

## A SEARCH FOR CEPHEID BINARIES USING THE CaII H AND K LINES

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**Abstract.** A survey of 24 classical Cepheids has been made to search for blue companions using the CaII H and K lines. It is shown that this technique can detect an early A companion for a typical Cepheid. A blue companion of SU Cas was discovered and upper limits for the companions for a number of previously suspected binaries were established.

### Introduction

Miller and Preston (1964) demonstrated that for a Cepheid which has a blue companion the line depths of the CaII H and K lines are reversed as compared those of with single supergiants, where K is stronger than H. The light from the companion fills in the K line, but since H $\epsilon$  is close to H, the strong H $\epsilon$  absorption of the hot star results in a deeper total absorption in that region than in the center of the K line.

A study has been undertaken to explore the limits of this technique and to survey a list of Cepheids suspected of having companions. Several factors complicate such an analysis. Since Cepheids vary typically from mid-F to late-G during their cycles, at some phases H and K lines will have central emission. Interstellar absorption lines can also complicate the interpretation of the line cores. For companions later than early A stars, their CaII lines will be strong enough to dilute the effect.

### Observations

Spectra with a reciprocal dispersion of 12 Å/mm were obtained with the Cassegrain spectrograph of the 1.9 m telescope at the David Dunlap Observatory. Exposure times were adjusted to obtain a good exposure at 4000 Å on IIA0 plates. The plates were scanned on the PDS microdensitometer at the observatory and calibrated by means of spot sensitometer plates. For comparison a series of spectra of nonvariable supergiant standards was obtained covering the same spectral range as the Cepheids. In addition spectra of several nonvariable supergiants known to have blue companions were obtained ( $\mu$  Per G0Ib +, 22 Vul G2Ib +, and 58 Per G8II + B). Although emission is clearly present in these profiles, the reversal in the line strengths is evident as late as G8, if a companion is bright.

### Cepheids

The following list summarizes the Cepheids surveyed and (C) indicates the detection of a companion, (N) indicates not yet reduced: HR 7308, SU Cas (C), TU Cas, DT Cyg, SZ Tau, HR 8157 (C), Alpha UMi, RT Aur, SU Cyg (C), T Vul, FF Aql, Delta Cep, Eta Aql (C),

HR 690, W Gem, HR 9250 (N), S Sge,  $\xi$  Gem, TT Aql, X Cyg, Y Oph, T Mon (N), HD 161796, and 89 Her. The only new blue companion which was discovered was that of SU Cas. It was later confirmed by the author on IUE spectra to be approximately spectral type A0. The companion to  $\eta$  Aql which was a complete surprise on IUE spectra (Mariska, Doschek, and Feldman, 1980) would have been discovered by this survey. During the course of this survey a number of stars were observed with IUE, and the CaII and IUE results are in agreement. Both the full amplitude and small amplitude pulsators are mixtures of single and double stars.

What limits can be placed on an undetected companion? The companion of Eta Aql produces an easily discernable effect on the profiles. If we adopt the temperature Mariska, Doschek, and Feldman determined (9500° K), the companion is an A0V star. We estimate that a companion contributing half as much light at 3900 Å should be detectable. This corresponds to an A3V star for a typical star on the list. This limit is coincident with the limitation imposed by the strengthening of the Ca lines in main sequence stars.

#### Unusual Line Profiles

The H and K profiles confirm that the wings of HD 161796 are a very good match for those of 89 Her, in agreement with the F3Ib spectral type of Fernie and Garrison (1984), however the line cores are markedly different. For 89 Her the cores are blue shifted with respect to weaker features. This is not true for HD 161796, implying that in this respect the atmospheres are quite different. For HR 7308, there is always light in the line cores, although the strength of the profiles corresponds to a spectral type no later than F7. This is not true for other cepheids.

#### References

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