REVIEW OF IAU SYMPOSIUM No. 59 ON STELLAR INSTABILITY AND EVOLUTION, CANBERRA, AUGUST 1973*

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Abstract. Since the results of the Canberra Symposium are to be published, a complete review here would be redundant. I will therefore confine my written remarks to an enumeration of several topics which were discussed.

(1) Cepheid masses estimated in several different ways (using observational data in conjunction with theoretical evolutionary properties or in conjunction with theoretical pulsation properties) give discrepant results which may be interpreted to mean that stars lose considerable mass between the main sequence and Cepheid phases. One of the discrepancies disappears if the currently adopted distance to the Hyades is an underestimate by 0.2 mag. to 0.3 mag. A review by Van Altena at the IAU meeting in Sydney reveals that the convergent-point technique (which determines the current standard) gives a distance 0.2 mag. smaller than that given by all other techniques. It is therefore probable that Cepheids have essentially the same mass as their main sequence progenitors.

(2) The period-luminosity relationship for population I periodic variables now extends all the way to the main sequence, where a small pulsation amplitude has, until recently, prevented careful study. P-L relationships for Population I and Population II regular variables are now reasonably complete and the difference in slope and normalization between the two relationships is one of the most powerful discriminants between the two population types. Population I variables are represented by stars of many different ages and masses with a well defined mass-luminosity relationship ($L \underset{\sim}{\propto} M^4$) connecting them. Population II variables are all of low mass ($M \sim 0.5\ M_\odot$), with luminosity essentially uncoupled from mass.

(3) The evolutionary status of all Population II regular variables is understood in rough outline. For example: variables of intermediate period ($\sim$ 2 days) are evolving through the instability strip on a nuclear burning time scale, helium burning in one shell, hydrogen in another; long period variables are evolving through the strip on a Kelvin-Helmholtz time scale during excursions from the giant branch that are engendered by relaxation oscillations initiated in the double-shell source region.

(4) Understanding of detailed properties of Population II variables is still highly incomplete. Estimates of envelope helium abundance are a strong function of the mode of estimation. The quantitative influence of over-shoot and semi-convection at the edge of the convective core during core helium burning has not yet been satis-

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factorily demonstrated. A satisfactory understanding of the Osterhoof dichotomy is not yet at hand, although it is becoming increasingly probable that hysteresis in the domain of a transition region (between pulsation in the fundamental and in the first harmonic mode) may be responsible.

(5) Low-mass red giants that are in the double shell source stage lie on an extension of the normal giant branch that has a slope in the $\log T_e - M_{\mathrm{bol}}$ plane much shallower than exhibited by the normal giant branch. This may be evidence for mass loss from very cool, luminous giants or may be an indication of a deficiency in stellar models.

(6) The formation of planetary nebulae may occur as a consequence of a final, large amplitude pulsation which terminates the Mira variable phase along the extention of the giant branch discussed under 5. Responsible for pulsation are properties of the star in the neighborhood of the hydrogen ionization zone, despite the fact that convection is important in this neighborhood. The final pulse may carry off all matter above the hydrogen-burning shell except for a very minute layer ($\sim 0.0003\ M_\odot$). The remnant is consistent with recent models of evolution for the central star of planetary nebulae. Of major interest is the fact that, in order to eject the nebula, it is not necessary to invoke either a large amplitude thermal pulse initiated in the helium-burning shell or radiation driven mass loss (the envelope-driven pulsation ejects matter before the critical luminosity for this process is reached).

(7) The observed properties of oscillations following the nova outburst are very strong evidence for non-radial pulsation. Observed periods are too long to be radial oscillations and an increase in period with decreasing radius (observed in one star) is a property unique to a non-radial g-mode.

(8) Statistical evidence makes it more and more likely that the progenitors of type I supernovae are binaries consisting initially of a star of intermediate mass (3–8 $M_\odot$) orbiting a star of low mass ($< 0.8\ M_\odot$) with initial periods in the range 1–6 yr. Following two phases of mass loss and mass transfer, the immediate supernova progenitor consists of a carbon-oxygen white dwarf orbiting about a red giant that is swelling beyond its Roche-lobe.