THE DISTRIBUTION OF MASS IN THE PLANETARY SYSTEM AND SOLAR NEBULA

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Abstract. A model 'solar nebula' is constructed by adding the solar complement of light elements to each planet, using recent models of planetary compositions. Uncertainties in this approach are estimated. The computed surface density varies approximately as $r^{-3/2}$. Mercury, Mars and the asteroid belt are anomalously low in mass, but processes exist which would preferentially remove matter from these regions. Planetary masses and compositions are generally consistent with a monotonic density distribution in the primordial solar nebula.

1. Introduction

Most theories of cosmogony assume that the planetary system formed from a nebula of solar composition, but assumptions as to its mass and structure vary widely. A lower limit on the mass is set by augmenting the planets with H and He to restore a solar composition. One may also try to 'reconstruct' the solar nebula by spreading the augmented planetary masses through zones surrounding their orbits. Such an *ad hoc* nebula can resemble the original only to the extent that the formation of the planets was the reverse of the spreading process. Alternatively, some of its features may provide information about planetary formation, rather than the nebula. Kuiper (1956) and Kusaka *et al.* (1970) modeled the solar nebula in this fashion, on the assumption that the reconstructions represented the original nebula. Similar calculations for various purposes were performed by Edgeworth (1949), Safronov (1967), Alfvén and Arrhenius (1970), and Lecar and Franklin (1973). The results of these efforts differ significantly. While the calculations are simple, the assumptions used are, unfortunately, rarely described in detail. Also, our knowledge of solar elemental abundances and planetary compositions has improved significantly within the last few years. Another calculation of this sort, with assumptions clearly stated, appears justified. I shall try to estimate the range of uncertainties involved, and the types of information which may be derived.

2. Assumptions

Equivalent solar-composition masses of the terrestrial planets are computed from their iron contents. By use of Cameron's 1973 abundances, the mass fraction of Fe in solar matter is 1.2×10^{-3}. Nominal Fe contents by mass are 0.62 for Mercury (Siegfried and Solomon, 1974), 0.35 and 0.38 for Venus and Earth (Reynolds and Summers, 1969),

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