# SUMMARY OF IAU SYMPOSIUM 90

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In summarizing the papers of this symposium I will emphasize general trends and broad conclusions, rather than make any attempt to note the detailed results of the many contributors. Essentially, the presentations have involved the solid particles of the meteoritic complex in the mass range from $10^{-15}$ to $10^{5}$ g, a range which happens to be centred on the integrated particle mass peak at $10^{-5}$ g. Naturally, the majority of the papers deal with the central portion of this range rather than with the two extremes. I have the distinct impression that dialogue among the scientists concentrating in various specific fields of investigation is steadily improving. For example, zodiacal-light experts, experimenters with spacecraft, meteor astronomers and comet observers can now discuss together their assorted contributions to our knowledge of the interplanetary dust particles with considerably greater facility than was possible a decade or two ago.

This situation has developed with the growing realization that the zodiacal dust particles are considerably larger than had been assumed previously, while at the same time the increased efficiency of meteor observing techniques has made it possible to secure significant data on very much smaller meteoroids than in the past. The net result is that the size ranges for zodiacal light and meteor observations now overlap to a considerable extent, while in-situ records from spacecraft have also made important contributions to the data bank, especially at solar distances other than one AU. It is not surprising that papers dealing with the theoretical aspects of detailed data analysis now outnumber the strictly observational papers by a considerable margin. It must also be remembered that the availability of large computers makes possible the theoretical modeling of various particle complexes, a type of operation that was quite impractical when we had to rely on the old-fashioned mechanical desk calculators.

Among the observational papers one-third deal with data recorded on spacecraft operating at various distances from the Sun. This capability has added a new dimension in the study of the meteoritic



*I. Halliday and B. A. McIntosh (eds.), Solid Particles in the Solar System, 429–431.*

complex and has eliminated some of the selection effects that handicap earth-based programs. Most of the data currently available come from records made between 0.3 and 3.0 AU radial distances from the Sun, and relatively near the ecliptic plane. A problem for the future is to secure in-situ data for the parameters of interplanetary dust at points well away from the ecliptic. Explorer 35 and other spacecraft operating near the Moon have recorded evidence of submicron-sized particles ejected from the lunar surface by impacts of interplanetary dust. In two papers the power of a computer-assisted technique is demonstrated by modeling the lunar ejecta complex with the computation of over 17,000 orbits. The conclusion is that at favorable lunar phases, some 80% of lunar ejecta enter the earth's magnetosphere while 20% can enter the earth's atmosphere.

Other observational papers deal with recording the zodiacal light from balloons and mountain observatories, and studying the structure of various meteor streams, using visual, radar and television techniques. The results of the laboratory analysis of meteoritic chondrules, and of interplanetary dust collected in the stratosphere and from deep-sea sediments, have been detailed in a pair of papers. Several other presentations have recorded ground experiments in a laboratory study of the physical and chemical parameters of both disordered and amorphous silicate grains, and of the relation between grain densities and penetration into various types of target material. We have now reached the point where useful discussions, involving quantitative detail, can take place re the physical shape and structure, together with the chemical and mineral composition, of the micron- and submicron- sized particles of the interplanetary dust.

The theoretical papers can be divided up with approximately equal numbers in each of six general areas:-

1. physical parameters, chemical composition and differentiation,
2. particle size and mass distribution, flux rates,
3. charged particles and the effect of electromagnetic fields,
4. effects of collisions and Poynting-Robertson drag,
5. particle orbits, their elements and perturbations,
6. the history and evolution of the particle complex.

That these six subjects account for half the symposium papers is a sign of growing maturity in our field. However, much remains to be accomplished in applying the above range of theoretical studies to the same group of particles. For example, we may have good orbital data but lack information on the physical parameters of the particles; or we may have information on the chemistry without knowing the size and mass distribution. This points to the importance of giving estimates for the mass or size range of the particles for which data are published in an observational paper.

The close connection between comets and the great majority of very small particles in the solar system continues to be a valid assumption.

It is interesting to note that detailed studies of particle dynamics in the tails of comets are being applied directly to the meteoritic complex. Here, and also elsewhere in the theoretical papers, hints of a bimodal particle distribution keep surfacing among the chemical, the physical, or the dynamical parameters reported. A comprehensive investigation of this from all aspects could well be listed as one of the immediate problems of the future. Other questions awaiting an answer include the details of the evolution of the $\beta$-meteoroids, the physical and chemical delineation of the meteoroids producing the major fireball groups (including the Tunguska object), and a study of the similarities or differences in the chemistry of the meteoroids belonging to the various major meteor streams.

Continuing the theme of research into the future, five papers have given us an outline of equipment designed for the Shuttle and its associated flights, and for a comet probe. These experiments will involve zodiacal light and interplanetary dust recording from Spacelab and LDEF respectively and a mass spectrometer operating on a comet probe.

One completely new field of research has appeared in this symposium, the concept of complex rings of particles around planets as a normal feature to be searched for, especially where the planet is massive enough to have acquired one or more natural satellites. We already know of rings with a certain degree of complexity around both Jupiter and Uranus, while additional features in the rings of Saturn have been detected by Pioneer 11. Rings of various degrees of stability can be created around a planet by assuming models which usually involve one or more satellites. Certain evidence points to the possibility that the earth had a temporary ring of small particles about $3.4 \times 10^7$ years ago. It is also quite possible that Neptune is surrounded by one or more narrow rings similar to those found around Uranus. In any comprehensive survey of small solid particles in the solar system this new concept must not be forgotten.

In conclusion, I should like to take this opportunity of expressing my sincere thanks to the Organizing Committee of IAU Symposium 90 for dedicating the symposium to me. I have thoroughly enjoyed this occasion for meeting with so many of my long-time friends from around the world, and I greatly appreciate the good wishes extended to both my wife and myself. May we all enthusiastically continue to "kick up the dust" in the solar system so that it will be compelled to reveal the remaining secrets that lie hidden within it.