EXPERIMENTS ON INTACT CAPTURE OF HYPERVELOCITY PARTICLES

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Introduction

Knowledge of the mineralogy, as well as the elemental and isotopic compositions [1], of comet particles is essential to understanding the nature of comets. Underdense media may make it possible to capture intact comet particles on a spacecraft flying through the coma of a comet. Relatively simple and inexpensive missions have been studied that would fly through the coma and return to earth orbit [2].

Werle et al. have performed impact accretion experiments by impacting steel spheres into 0.18 density Saffile (Al_2O_3 felt) at hypervelocities of 0.5 to 8 km/sec [3]. At 7.9 km/sec, about 67% of a steel projectile was captured within 18 cm; although, the particle was in some cases broken into pieces. A set of experiments to explore the potential of using various underdense media for intact comet sample return was performed at NASA-Ames Research Center Vertical Gun Range. These experiments have proven that capturing intact particles during a comet flyby through a comet is feasible and deserving of further research.

Experiment

Two types of underdense media were explored: fiber felts and polymer foam. Graphite and Kevlar felts with densities 0.15 and 0.036, respectively, were used. The felt targets were stacked to gain depth and to facilitate separation for examination after impact. A solid piece of polymer foam with low density was used since foam can be easily cut. Polished aluminum spheres of 3.175 mm diameter were accelerated with the Ames two-stage vertical light-gas gun to 6 - 6.5 km/sec. Two non-consecutive shots were made for each material.

Results

The projectile left a typical carrot-shaped tract in the media. For Kevlar, projectile break-up was clearly evidenced by irregular perimeters beginning at 2.5 cm into the tract. In 6 cm the characteristic black track in bright yellow Kevlar disappeared, and, insofar as we could determine, no solid projectile remained. It is believed that the strong Kevlar fiber broke the projectiles into pieces and then abraded them. For graphite felt, however, the projectile track was smooth and terminated in 6.35 cm without a trace of the projectile. It is believed that, at hypervelocity, the graphite was abrasive and the aluminum sphere was totally abraded. Neither graphite nor Kevlar felts proved suitable for capturing particles intact at hypervelocities.

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A uniform polystyrene foam with density of 0.018, however, caught intact the aluminum projectiles at about 6.5 km/sec in 76.2 cm. In each experiment, 75% of the projectile's mass was captured in a single piece at the end of the a carrot-shaped tract. Figure 1 is the perspective view of one of the captured projectiles. A cross-sectional SEM view of one of the projectiles is shown in Figure 2. Note that the forward hemisphere, in the direction of the velocity vector, unexpectedly retained the original polished gloss surface. However, there was distinct irregular loss on the aft hemisphere. The cross-sectional view indicates some widening of the projectile curvature in the aft portion.

Findings

This polymer foam experiment is very encouraging for the possibility of intact sample return from a flyby. An model with infinite number of thin diaphragms is being developed to help us further understand the ablation process in underdense polymer foams. The ability to capture fragile cometary particles and methods to detect small particles in the underdense media are some of the concerns to be examined. Further experiments will be performed with different projectiles and underdense media of different material strengths, elasticities at hypervelocities, vaporization energies, and densities.

[1] Tsou, P., D. Brownlee & A. Albee (1983) Lunar Planet. Sci. Conf. Abstracts, 14th, p. 794-795.

[2] Tsou, P, T. Ryan & R. Farquhar, "Planetary Observer - Comet Intercept Sample Return", JPL-D-1153, Sept. 1983.

[3] Werle, V, H. Fechtig & E. Schneider (1981) Proc. Lunar Planet. Sci. Conf. 12th, p. 1641-1647.

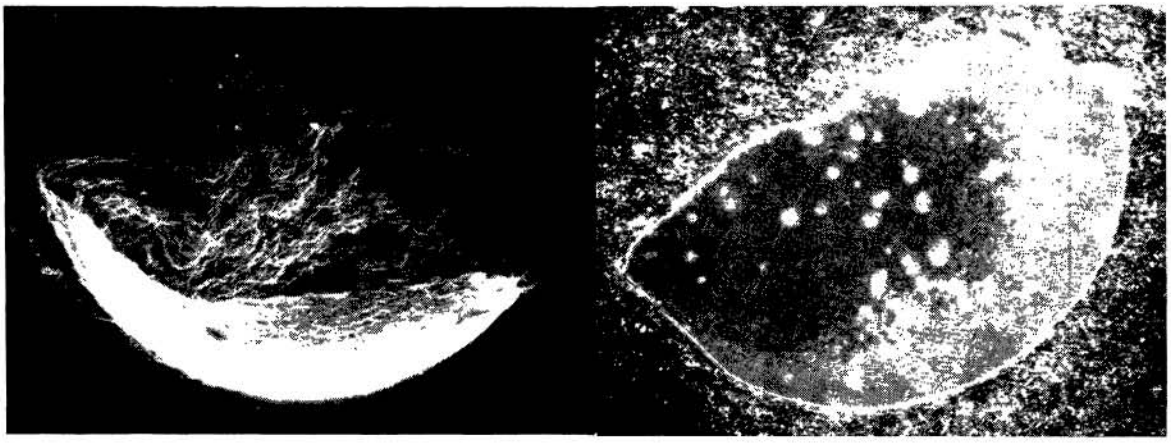

Fig. 1 Perspective View

Fig. 2 Cross-Sectional View