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OBSERVATIONS OF RAPID BLUE VARIABLES—X
G61–29

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SUMMARY

Photoelectric observations of the helium emission line white dwarf G61–29 are presented. The presence of rapid flickering, occasionally with an amplitude ~0·20 mag on a time scale ~20 s, is established. The light curve contains features resembling that of the binary VV Pup, including effects which can be ascribed to an eclipse by the secondary and obscuration by an optically thick ring. A tentative orbital period of $6^h\ 16^m$ is determined for G61–29.

It is suggested that G61–29 resembles the cataclysmic variables, but that helium rather than hydrogen is being transferred between the components of the binary system. Both components are therefore probably the helium cores of evolved stars.

1. INTRODUCTION

This series of studies of rapid blue variable stars has principally been devoted to photometric observations of cataclysmic variables. The dominant photometric characteristics of these objects are their flickering activity and the various phenomena associated with their short period binary nature. In addition, these objects characteristically have strong emission lines of hydrogen, usually broad or double, with widths or separations in the range 200–1500 km s^{-1}. The flickering activity and emission lines are ascribed to effects of mass transfer from the secondary to the primary; the latter star, at least when visible, is a hydrogen-rich white dwarf.

In Paper IX (Warner & Robinson 1972) it was pointed out, however, that the variable AM CVn may be understood in terms of a model similar to that proposed for the cataclysmic variables, but in which all hydrogen has been depleted and as a result helium is currently being transferred between the components of the system. In AM CVn the mass transfer rate is such that helium emission lines are found only as core-reversals of the DB absorption spectrum.

At the time that Paper IX was being written, Burbidge & Strittmatter (1971) announced the discovery of a star, apparently a white dwarf, in which the line spectrum contains only strong, broad helium emission. It immediately occurred to the author that this star, G61–29, may be similar in nature to AM CVn. In order to test this possibility, photometric observations were made which resulted in the detection of flickering (Warner 1971). This paper reports further photometry, the interpretation of which provides a first tentative model for G61–29.

2. OBSERVATIONS

All observations were made at the Cassegrain focus of the 82-in. Struve telescope at McDonald Observatory. The data acquisition equipment was the same as described in Paper I (Nather & Warner 1971). The photometry was carried out in white light using 5-s integrations. Details of the observing runs are given in Table I.

TABLE I

Photometric runs on G61–29

Run No.	Date (U.T.)	$JD_{\odot}$ Start 2441000+
1234	23 Nov 1971	278·96222
1240	26 Nov 1971	281·94962
1249	9 Feb 1972	357·83947
1252	12 Feb 1972	360·91769
1263	17 Feb 1972	365·81731
1267	18 Feb 1972	366·80054

The light curves for four of the six runs are shown in Figs 1–4. Run 1249 shows low amplitude flickering activity but no other features of interest; Run 1252 shows larger amplitude flickering but the light curve is slightly affected by clouds; neither of these runs is illustrated here.

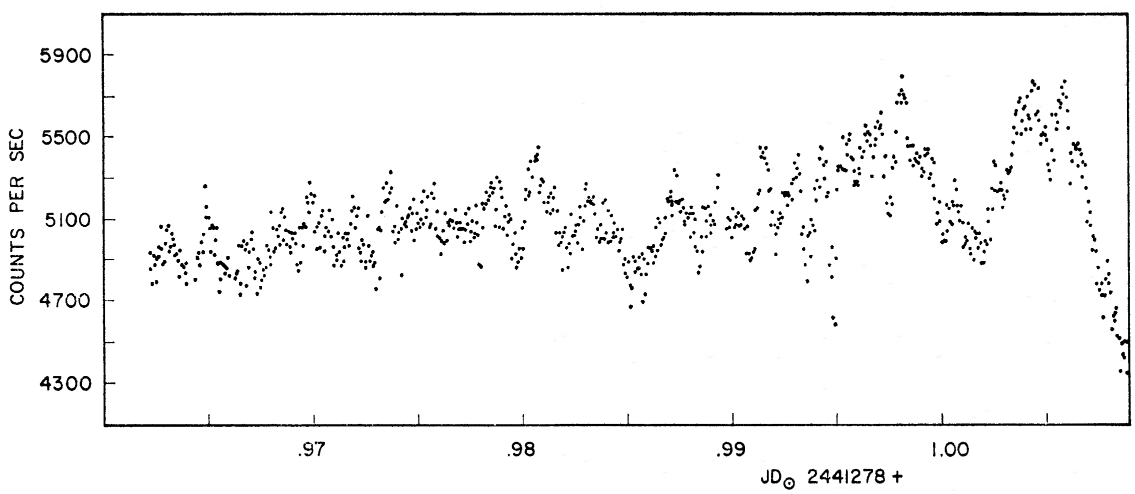

FIG. 1. *Light curve for* 1971 *Nov* 23.

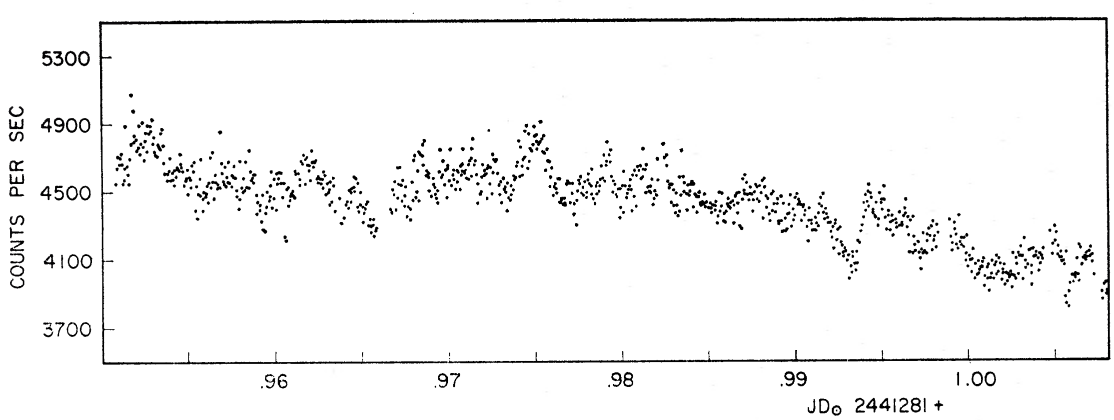

FIG. 2. *Light curve for* 1971 *Nov* 26.

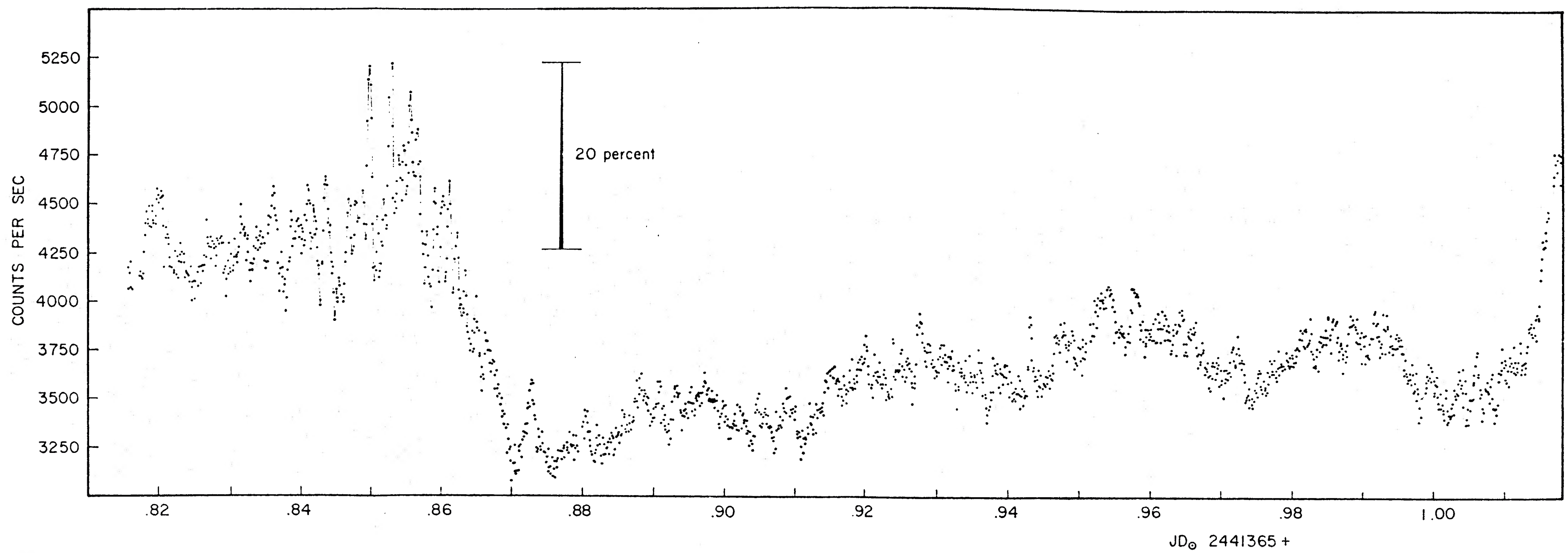

FIG. 3. *Light curve for 1972 Feb 17.*

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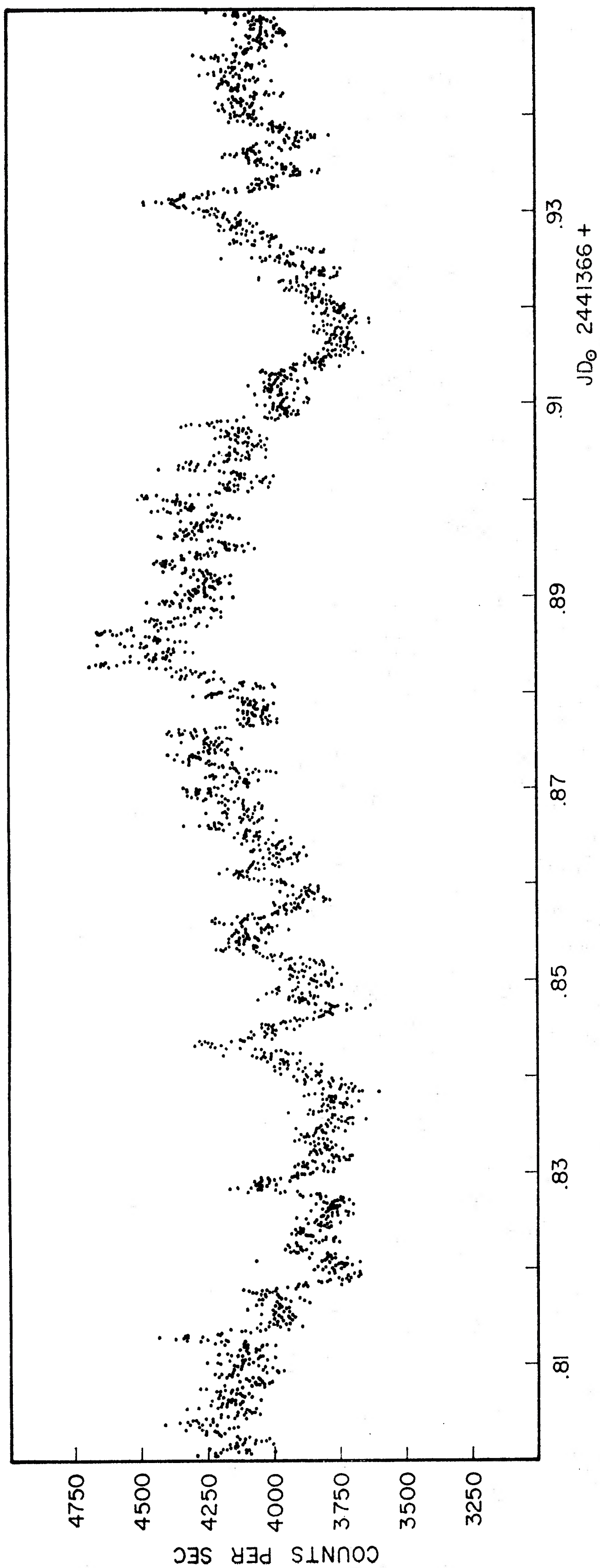

FIG. 4. *Light curve for 1972 Feb 18.*

3. DISCUSSION

The presence of rapid flickering is evident in all of the light curves. We feel, however, that the principal clue to the nature of G61–29 is contained in Fig. 3. Near the beginning of the run we have connected some of the 5-s integration points in order to emphasize the amazing high frequency activity of the star in that region. In the region just before the rapid drop, G61–29 several times increased brightness by 20 per cent (0·20 mag) in ~20 s followed by decreases of brightness on the same time scale. This activity is even more dramatic than that already observed in VV Pup (Warner & Nather 1972, Paper V). The fact that the high amplitude flickering is at once followed by a large drop in brightness is reminiscent of the same phenomenon in VV Pup. And just as in VV Pup, the minimum is followed by a region of lowered brightness and activity, abruptly terminated by a sharp increase in brightness.

In VV Pup, we ascribed this behaviour to the properties of a flickering bright spot, obscured for approximately half of a binary cycle by an optically thick ring, and additionally obscured by a partial (or grazing) eclipse by the secondary. The behaviour depicted in Fig. 3 is thus very similar to that shown in Figs 4 and 5 of Paper V. We thus tentatively suggest that G61–29 is a binary with similar properties to those deduced for VV Pup. We notice that the presence of eclipses in other cataclysmic variables is usually accompanied by doubling of the spectral emission lines, which is compatible with the appearance of the spectrum of G61–29 described by Burbidge & Strittmatter.

In VV Pup, the time interval between midpoint of ingress (during eclipse by the *secondary*) and the midpoint of egress of the spot (as it appears around the limb of the *ring*) is 0·5879 of the orbital period. The time interval between the same alleged points in Fig. 3 is $0^{d}\cdot1500$. If the models for VV Pup and G61–29 are similar we would therefore expect the orbital period of G61–29 to be $\sim 0^{d}\cdot1500/0\cdot5879 = 6^{h}\,8^{m}$.

This approximate period prompts us to examine Fig. 4, which contains the light curve for the night following that given in Fig. 3. The eclipse in Fig. 3 occurs at $\sim$JD$_{\odot}$ 2441365·873, so we should expect an eclipse (4 binary cycles later) in the vicinity of JD$_{\odot}$ 2441366·89. As can be seen from Fig. 4, there is a noticeable depression centred on JD$_{\odot}$ 2441366·917. If this is identified with the expected eclipse the revised period would be $6^{h}\,16^{m}$; the uncertainty in this period is $\sim \pm 2$ min. The activity seen in Fig. 4 is of considerably lower amplitude than that of the previous night and we consequently cannot be sure that the observed depression is truly the expected eclipse. It may be noted that the run shown in Fig. 1 (which was terminated by the approach of dawn) contains higher activity, which ends with a rapid drop. It is possible that this is also an eclipse, but until an improved period is obtained from more extensive photometry, we cannot link all these observations together.

If our tentative model is verified by further spectroscopic observations, it would appear to imply that the evolutionary status is similar to that suggested for AM CVn. However, the longer period and the presence of radial velocity variations (Burbidge & Strittmatter 1971) suggest that the mass ratio in G61–29 is nearer unity than that deduced for AM CVn. With continued mass transference, probably caused by the same effect of loss of angular momentum by gravitational radiation proposed by Faulkner (1971) to account for the properties of the normal cataclysmic variables, we might expect G61–29 to evolve into a configuration similar to that proposed for AM CVn.

There is clearly a need for further theoretical work on the evolution of close binary stars. In Faulkner's theory, as currently presented, the secondary is prevented from developing a helium core because the gravitational radiation time scale, for binaries with periods less than about 15 hr, is shorter than nuclear burning time scales. In binaries with periods greater than a day the secondary is able to move off the main sequence before filling its Roche lobe and therefore develops a helium core; but in this case gravitational radiation alone is unable to reduce the orbital period to $\sim$hr in less than 10^{10} yr.

Thus it will probably be most profitable to study the evolution of a binary with initial period ~ 1 day, including the effects of loss of angular momentum caused both by mass-loss (by nova outbursts for example) as well as by emission of gravitational radiation.

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