MICROMETEOROID IMPACTS ON THE LUNAR SURFACE. V. Vanzani, F. Marzari, and E. Dotto, Dipartimento di Fisica "G. Galilei" and Centro Interdipartimentale Studi e Attività Spaziali "G. Colombo", Università, 35131 Padova, Italy.

The purpose of our work is to reevaluate the lunar micrometeoroid flux and quantify meteoroid collision hazards on the Moon, on the basis of the recent data obtained for the Earth by Love and Brownlee [1]. These authors, by examining hypervelocity impact craters on the space-facing end of the Long Duration Exposure Facility (LDEF) satellite, which operated from April 1984 to January 1990, determined the terrestrial mass flux and the distribution of micrometeoroids in the submillimeter size range.

To extrapolate the terrestrial flux to the Moon, we took into account the different gravitational focusing factor, considering that the micrometeoroid flux on the Moon can be computed from that on the Earth as:

$$F_M = F_E \upsilon_{iM}^2 / \upsilon_{iE}^2$$

where υ_{iM} and υ_{iE} are the average impact velocities on the Moon and on the Earth (neglecting atmospheric deceleration), respectively. Love and Brownlee [1] found an average impact velocity on the Earth of about 16.9 km s^{-1} at about 458 km from the Earth surface. From this value we derived an average impact velocity on the Moon of 13.3 km s^{-1} and the cumulative lunar micrometeoroid flux per year shown in Fig. 1.

Figure 2 shows the estimated mass influx per year on the Moon scaled from the Earth influx after proper adjustments for the different gravitational focusing and for the different average impact velocities on the environments of the two bodies. A strong peak in the mass flux for log mass interval is observed at about $1.5 \cdot 10^{-5}$ g corresponding to a particle diameter of ~220 µm. This peak, found also in other works [2,3] based on data obtained with different methods, corresponds to the diameter of particles carrying most of the kinetic energy flux. The total mass accreted by the Moon per year, as resulting from the integration of the mass distribution of Fig. 2, is about $1.8 \cdot 10^6$ kg yr^{-1}.

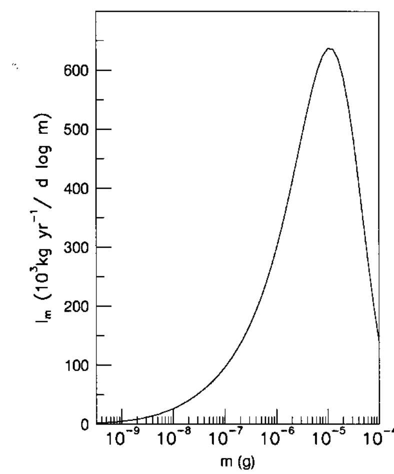

Fig. 2. Mass of micrometeoroids accreted by the Moon annually per log differential particle mass interval. Integration of this mass distribution yields a total mass of micrometeoroids, accreted by the Moon per year, of about $1.8 \cdot 10^6$ kg.

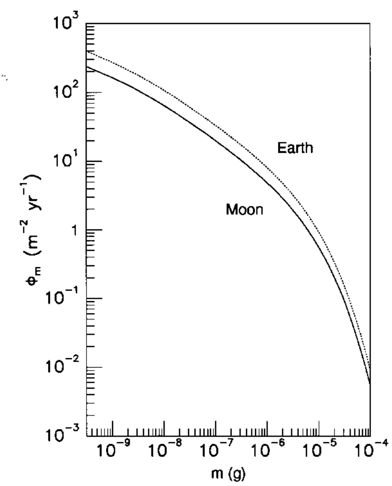

Fig. 1. Comparison between the cumulative micrometeoroid flux on the Earth (dotted line), obtained in [1], and the rescaled cumulative micrometeoroid flux on the Moon (continuous line).

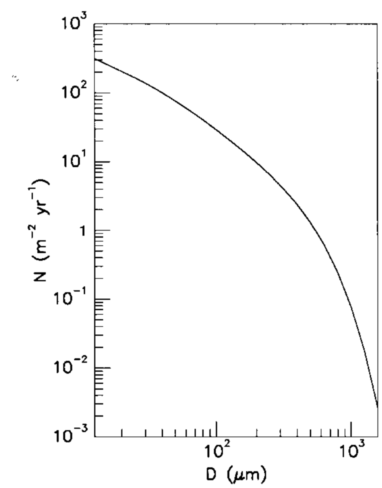

Fig. 3. Expected cumulative crater density on an hypothetical flat aluminum alloy target exposed on the lunar surface for one year.

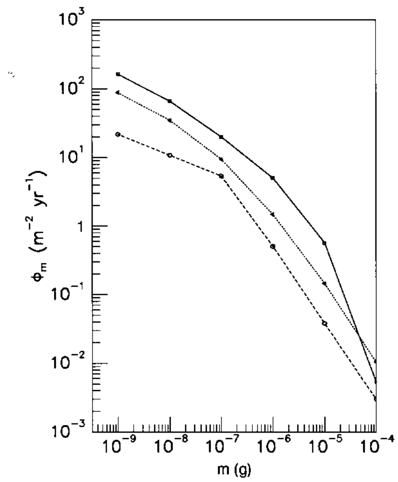

Fig. 4. Comparison between lunar micrometeoroid flux deduced from LDEF data (continuous line) and previously published models of [5] (dotted line) and of [2] (dashed line).

On the basis of the lunar meteoroid flux, derived from LDEF data, we have predicted the cratering rate on an hypothetical flat aluminum alloy target exposed on the lunar surface for one year. The diameters of craters have been scaled with the impact velocity in agreement with the Christiansen's formula [4]. Fig. 3 shows the cumulative density of craters, as a function of diameter: about 30 micro-craters with size larger than 0.1 mm are produced per m^2 per year. Our analysis shows that the lunar influx is similar in shape but significantly higher than previous models available in literature (see Fig. 4) and discussed in [2].

In conclusion, the lunar meteoroid flux we predict from our results is two-three times larger than previous estimates, significantly increasing the meteoroid collision hazard on the Moon surface. As an example, a surface of about 150 m^2 located on the Moon is hit, on average, by one micrometeoroid larger than 0.5 mm in diameter per year: a projectile of that size, impacting with an average velocity of about 13 km s^{-1}, excavates in aluminum alloy material of an hypothetical lunar basis structure a crater with diameter larger than about 1.8 mm and depth greater than about 1 mm. Micrometeoroids of about 0.1 mm in size can produce craters of 350 µm in diameter and of comparable depth in metal targets.

The actual risk to critical structures exposed on the Moon is difficult to estimate, but the flux of meteoroids represents a significant hazard and requires proper protection to critical structure—habitats, base support facilities, processing plants or research instruments, especially optical systems and detector packages—that are expected to last on the lunar surface for many years.

References: [1] Love S. G. and Brownlee D. E. (1993) *Science, 262*, 550. [2] Grun E. et al. (1985) *Icarus, 62*, 244. [3] Hughes D. W. (1978), in *Cosmic Dust* (Wiley, UK), 123. [4] Christiansen E. L. (1992) *AIAA Pap. 92*, 1462. [5] Fechting H. et al. (1974), *Proc. LSC 5th*, 2463.