Convection in Astrophysics
Proceedings IAU Symposium No. 239, 2006
F. Kupka, I. W. Roxburgh & K. L. Chan, eds.

doi:10.1017/S1743921307000579

Round table discussion on session D: stellar evolution, nucleosynthesis and convective mixing

Achim Weiss[1]

[1]Max-Planck-Institut für Astrophysik, Karl-Schwarzschild-Str. 1, 85748 Garching, Germany
email: aweiss@mpa-garching.mpg.de

Abstract. Summary of the round table discussion following Session IV on "Stellar evolution, nucleosynthesis, and convective mixing".

Session IV on "Stellar evolution, nucleosynthesis, and convective mixing" ended with a round table discussion, which is summarized in the following. The discussion panel consisted of the following speakers: C. Chiosi, D. Arnett, P. Ventura, L. Deng, and M. Spite. It was chaired by A. Weiss. The audience very actively took part in it.

The discussion was opened with the provocative statement by the chairman that Mixing Length Theory has been in use for such a long time and so few efforts to improve the treatment of convection had been attempted because of the fact that the existence of a free parameter, the mixing length, provided a means to be able to correct for all deficits of solving the energy transport equation, and to reproduce successfully observed stellar temperatures respectively radii, including that of the solar model. With the help of $\alpha_{\rm MLT}$ errors in opacities, boundary conditions, and of course the treatment of convection itself can be compensated. On the other hand, for the same reason stellar models do not have much predictive power for stellar temperatures, except when assuming that an adjustment of $\alpha_{\rm MLT}$ with one "calibrating" case is an accurate approximation for other circumstances. In view of the fact that effective temperatures are used, for example, to derive masses of main-sequence stars or red giants and to infer the age of old galaxies, this is a serious deficit of stellar evolution theory.

C. Chiosi agreed to that, but pointed out that the comparison to observations in addition provides means to learn about convection beyond the local MLT. For example, adjustments of $\alpha_{\rm MLT}$ do not solve problems connected with the size of the convective core in massive main-sequence stars, for which non-local properties have to be introduced.

The discussion then turned to the question of how to proceed in the future. D. Arnett envisages that his multi-dimensional calculations of stars will provide enough information to learn about properties of convection, such as temperature stratifications, overshooting, and mixing efficiencies such that reliable recipes can be derived that allow the one-dimensional models to become more realistic. A similar approach was already done (A. Weiss) using the two-dimensional models of Ludwig to derive a depth-dependent $\alpha_{\rm MLT}$ for the solar convective zone to reproduce the actual temperature gradient successfully. B. Stein and J.-P. Zahn strongly supported this view that the multi-dimensional hydrodynamical simulations will eventually lead to much improved one-dimensional stellar models.

On the other side, the Reynolds-stress convection theories as developed by Xiong, Canuto, and Kupka may eventually be developed into comparably simple formulae that can in fact be incorporated into the stellar evolution codes and are acceptable approximations for both time-dependent and non-local convection. So far, the theory of Kuhfuß in its one-equation form seems to be the only one which has been used, for example by Wuchterl (star formation) and Straka and Flaskamp (full stellar model) for complete and implicit modeling, while that of Xiong is applied by him and Deng for envelope calculations (see the contribution by Deng in this volume). In all these attempts, however, numerical problems limited the full application and tuning of the theory had been necessary.

V. Canuto pointed out that a good theory should contain information about a typical dissipation scale (such as the mixing length), the eddy spectrum, and non-locality. The improvement of the Canuto-Mazzitelli approach compared to mixing length theory is the consideration of the full Kolmogorov eddy spectrum (in his words, this theory has not yet been "plumarized"). He announced that in the future he will be able to provide a new version that also contained a simple, but sufficiently accurate non-local term. The stellar modelers are curious for this theory to appear.