A PHOTOMETRIC STUDY OF THE ALGOL SYSTEM Y PISCium*

K. WALTER

Astronomisches Institut der Universität Tübingen, Germany

(Received 16 April, 1973)

Abstract. From the discussion of 417 photoelectric observations of this semi-detached Algol system, obtained in B and V during 82 nights in 1965-1971, the existence of a gas stream may be inferred for the following reasons: The scatter of the single observations is dependent on the orbital phase; the largest scatter occurs at the phases following both eclipses. The conventional photometric solution which is based on the ‘long region rectification’ and neglects the photometric influences of the gas stream, gives for the two colours different geometric parameters of the system. However, the ‘short region rectification’ allows a consistent photometric solution. According to this solution a short total phase exists, and the luminous regions caused by the impact of particles of the gas stream are hidden during the central part of the primary eclipse. Outside of eclipses, the additional light is seen during about half of the orbital period. From the variation of the visibility of the additional light during the primary eclipse it may be concluded that during about the first half of the observing time the luminous regions were situated at the high latitudes of the bright component, indicating the existence of magnetic fields on this component at this epoch, whilst later on the additional light came from an equatorial region on the following side of the massive component.

Though already discovered by Miss Cannon in 1910, the Algol variable Y Piscium (\(23^h31^m9\ \delta +7^\circ38';\ BD+7^\circ5056,\ Sp. A3+gK0\)) has not been much observed as yet. The system stands out for the large depth of its primary minimum which, according to Shapley (1913), amounts to 3\(\%\)0 visually and 3\(\%\)40 photographically and results from an eclipse of the bright A-component by a subgiant. Shapley gave photometric u-and d-solutions according to which, in spite of the large depth of the primary minimum, this eclipse should still be a partial one. A series of 365 visual photometric observations made by Pierce at Princeton Observatory chiefly in 1938 has been published by Wood (1951); but unfortunately these observations do not cover the most central part of the primary eclipse. Only few photometric observations outside of the primary eclipse are known. The secondary eclipse has not been observed as yet.

According to spectroscopic observations made by Struve (1946), in the centre of the primary minimum a K0 spectrum appears. This fact suggests the existence of a total phase of this eclipse. Bright lines have not been found during the primary eclipse. The spectroscopic orbit shows a conspicuous eccentricity (\(e=0.12,\ \omega=103^\circ\) according to Struve) which was confirmed by Lucy and Sweeney (1971) who found, from the same material, \(e=0.15,\ \omega=130^\circ\) and considered, adopting a 5\(\%\) level of significance, these values to be significant. However, it may be suspected that in the case of the semi-detached system of Y Piscium the measurements of the radial velocities are influenced by a gas stream and the eccentricity is only a fictitious one. The discussion of our own observations confirms this suspicion. From the mass function \(f(m)=0.019\ m_\odot\) given by Struve a mass ratio of \(m_1/m_2=0.24\) is derived, if for the A-component (2) a mass of \(m_2=2.5\ m_\odot\) is assumed.

* Originally presented at the IAU Colloquium No. 16 held at the Univ. of Pennsylvania, Philadelphia Pa., U.S.A. September 8-11, 1971.

Astrophysics and Space Science 24 (1973) 189-214. All Rights Reserved
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1. Observations and Light Curve

Y Piscium has been observed photoelectrically with the 40 cm reflector of the Astronomical Institute of the University of Tübingen in 1965 at Serra la Nave, the Etna station of the Osservatorio Astrofisico di Catania, and 1967–1971 at Tübingen. Blue and yellow filters were used giving for the photometric equipment isophote wavelengths of 433 and 531 nm, respectively. The star BD $+6^\circ 5164$ was taken as the comparison star ($g$); it is 10' southward of the variable and precedes it by 4.1 min. In the UBV-system, its brightness was found to be V $10^m 03$, B $- V + 0^m 29$. Checks based on observations of this star in V from 8 nights confirmed constant brightness, yielding for a single measurement in V a mean error of $\pm 0^m 006$. Of course, in the central parts of the primary minimum, when the variable falls (in B) below $13^m$, the accuracy of the observations was very much lower. On the Etna station, for one measurement three settings on the variable and on the comparison star have been used, while at Tübingen mostly four. The observations were corrected for differential extinction in order to obtain extraterrestrial values of brightness differences between the variable and the comparison star; special attention was given here to the varying colour of the variable during the primary eclipse.

Within 82 nights I obtained 208 measurements in Blue and 209 in Yellow. From these, 56 and 63, respectively, were made at the Etna station. The measurements are given in the Appendix.

From this data, the period was derived to be $3^d 765 876$. The primary eclipse was found to be nearly symmetric. For the two colours, the observations have somewhat different mean heliocentric times of minima: Blue JD 24 39 022.4355, Yellow JD 24 39 022.4350. Taking the mean of these epochs for a good deal of the evaluation of the observations – especially rectification and conventional solution – the calculation of the phase was based on the following formula for the times of primary minima:

$$\text{JD}_{\text{hel}} = 24 39 022.4352 + 3.765 876 E. \quad (1)$$

The phase values given in Table I are calculated in this way. However, the photometric solution at which we shall arrive later on and which is based on the 'hot spot model' requires an epoch of minimum which is earlier by 0.0004. Therefore, for this solution (Table V) the epochs of primary minima were calculated from the formula

$$\text{JD}_{\text{hel}} = 24 39 022.4348 + 3.765 876 E. \quad (2)$$

The amplitude of the variable is in Blue $3^m 88$, in Yellow $2^m 94$ (in UBV: $3^m 79$ (B), $2^m 79$ (V)). Since its brightness during primary minimum falls to $13^m 4$ (Blue) and $12^m 2$ (Yellow), measurements at these phases had to be confined to nights of excellent transparency. Although here, near the limit of the power of the instrument, much more time was given for a single measurement than at other phases, only an accuracy of some hundredths of magnitude could be reached for a single measurement.

Table I gives the observed brightness differences of the variable ($v$) and the comparison star ($g$) in Blue and Yellow, combined to normal points. If there is a need, these