Inside the Stars, IAU Colloquium 137
ASP Conference Series, Vol. 40, 1993
Werner W. Weiss and Annie Baglin (eds.)

NEW PHYSICS, NEW EVOLUTIONARY TRACKS, NEW ISOCHRONES

P. DEMARQUE, D.B. GUENTHER and M.H. PINSONNEAULT
Center for Solar and Space Research and Department of Astonomy,
Yale University, P.O. Box 6666, New Haven, CT 06511, USA

INTRODUCTION

Work has begun on the construction of a grid of theoretical isochrones based on important recent refinements in stellar physics. These refinements have already been applied to the construction of a standard solar model, which, for the first time, free of any *adhoc* assumptions, reproduces the observed p-mode oscillation spectrum within the errors of the physics (Guenther *et al.* 1992).

SCIENTIFIC GOALS

(1) To test the theory of *STELLAR STRUCTURE* and *EVOLUTION* using state-of-the art physics
(2) To provide a framework for detailed study of *INTERNAL DYNAMICS* (e.g. rotation, convection), and other *TRANSPORT MECHANISMS* (e.g. chemical diffusion, angular momentum transfer) in stars
(3) To help understand star cluster cmd's in the Galaxy and nearby systems by interpreting the *FOSSIL RECORD* left by *STAR CLUSTERS* and related systems
(3) To upgrade the building blocks for *POPULATION SYNTHESIS* for the study of *DISTANT GALAXIES* and *GALAXY EVOLUTION.*

NEW PHYSICS

(1) Solar abundance mixture from Anders and Grevesse (1989).
(2) OPAL opacities from Livermore (Iglesias and Rogers 1991).
(3) Nuclear energy generation rates from Bahcall and Pinsonneault (1992)
(4) Inclusion of Debye-Hückel corrections in the equation of state at high temperatures.
(5) In the case of stars with a convective core near the main-sequence, the effects of modest core overshooting (in the range 0.1 to $0.2H_p$) at the convective boundary are studied.
(6) In the case of stars with convective envelopes a solar calibration of the mixing length is adopted. Effects of small variations of the mixing length are explored.
(7) The Kurucz (1992) model atmospheres are used as surface boundary conditions.
(8) The color calibration grids of Green (1988) and Kurucz (1991) will be used. Improved color grids will be easy to implement.

https://doi.org/10.1017/S0252921100018212 Published online by Cambridge University Press

GRID PARAMETERS

Metallicity
(1) Z= 0.0001 to 0.1

(2) For low Z (Z less than about 0.007), α-capture element abundances enhanced by 0.4 dex
Helium
(1) For $Z < 0.01$: $Y = 0.20$, 0.23 and 0.25
(2) For $Z = 0.01$ to 0.02: $Y = 0.25$, 0.30 and 0.35
(3) For $Z = 0.04$ to 0.10: $\Delta Y/\Delta Z = 2$, 3 and 4
Initial mass
About 0.5M⊙ to 10M⊙, depending on chemical composition

EXAMPLE

The poster displayed comparisons of isochrone fits to the old open clusters M67 and NGC 188. Fig. 1 and 2 illustrate only the most important results. For the purpose of comparison, both fits use the same distance modulus (m-Mv)=9.70 and interstellar reddening E(B-V)=0.07 for M67. The solar Y and α for each opacity was also adopted, reasonable assumptions since the metallicity of M67 is close to solar. At this point, the main uncertainties (other than in the photometry) relate to the problem of the color calibration (we used here the Green et al. (1987) table), and to the treatment of convection. For recent convection improvements (which do not require the free parameter α), see D'Antona et al. (1992) and Lydon et al. (1992). Under these assumptions the derived age for M67 remains within the range $4.0^{+1}_{-0.5}$ Gyr. The OPAL age may be lower by about 0.5 Gyr.

ACKNOWLEDGEMENT

We acknowledge support from NASA grants NAG5-1486 and NAGW-2531.

REFERENCES

Anders, A. and Grevesse, N. 1989, Geoch. & Cosmoch. Acta, 53, 197.
Bahcall, J.N. and Pinsonneault, M.H. 1992 Rev. Mod. Phys. in press.
Cox, A.N. and Stewart, J.N. 1970, Ap.J.Sup., 19, 261 (CS).
D'Antona, F., Mazzitelli, I. and Gratton, R.G. 1992, A&A, in press.
Demarque, P.,Guenther, D.B. and Green, E.M. 1992, A.J., 103, 151.
Green, E.M.,Demarque, P. and King, C.R. 1987, Revised Yale Isochrones
Grevesse, N. 1984, Phys. Scripta, T8, 49.
Guenther, D.B., Demarque, P., Kim, Y.-C. and Pinsonneault, M.H. 1992, Ap.J., 387, 372.
Huebner, W.F.,Merts, A.L.,Magee, N.H. and Argo, M.F., 1977, LASL Report No. LA-6760-M (LAOL).
Iglesias, C.A. and Rogers, F.J. 1991, Ap.J., 371, 408 (OPAL).
Kurucz, R.L.1992, personal communications.
Lydon, T.J., Fox, P.A. and Sofia, S. 1992, Ap.J.,in press.

https://doi.org/10.1017/S0252921100018212 Published online by Cambridge University Press

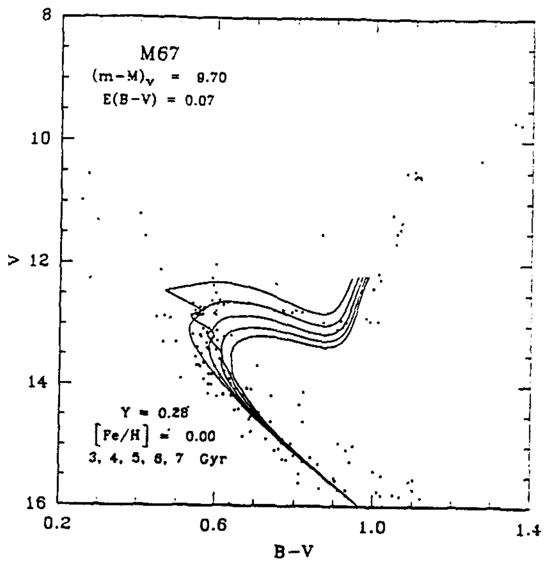

Fig.1 M67 fit. The isochrones include core overshoot (overmixing) by 0.1Hp. With the CS and LAOL opacities, convective overshoot at the core edge must be included to reproduce the observed gap in the cmd near the main sequence. The turnoff fit is good, but the giant branch does not match observations using the solar calibration for alpha.

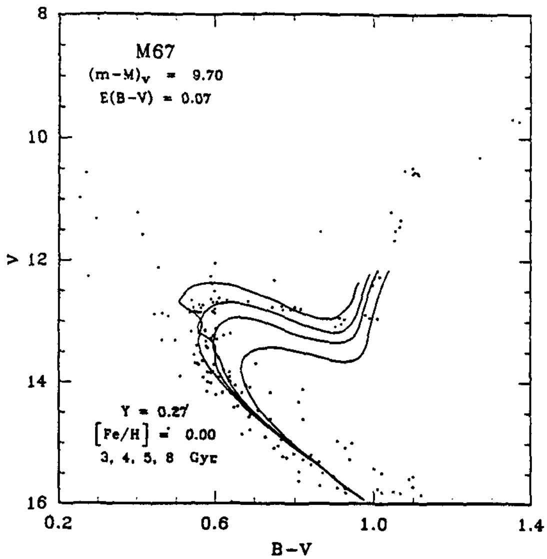

Fig. 2 Isochrones including the improvements in the physics described in the text. No convective overshoot was included. The fit around the gap suggests that the amount of convective overshoot needed to fit the gap is smaller when the improved physics is adopted. Note also that when using the OPAL opacities and the Kurucz atmospheres, the position of the theoretical giant branch is much more faithful to the observations. This illustrates the important role of low temperature opacities, in addition to the treatment of convection, in calculating reliable radii for red giant stars.

https://doi.org/10.1017/S0252921100018212 Published online by Cambridge University Press