irradiated-healing and non-healing mice were similar. A more direct approach to the role of antibody has involved the use of Biozzi high- and low-responder mice. In Biozzi high responders (Ab/H) antibody levels are high and macrophage activity low while in low responders (Ab/L) the reverse is the case[9]. In Ab/H mice infected with *L. tropica*, large, progressive, ulcerating lesions are produced in the presence of high specific antibody titres while in Ab/L mice the lesions are small and healing and antibody levels are minimal[10]. These results confirm unequivocally the widely held belief that in *L. tropica* infections the main protective mechanism is a DTH response and that antibody plays little or no part in recovery. The actual outcome of the infection depends on the interplay of $T_D$ and $T_S$ cells and in due course this information should give us some insight into why some human patients easily overcome the infection and experience only an insignificant lesion while others suffer from spreading and sometimes fatal infections. These findings are relevant not only to *L. tropica* but also to other species. There are indications that similar mechanisms may be involved in infections with the New World species, *Leishmania mexicana*[11], and it may be that the failure to overcome *L. donovani* infections also involves a defect in the DTH mechanism. □

# Interstellar grains: models and measurements

*from David A. Williams*

INTERSTELLAR GRAINS are small solid particles mixed with the interstellar gas which reveal their presence to astronomers in various ways: by causing extinction and polarisation of starlight, or by emitting in the infrared (IR). Extinction is caused by absorption, which heats the grains, or by scattering, which gives rise to an observable, diffuse radiation. Grains also have chemical effects on the interstellar gas, being responsible for conversion of atomic to molecular hydrogen by surface catalysis, and for heavy element depletion. Although grains have been discussed for more than forty years, a recent conference* showed that the questions astrophysicists ask about them have not greatly changed: what are they made of, how are they formed and destroyed, and what is their interaction with gas and radiation?

Astrophysicists have traditionally relied on the curve showing variation of interstellar extinction with wavelength as a pointer to grain identification. In reviewing visual and UV observations Wolstencroft (Royal Observatory, Edinburgh) emphasised the remarkable constancy of the extinction curve in different regions of the Galaxy, especially in visual wavelengths. Some variation does occur in the UV suggesting that (at least) the grain size distribution may vary. Whittet (Preston Polytechnic) showed from a study of the $\varrho$ Oph cloud that, contrary to previous reports, such variations are not accompanied by significant changes in the gas to dust ratio. Measurements of the diffuse (scattered) light in the visual and UV place conflicting constraints on grain properties. Duley (York University, Toronto) and Williams (UMIST) offered a solution in terms of an additional UV component arising from $H_2$ fluorescence that is not normally allowed for.

Participants were excited to hear from Scarrott (University of Durham) of several peculiar emission features longwards of 5,700Å from the mysterious Red Rectangle. The origin of these features caused much speculation and Greenberg (Rijksuniversiteit te Leiden) suggested an answer based on the laboratory simulation of grain mantles. Ices of simple gases (such as water, methane and ammonia) in approximately cosmic proportions are irradiated by UV and dramatic changes in the material are observed. Flashes of light may be emitted as warm-up occurs and the residue has optical features which Greenberg proposes are the diffuse bands.

Unidentified spectral features associated with grains also abound in the IR. Whittet reviewed recent observations of emission features from HII regions, planetary nebulae, galactic nuclei, and the absorption features in the cool interstellar gas. Most participants were convinced that the prominent 9.7 μm feature (seen in emission at high temperature and in absorption) is to be attributed to the SiO bond in refractory material such as amorphous silicates or oxides. The 3.1 μm feature, seen only in absorption in dark clouds, was generally attributed to molecular mantles accreted by cold grains.

A number of other IR absorption and emission features in the range 3–12 μm are known and two alternative interpretations were given. Allamandola (Rijksuniversiteit te Leiden) presented results of laboratory measurements of absorption features from ices such as $H_2O$, CO and $CH_3OH$, and identified them with observed absorption features at 3.4, 3.5, 6.0 and 6.8 μm. Duley and Williams suggested that radicals bound at reactive sites on amorphous carbon grains produce these and other absorption features, and also emission features from warm grains. The precise spectral properties of such grains will change according to their environment. Clearly, the flood of IR observations is providing a set of tight constraints on grain composition.

These and other constraints were discussed by Greenberg, who suggested that all observations so far were consistent with models of amorphous silicates or oxides, carbons, dirty ice mantles and photoprocessed material. The interaction of gas and grains can be studied in detail when the grain material is specified, for then the vast surface chemical literature can be tapped. Duley showed how effectively this can be done. He described a consistent model, including depletion, chemical reactions and optical properties, with the attractive feature that the chemical and optical nature of grains change as grains move from one environment to another. Apparent changes in grain properties may merely reflect their physical state.

The formation of grains is indicated astronomically in a number of sources: late-type giants and supergiants, other special stars, planetary nebulae, novae and supernovae. Some problems remain in understanding nucleation processes. Mechanisms of destruction (sputtering, evaporation and shattering in collision) seem able to account for the life times of grains. Evans (University of Keele) reviewed observations of a nova exhibiting grain formation. There are some difficulties in explaining why the grain temperatures increased after the nova had already started to decline in brightness. There are also some quite puzzling observations of ejection in WR stars in which optical and IR intensities decline with time but the measurement at 3.4 μm remains high.

The Durham group, in work described by Smith, demonstrated that sophisticated modelling of optical polarisation in reflection nebulae is particularly rewarding in understanding the nebulae and the grains. Robinson (Queen Mary College, London) convinced the workshop that in such modelling, especially of IR sources, workers must account correctly for radiative transfer or quite spurious interpretation concerning grains and source properties may result.

The meeting ended in a mood of some optimism. Although much controversy remained it was felt that new observations, particularly in the IR and UV, allied to sophisticated modelling, will enable significant progress to be made in the next few years. □

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*A workshop on interstellar grains was held in Manchester on April 7–8, 1981.

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