THE SHORT-PERIOD NON-CONTACT BINARY SYSTEMS UU LYN AND GR TAU

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ABSTRACT

Two binary systems UU Lyn ($P = 0^d.468$) and GR Tau ($P = 0^d.430$) are discussed on the basis of BV photoelectric observations and spectroscopic observations which were made between 1980 and 1981 at the Tokyo Astronomical Observatory. The component stars in both systems are found to be still inside their Roche lobes but very close to them.

UU LYN

The eclipsing variable UU Lyn was discovered by Geyer, Kippenhahn and Strohmeier (1955) in Bamberg. Strohmeier, Knigge and Ott (1963a) gave the orbital period ($P = 0^d.468461$) and presented the photographic light curve for this system. The spectral type was given to be A4 by Götz and Wenzel (1962b). We are interested in this system because of its rather flat maxima and of the early spectral type for such a short orbital period.

We have made photoelectric and spectroscopic observations for this system. BV photoelectric observations were done with the 0.9-m reflector at the Dodaira Station of Tokyo Astronomical Observatory on 6 nights between February 1980 and March 1981. The V magnitude and B - V colour outside eclipse have been determined to be

$$V = 11.60 \quad \text{and} \quad B - V = +0.41.$$

We found an (O - C) in times of minima calculated by the ephemeris of SAC (1981), and it amounts to -0.0037 days or $-0^p.0079$. Therefore, our observations together with many other visual and photographic observations were used to improve the ephemeris to be

$$\text{Min I} = \text{HJD } \underset{\pm 19}{2444674.0507} + \underset{\pm 6\,(\text{p.e.})}{0.46846023}\ E.$$

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Our B and V light curves (Fig. 1) show continuous variations, even outside eclipse, which reflect strong proximity effects.

These light curves have been analysed by the light-curve synthesis method assuming that the surface of either component is represented by the Roche equipotential surface. The results are

$q = 0.40 \pm 0.03$(p.e.)
$i = 88^\circ\!.5 \pm 1^\circ\!.5$
$r_1 = 0.45 \pm 0.01$
$r_2 = 0.28 \pm 0.02$
(V) $u_1 = 0.4 \pm 0.1$, $u_2 = 0.4 \pm 0.1$
$\ell_1 = 0.98 \pm 0.01$, $\ell_2 = 0.02 \pm 0.01$ (at maximum light)
(B) $u_1 = 0.4 \pm 0.1$, $u_2 = 0.4 \pm 0.1$
$\ell_1 = 0.98 \pm 0.01$, $\ell_2 = 0.02 \pm 0.01$ (at maximum light)

for assumed albedos $A_1 = 1.0$ and $A_2 = 0.5$, and assumed gravity-darkening $\beta_1 = 0.25$ and $\beta_2 = 0.08$, where subscripts 1 and 2 represent the primary and the secondary stars, respectively.

From the analysis both components have been found to be still inside, but very close to the respective Roche lobes.

Spectroscopic observations have also been done for UU Lyn with the 1.9-m reflector at the Okayama Astrophysical Observatory between December 1980 and April 1981. Spectra (with the dispersion 37 Amm^{-1}) outside eclipse show the spectral type of F3V. No significant changes in the spectral features were found within the orbital cycle although we need spectra of much higher dispersion to conclude this point definitely.

Fifteen spectrograms have been measured for the radial velocities of the primary component giving

$K_1 = 100 \pm 6$(p.e.) km s^{-1}
$V_0 = -43 \pm 7$ km s^{-1} (e = 0 assumed)

which leads to the mass function

$$f(M) = 0.049\ M_\odot .$$

Adopting $M_1 = 1.5\ M_\odot$ for the mass of the primary component for an F3V star, the mass of the secondary component is estimated to be $M_2 = 0.6\ M_\odot$. The resulting mass ratio is $q = 0.4$, being in good agreement with the results of the light curve analysis. The absolute dimensions of the system have been estimated as

$A = 3.2\ R_\odot$ (separation)
$R_1 = 1.5\ R_\odot$
$R_2 = 0.9\ R_\odot$

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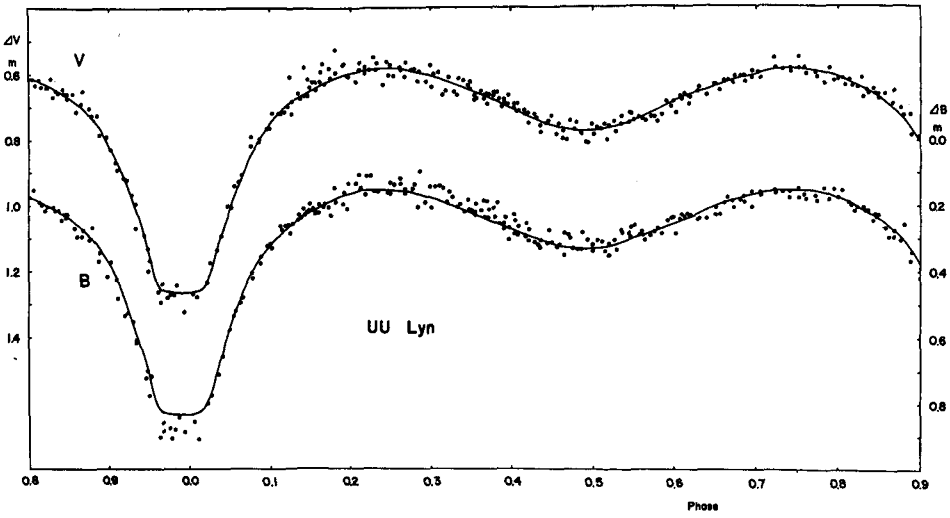

Figure 1. Photoelectric BV light curves of UU Lyn and the theoretical solutions (solid line).

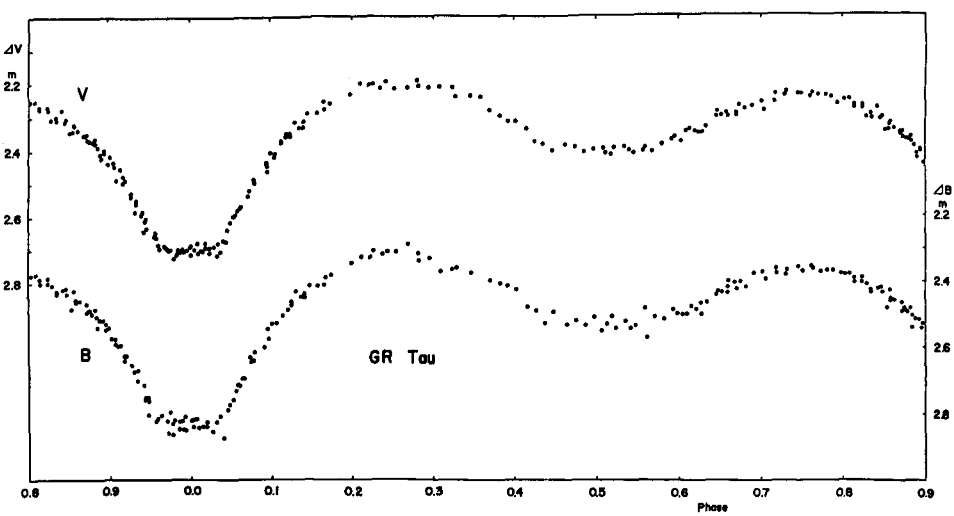

Figure 2. Photoelectric BV light curves of GR Tau.

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(it is difficult to assign the errors to these numbers since they depend on the assumption of the mass for the primary component of UU Lyn). Note that the radius of the primary component is a little larger than that of a main sequence star of F3V.

GR TAU

This eclipsing binary system was also discovered in Bamberg (Strohmeier, Kippenhahn and Geyer, 1957). Strohmeier, Knigge and Ott (1963b) gave the photographic light curve and the orbital period ($P = 0^{d}.474012$). Götz and Wenzel (1962a) determined the spectral type to be A9. This system looks very much like UU Lyn.

We have made UBV photoelectric observations with the 0.9-m reflectors at the Dodaira and Okayama Observatories on 7 nights between October and December 1980. Magnitude and colours have been determined as

$$V = 10.26, \quad B - V = +0.32 \quad \text{and} \quad U - B = +0.24.$$

We have found that the previous period is incorrect, and the ephemeris is given by

$$\text{Min I} = \text{HJD } 2444573.1070 + 0.42985 \text{ E.}$$
$$\pm 9 \qquad\qquad \pm 2 \text{(p.e.)}$$

B and V light curves show distortions and asymmetries (Fig. 2). The second maximum was fainter than the first maximum by 0.03 mag in V and 0.05 mag in B, respectively.

The spectral type outside eclipses has been determined to be A3V from the spectroscopic observations which were made with the 1.9-m reflector at Okayama between January 1980 and January 1981 with the dispersion of 32 $\text{Å}\,\text{mm}^{-1}$.

A preliminary analysis of the first half of the light curve (phases 0.0 - 0.5) shows that both components are found to be inside the respective Roche lobes but they are definitely very close to them.

Distortions in the light curves indicate that some kind of activity should occur in the system which must be important from the evolutionary point of view for close binary systems off the main sequence.

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