N89-10721

THE NOVEMBER 1987 ECLIPSE OF THE ζ-AUR SYSTEM HR 2554

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ABSTRACT

We confirm that HR 2554 (G6 II + A0 V) is an atmospheric eclipsing system of the ζ-Aur type. IUE observations of the November 1987 eclipse indicate that the eclipse of the A star lasts about 4 days and is not total. Absorption lines due to the extended atmosphere of the primary can be seen a day before and after the eclipse and are missing 2 days from first and fourth contact. Thus the outer envelope of the primary extends to less than 1 stellar radius beyond the photosphere. Compared to 22 Vul (G3 Ib-II + B9 V), where the absorption can be traced to a few stellar radii, HR 2554 is a more moderate case of mass outflow, which implies there is reduced interaction of the secondary within the wind from the primary as is seen in the other ζ-Aur systems.

1. INTRODUCTION

In Ref. 1, we announced that the 195 day spectroscopic binary HR 2554 was a possible member of the ζ-Aur class of eclipsing stars. ζ-Aur systems usually have K to M type primaries, although this is a selection effect due to the fact that in the optical region the contrast between the components with earlier type primaries is smaller. For HR 2554, the primary is a G6 II star, and from the IUE observations, the secondary is of type A0 V, visually about 3.0 mag fainter. We have obtained IUE observations of the predicted November 1987 conjunction and confirm that atmospheric eclipses do occur. We discuss here some early results and compare them to the first recognized ζ-Aur system with a G-type primary, 22 Vul (refs. 2-3).

2. LOW DISPERSION OBSERVATIONS

As is typical for these systems, the circumstances of the eclipse depend upon the wavelength examined. The light from the secondary dominates up to 2800 Å, so few photospheric lines from the primary shortward of this are seen far from eclipse. In regions where low level lines are found, such as those for Fe II and Cr II, the eclipse of the secondary passing behind the G star's outer atmosphere will appear deeper than in relatively line-free regions. In addition the eclipse should last longer in the lines depending on the extent and physical conditions of the outer envelope of the primary, including distances far from the surface where the stellar wind of the primary could be seen.

In figure 1 we present observations of HR 2554 made at four bandpasses, 2 "continuum" points at 3150 and 1850 Å, and 2 areas strongly affected by Fe II, 2550 and 1650 Å. As can be seen, the eclipse duration apparently is about 4 days. Because of uncertainties in the orbital solution, the ingress phase was not well-covered, and at the deepest observed part, the eclipse of the secondary was not total. If we include the observations

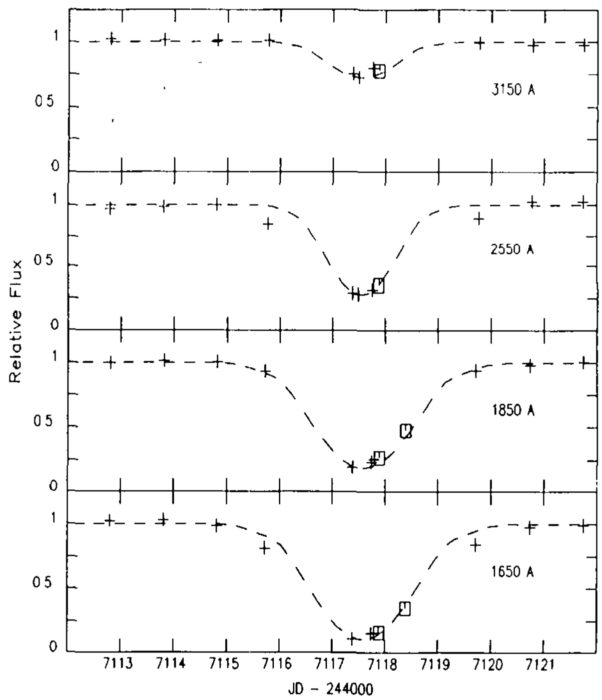

Figure 1. IUE observations of the October 1986 (squares) and November 1987 (crosses) eclipses of HR 2554 at four bandpasses. The 2550 and 1650 A measures are in line-rich regions and show longer eclipse durations by a day on each side.

of the Oct. 1986 conjunction and assume that the eclipse is symmetric and repeatable, we find that our deepest observations did occur at centrality, and thus the system is a grazing one. We find that this conjunction occurred at JD 2447117.45. The depth of the eclipse in V, as obtained from the FES measures, was 0.04 mag.

As expected, we find that the eclipse does begin earlier and end later in the Fe II bandpasses, but not as long as in 22 Vul where the 2550 and 1650 Å partial phases last about 10 days (Ref. 2). Furthermore the depths in these regions are not as great prior to geometrical eclipse as for 22 Vul, indicating that the outer envelope for HR 2554 is not as large or dense as in 22 Vul. Some of this difference arises because 22 Vul is a somewhat longer period system (249 days) and the primary is a supergiant compared to a bright giant for HR 2554, but based on the diameters of the components, the added absorption lines in HR 2554 extend less than one stellar radius from the surface, while for 22 Vul absorption is seen for several radii.

3. HIGH DISPERSION OBSERVATIONS

The results of the low dispersion observations can be better understood when studying the absorption line spectrum at high dispersion. In figure 2 we show the temporal variation of the region around the Fe II multiplet 1 lines. Two days prior to first and after fourth contacts, only narrow interstellar components of the Fe II lines are seen. At partial phases the lines become stronger, but their structure remains relatively simple. At centrality, the lines deepen further and are still seen since the eclipse is not total, but no unusual behavior is displayed.

In contrast, the lines of 22 Vul show multiple components and some P-Cyg features due to the interaction of the hot secondary in the wind (Ref. 3). At centrality, forward scattering of the light from the eclipsed B star causes some lines to appear in emission. HR 2554 does not exhibit these anomalies.

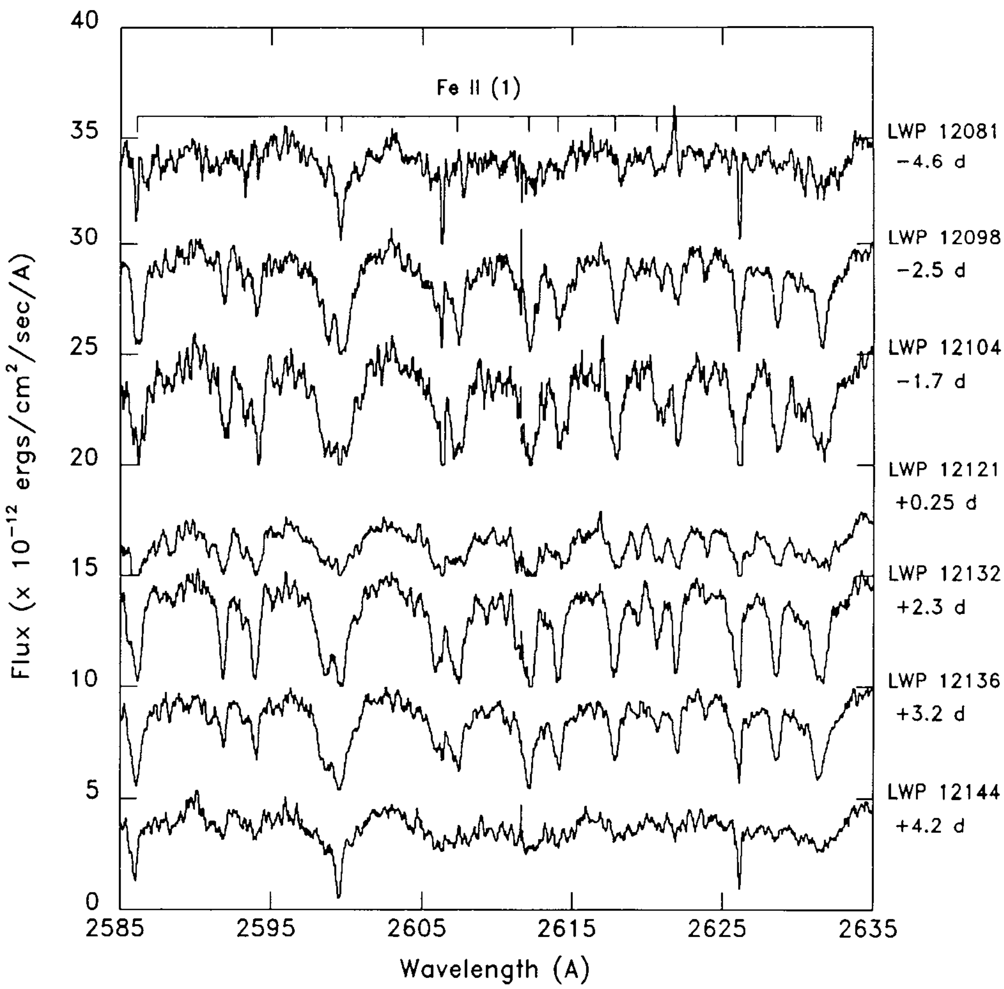

Figure 2. LWP high dispersion observations of the November 1987 eclipse of HR 2554. Each succeeding spectrum is offset by 5 x 10^{-12} ergs/cm^2/sec/Å. Fe II multiplet 1 line positions are labelled. Dates are differences from centrality at JD 2447117.45.

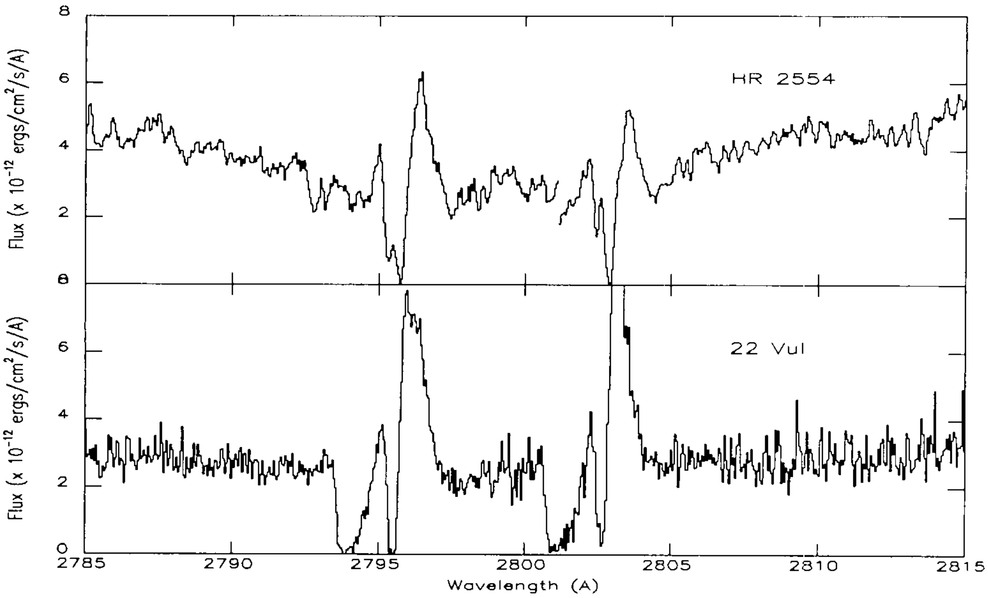

Figure 3. Mg II h and k emission features for HR 2554 (above) and 22 Vul (below).

The reason for these differences can been gathered from the Mg II profiles, shown in figure 3. 22 Vul has a dense, high velocity wind component indicating the primary is providing substantial circumsystem material within which the hotter companion moves. At each observed line of sight, a range of velocities is sampled, and any density fluctuations appear as multiple components in the the absorption lines. Emission features appear from a shock front at the B star since it is moving supersonically through the material. For HR 2554, the wind is of lower velocity and is less dense so that the outflowing material is more tightly bound to the primary. The range of velocities sampled along a line of sight is smaller, and there is little interaction between the wind and the hot star.

4. DISCUSSION

Most of the members of the ζ-Aur class exhibit behavior like that seen in 22 Vul. At one level they can be considered to be interacting systems, although the interaction involves the components and extended circumstellar material rather than the stars themselves. The hot star plows through the stellar wind of the primary, and along with its radiation field, disrupts the flow. HR 2554, on the other hand, provides an important example of a system where the outer atmosphere and wind of the primary is undisturbed by the secondary. Since the value of the ζ-Aur stars lie in the ability to use the hot star as a probe of the cooler one, systems where the interaction is minimized are more appropriate candidates for study.

Further optical observations are needed for this system to determine the parameters of the eclipse and derive absolute dimensions. Currently the eclipses occur when the system is either far east or far west of the meridian in the evening. With a period that is 2 weeks longer than 6 months, the system should become more favorable for ground based observers. If the eclipse had been total, we predicted ΔB would be 0.14 mag, and ΔU, 0.27 mag. Based on the IUE observations, these should be reduced to 0.09 and 0.17 mag respectively.

5. ACKNOWLEDGEMENTS

This work was supported by NASA grant NAS 5-28749 to Computer Sciences Corporation.

6. REFERENCES

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