MICRON AND SUBMICRON PARTICLE FLUX ENHANCEMENT WITHIN THE EARTH'S MAGNETOSPHERE I: IN-SITU AND LABORATORY SOURCE DATA; W. M. Alexander and T. W. Hyde, Space Science Lab., Department of Physics, Baylor University, Waco, Texas 76798-7303, USA

It has been established that a dust belt/sphere in near-earth space does not exist for particles larger than 10 μ. For particles of radii 10 μ or larger, no evidence of any spatial density enhancement has been discovered in the earth/moon system. Furthermore, within a factor of 2, current data indicates that the cumulative flux in this size regime is comparable to that found in interplanetary space at 1AU (1). The HEOS-2 experiment was sensitive to particles in the micron and submicron range and had an earth centered orbit that was highly eccentric. Except for that portion of the orbit near perigee, the cumulative flux determined by HEOS-2 confirmed the earlier in-situ measurements. However, there were a few times when submicron fluxes were larger than expected during these perigee passes. These anomalous fluxes were defined as "swarms" (2). Other in-situ measurements in interplanetary space with submicron sensitivity (for example, Pioneer 8 and 9 and HELIOS) have not detected 'swarms" or any other form of cumulative flux enhancement (3).

In 1967, the Lunar Explorer 35 (LE35) spacecraft was launched and subsequently placed in a stable orbit around the moon. The LE35 in-situ dust measurement continued for several years with the total results of this in-situ measurement showing a cumulative flux having two distinct and different characteristics (4). An overall cumulative flux rate in selenocentric space derived from the LE35 in-situ measurement from launch until 1971 is depicted in Fig. 1 (4). The cumulative flux is shown in 8-day increments so that the entire data period can be seen. Though this presents a considerable smoothing of the data, an enhancement of the cumulative flux as measured by the LE35 experiment during meteor shower periods is evident. The non-shower times show a cumulative flux that is essentially the same as the interplanetary flux for the particle size detectable by the experiment. A more detailed representation is seen in Fig. 2 (4), where the total number of events for 4-day periods during 6 major showers is shown. A flux enhancement of at least an order of magnitude occurs during shower periods as compared to non-shower periods. Flux measurement comparisons over a 4 year period show the variance in the measurement during shower periods to lie well within variations obtained from ground-based data. The experimental data depicted in Figs. 1 and 2 was obtained from a sensor having a mass threshold sensitivity of 5 picograms. The LE35 dust experiment also included a sensor with a threshold sensitivity of 100 picograms. The data rate for the 100 picogram sensitivity sensor did not show any discernible enhancement during shower periods and was essentially the same as the data rate in interplanetary space, for particles whose masses exceeded 100 picograms. This latter measurement confirmed earlier flux rates for picogram and larger particles in selenocentric space as reported by Gurtler and Grew (5).

The two possible mechanisms, by which the flux enhancement described can be explained, are (i) the enhancement is due to particles actually in the meteor stream since it is seen annually throughout the 4 year period, or (ii) the flux enhancement is directly related to the meteor shower but is caused by micron/submicron particles ejected from the lunar surface by hypervelocity impacts on this surface from the primary stream particles. If the former is the case, these minute particles have to be of extremely recent origin because they are removed from their original orbits by radiation pressure and various drag forces in a short period of time.

The second explanation is considered to be the most likely mechanism for the production of particles detected by the LE35 experiment. However, before a quantitative analysis of the magnitude of ejecta escaping the lunar gravitational sphere of influence (SOI) is made, results of laboratory studies, which examine hypervelocity impacts on various surfaces and the corresponding ejecta that occurs, have to be considered. The cumulative flux of micron and submicron ejecta, from a hypervelocity impact between 4 and 7 km/s, has been determined (6,7,8,9). In addition, the mass index, for these cumulative fluxes, was derived and found to be between 0.8 and 0.85. For primary particles impacting normally, on basalt-type material, about 10^{-4} percent of the total primary mass was found in the ejecta with particle velocities greater than 2.3 km/s. For hypervelocity impacts, with angles oblique to the impacted surface, the flux for these velocities increased by over 2 orders of magnitude.

With the above information, it is possible to make a first approximation of the mass and therefore, flux of ejecta leaving the lunar surface. This is done by using a current mass model for interplanetary cumulative flux impacting the total lunar surface. Hypervelocity studies give an efficiency for the production of micron and submicron lunar ejecta which escapes the lunar SOI. A comparison is then made between the total mass of the ejecta from this calculation and the amount of mass from the model in the corresponding size range. For the case of the sporadic background impact flux, the ejecta mass and flux for this condition is on the same order of magnitude as the primary micron/submicron flux. The next consideration is that of a meteor stream where the cumulative flux distribution is known. An example used for this case is that of the Geminid showers (10). The technique used is the identical to that used above for the sporadic background. The total mass in the Geminid shower can be obtained by integrating the cumulative flux distribution curve. Using the same ejecta efficiency production as before, the micron/submicron mass that is ejected can be determined. A comparison, of this mass with the mass obtained using a sporadic background, reveals over an order of magnitude increase, for particles with masses less than a nanogram. The event rates that are shown during the Geminid period in Fig. 2, show a maximum change of 2 orders of magnitude and a minimum change of 1.5 orders of magnitude. This is for 4 occurrences of the Geminid showers during the LE 35 measurement.

In a first approximation, one can relate the total ejecta with the incident particle energy. However, laboratory experiments have shown that there is an additional dependence on the particle velocity. Thus, the amount of mass in a meteor stream is a major controlling factor to the magnitude of the particle flux in the lunar SOI. In addition, velocity considerations are the other very major factor in such instances. Thus, medium velocity streams with high total mass should produce ejecta mass well above that of the sporadic background. A meteor stream having high mass and high velocities is a prime candidate for the largest amount of ejecta mass.

The information from this study therefore provides a means to specifically consider spatial densities of dust in selenocentric, interplanetary and geocentric regions of the magnetosphere.

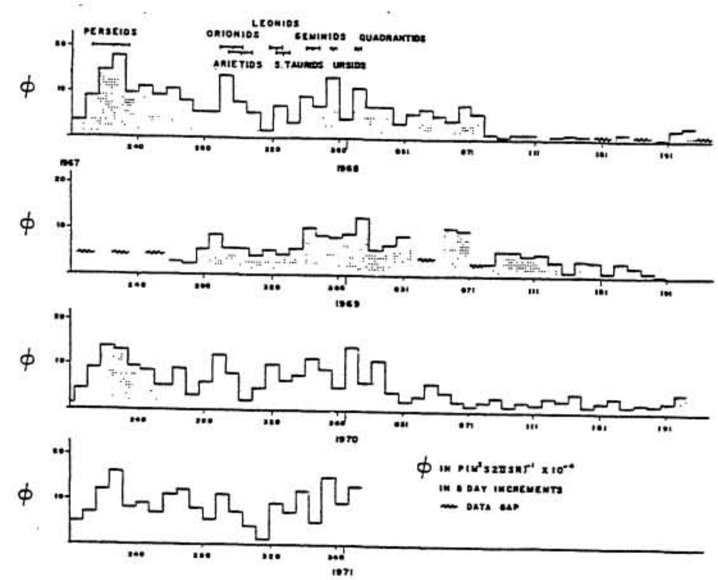

Figure 1

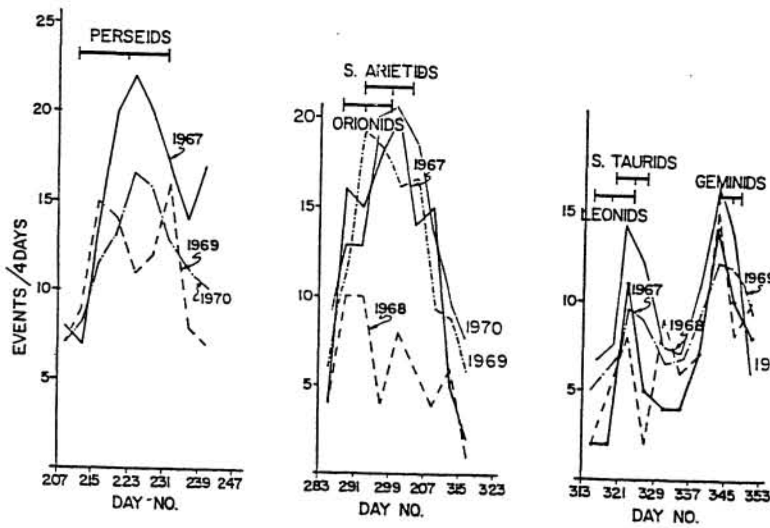

Figure 2

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