Late–Type Binary Systems

THE COOL ALGOLS

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ABSTRACT. Five semi-detached systems have been identified having detached components with spectral types G or K. These stars form a sequence having temperature decreasing with increasing mass, in contrast to the "classical" Algols with hotter detached components having properties roughly approximating those of detached main sequence stars. The status of the cool Algols is discussed briefly. A second group of 3 detached components in Algols is identified having higher temperatures than main sequence stars of the same mass.

Cool Algols may be defined as semi-detached eclipsing systems in which the more massive, hotter, detached component is type G or K. Five such systems have spectroscopic orbits of both components: the giant systems RZ Cnc and AR Mon (Popper 1976) and the subgiant systems AD Cap, RT Lac, and RV Lib (Popper 1991). There is a selection effect against the cooler systems in that the primary minima are generally deeper in the classical Algols of earlier type.

It appears to have become widely accepted (e.g. Hall and Neff 1979; Budding 1989) that, in Algols with detached components of types B and A, these stars have properties not differing greatly from those of main sequence stars of the same spectral types, a condition not satisfied by the cool Algols. This situation is displayed in Fig. 1, which shows in the log m-log Te plane those detached components for which the masses are based on radial velocities of both components. Because of non-photospheric effects in the absorption lines of the hotter stars, their true velocities, in a considerable fraction of the systems, are poorly known. While the effects of these uncertainties cause the masses of the losers to be quite uncertain, the masses of the gainers are affected to a much less extent. The more uncertain masses of the gainers are shown with parentheses in Fig. 1. Also shown in Fig. 1 are the positions of detached eclipsing binaries, for which the solid curve defines a main sequence mass-Te relation. We note from Fig. 1 that the hotter detached components of Algols appear generally somewhat cooler than the components of detached binaries of the same mass, so that the assumption that masses in the hotter Algols can be assigned according to their types is not strictly valid. This difference in types is, in part at least, due to effects of nonphotospheric material, causing a spectrum to appear later than its photospheric type (e.g. Table 36 and references in Popper 1989). There may be an additional effect of evolution. This matter is not pursued further.

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The most striking feature of Fig. 1 is the departures of the detached components of the cool Algols, in which significant nonphotospheric effects are most likely absent in the spectra (Popper 1991), from the mass-spectral type relation for the other stars--the more massive the star, the greater the departure.

A second result seen in Fig. 1 is that the least massive A-type detached components, namely those in R CMa, RY Aqr, and TW Dra, are considerably hotter than main sequence stars of the same mass. This result has been emphasized by Helt (1987) for RY Aqr. These are short period systems in which there is no evidence in the spectrum of nonphotospheric material. In all three systems the detached components are well inside their Roche lobes, so that there is no constraint on their ability to expand and cool as they accrete matter from their companions.

In a search for evidence that might serve as clues for the dichotomy between the cool and the classical Algols, we may examine Fig. 2. There the systems of Fig. 1 are shown in the orbital angular momentum-total mass plane. Shown also are detached subgiant RS CVn systems. (In this diagram the three A-type Algols of lowest mass are referred to as "deviant" Algols.) The classical Algols lie, for the most part, below the detached systems in this plane, presumably because of loss of mass or of angular momentum or both. This conclusion was reached some time ago by those who have attempted to model the evolutionary histories of individual systems (e.g. several contributions in Batten 1989 and references therein). On the other hand, the cool Algols show no similar departures from the distribution of detached systems in Fig. 2. A simple interpretation would be that the cool Algols are in an earlier stage of their interactive evolution than are the classical Algols. If this interpretation were generally valid for the cool Algols, one might expect their mass ratios to be closer to unity than in the presumably more evolved classical Algols. There is no clear evidence in the mass ratios supporting this hypothesis. Eggleton and Tout 1989 have proposed that AR Mon, one of the giant cool Algols, reached its present condition from case B of mass transfer, aided by enhanced stellar winds from both components, the initial masses of the two components having been nearly equal.

The detached components of the deviant Algols lie below the components of detached binaries in the HR diagram, departures reminiscent of main sequence models having higher helium content. They are also more luminous for their masses. The detached components of the cool Algols show a smaller slope in the luminosity versus mass relation than do the detached components of the hotter Algols, which conform approximately to the relation for detached binaries. Because of the small number of cool Algols and uncertainty in their luminosities (radii not well determined), this result is merely suggestive.

My intent is to bring these interesting relationships to your attention, not to propose explanations, which is outside my sphere of competence.

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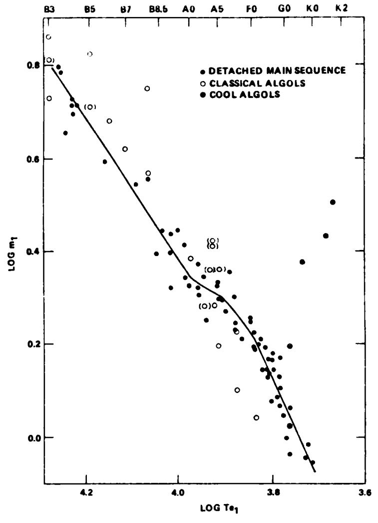

Figure 1. Detached components of close binaries in the mass-temperature plane.

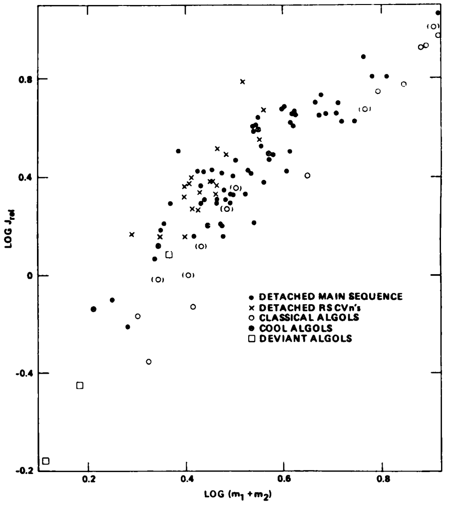

Figure 2. Close binaries in the total orbital angular momentum-total mass plane.

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