RECENT ADVANCES IN CONVECTION THEORY AND MODELLING

Summary by: **S. SOFIA**

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This Joint Discussion (Number 13), took place on August 22, 1994 at The Hague, in connection with the XXII General Assembly of the IAU. At the one-day long meeting, there were presentations by 15 invited speakers and 15 posters.

The Joint Discussions had been organized in response to the considerable progress made in this field of research during the previous decade. Although it had long been known that the prevailing mixing length theory (MLT), used extensively and very successfully in Astrophysics for several decades had become needlessly limited, until recently it was impractical to contemplate more realistic approaches. The situation has changed recently as a consequence of advances in numerical techniques and computational capabilities, and thus JD 13 was organized to discuss the advances, and perhaps to understand the strengths and weaknesses of each approach.

There were two presentations which addressed the main issues in convection theory (E. Schatzman), and the astrophysical implications (P. Demarque). Several talks covered current numerical codes, which included deep convection in a rotating reference frame (K. Chan), convection in the presence of magnetic fields (P. Fox), and shallower solar convection simulations on a wide range of spatial scales (A. Nordlund). Although these approaches have enriched (and are continuing to enrich) our understanding of the physics of convective fluids, they are much too detailed (both in space and in time) to be integrated in the study of stellar evolution. To overcome this shortcoming, S. Sofia described a technique developed together with Lydon and Fox to use relationships between dynamical and thermodynamic properties of convective flows derived in numerical models to be applied in stellar structure and evolution codes by performing small modifications of the standard MLT formalism. The advantage of this technique is that it does not contain a mixing length or any other arbitrary parameter, and it was used successfully in modeling the evolution of the Sun and other solar analogues. V. Canuto also presented a formulation of convection both amenable to be used in stellar evolution studies, and not requiring an arbitrary mixing length-like parameter. His formulation uses the Reynolds stress method, which has the advantage of modeling the full eddy spectrum of the turbulence, rather than the narrow wavenumber range for energy containing eddies assumed in the MLT. Additionally,

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this technique can address the problems of non-locality and overshoot. M. Stix also addressed non-locality and overshoot by presenting results of a non-local mixing length model of the Sun derived from the
Shaviv and Salpeter model.

C. Chiosi addressed the role of semiconvection and overshooting in supergiant stars, and he showed how these effects account for intermittency and stirring thought to occur in those stars. K. Nomoto discussed the role of convection in supernova explosion, presenting calculations that suggest that this process is important in triggering the shock wave propagation which ejects the stellar envelope.

J. Christensen-Dalsgaard discussed the implications of helioseismology on the properties of the convection zone, and concluded that the new models of Canuto and Mazzitelli, of Montiero, and the mean model of Nordlund and Stein all give better agreement between the theoretical and the observed oscillation frequencies than the MLT model.

Finally, D. Grey, H. Snodgrass, and P. Gilman addressed issues relating the generation and observational properties of the magnetic cycle in the Sun and in other stars. The specific links between these phenomena and convection theory are still tenuous. However, it is clear that as the sophistication of convection theory increases, the link with dynamo processes will have to become more obvious. Eventually, the accuracy of the emerging picture will be assessed by its ability to account for properties of the convective fluids at the same time that it explains the properties of the solar and stellar dynamos.

The feeling arising from the presentations and the posters of JD 13 is that we are clearly making progress in attempting to understand and model the structure and processes which occur within the surface convection zone of the Sun and other cool stars, a progress that is spurred both by theory and observations. The latter will undergo an explosive growth as GONG, SOHO, the SDS, and other observational programs become operational. To fully utilize the expected data, it is necessary to expand the efforts required to increase the accuracy of the numerical and theoretical models. Moreover, as the sophistication of the convective models increases, we are better equipped to assess the role of convection in the more exotic environments of giants and supergiants, and in supernova explosions.