observations. Recent improvements in the experimental methods reported at the conference, hold considerable promise for measuring the intensity of beryllium isotopes as a function of energy thereby obtaining a direct measure of the mean life of cosmic rays using ^{10}Be as a clock. One is also on the threshold of witnessing a capability for resolving isotopes of elements upto iron in the near future; such advances will then permit us to make important deductions about the processes of nucleosynthesis involved.

At extremely high energies—greater than about 10^{17} eV—some interesting results were presented. Of the three major groups working in this area from the UK, USA and Australia, the former two presented evidence for a flattening of the energy spectrum beyond 10^{17} eV extending upto 10^{20} eV. If confirmed this will have very important implications as can be seen from the following. It is generally believed that since the radius of gyration of such particles in galactic magnetic fields have values larger than galactic dimensions, they should be of extragalactic origin. On the other hand at energies in excess of 10^{19} eV, the protons, if they are, universal, will be effectively eliminated from the cosmic ray beam because of the onset of their interactions with photons of the universal microwave background radiation at 2.7°K. The observed flattening of the cosmic ray spectrum will therefore imply that cosmic rays at these energies are either reasonably "local" or that the microwave background radiation is not universal. If the former alternative is the case, cosmic ray particles at these energies should show preferred directions of arrival. Attempts made by the same three groups so far regarding the anisotropy in arrival directions have resulted in contradictory findings and hence this problem will have to await better statistcis bearing in mind the fact that the particle intensities involved at energies greater than 10^{17} eV are less than one per year per square kilometer.

For the first time convincing evidence was presented for the emission by Jupiter of electrons between about 1 and 30 MeV. This conclusion was derived from the following two observations: (i) the 13 month periodicities of electron intensity enhancements obtained from various satellites when the Earth and Jupiter came within the same solar magnetic field structure permitting thereby the Jovian electrons to spiral along field lines connecting the Earth and Jupiter; and (ii) the positive intensity gradient of about 150 percent per AU observed while approaching Jupiter from the Earth. Such observations have become possible because of deep interplanetary missions particularly Pioneers 10 and 11; attempts to understand how Jupiter accelerates these electrons are now the subject of study by several workers. Interesting findings were also reported about certain correlations associated with solar events which are rich in energetic ^{3}He. These events show the following features: (i) they are generally associated with weak or no observable flare; (ii) there is pronounced enhancement of heavier nuclei including iron among the energetic solar particles emitted; (iii) at least 8 events with ^{3}He / ^{4}He ratio greater than 0.5 have been seen; (iv) the ^{3}He enhancement is seen to an energy down to 1 MeV per nucleon; and (v) there is no detectable flux of ^{3}H or ^{2}H in these events. There were indications that a suitable interpretation of these observations will hold the key to a better understanding of some aspects of the happenings in the inner parts of the Sun.

Finally it may be of general interest here to comment on the reported discovery of a moving monopole (for details see Apparao's article in this issue). Three important points emerged from the discussions at the conference. (i) With the evidence presently available one can advance a not too unlikely alternate interpretation to the observations wherein a cosmic ray nucleus of charge 79 with a velocity close to 0.7c makes two successive nuclear collisions within the detector assembly losing in each case two to three charges. If this were the case there is nothing unusual in the event. (ii) A nuclear collision of a superenergetic cosmic ray nucleus in the air above the balloon could not have produced the monopole observed because of its relatively low velocity of 0.5c and high mass; hence if it is a monopole it should be of cosmic origin. (iii) While, on the basis of the single event seen, the authors assign a flux value of the order of 10^{-13} monopoles cm^{-2} sec^{-1} sr^{-1}, many searches to detect trapped monopoles from lunar, meteoritic and terrestrial samples have only yielded upper limits of 10^{-18} so far. Because of the profound implications of such a discovery and the lack of finality of the present evidence, delegates were generally of the view that for final acceptance, one would need another unambiguous event.

R. R. Daniel

Tata Institute of Fundamental Research
Bombay 400 005

ASTROPHYSICAL CONVECTION

An informal meeting of the Fluid Dynamicists and Astrophysicists was held at the Institute of Astronomy from June 16-27, 1975. The primary motive of the meeting was to highlight those recent developments in Fluid Dynamics that may be relevant in developing 'theories' of convection that can be used by the Astrophysicists.

The necessity to have an experimental basis for any theory applied to stars was emphasized by Spiegel. He pointed out the astrophysicists desire for fluids like Na with low Prandtl number (10^{-2}) and high Rayleigh number (10^{15}). Even though these are far removed from the astrophysical situations with Prandtl numbers of $\sim 10^{-8}$ and Rayleigh numbers $\sim 10^{20}$, he wanted the astrophysicists to see whether their mixing length theory extended to these limits yield correct results. He outlined the major astrophysical problems which have a fluid dynamical basis like the solar granulation, penetrative convection or overshooting, semiconvection or double diffusive convection, the effects of rotation on convection and the relationship between convection and pulsation.

Hill presented the recent experimental observations on the solar oblateness. By eliminating major systematic errors, the measurement of the edge of the Sun were made seeing independent, and the oblateness yielded a low value of 18 ± 12 m arc sec. Another major importance of the experiment lies in the detection of periodic varia-

tions. Hill mentioned that the modes looked both radial and nonradial and the l-values for all these modes could also be determined. Towards the end of the conference preliminary results from the investigations of Gough and Dalsgaard indicated that all these modes may be acoustic p-modes.

Schwarzschild outlined the mixing length theory as used by the astrophysicists and mentioned its inadequacy in connection with the supergranules. Further, in order to emphasize the overriding importance of a good theory of convection, he extended his evolutionary calculations to the red supergiant stage, using the mixing length theory. He also mentioned the recent trend towards incorporation of nonlocal mixing length theories.

The close relationship between the loops in the theoretical HR diagram and the extent of the convective core was discussed by Maeder. The absence of any loops in the observed HR diagram was explained by him by taking into account the phenomenon of overshooting. For this purpose he adopted the criterion of zero convective velocity instead of Schwarschild or Ledoux criterion for the onset of convection. The ratio of mixing length to pressure scale height was taken to be 0.5.

The termination of the Cepheid strip in the HR-diagram was sought to be explained by Gough on the basis of convection. He used the mixing length theory generalized to take into account the time dependence, and computed the model of $7M_{\odot}$ star and obtained some hopeful trends towards explaining the termination of the Cepheid strip and also the existence of the long period variables. Since the stellar evolutionary model did not properly take into account the turbulent pressure term, he felt the results to be quite preliminary.

A stability analysis to non-radial pulsation of the Sun was outlined by Gabriel. He found g_1 and g_2 unstable modes with $l=1$ for solar models with ages in the range 2.4×10^8 to 3×10^9 yrs which are in agreement with earlier calculations by Dalsgaard, Dilke and Gough. The extension of his theory to other stellar masses indicated that while 1.1 $M_{\odot}$ model was stable, the 0.6 and 0.8 $M_{\odot}$ were unstable. An interesting aspect of the analysis was the use of a perturbed static mixing length theory of Unno.

From the Fluid Dynamics point of view results of several real time experiments were presented by Malkus, Weiss, Busse and Weir. Malkus pointed out that in experiments with fluids with Prandtl number 0.7 and Rayleigh number 4000, the subcritical and oscillatory types instabilities occurred. The important aspect of penetrative convection arising out of such instabilities was noted by Weiss who did numerical experiments of ice-water type. He analysed the dependence of Nusselt number (representing the convective energy transport) on the ratios of R/R_c. The overshooting is clearly seen in such an analysis and numerical experiments also verified these results. Busse listed the various types of instabilities which can occur in a fluid of interest to us (1) cross-roll, (2) bimodal, (3) zig-zag motion, (4) oscillatory, and (5) hexagonal convection.

The major development in the theories of convection in recent times is the serious attempts being made to simulate several numerical experiments. The old Boussinesq type of approach (a representation of which appears as mixing length theory) was replaced by the anelastic approximations and two dimensional solutions under these constraints were obtained by Gough, Latour, Spiegel and Toomre. Physically these approximations correspond to the situations where motion-induced fluctuations are rather small. Numerical experiments using compressible fluids were performed by Graham who found that compressibility may lead to large convective velocities and enhanced fluxes at low Prandtl numbers. These results were interesting in the light of Flywheel olutions obtained in cylindrical geometry by Weiss and Moore. They showed the results of their numerical experiments on the unexpected dependence of the Nusselt number on R/R_c, which was hardly different at low Prandtl number from the dependence at moderate Prandtl numbers. It was pointed out by several participants that this behaviour would have far reaching implications for astrophysical convection if indeed it is relevant to stars, and would probably imply complete inadequacy of the mixing length approach. However participants doubted its relevance, especially with reference to the problems of solar granulation and stellar evolutionary calculations.

The analogy of thermohaline experiments to semi-convection was emphasized by several speakers and a thorough analysis of such experiments in laboratory as well as in Oceanography was presented by Turner and Huppert. The main interest of Turner's result lies in the fact that there is a sort of layering in the double diffusive (semiconvective) fluid. It was not at all clear how such layering phenomena have to be taken into account in the treatment of semi-convection in stellar interiors. The Oceanographic numerical experiments of Huppert clearly demonstrated the importance of non-linear effects in treating convection and he showed the existence of several periodic and aperiodic instabilities due to such effects. This once again emphasized the importance of replacing mixing length theory by a more suitable, but manageable treatment of stellar convection and semiconvection.

The statistical theories of treating turbulent phenomena were outlined by Herring and some experimental results in this connection were presented by Whitehead.

A brief discussion on the effects of rotation on convection was held. Busse presented his experimental results on the Benard cells due to rotation and outlined his theory of Jovian atmosphere based on these cells. Tayler mentioned the effect of rotation on the criterion for the onset of convection as well as the effects on fully developed convection. There was a lucid lecture on dynamo theory by Moffet.

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Institute of Astronomy
Cambridge University
Cambridge

S. Ramadurai*

* On leave from Tata Institute of Fundamental Research, Bombay, India.