0.1-5mm in diameter and a few m/sec) ejected nearly perpendicular to the target surface characterizes the last stage (3msec-). 3/4 fragments are ejected normal to the target surface slower than 6m/s at this stage.

To discuss the size-velocity correlations, three results from the experiments of 7mm nylon sphere on gypsum target at about 4km/sec at 0degree, are shown in Fig. 2. The line in Fig. 2 shows the mass-velocity relation fit for the fragments ejected earlier than 5msec. The velocity of Fragments in this stage can be expressed as follows.

$$v_{spall} = 6 \times m_{spall}^{-0.16}$$

It should also be noted that up to 90% of perticles in number is slow (0.1 - 10m/sec), and small (less than 2mg) fragments.

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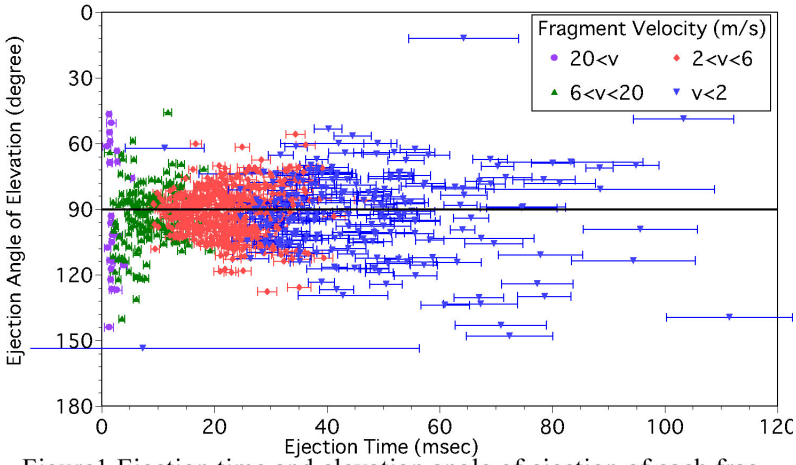

Figure1 Ejection time and elevation angle of ejection of each fragment in the impact at 0degree.

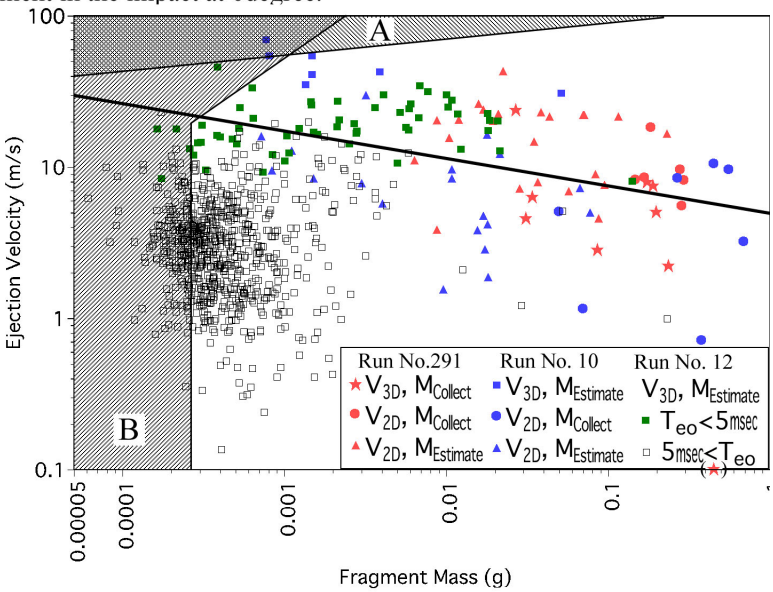

Figure 2 Fragment radius and ejection velocity of 0degree Impact: Area A and B represent the region which is difficult to measure because of too fast and too small, respectively.