RECENT THEORETICAL RESULTS FOR δ SCUTI AND DWARF CEPHEID VARIABLES

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Recent evidence suggests that δ Sct stars and most dwarf Cepheids are population I objects of normal mass. The remaining dwarf Cepheids, including CY Aqr, DY Peg, SX Phe and GD 428, have low masses, are metal-deficient, and are in a presently undetermined stage of evolution (Breger 1979, McNamara and Feltz 1978, but see also Simon 1979).

Many δ Sct and dwarf Cepheid variables are multiperiodic and, in principle, multiple periods can be used to infer physical properties of these stars. The component periods must be determined accurately and reliably, and several workers (Breger, Fitch, Kurtz, Pelt, Percy, Shobbrook, Stellingwerf, Stobie and Warman) are active in developing and applying new methods of period analysis; see Wizinowich and Percy (1979) for a representative example.

One result of these analyses is the discovery that in some stars, modes may vary in amplitude or appear or disappear completely within a few days (Stobie and Shobbrook 1976). Methods of period analysis must allow for this possibility if they are to be accurate and reliable.

In all dwarf Cepheids and in many δ Sct stars, the multiple periods are consistent with radial pulsation (RP) as are the relative amplitudes and phases of the light, colour and velocity curves. In a few δ Sct stars, notably 1 Mon and 14 Aur, the periods can only be explained by non-radial pulsation (NRP). Dziembowski (1977b) and Balona and Stobie (1979) have studied the light, colour and velocity variations produced by RP and NRP. This approach is capable of determining both the radius and the types of modes (R or NR) present. The presence of NRP in δ Sct stars is also supported by line profile studies by Campos and Smith, and by a study of δ Sct star models by Dziembowski (1977a), who finds these to be unstable against low-ℓ NRP.

Contrary to previous belief, multiple radial periods cannot determine unambiguously the masses of δ Sct and dwarf Cepheid variables (see Cox et al. 1979a for instance). However, multiple R and NR periods, in conjunction with other observational data, are capable of determining physical properties very accurately (see Fitch and Wisniewski 1979 for an impressive analysis of 14 Aur).

Stability analyses of δ Sct models confirm that they are destabilized by the combined effects of the H and He ionization zones. [A

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destabilization zone at T = 1.5 × 10^5 K, due to an ionization edge of He, was discovered independently by Pamjatnykh (1974) and Stellingwerf (1979). It is not very important in the δ Sct stars, but may be the long-sought destabilization mechanism in the β Cep stars.] A comparison of the observed and various theoretical blue edges (see Cox et al. 1979a for instance) shows mainly how sensitive the theoretical blue edges are to the treatment of opacity and other input physics.

Metallic-line (Am) stars lie on or near the main sequence. Many lie in the δ Sct instability strip, but not one pulsates with Δm ≥ $0\overset{m}{.}01$. The most widely accepted explanation for the Am phenomenon is element separation by diffusion. In the context of this explanation, the non-pulsation of Am stars is due to the diffusion of helium from their envelopes (Pamjatnykh 1974).

The δ Del stars lie above the main sequence, generally in the δ Sct instability strip. Many of them pulsate. Kurtz (1976) has proposed that δ Del stars are evolved Am stars, and have therefore undergone diffusive element separation. How therefore do they pulsate? Cox et al. (1979b) have shown that, although the hydrogen ionization zone is not sufficient to excite pulsation, there is sufficient helium remaining after diffusion to excite the pulsation.

Many theoretical questions about δ Sct and dwarf Cepheid variables require a non-linear approach for their solution. What determines the amplitude? What determines which mode or modes (R or NR) are excited? Why do some modes appear and disappear? Why are there non-variables in the instability strip? What is the role of rotation and of diffusion? So far, non-linear approaches have been very difficult to apply (Stellingwerf 1976), and the results obtained may depend critically upon the artificial viscosity parameters used. Therefore, in order to understand these objects, we may have to know the actual dissipation mechanisms which are present. Simon (preprints) reports promising results using successive approximations to the full non-linear technique.

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