6 CONCLUDING SUMMARIES

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THE ZODIACAL LIGHT

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As one of the most important results of what we heard in these days I consider the density law of interplanetary dust derived from zodiacal light observations by the deep space probes going out to Jupiter and going in to 0.3 AU. The dependence on the distance to the sun R seems to be nearly as R^{-1}. This finding is in agreement with a new discussion of ground based observations which was reported by Dumont. The density law was one of the open questions for a long time; for me this represents a break-through.

In the case of number per unit volume, particle flux and size distribution we have now a delightful situation too, since different methods lead to the same picture. Whereas years ago we were facing large differences in fluxes determined by registrations in situ and based on zodiacal light, respectively, the agreement is excellent now and we are already looking for real variations due to the moon etc. May I remind you that the size distribution of the particles can be derived, too, by analyzing the scattered light in interplanetary space, that means in particular from the F-corona as forward scattered sunlight. This was done first by van de Hulst who found an exponent 2.6 for the power law spectrum of the particle radii. My own work 20 years ago led to an exponent 2.0; and this is very much the same as what we see nowadays from the other measurements in this range of particle dimensions.

No comparable progress was experienced in what we know about the particles' nature and their chemical composition. This depends in part on the scattering function, the other function which appears under the well known integrals for brightness and polarization of the zodiacal light. An unique solution of this integral equation is as out of sight as before. On the other hand, in my opinion evidence is accumulating that we have to take into account seriously deviations from the spherical Mie scatterers. But the final answer to the question of the particles nature, I do not expect from derivations of the scattering function.

New and important results on the spectrum and the color of the zodiacal light were reported which show that within a wide range of

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wavelengths no significant deviations from the solar spectral distribution curve can be observed. There seem to be pecularities in the UV; to verify and to look for such spectral features as Lillie and his colleagues have done is certainly one of the important tasks of the future. Here we could see specific properties of the interplanetary dust which might be on the other hand similar to properties of interstellar dust. These spectral features certainly could give essential hints as to the particles'nature and could inform us about links between interplanetary and interstellar dust.

Now I would like to add a few words about submicron particles (radii $\lesssim 0.1$ μm) which were discussed by Dr. Hemenway with enthusiasm. From the color of the zodiacal light, in particular from the new observations presented here and the model calculations Dr. Giese reported, it is obvious that the appearance of the zodiacal light is not determined by submicron particles. The color would be bluer than what we really observe and from this consideration one can derive an upper limit to the number of submicron particles which could be present in interplanetary space. This upper limit seems to lie near the flux curve given for instance by Dr. Grün and his colleagues.

In addition I should point out that the evidence for submicron particles which was presented here, in my opinion rests at least in parts on an unsound basis. Let me pick out two points: The limb darkening of the sun certainly has nothing to do with particles in the solar atmosphere. It is due to a temperature stratification of the solar atmosphere which causes not only the limb darkening of the continuum but also a center to limb variation of the Fraunhofer lines. - The discrepancy in the coronal temperatures was solved some years ago by new studies of the ionization equilibrium in the solar corona. It became clear that the older investigations had overlooked one important physical process, namely dielectric recombination, and that the correct temperature lies between 1 and 2 million degrees. I could add further points, but do not like to go in more details here.

It is not at all my intention to deny the existence of submicron particles in interplanetary space. Mass loss of stars, in this case of the sun, is a modern concept of astrophysics. Circumstellar dust shells of late type stars which radiate in the IR seem to be one result of stellar mass loss. Also the amount of mass loss which would correspond to Dr. Hemenway's submicron population is not excessively high. But what we need is more reliable evidence and this will most certainly not come from zodiacal light studies.

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In a final remark concerning future problems I would like to mention one aspect, the thermal emission of interplanetary dust. In my view it is one of the most important tasks for the future to measure this emission at wavelengths between about 5 and 20 μm and, if possible, to look for spectral features of the same type as they are indicated in the UV. By such observations we could get rid of the scattering function and the Mie scatterer problems and approach the question of the particles nature from a new direction because we observe the dust in a very different mode of behaviour from the visible and UV. Measurements of this kind are not easy. Even from the balloon they are very difficult; one of the problems there is our poor knowledge about airglow emission in that part of the spectrum. It may well be that these measurements need Spacelab.

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