The Spot Activity of FK Comae Berenices

Lauri Jetsu [1], Jaan Pelt [2], Ilkka Tuominen [1], Harold Nations [3]

[1]Observatory and Astrophysics Laboratory, University of Helsinki,
Tähtitorninmäki, SF-00130 Helsinki, Finland
[2]Tartu Astrophysical Observatory, Tóravere, Estonia, USSR
[3]Franklin and Marshall College, Lancaster, Pennsylvania 17604, USA

Abstract: The active regions of FK Comae Berenices show a flip-flop behaviour, *i.e* the concentrated part of spot-activity shifts exactly to the other side of stellar surface, and then remains on the same longitude for a time interval from a few years to a decade. The activity shows excellent phase coherence with respect to these two active longitudes separated 180 degrees from each other. FK Comae may provide a physical example of a non-linear dynamo, which shows surprisingly simple observational changes in the pattern of the magnetically induced spot configurations.

1. Introduction

FK Comae (HD 117555) is an extremely rapidly rotating single late-type giant (Bopp and Stencel, 1981; McCarthy and Ramsay, 1984: G2 III; $P_{\rm phot} = 2\overset{\rm d}{.}4000$; $v \sin i = 120\,{\rm km/s}$; $v_{\rm rad} = -21.3\pm6.2\,{\rm km/s}$). It is also the prototype for the definition of the FK Comae class, which originally contained two other candidates, UZ Librae and HD 199178 proposed by Bopp and Stencel (1981). A long-term photometric study of FK Comae has now been performed using basically the same methods as those presented by Jetsu *et al.* (1990a,b) for HD 199178.

2. The long-term study

The collected UBVRI photometry contains the previously published observations combined with new observations. The total time interval of the collected observations made at six observatories is nearly a quarter of a century (from 1966 to 1990). A more detailed description of the observations and the results derived from them will be published in a separate paper. This paper concentrates on one of the main results, which has been derived from the normalized magnitudes of

https://doi.org/10.1017/S0252921100079963 Published online by Cambridge University Press

FK Comae. The normalization has been done by dividing the data into individual seasons, which have an average length of about one month, since during this time the light curve of FK Comae does not change significantly. The observations were normalized inside individual seasons in every UBVRI passband with exactly the same method as used for HD 199178 by Jetsu *et al.* (1990a). The flares were naturally excluded before the normalization.

The time series analysis of the normalized magnitudes was performed by the methods developed by Pelt (1983). However, there is no time series analysis method available that can deal with phase shifts of the light curve. The result presented in this paper was derived by dividing the data into separate pieces, which surprisingly gave the same value for the photometric rotation period, but at the same time indicated the presence of a phase shift. The time interval between two consecutive phase shifts seems to vary from a few years to nearly a decade. The phase shift is the simplest possible *i.e.* half a rotation period. We call this phenomenon the "flip-flop" of the photometric minimum.

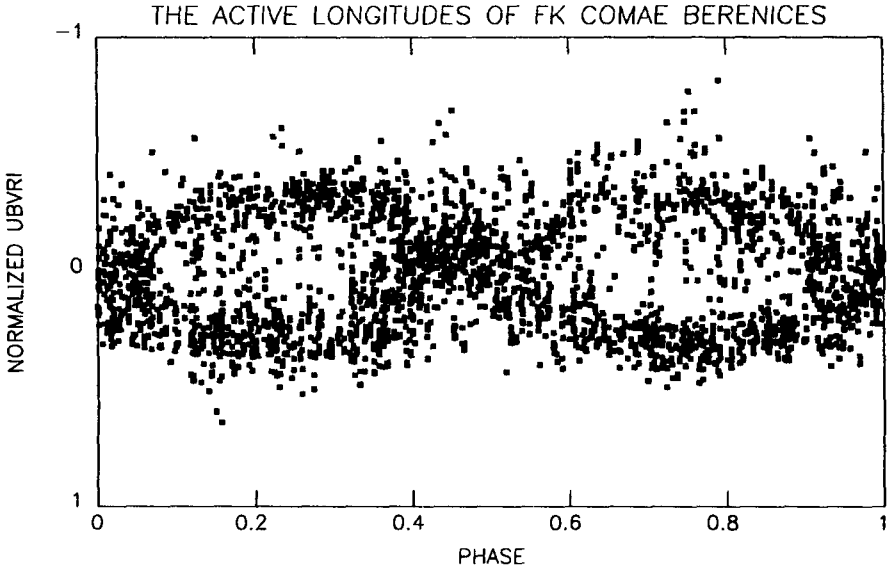

Fig. 1. The phase coherence of ϕ_{min} of all normalized UBVRI-observations from 1966 to 1990 plotted as function of phase derived from the ephemeris HJD 2439253.4375 + 2.400285 E.

https://doi.org/10.1017/S0252921100079963 Published online by Cambridge University Press

3. Conclusions

Nearly a quarter of a century of photometry shows excellent phase coherence for the active longitudes of FK Comae Berenices. Inside individual observing seasons the activity has definitely been concentrated on only one of the *two active longitudes* separated by 180° from each other. The non-axisymmetric component of spot activity may suddenly shift exactly to the other side of the star after a long interval (from a few years to a decade) of phase coherence. The amount of differential rotation is very strictly limited, since the whole collected photometry can be described by one unique photometric rotation period with very small drifts of the photometric minimum. Furthermore, the "flip-flop" excludes the accretion stream model proposed by Walter and Barsi (1982) as the cause of rotational modulation of brightness of FK Comae.

The "flip-flop" phenomenon derived from the long-term photometry should give new impetus to the studies of nonlinear dynamos. It also stresses the need to develop time series analysis methods, which can deal with the phase shifts inherent in such data.

References

Bopp, B.W., Stencel, R.E.: 1981, *Astrophys. J. Letters* **247**, 131

Jetsu, L., Huovelin, J., Tuominen, I., Vilhu, O., Bopp, B.W., Piirola, P.: 1990a, *Astron. Astrophys.* **236**, 423

Jetsu, L., Huovelin, J., Tuominen, I., Bopp, B.W., Efimov, Yu.S., Linnaluoto, S., Nations, H. L., Piirola, P., Shakhovskoy, N.M., Virtanen, H.: 1990b, *Astron. Astrophys. Suppl.* **85**, 813

McCarthy, J.K., Ramsay, L.W.: 1984, *Astrophys. J.* **283**, 200

Pelt, J.: 1983 *ESA Spec. Publ.*, ESA SP-201, 37

Walter, F.M., Basri, G.S.: 1982, *Astrophys. J.* **260**, 735