THE METALLIC-LINE CLOSE BINARY SYSTEM IW PERSEI

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Abstract. The $UBV$ photoelectric light curve of IW Per as an ellipsoidal variable was obtained and a number of spectrograms were taken with dispersion of 10 Å mm$^{-1}$. New spectroscopic orbital elements are determined for this single-line spectroscopic binary to be $K_1 = 99.3$ km s$^{-1}$, $\gamma = 0.2$ km s$^{-1}$, $a \sin i = 1.80$ $R_\odot$ and $f(m) = 0.093$ $m_\odot$. From analysis of the light curve, the geometric ellipticity coefficient of the distorted components is determined to be $Z = 0.037$.

Applying the second-order theory of light variation due to distorted components (Kopal and Kitamura, 1968), the orbital inclination and fractional radius of the primary component can be deduced simultaneously to be $i = 63^\circ$ and $r_1 = 0.294$. By taking $m_1 = 2.0$ $m_\odot$ for the mass of the primary component with spectral type A5Vm, the mass of the secondary can be also deduced to be $m_2 = 1.08$ $m_\odot$, which would correspond to a G0-type if it is a Main-Sequence star. These elements indicate that the system is a non-eclipsing detached close binary.

From intensity measurements of the lines Ca II-K, Sr II $\lambda 4215$ and Sc n $\lambda 4320$ on twenty-eight good spectrograms taken at various phases, those intensities and the intensity ratio Sc/Sr are found to vary systematically with phase. From these variations the distribution of the local metallicity on the surface of the Am primary component is discussed in connection with the distribution of the local surface temperature.

1. Introduction

The variable IW Per is an important star in many respects. First of all, this star is one of the very few known ellipsoidal variables. Second, it is a single-lined close binary system with metallic-line A-type spectra. The light variation of an ellipsoidal variable usually arises from a rotating (or revolving) distorted component in a non-eclipsing close binary; therefore, the visible component of IW Per should have a distorted configuration of nearly ellipsoidal figure. The gravity and temperature of such a distorted star should not be uniform over the surface but should be functions of the longitude and latitude on the surface. The metallic-line features of an Am star should depend upon the surface temperature and gravity, and therefore IW Per would provide a valuable sample to inspect how the metallicity and temperature (or gravity) correlate with each other over the Am stellar surface.

IW Per was first recognized by Young (1919) as a spectroscopic binary from change of the radial velocity on four spectrograms taken with the 72-inch reflector of the Dominion Astrophysical Observatory. He continued spectrographic observations and obtained twenty-four plates of the system. Several years later, Harper (1927) published a set of spectroscopic orbital elements with a period of 11.422 days from twenty-nine plates, including Young's former plates. However, the period of 11.422 days was found to be erroneous by Pogo (introduced in Harper's article, 1935), who pointed out that a
period just slightly under one day should suit the observations. Eventually he used $P = 0.9172$ days and the period was later revised by Harper (1935) from his thirty-six plates to be $P = 0.9171877$ days.

The first photoelectric light curve was published by Magalashvili et al. (1956) and this star was registered as an ellipsoidal variable with an amplitude of light variation of $0^m 05$ and a period of $0.9171877$ days. However, they observed the system without the use of a colour filter. Wide-band photoelectric photometry with no colour filter might produce serious errors in the course of photometric reduction for differential extinction. No photoelectric observations in the standard $UBV$ colours have been published previously.

The spectral type of IW Per is classified as A0 in the Henry Draper catalogue. However, in view of the strengths of the Ca II-K line and other metallic lines, Harper (1927) suggested that the spectral type should be A2 rather than A0. Slightly different spectral types have been assigned to IW Per by various workers (see Section 7). The colour observations in the $UBV$ system or in the Strömgren system have been also published by several workers, as shown later. However, those published colour values for IW Per are not in good agreement, although they all confirm the Am characteristics.

In the present paper, the author attempts to study the system in detail, based upon his own extensive photoelectric observations in $UBV$, with the $UBV$ colour indices carefully measured and his new radial velocity curve obtained from a sufficient number of spectrograms (in $10 \text{ Å mm}^{-1}$).

2. Photoelectric Observations

Differential photoelectric observations of IW Per were carried out on eighteen nights in the winters of 1975, 1976 and 1977. For these observations the 36-inch reflectors at the Dodaira Station and the Okayama Astrophysical Station of Tokyo Astronomical Observatory were used. The photometers attached to these telescopes are furnished with EMI 6256B photomultiplier tubes and Matsuda colour filters of UVDIC (for $U$), UV39 + VV42 (for $B$) and V0-51 (for $V$). These colour filters are very similar to the standard $UBV$ of Johnson. The photomultipliers were used without refrigeration throughout the observation periods.

The output of the photometer amplifier is fed to an integrating system which has a digital output and a chart recorder. The integration time was 10 s per reading, and the mean value of two deflections was taken as one observation.

BD + 40\°772 was used as the comparison star, which was the same as that used by Magalashvili et al. (1956). The check star BD + 40\°776 was also observed occasionally in order to check the comparison for any variability, but no significant variations were detected between the comparison and check stars. In Table I the positions of the variable, comparison and check stars are given with other pertinent information in which the colour values were obtained from the author’s observations.