HYDROGEN DEFICIENCY IN ALGOL SECONDARIES

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ABSTRACT. A study was carried out for 309 Algol systems to show that most of the secondary components of low mass-ratio systems are hydrogen deficient stars. This hydrogen deficiency is evident from their positions on a Δ log L - Δ log T plot, where Δ is the difference between the observed quantity, log L or log Te, and the value of the same quantity for a star of the same mass on the empirical Main Sequence. The secondary components are shown to occupy the region of mass losing helium dwarfs on this plot. A correlation has also been obtained between the excess of effective temperature and the mass ratio of the system.

1. INTRODUCTION

A method of distinguishing the mass-losing components of close binaries from the post and pre-main sequence objects was proposed by Abhyankar (1984). This method makes use of a transformation of variables (log L, log Te) to (Δ log L, Δ log Te), where the new set of variables is defined as follows:

Δ log L = Observed log L - log L for a star of same mass on the empirical Main-Sequence,

and Δ log Te = Observed log Te - log Te for a star of same mass on the empirical Main-Sequence.

A plot of these two quantities, (Δ log L vs. Δ log Te), provides a powerful tool for distinguishing the stars in various stages of evolution. In Figure 1, which is taken from Abhyankar (1984), all the stars in pre-Main-Sequence contracting phase and the post-Main-Sequence expanding phase lie on the right hand side of the origin. The origin itself represents the empirical Main-Sequence. The track marked as I is for a rapidly mass accreting star of mass 1.5 M(Sun) in a binary according to Neo et al (1977) and the track marked as II represents the mass-losing component in a binary with initial masses of 1.8 and 0.7 solar masses; it is based on the

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calculations of Refsdal and Weigert (1969). The numbers along both the tracks indicate the mass of the star at various stages. The evolutionary tracks of helium white dwarfs in close binaries are marked as III and are based on the calculations of Webbink (1975). The helium Main-Sequence given by the dash-dot curve is due to Hansen et al (1972). Here track I shows that as the mass-gaining star heats up due to the infalling material it moves slightly to the right indicating a cooling of the surface due to the enlarged envelope which does not allow accretion of more mass.

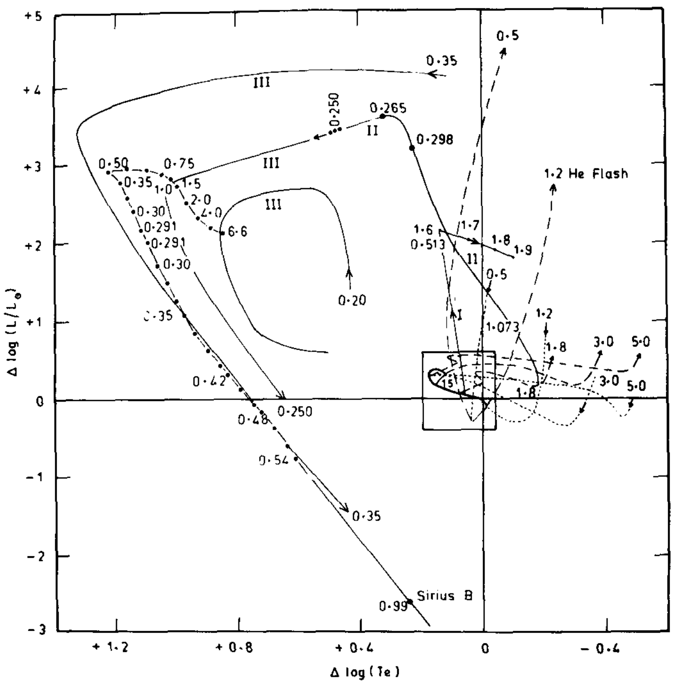

Figure 1. - A Δ log L - Δ log Te plot for the evolutionary tracks of various objects. The numbers along the tracks represent mass of the evolving star.

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It is the track for the mass-losing component of the binary which is of the main importance to us here. As we can see in track II a mass-losing star gets hotter and more luminous compared to the star of same mass on the empirical Main-Sequence. As a consequence of the mass loss from the envelope the hotter layers are exposed which also have a lower hydrogen to helium ratio.

It was shown by Abhyankar (1984) that nearly 70 per cent of the secondary components of semi-attached systems with well determined absolute dimensions and mass lie in the region of mass-losing stars in which hydrogen to helium ratio is reduced considerably. But the number of stars in his sample was small, only 26 semi-detached systems if we exclude the few RS CVn systems. It was felt that in order to get a confirmation for his results a much larger sample is needed. In the next section we talk about the data used in the present study.

2. THE DATA AND RESULTS

A catalogue presented by Brancewicz and Dworak (1980) is the source of data for the present study. In this catalogue they have provided calculated values of the geometric and physical parameters for 1048 binaries. The intrinsic error in these calculated parameters is about 5 per cent. In the above mentioned catalogue 701 systems are classified as Algols.

Using another catalogue of classical Algol type systems by Budding (1984), we put these 701 systems in five different groups depending on their semi-detached status (SD) which varies from 0.1 to 0.9 in steps of 0.2. Since we are interested only in those systems where the secondary has evolved and has lost considerable mass from its envelope, we consider stars with SD = 0.9, 0.7 and 0.5 as true representatives of evolved Algols. Therefore, finally we are left with 309 systems that we have used here in the present study.

In Figures 2 and 3 the primary and secondary components of the above 309 systems are plotted in a Δ log L - Δ log Te plane. Systems with different SD status are shown with different symbols. Figure 2 shows the primary components to be concentrated around origin, which represents the unevolved Main-Sequence. But on the other hand the secondary components of the same systems have a marked luminosity and temperature excess as shown in Figure 3. It is also clear from that figure that the secondary components of the most Algol systems lie in the region occupied by the mass-losing stars and the helium white dwarfs. This indicates that these secondary components have lost a significant portion of their envelope and therefore are exposing their helium rich cores. It is almost certain that only a fraction of the mass lost by the secondary is transferred to the primary component, the rest of

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the mass is lost from the system thereby reducing the mass ratio q of the two stars.

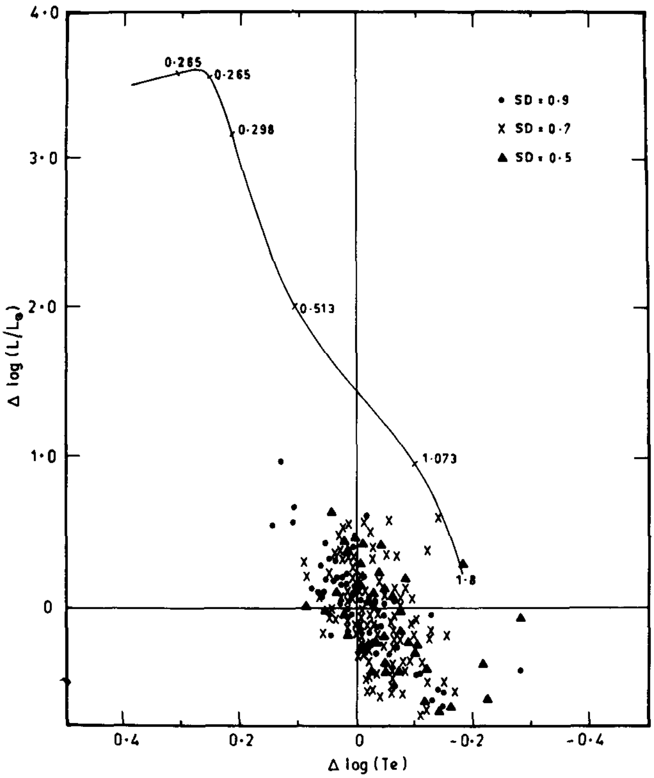

Figure 2. - The primary components of Algol systems plotted on Δ log L - Δ log Te plane. Stars with different semi-detached status are shown by different symbols. The solid curve is the evolutionary track of a mass losing star.

We have already seen in Figure 3 that in addition to the well known excess of luminosity we also have an excess of effective temperature (Δ log Te) arising due to mass loss, therefore one would expect a correlation between Δ log Te and q.

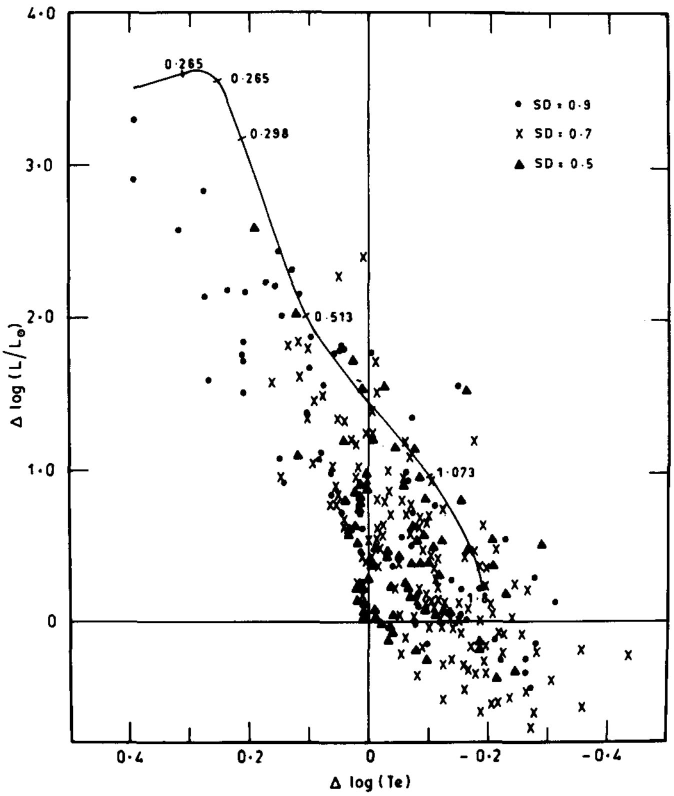

Figure 3. - The secondary components of Algol systems plotted on the Δ log L - Δ log Te plane. The different symbols and the solid curve have the same meaning as in Figure 2.

In Figure 4 we have plotted these quantities for all the Algols with SD = 0.9, .07 and 0.5. One can easily make out the trend that the temperature excess is less for the stars with high mass ratio and becomes more for the ones with lower values of q. In order to see this trend clearly we reduced the scatter by averaging the points lying in small intervals of q. The smooth curve obtained by joining these averaged points is also shown in Figure 4. It follows closely the trend expected from a mass losing component of the Algol System.

In Figure 5 we have plotted the luminosity excess against the mass ratio. This plot confirms the results of previous studies by Ziolkowskie (1969) and Giuricin et al (1983) that the systems with low mass ratios have large luminosity excesses for the secondary components.

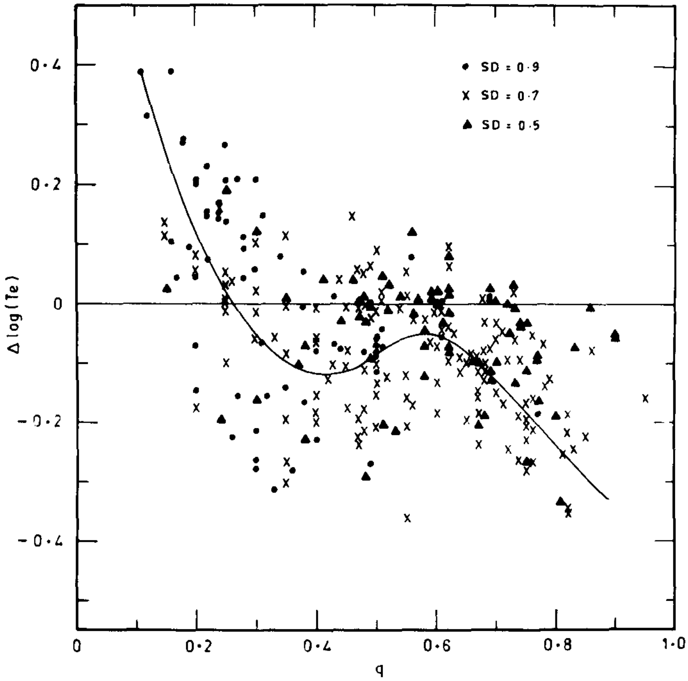

Figure 4. - A plot of temperature excess Δ log Te vs. mass ratio for Algol secondaries.

3. CONCLUSION

With the help of Figures 3, 4 and 5 we can conclude that the secondary of an Algol system with small mass ratio ($q > 0.5$) is likely to show temperature and luminosity excesses, and therefore can be classified as a hydrogen deficient star. It is clear from Figure 3 that good fraction of our sample occupies the region of mass losing stars and helium dwarfs. We suggest that spectroscopic observations should be made for these systems in order to do abundance analysis of the secondary components although these observations may not be easy to make due to the complications caused by the spectrum of the primary component.

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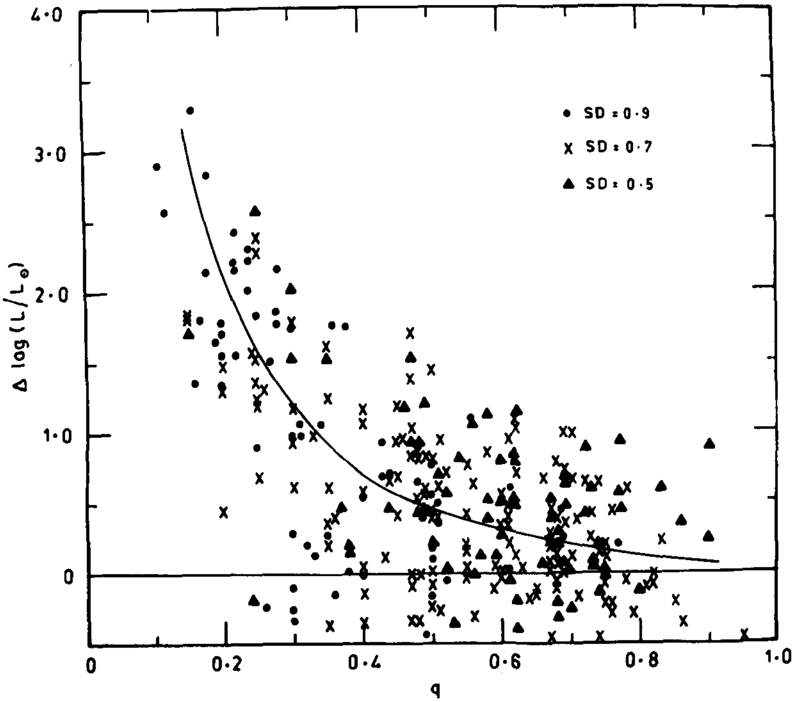

Figure 5. - A plot of the luminosity excess
Δ log L vs mass ratio for Algol secondaries

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