Time Scales of Stars during the Crossing of the Cepheid Strip

D. LAUTERBORN, S. REFSDAL and M. L. ROTH (Hamburg, Oslo)

In a recent paper (LAUTERBORN, REFSDAL, WEIGERT, 1971) the central He burning phase of 5 $M_\odot$ stars was investigated. It was shown that the structure of such stars is very sensitive to the chemical profile in and above the hydrogen burning shell. The loops in the H-R diagram which such stars often make were for instance found to be very sensitive to changes in this profile. It was also shown that an assumed mass loss of about 10 % in the red giant region will suppress a loop completely.

For large enough loops the star will come into (and usually cross) the Cepheid strip. This has implications for the number of Cepheids one should expect to observe.

I will now discuss some more recent results (LAUTERBORN, REFSDAL, ROTH, 1971) for 7 $M_\odot$ and 9 $M_\odot$. For these stars secular instabilities sometimes occur during the loops so that they in many cases will evolve on a thermal time scale through the Cepheid strip. We have found that the tendency for such an instability increases with increasing M, and with decreasing ratio of mixing length to pressure scaleheight (l/H_P).

For some of the stars investigated, we have also constructed sequences of equilibrium models with central He-burning, varying the chemical structure (for instance the core mass) of the star. For the stars which were secularly unstable during some phases of central He-burning one could always find some chemical structures for which two different stable models in thermal equilibrium could be found. One of these solutions always gave a model close to the Hayashi-line in the H-R diagram, whereas the other one was always clearly to the left of the Hayashi-line. Between these two regions of solutions there is a gap, where no stable equilibrium solution can be constructed. This gap was usually found to include the Cepheid strip. The instabilities mentioned above seem always to occur when the star „runs out" of possible solutions in one region. The star will then cross the gap on a thermal time scale, before it finds a stable equilibrium model in the other region. The existence of this instability can considerably increase the speed with which a star crosses the Cepheid strip, and thus influence the expected number of observed Cepheids.

References:

LAUTERBORN, D., REFSDAL, S., WEIGERT, A., 1971, Astr. Astrophys. **10**, 97.
LAUTERBORN, D., REFSDAL, S., ROTH, M. L., 1971, Astr. Astrophys. **13**, 119.

Discussion to the paper of LAUTERBORN, REFSDAL and ROTH

SMAK: I wish to add that a very similar multiplicity of solutions was recently obtained by M. KOZOWSKI in Warsaw, although he had a slightly different hydrogen profile.

KIPPENHAHN: In testing stellar evolution theory one can compare the number of observed Cepheids in a given volume of space with the number of main sequence stars above a certain luminosity. On the other hand one can also make statistics by determining the number of Cepheids in different period intervals. Do both types of tests depend on the mixing length or is there some hope that at least one is not too much influenced by the uncertainties of convection theory?

REFSDAL: If one considers a reasonable range of l/H_P values, say between 1 and 2, the effect discussed in this paper should only affect the number of high mass and high period cepheids ($M \geqslant 6\ M_\odot$, $P \geqslant 5$ d). The number of low period (low mass) Cepheids will however, also probably be affected by the value of α, because the location of the Cepheid strip depends somewhat on α. This can have a large effect when the high temperature tip of the loop lies in the Cepheid strip. In conclusion I think both types of tests mentioned in the question may be considerably influenced by the value of α.

https://doi.org/10.1017/S0252921100032759 Published online by Cambridge University Press