approximately monochromatic phonons at frequencies corresponding to, or greater than, the thermal energy over a considerable range of temperature. This opens up many possibilities for the study of thermal conductivity and thermal contact. Thus Anderson and Sabisky (in *Physical Acoustics*, 8; Academic Press, New York, 1971) report an experiment on the flow of high frequency phonons in a dielectric rod immersed in liquid helium, which may well help elucidate the problem of the Kapitza thermal boundary resistance (see J. Wilks, *The Properties of Liquid and Solid Helium*, Clarendon Press, Oxford, 1967).

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INTERPLANETARY SPACE
Solar System Plasmas

from a Correspondent

THE Royal Astronomical Society's discussion meeting on plasmas in the solar system which was held in London on March 24 was introduced by Professor T. G. Cowling (University of Leeds).

One of the chief difficulties is to reconcile the tangled nature of the magnetic field at the Sun with the orderly sector structure of the solar wind. Harmonic analyses of the fields have been performed recently by Newkirk and colleagues, and by Schatten, which ignore coronal currents, but these are probably important, particularly at neutral sheets. These calculations have used the measured field at the photosphere, and fair agreement with the solar streamer structure has been obtained. The best picture of the average magnetic field at present is of an equatorial dipole rather than an axial one, although higher multipole moments are clearly important when close to the Sun.

Professor L. Biermann (Max-Planck-Institut, Munich) gave an account of his work on cometary tails. The structural model is as follows: close to the comet and extending downstream is an inner zone composed of plasma of cometary origin, which is separated from an outer zone of solar wind plasma by a contact surface, which may be of a diffuse nature. Biermann suggests the existence of a collisionless bow shock about 10^6 km upstream of the comet body, of the kind associated with the Earth. Computed flow patterns of the outer zone agree well with the observed motions of filamentary structures, and the model also allows a reasonable explanation of observed Lyman emissions from the tail.

Dr P. Hedgecock (Imperial College, London) presented measurements of the solar wind magnetic field near sunspot maximum, made by the HEOS 1 satellite during 1968 and 1969. Evidence

was presented that the rotation rate of the magnetic sector structure changes over the sunspot cycle, possibly in response to the changing solar latitude of sunspot occurrence. The average field magnitude of 6.3γ ($1 \gamma = 10^{-5}$ Gauss) was not appreciably different from measurements during sunspot minimum obtained from Imp 1, but more large field magnitudes ($\sim 15 \gamma$ for example) were observed by HEOS. Periods of large field values were associated with "interaction regions" where a hotter, faster region of plasma "overtakes" another.

Two talks dealt directly with data obtained from recent Apollo missions. The first was by Professor J. Geiss (University of Berne) who was in charge of the solar wind composition experiment, in which an aluminium sheet is exposed on the lunar surface where solar wind ions become embedded in the metal lattice. On return to Earth the sheet is heated to drive out the gaseous component of the embedded material, which is analysed by mass spectrometer. The ratios of the abundances of various ions (^4He to ^3He for example) obtained from the several Apollo flights were consistent, and when compared with ratios obtained from lunar soil and meteorites should give much information on past and present processes.

In the second talk Professor C. P. Sonett (Ames Research Center, California) reviewed the extensive measurements of the interaction of the solar wind with the Moon made by Explorer 35, a lunar orbiting spacecraft, and by surface magnetometers carried on Apollo flights. The lack of a bow shock and any measurable lunar dipole moment ($\lesssim 10^{20}$ cgs units) indicate the low conductivity of lunar material.

Sonett has considered a model of the Moon with three concentric layers of differing conductivity, and has computed its response to waves in the solar wind. Application of this theory to observed fields suggests core temperatures of only 800–1,000 K. More recently the small satellite released into lunar orbit from Apollo 15 has detected permanent magnetism associated with small-scale crustal or sub-crustal features. The magnetic field embedded in the lunar rocks is most readily explained in terms of a strong lunar field, existing about half a billion years after the formation of the Moon. This indicates a large spin rate at that time, so that the Moon could not then have been a satellite of the Earth.

The simulation of space plasmas in the laboratory has received little attention in comparison with *in situ* spacecraft measurements, in spite of its recent strong advocacy by the Scandinavians (Alfvén, Fälthammar and coworkers). Such experiments have numerous difficulties, but have the advantage of

repeatability, and, hopefully, some control of the parameters. L. Srnka presented the initial results of an experiment at Culham Laboratory in an attempt to simulate the interaction of the solar wind with the Moon. An ideal scaling of the parameters was not achieved, but the important ratios of the system (flow time to collision time, flow speed to Alfvén speed, and so on) were at least on the appropriate side of unity. Photographs of the flow around a glass sphere clearly showed a wake region with embedded plasma cavity.

It was also found in this experiment that the plasma flow energy was limited by the presence of neutral particles in the system. These strongly interact with the plasma when the particle kinetic energy of the flow approaches some ionization threshold of the neutrals. An experiment designed to look at these effects was described by Dr L. Danielsson (Royal Institute of Technology, Stockholm) who has studied the interaction of a hydrogen plasma stream with neutral helium. Spectroscopic measurements have shown that some electrons have been energized twenty-fold in the interaction (from 5 eV to 100 eV), possibly by a two-stream instability. Such effects are of interest when considering the interaction of solar wind with comets, planetary atmospheres and galactic gas.

The remainder of the meeting was devoted to theoretical discussions of some important aspects of the plasma physics of the magnetosphere. Professor V. C. A. Ferraro (Queen Mary College, London) considered the effect of the induced electric field (produced by $\partial B / \partial t$) on the motion of particles constituting the magnetospheric ring current during the growth phase of a worldwide magnetic storm. The electric field causes the particles to drift outwards from the Earth as the ring current increases.

Professor J. W. Dungey (Imperial College, London) and Dr K. Schindler (formerly at ESRIN, Frascati, now at the Max-Planck-Institute, Munich) discussed different aspects of the theory of "X"-type neutral lines in magnetic fields. Dungey remarked that the cross-fertilization between the neutral sheet problem as applied to solar flares and as applied to the aurorae took place from the former to the latter twenty years ago; now, however, the process operates exclusively in the opposite direction, due to *in situ* magnetospheric measurements. Dr Schindler gave a very elegant treatment of the stability of two-dimensional static equilibria of systems containing magnetic neutral lines (which leads to the tearing mode for strictly neutral sheets), although Professor Dungey considered that the dynamic situation, involving particle acceleration and field-line reconnection, was more interesting.