

EFFICIENCY OF ANGULAR MOMENTUM TRANSFER FOR IRON TARGETS;
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Average rotation rate of M-type asteroids (3.2 rev/day) is significantly larger than that of C or S-type asteroids (2.4 rev/day)(1). M-types are inferred to be made mainly of iron from the studies of their reflectance spectra, while the others would consist of stony or chondritic materials. There would be the following three possibilities as the cause of the difference.

1. M-types would have higher impact strength than S and C-types, and undergo more energetic collisions without being disrupted. They could obtain more angular momentum through these collisions.
 2. The disruption of iron rich parent body may generate fragments rotating faster than those born to stony or chondritic parent body.

3. The efficiency of angular momentum transfer at off-center collision may be larger for iron target than stony one.

We measured the efficiencies of angular momentum transfer in laboratory impact experiments for iron targets, and compared them with the results of mortar and aluminum targets.

The experiments were made at the electromagnetic railgun facility of Institute of Space and Astronautical Science (ISAS). Cylindrical projectiles of about 1 g in mass are made of plastic (polycarbonate, about 1 g/cm³ in density). They were fired obliquely into one of the flat surfaces of cylindrical targets as shown in Fig. 1. The motions of the impacted targets were recorded by means of a commercial video movie camera (30 frames/sec). The efficiencies of momentum transfer are calculated for the component which is tangential to the surface as,

$$\zeta = (MV_t)/(mv \sin\theta)$$

where m , v and θ are the mass, velocity and incident angle of the projectile, and M and V_t are the mass and the tangential component of the velocity of the impacted target. Assuming that the impacted surface is a part of big spherical target (R in radius), the formula can be written as,

$$\zeta = (MV_t R)/(mv \sin\theta R) = (FdtR)/(mv \sin\theta R).$$

Here, Fdt is impulse which acts on target. Numerator represents time integrated torque, that is, the angular momentum the spherical target obtained, and denominator is angular momentum

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input. Thus, ζ , measured in our experiments, correspond to the angular momentum transfer efficiency.

Results are plotted in Fig. 2 where ordinate is the efficiency and abscissa is the incident angle measured from perpendicular on the surface. Solid squares, circles and open squares correspond to iron, aluminum and mortar (filled in aluminum frame) targets, respectively. Projectile velocities are attached to each plot. The values of ζ for two iron plots in parentheses may be affected by force from target supporting system. In spite of small number of data points, it could be say that ζ for iron does not exceed ζ for aluminum and mortar. Metallic aluminum is not a constituent of asteroids. However, its density is close to rock, and rock would be more similar to aluminum than to iron in impact phenomena. So, the possibility of higher efficiency of angular momentum transfer for M-type asteroids than S and C-type ones could be excluded.

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References. (1) Binzel, R. P., P. Farinella, V. Zappala and A. Cellino (1989) in Asteroids II, 416-441, Univ. Arizona Press, Tucson.

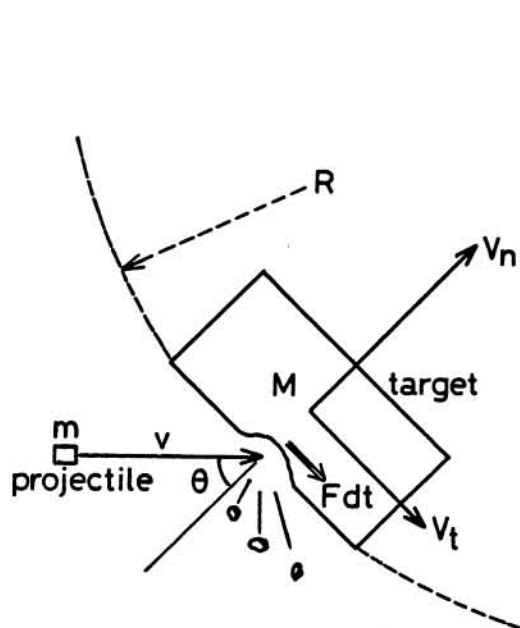


Fig. 1. The efficiency of angular momentum transfer is derived from that of momentum transfer.

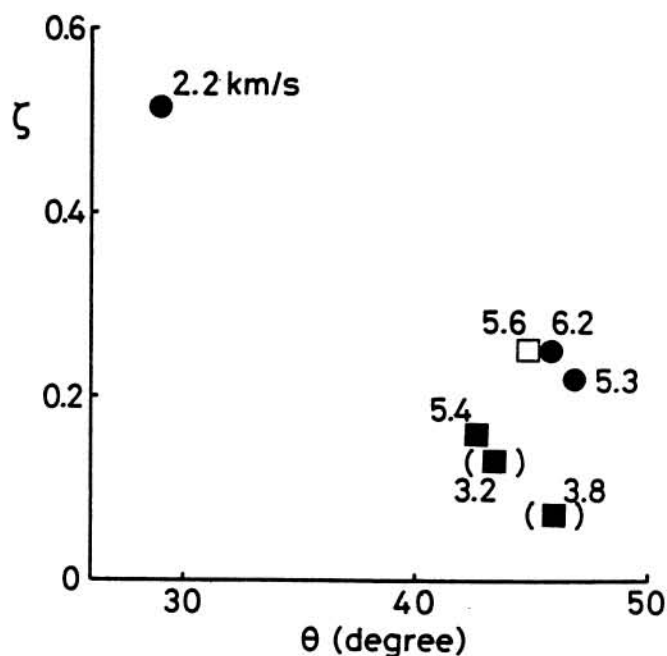


Fig. 2. The efficiency vs. projectile's incident angle for iron and other targets.