COMMISSIONS 27 AND 42 OF THE IAU
INFORMATION BULLETIN ON VARIABLE STARS
Number 4305

Konkoly Observatory
Budapest
11 March 1996
HU ISSN 0374 – 0676

OPTICAL OBSERVATIONS OF THE ACTIVE STAR FF CANCRI

The star FF Cancri = GSC 1383_600 was discovered to be an eclipsing binary by Pravec (1993), who found it to have a color of (V−R)=0.48 and a brightness V=10.83-11.40.

The automated 0.5-m. telescope, Cousins R filter and CCD camera of the Climenhaga Observatory of the University of Victoria (Robb and Honkanen, 1992) were used to make photometric observations of FF Cancri. 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 7 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=$08^h29^m43^s$, Dec=$17°15'38''$, V=10.6 and of the check star are RA=$8^h30^m09^s$, Dec=$17°16'19''$, V=12.5 (J2000). The standard deviation of the difference between the check and the comparison star during a night ranged from $0\overset{m}{.}008$ to $0\overset{m}{.}024$. The mean and standard deviation of the six nightly mean differential R magnitudes are $-1\overset{m}{.}284\pm0\overset{m}{.}006$ 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 R magnitude to a standard system.

Photometric observations were made between the 2nd and the 16th of February 1996 UT. By the method of Kwee and Van Woerden (1956) Heliocentric Julian Dates of primary minima were found to be $2450124\overset{d}{.}6402$, $2450125\overset{d}{.}9613$ and $2450129\overset{d}{.}9304$ and secondary minima occurred at $2450123\overset{d}{.}9750$ and $2450126\overset{d}{.}6235$. The uncertainty in the times of minima were formally about $0\overset{d}{.}0005$ days, but this estimate does not include an allowance for the asymmetry in the minimum, and thus the true uncertainty is larger. These minima unambiguously determine the orbital period to be about $1\overset{d}{.}32$. Pravec's 1992 data include the sharp shoulder at the end of the primary eclipse at a time we estimate to be $2448985\overset{d}{.}5006$. We have similar observations at $2450124\overset{d}{.}7099$ and $2450130\overset{d}{.}0158$; requiring an integral number of cycles to have elapsed gives us the following ephemeris:

$$\text{HJD of Primary Minima} = \underset{\pm\overset{d}{.}0012}{2450123\overset{d}{.}3152} + \underset{\pm0\overset{d}{.}00004}{1\overset{d}{.}32313} \times E$$

[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

Plots of the light curve for periods corresponding to one cycle less and one cycle more than this period look significantly noisier.

A plot of the 831 differential R magnitudes phased at this period is shown in Figure 1 with different symbols for each of the different nights. The obvious out-of-eclipse modulation of the light curve indicates that one or both of the stars are spotted, since proximity effects would be symmetrical about the minima. The points marked with a + represent data from a night 8 days earlier than the other data and show a shift of a few hundredths of a magnitude in the depth of the secondary minimum and at the beginning of the secondary minimum, indicating that the cool spots are probably on the primary star.

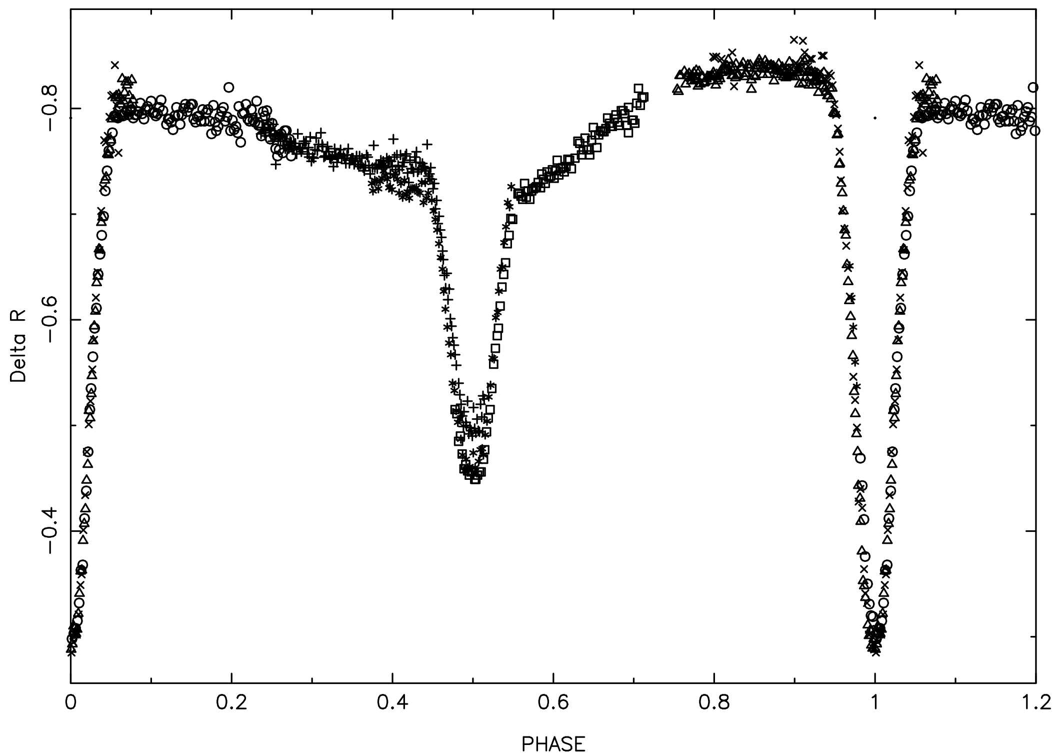

Figure 1. Light curve of 1996 differential R data of FF Cancri

The (V−R) color of Pravec (1993) and a cursory inspection of a spectrum taken with the Dominion Astrophysical Observatory 1.8m telescope indicate approximately a K0V spectral type for the primary star. Using "Binmaker2" (Bradstreet 1993) and a temperature of 4900 K for the primary star of the system, we have constructed a model light curve which fits our observed light curve and can be seen in Figure 2. Using albedo and limb darkening coefficients appropriate for the assumed spectral types the best fit we found was for an approximately K5V secondary star in an orbit inclined at 83°. Two large spots on the primary star are necessary to fit the out-of-eclipse variations, and this is consistent with a presumably synchronous rotation period and the temperature of the stars. A 3-dimensional diagram of the system is shown in Figure 3. Note that this is not a unique solution; in particular the spot latitude is not well determined.

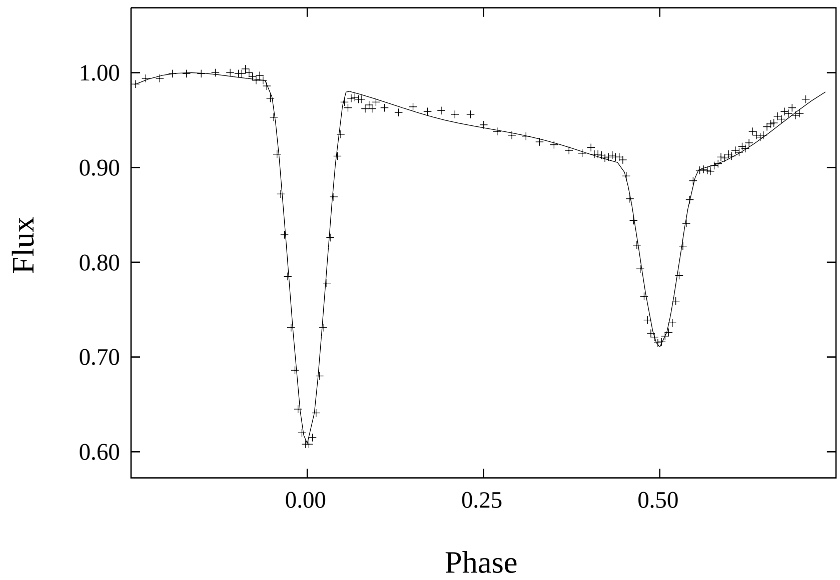

Figure 2. Light curve and a possible Binmaker2 model for FF Cancri

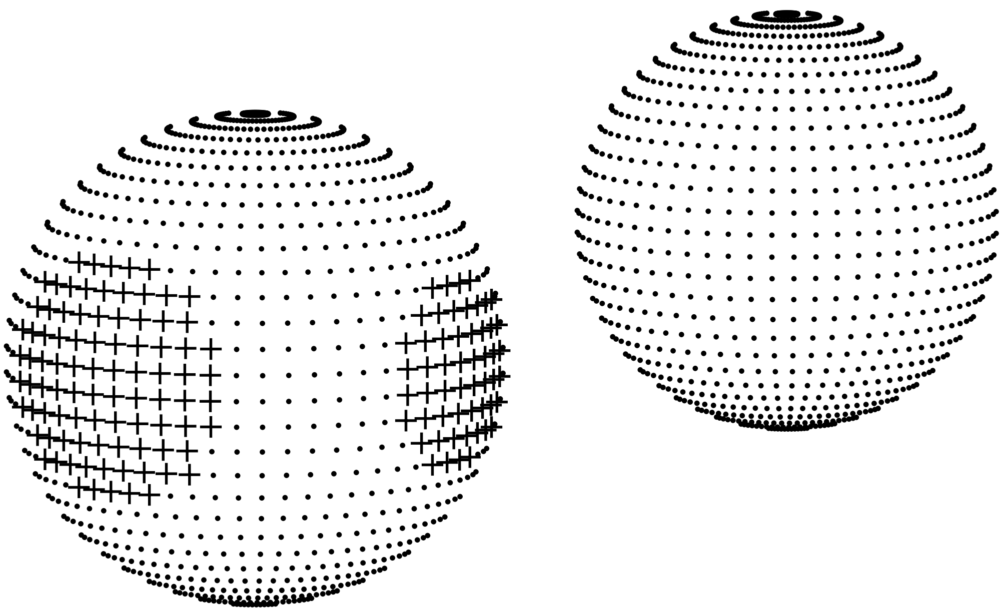

Figure 3. Three dimensional diagram of a possible Binmaker2 model of FF Cancri at phase 0.43

Further measurements will be very valuable to increase our knowledge of this important system. Photometric monitoring will be of interest since the changes in the light curve shape are probably due to differential rotation or active region evolution. Radial velocity measurements will be very important for the determination of the absolute dimensions of the system, the distance, and the gamma velocity. A careful spectral classification would confirm the temperature of the primary star and check for the presence of Ca H & K emission. We note that the star is in the direction of Praesepe in the sky and current estimates of its distance are too uncertain to rule out membership in that cluster, so proper motion and the radial velocity measurements will test for the star's membership in the cluster. Although FF Cancri has not been detected in X-rays or the extreme ultraviolet (EUV) (Pounds et al. 1993, Malina et al., 1994), it should be expected to be a source since it has large active regions. The eclipse of these active regions by the secondary star would help to measure the spatial extent of the emitting region.

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