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OPTICAL OBSERVATIONS OF THE ACTIVE STAR RE J2220+493

The sky was surveyed in the extreme ultraviolet (EUV) region of the spectrum by the EUVE satellite (Malina et al., 1994) and the ROSAT satellite (Pounds et al. 1993) and catalogs of the sources included RE J2220+493 = EUVE J2220+49.5 = SAO 51891 = BD +48°3686. The star was one of the subjects of an investigation by Jeffries (1995), who concluded it was a "single, rapidly rotating K0V-IV star with a v sin i of 15 km/sec".

The automated 0.5-m. telescope, Johnson V filter and CCD camera of the Climenhaga Observatory of the University of Victoria (Robb and Honkanen, 1992) were used to make photometric observations of RE J2220+493. The frames were bias subtracted and flat fielded in the usual manner using IRAF [1]. The magnitudes were found from aperture photometry using the PHOT package. The x y pixel coordinates of each star for photometry were found from inspection of a few frames and these positions were used as starting points for the Gaussian centering option which precisely centered the 5 arc second aperture on each star for each frame.

From the Hubble Space Telescope Guide Star Catalog (Jenkner et al., 1990) the coordinates and magnitudes of the comparison star are RA=$22^h19^m38^s$, Dec=49°32′20″, V=9.6 and of the check star are RA=$22^h19^m38^s$, Dec=49°28′07″, V=8.9 (J2000). The standard deviation of the difference between the check and the comparison star during a night ranged from $0\overset{m}{.}003$ to $0\overset{m}{.}007$. The mean and standard deviation of the eleven nightly mean differential V magnitudes are $0\overset{m}{.}429 \pm 0\overset{m}{.}005$ ensuring the constancy of both comparison and check stars at this level. The precision of the differential variable star minus comparison star measurements are expected to be at this level. Due to the small field of view first order differential extinction effects were negligible and no corrections have been made for them. No corrections have been made for the colour difference between the stars to transform the V magnitude to a standard system.

Photometric observations were made 22 to 25 September and 29 October to 4 November 1995 UT. Brightness variations were evident both during a night and from night to night. A "Phase Dispersion Minimisation" routine modelled after that of Jurkevich (1971) reveals a minimum average sigma at a period of 2.43±0.02 days. A least squares fit of a single sine wave to the data also shows a deep minimum in chi squared at a period of $2\overset{d}{.}43$ as seen in Figure 1. The other deep minima correspond to periods of $2\overset{d}{.}58$ and $2\overset{d}{.}29$ and inspection of the light curves at these periods show rather unlikely discontinuities.

So the best ephemeris from our data is:

$$\text{HJD of Maxima} = 2449981.94 + 2.43 \times E$$
$$\pm.20 \quad \pm 0.01$$

[1] IRAF is distributed by National Optical Astronomy Observatories, which is operated by the Association of Universities for Research in Astronomy, Inc., under contract to the National Science Foundation

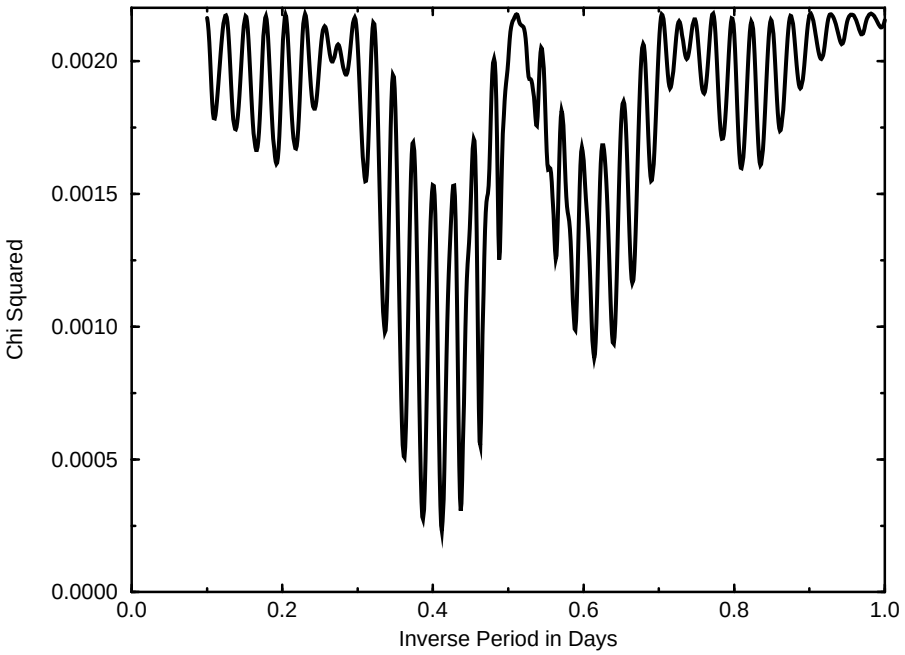

Figure 1. Chi squared of a single sine curve fit for various periods for RE J2220+493 for 1995

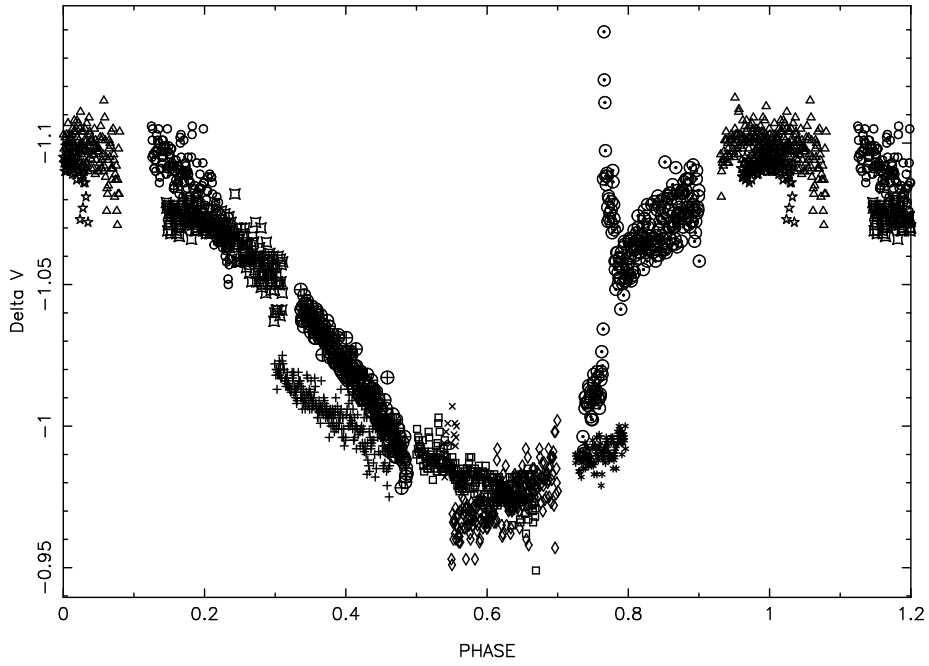

Figure 2. Light curve of 1995 differential V data of RE J2220+493

A plot of the 2112 differential V magnitudes phased at this period is shown in Figure 2 with different symbols for each of the different nights. Close inspection of the "$\odot$" points at phase 0.75 (HJD = 2450022.68) shows a small flare, which was ignored during the period finding runs. The flare had an amplitude of approximately $0\overset{m}{.}1$ and a duration of an hour. The light curve also shows shifts of a few hundredths of a magnitude in mean level from night to night.

From our period, the $v\sin i$ and assuming a radius (Allen 1973), appropriate for the spectral type K0V we find the inclination of the axis of rotation to be $58° \pm 7°$. A luminosity class of IV is unlikely since it implies an inclination of approximately 20°, so the area on the star passing in and out of view is small compared to the amplitude of the light curve. From the shape of the light curve, the changes in the shape of the light curve, the flare, the spectral type, Hydrogen α emission (Mulliss and Bopp, 1994), and the brightness in the EUV, we conclude that this star has large active regions on it causing the brightness variations. The changes in the light curve shape are likely due to differential rotation or active region evolution and could be studied by further photometric observations.

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