THE OBSERVATIONAL EVIDENCE FOR MASS DISTRIBUTION IN THE METEORITIC COMPLEX*

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Abstract. The integrated mass index \( S \) for solid particles in the solar system is defined by the equation
\[
N = (\text{const}) \, m^{-s},
\]
where \( N \) is the number of particles counted down to a lower limit of mass \( m \). Independent values of \( S \) found from various observational programs are reviewed. These lie generally in the range from 0.4 to 1.4 for the average background of particles, and include data from lunar craters, satellite impacts, meteors, meteorites and asteroids. The trend of \( S \) with mass is reasonably well established for masses less than one gram, but there are many gaps in our knowledge concerning the objects of greater mass.

1. Introduction

The purpose of this paper is to summarize in one place the quantitative values of mass distribution in the solar system that result directly from statistically valid observational data. An attempt will be made to survey as many different observational techniques as possible and, in particular, to point out the assumptions made in converting from the parameters observed to the particle masses. The discussion will be confined to the general background of solid particles and will not include special groups such as the members of well-defined meteor showers. The value of the particle flux, a much bigger problem, will not be dealt with. A number of comprehensive reviews on this latter subject have appeared recently, Dohnanyi (1972) for example.

The term 'meteoritic complex' is used here in the same sense as employed by Whipple (1967) and Millman (1967) at the symposium on The Zodiacal Light and the Interplanetary Medium in Hawaii. It includes all solid particles of interplanetary space from a size somewhat larger than molecules up to the range of the smaller asteroids. Terminology and symbols will be based on those used previously (Millman, 1970a). Where \( N \) is number of particles and \( m \) the mass of an individual particle, the differential mass index \( s \) is defined by
\[
dN = (\text{const.}) \, m^{-s} \, dm;
\]
and integrating we have
\[
N = (\text{const.}) \, m^{-(s-1)} = (\text{const.}) \, m^{-s},
\]
where \( S \) is defined as the integrated mass index. It is also the negative slope between \( \log N \) and \( \log m \), where \( m \), in each case, corresponds to the particle size limit to which \( N \) is integrated. If a length \( a \), such as radius, diameter or circumference is used to

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define a particle rather than mass, we have two corresponding indices based on the equation
\[ dN = (\text{const.}) \ a^{-p} \ da, \]

where $p$ may conveniently be called the differential radius index, and $p - 1 = P$ the integrated radius index. Since mass increases as the cube of the radius where density is constant, it is obvious that $P = 3S$. Finally, since the astronomer uses a geometric scale of magnitudes, where the individual steps correspond to the fifth root of 100, or 2.512, it is useful to define a fifth index $r$, the magnitude ratio. This is the ratio between numbers of objects in successive magnitude steps, taken in the sense where $r > 1$. It is also the ratio between cumulative numbers where $r$ does not change rapidly (Millman and McKinley, 1963). From the definitions of $r$ and $S$ we find that the equation

\[ \log r = 0.4S \]

applies to situations where the indices listed remain relatively constant over a range of several orders of magnitude in mass. Corresponding values of the five indices are listed in Table I. In various papers dealing with size and mass distribution in the solar system all five indices in Table I have been used, and authors have employed a wide variety of symbols to represent them. In what follows comparisons among size distributions found by various observing techniques will be discussed only on the basis of the integrated mass index $S$, which is the slope of any curve reproduced on the commonly-used log $N$ vs log$m$ diagram.

### 2. The Zodiacal Light

The classical paper dealing with the nature of the particles which make the zodiacal light visible was published by van de Hulst (1947). By comparing the observed intensity of the outer corona and the zodiacal light with theoretical equations it was found that $p = 2.6$ or $S = 0.53$, where it was assumed that the space density of particles was uniform from the Earth to the Sun, the largest particle radius involved was 0.035