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The Six-day Rotation Period of 1689 Floris-Jan: A New Record Among Slowly Rotating Asteroids*

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Summary. The small sized asteroid 1689 Floris-Jan was observed photoelectrically in *UBV* at ESO and CTIO, Chile, and at Mt. Table Mountain JPL, California, during its opposition in 1980, between Oct. 7 and Nov. 6, 1980. A unique synodic rotation period $P = 145\overset{h}{.}0 \pm 0\overset{h}{.}5$ corresponding to $6\overset{d}{.}042 \pm 0\overset{d}{.}021$ could be derived from a lightcurve observed during 0.6 of the rotational phase. The lightcurve should show the usual double wave characteristic with an amplitude of 0.4 mag or slightly more.

Absolute magnitudes were computed with a linear extrapolation, using a mean phase coefficient of 0.039 mag/deg, yielding $\bar{V}(1,0) = 12.08$ and $V_0(1,0) = 11.88$; colors were derived as $B\text{–}V = 0.70 \pm 0.04$ and $U\text{–}B = 0.25 \pm 0.05$, with no variation over the observed rotational phases exceeding the scatter. From the colors alone it is evident that 1689 Floris-Jan is not a S-type asteroid, therefore belonging to groups CME or *U*, with a diameter between 9 and 27 km approximately, depending on the albedo assumption.

The rotation period of six days found for 1689 Floris-Jan is the longest one ever published for an asteroid. A histogram is therefore given for 300 published asteroid rotation rates in order to show the exceptional position of 1689 Floris-Jan among other asteroids. In addition there are indications that small asteroids are not necessarily fast rotators, but rather that they have also a trend to show up as slow rotators.

Key words: asteroids – photoelectric photometry – lightcurve – minor planets – 1689 Floris-Jan

1. Introduction

The asteroid 1689 Floris-Jan is one of the high-numbered objects and was at favorable opposition on Oct. 22, 1980, with $B_{\mathrm{opp}} = 12.9$ as announced in the Ephemerides of Minor Planets for 1980. There is nothing known about observations of the physical properties, even no photoelectric color measurements were made before, and no type assignment was given. A preliminar announcement of our own observations was circulated before, but only an indication of a long rotation period for 1689 Floris-Jan could be made. Knowing about our individual observations we decided to combine our measurements for the final result.

2. Observations in 1980

Surdej has observed 1689 Floris-Jan, using the ESO-0.5 m telescope at the European Southern Observatory, Chile, with standard *UBV*-equipment during seven nights on Oct. 7, 8, 9, 12, 13, 14, and 15 in 1980. He also frequently measured in *UBV* and his colors are the most representative ones.

Schober was using the CTIO-0.6 m telescope at the Cerro Tololo Interamerican Observatory, Chile, on the nights Oct. 13–15 (simultaneous with Surdej) and the CTIO-0.9 m telescope on Oct. 18 and 19 in 1980 additionally. Measurements were made only in *V* regularly, but a number of *UBV* observations were also obtained for the link to the *UBV* system.

Harris and Young have observed the same asteroid during four nights on Oct. 30, Nov. 4–6 in 1980, using the 0.6 m telescope at Mt. Table Mountain JPL, Pasadena, California. They also only observed in *V*, made single measurements just every hour approximately, but could not deliver reliable standard *V*-magnitudes in the *UBV*-system to be compared with the measurements at ESO and CTIO.

All the relevant informations for the aspect data are given in Table 1, computed as usually by Batrakov (1981). Differential photometry was made, using the comparison stars A, B, and C as listed in Table 2. We have decided to publish all single lightcurves obtained by us, but grouped together due to the telescopes used or due to simultaneous observations (Figs. 1–4). *V*-magnitudes in the *UBV*-system are plotted against time in UT.

3. Results

From measurements made during subsequent nights it was immediately clear that we had discovered an object with extremely low spin rate, the brightness of which was changing very slowly with time. As this fact was unknown before, we had not organized a systematic campaign, but just by chance we were lucky to obtain independent lightcurves in a very suited way to find a resulting rotation period. The most save consecutive lightcurve sequence was obtained on Oct. 12–15 in 1980 with simultaneous observations at ESO and CTIO on 13–15, for which magnitude levels

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* Based on observations partly collected at the European Southern Observatory ESO, La Silla, Chile

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Table 1. Coordinates, distances, and observational circumstances of 1689 Floris-Jan for the observing dates in Oct.–Nov. 1980; Surdej: JS at ESO, Surdej and Schober: JS+HJS, simultaneous observations at ESO and CTIO, Harris and Young: AH–JWY at JPL

Date 0^h UT	R.A. 1950.0	Decl. 1950.0	λ 1950.0	β 1950.0	Δ AU	r AU	α	5 log rΔ	Light-time	Obs.	Comp. star	Fig.
1980												
Oct. 7	$1^h57.54$	$-1^\circ20'.9$	$26^\circ.82$	$-12^\circ.52$	0.970	1.944	$9^\circ.3$	1.377	$0^d.00560$	JS	A	1
Oct. 8	1 56.87	-1 27.8	26.64	-12.57	0.968	1.944	8.9	1.373	0.00559	JS	A	1
Oct. 9	1 56.17	-1 34.6	26.43	-12.61	0.966	1.944	8.5	1.368	0.00558	JS	A	1
Oct.12	1 53.97	-1 54.4	25.78	-12.72	0.961	1.943	7.5	1.356	0.00555	JS	A	1
Oct.13	1 53.21	-2 00.7	25.55	-12.75	0.960	1.943	7.2	1.354	0.00554	JS+HJS	A,B	2
Oct.14	1 52.43	-2 06.9	25.32	-12.78	0.959	1.943	7.0	1.351	0.00554	JS+HJS	A,B	2
Oct.15	1 51.64	-2 13.0	25.11	-12.80	0.959	1.943	6.8	1.351	0.00554	JS+HJS	A,B	2
Oct.18	1 49.24	-2 30.1	24.43	-12.85	0.959	1.942	6.5	1.350	0.00554	HJS	B	3
Oct.19	1 48.42	-2 35.4	24.19	-12.86	0.959	1.942	6.6	1.350	0.00554	HJS	B	3
Oct.30	1 39.63	-3 18.5	21.83	-12.72	0.977	1.943	9.7	1.392	0.00564	AH-JWY	C	4
Nov. 4	1 36.05	-3 27.3	20.93	-12.53	0.995	1.944	11.9	1.433	0.00575	AH-JWY	C	4
Nov. 5	1 35.39	-3 28.2	20.77	-12.48	0.999	1.944	12.3	1.441	0.00577	AH-JWY	C	4
Nov. 6	1 34.75	-3 28.8	20.61	-12.43	1.003	1.944	12.8	1.450	0.00579	AH-JWY	C	4

Table 2. Magnitudes and colors of the asteroid 1689 Floris-Jan and of the used comparison stars. V_0 means magnitude of the primary maximum, $\bar{V}$ is the adopted mean over the lightcurve with an amplitude larger than 0.4 mag and $(V_{max}-V_{min})\,1/2=0.20$ mag

Object	B - V	U - B	$\bar{V}(r,\alpha)$ or V	$V_0(r,\alpha)$	$\bar{V}(1,\alpha)$	$V_0(1,\alpha)$	$\bar{V}(1,0)$	$V_0(1,0)$	$\bar{B}(1,0)$	$B_0(1,0)$
1689 Floris-Jan CTIO, mean from 8 meas. Oct.13-19	0.67 ± 0.02	0.28 ± 0.02								
		ref. to Oct.14,1980:	13.70 ± 0.03	13.50	12.35	12.15	12.08	11.88	12.78	12.58
1689 Floris-Jan ESO, mean from 280 meas. Oct.7-15 adopted colors	0.70 ± 0.04	0.25 ± 0.05								
Comp. star A-ESO not catalogued RA=$1^h57^m.2$ Decl.=$-1^\circ34'.5$ (1950.0)	0.54 ± 0.01	0.10 ± 0.01	11.66 ± 0.01							
Comp. star B-CTIO BD-2°317 = HD 11722, F8	0.48 ± 0.01	0.02 ± 0.02	9.41 ± 0.01							
Comp. star C-JPL BD-3°241 = HD 10428, G5			7.55:							

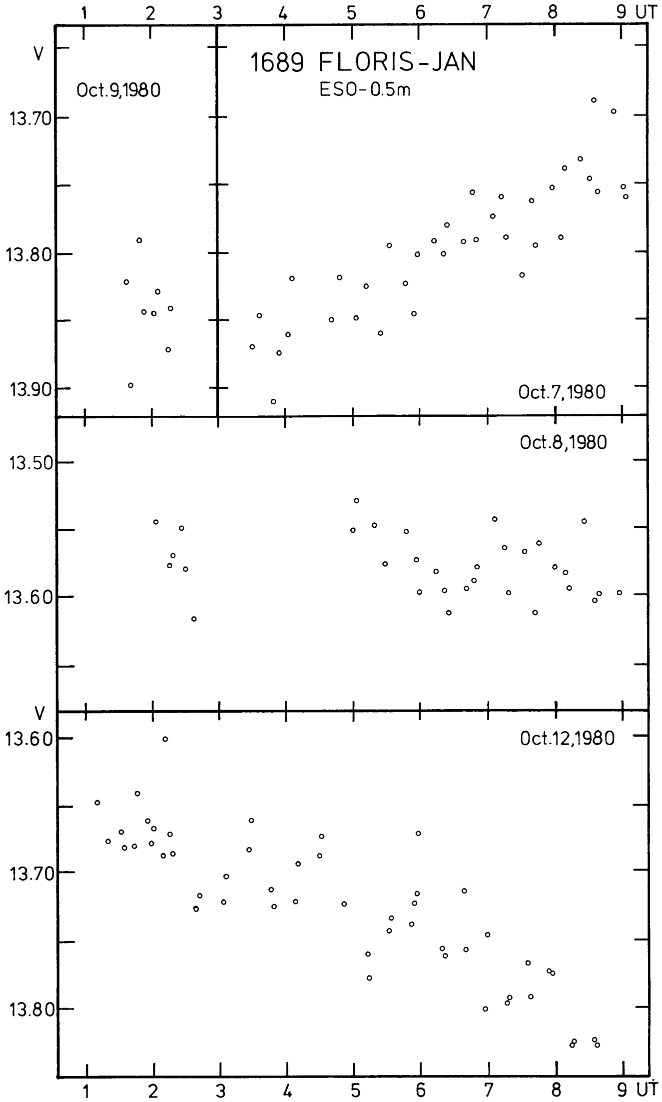


Fig. 1. Observations of 1689 Floris-Jan, obtained with the ESO-0.5 m telescope on Oct. 7–8 and 12 in 1980

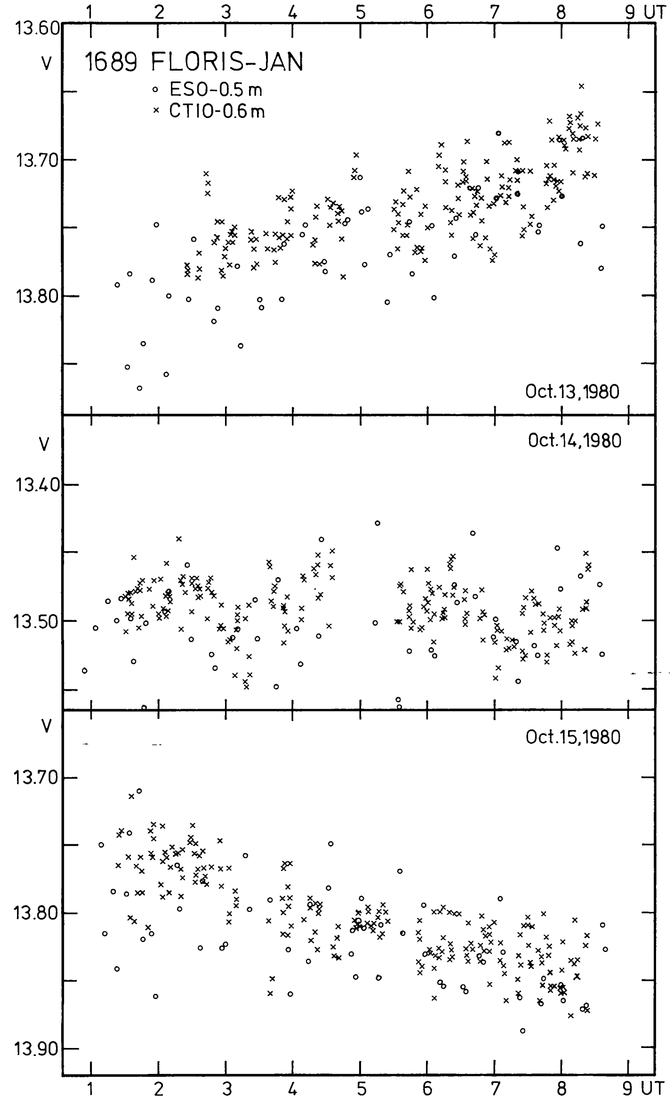


Fig. 2. Observations of 1689 Floris-Jan, obtained simultaneously with the ESO-0.5 m and CTIO-0.6 m telescopes on Oct. 13–15 in 1980

could be defined with a high confidence as we used different comparison stars at ESO and CTIO, both leading to the same result within the limits of accuracy. In addition we could get – again with the same comparison stars for each run – a few nights before and after that period (Oct. 7–9 and 18, 19) confirming later our initial assumptions. Reduction for geometric effects was done (Table 1) and in addition shifts of magnitudes were made compatible with a phase coefficient of 0.039 mag/deg, though of course the accuracy of the absolute magnitudes is limited by the fact that the *V*-magnitudes ranged only from 13–14 and that we had only telescopes of moderate size during most of the observing time. The lightcurves obtained by Harris and Young at JPL only consist of single individual lightcurve points rather than of a complete statistical set; the standard *V*-magnitudes do not agree with the values obtained at ESO and CTIO, but the observing sequence on Nov. 4–6 gives a differential lightcurve consistent with the final lightcurve.

3.1. Rotation Period

A first attempt to find a rotation period was made by fitting the consecutive nights and considering the same trends in the ascending or descending lightcurve branches of the partial lightcurves, together with the magnitude levels. The only possible fit to satisfy all observations could be done with a final period of

$$P_{\rm syn} = 145\overset{\rm h}{.}0 \pm 0\overset{\rm h}{.}5$$

corresponding to

$$P_{\rm syn} = 6\overset{\rm d}{.}042 \pm 0\overset{\rm d}{.}021,$$

a value which represents the longest rotation period published for asteroids until now. Of course, we have also tried to fit the observations with $P/2$ and $P/3$, but no compatibility could be found. Shorter periods can be excluded due to the consecutive

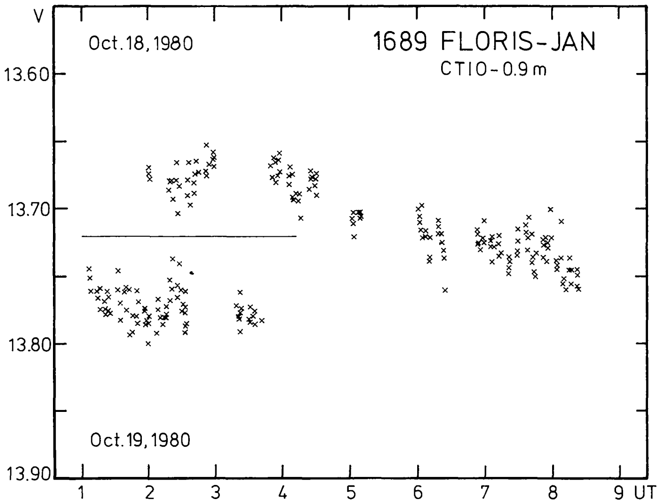


Fig. 3. Observations of 1689 Floris-Jan, obtained with the CTIO-0.9 m telescope on Oct. 18 and 19 in 1980

observations and the large variations in magnitude from night to night.

The error affecting the rotation period and indicated above, is an estimated one, considering the absolute shifts of the same observed features in the lightcurve with time and considering the number of elapsed rotation cycles.

3.2. Lightcurve

The composite lightcurve of 1689 Floris-Jan as made from all available accurate observations is shown in Fig. 5 and covers 0.6 of the rotational phase. In order to simplify the figure we have chosen the same symbols for all observations; due to the high number of

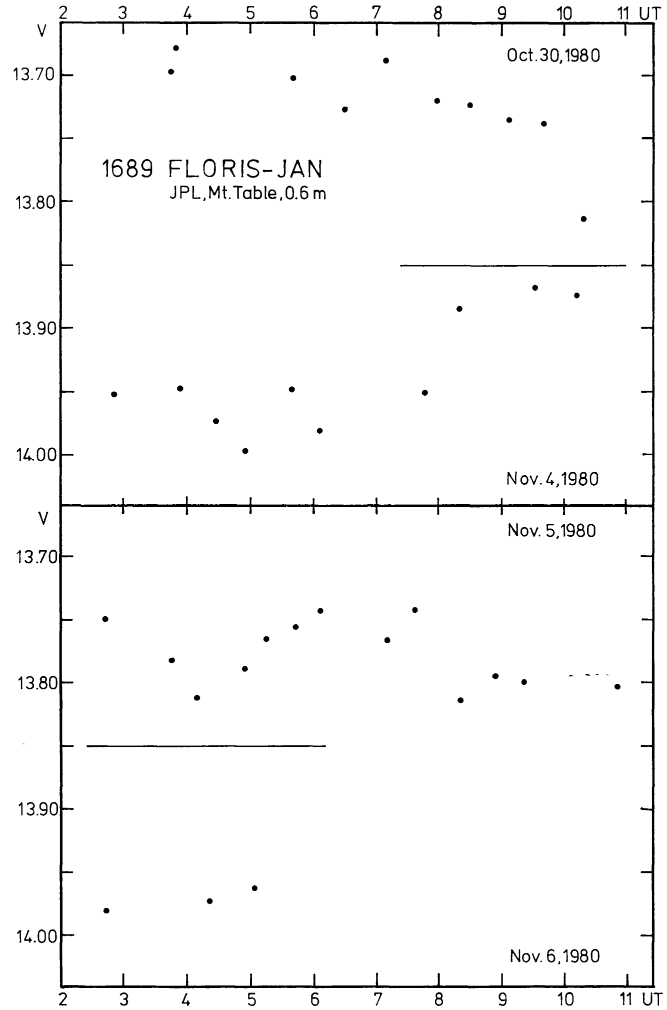


Fig. 4. Observations of 1689 Floris-Jan, obtained with the 0.6 m telescope at Mt. Table Mountain, JPL on Oct. 30, Nov. 4–6 in 1980

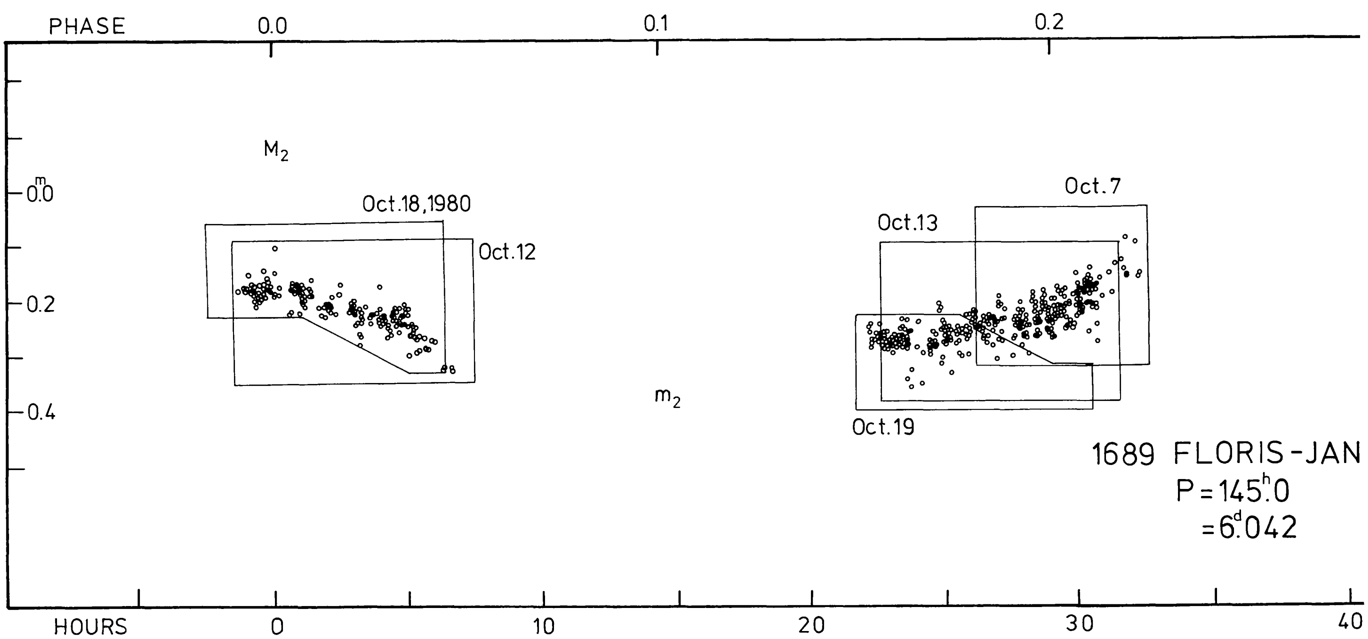


Fig. 5. Composite lightcurve of 1689 Floris-Jan, based on the resulting rotation period $P=145\overset{h}{.}0$ or $6\overset{d}{.}042$; rotational phases are given in the upper scale, hours in the lower scale

the single lightcurve points collected at CTIO, not every point was repeated from the individual lightcurves. In order to recognize the observation dates we have drawn the same frame for each observing night in Fig. 5 as used in Figs. 1–3. The lightcurves obtained at JPL (Fig. 4) are not included in Fig. 5 because of the missing accuracy for the zero-point of the V-values; but the differential photometric sequence Nov. 4–6 fits the same rotation period and overlaps in the final lightcurve with the same maximum M 2 observed on Oct. 12, 18, 30 and Nov. 5.

The rotational lightcurve of 1689 Floris-Jan shows a non-symmetrical double wave characteristic as typical of other asteroids previously observed, with maxima M 1 and M 2, and minima m 2 (and m 1) as indicated in Fig. 5. The maxima amplitude is at least 0.4 mag. Of course, not all lightcurve parts are covered by observations due to gaps caused by missing daytime observations, and/or by weather conditions, and by the fact that the period is almost equal to an integer number of days. Of course, future observations are needed to confirm the conclusions derived here, especially to cover also the minimum m 1, which seems to be flat and should last relatively long.

3.3. Magnitude and Color

The magnitude and colors of 1689 Floris-Jan are listed in Table 2, altogether with explanations. From the adopted colors $B-V=0.70 \pm 0.04$ and $U-B=0.25 \pm 0.05$ it can be concluded that 1689 Floris-Jan is definitely not a S-type asteroid and should be classified as CMEU as long as no spectrophotometric and/or polarimetric measurements are available. From the consistency of the 280 *UBV* measurements made by Surdej and those additionally made by Schober it can be concluded, that at least from the observed rotational phases there is no variation of the color indices $B-V$ and $U-B$ exceeding the scatter, reported in Table 2.

4. Comparison with other Asteroid Rotation Periods

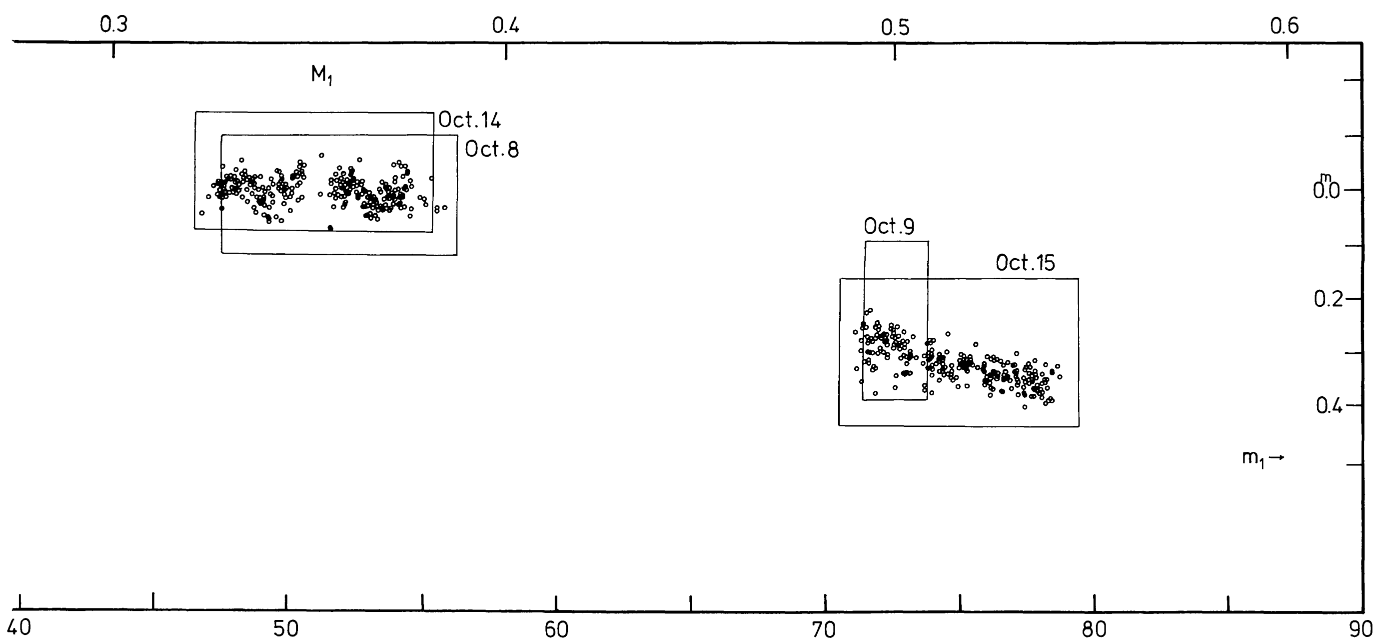
The rotation period presented for 1689 Floris-Jan is unique among the asteroids with known physical properties, because it is the longest rotation period observed for asteroids until now. In Fig. 6 we present a histogram of rotation rates for 300 asteroids with published data; the numbers and names of those objects with long periods, $P > 50$ h are as well indicated. It is quite interesting to compare similar histograms made by Schober (1975, 1978), when the periods for 654 Zelinda and 200 Dynamene were found, or to compare the results obtained by Scaltriti et al. (1979) for 128 Nemesis and 393 Lampetia – all periods $P < 50$ h! During the last years there seemed to be a special effort by observers to consider slow-rotating asteroids as important as those showing rapid light variations. Consequently, the selection effect of just covering light variations during relatively short periods was partially removed; this is also the explanation why in Fig. 6 all long rotation periods just appear to be published and found in the last years.

A final remark should be made: Using the well known formula (Zellner, 1979) for the diameter D of an asteroid with visual albedo p_v:

$$2 \log D(\mathrm{km}) = 6.244 - 0.4\ [B(1,0) - (B-V)] - \log p_v$$

we get for the diameter of 1689 Floris-Jan a size between approximately 9 km ($p_v = 0.30$, typical M-object) and 27 km ($p_v = 0.037$, typical C-object) and 0.8–2 km for 1981 QA, an asteroid for which an unusually long rotation period of also six days was reported recently (Marsden, 1981 and Harris, 1982). Harris (1982) also reports extremely slow variations in the lightcurve of the 30 km sized S-type asteroid 288 Glauke.

Among the asteroids with rotation periods longer than 50 h there appear to be no objects with diameters larger than 100 km. Although it is still premature to conclude, it seems that small asteroids prefer slow rotation rates whereas larger objects with $D > 200$ km prefer fast rotation with periods around 8–10 h!



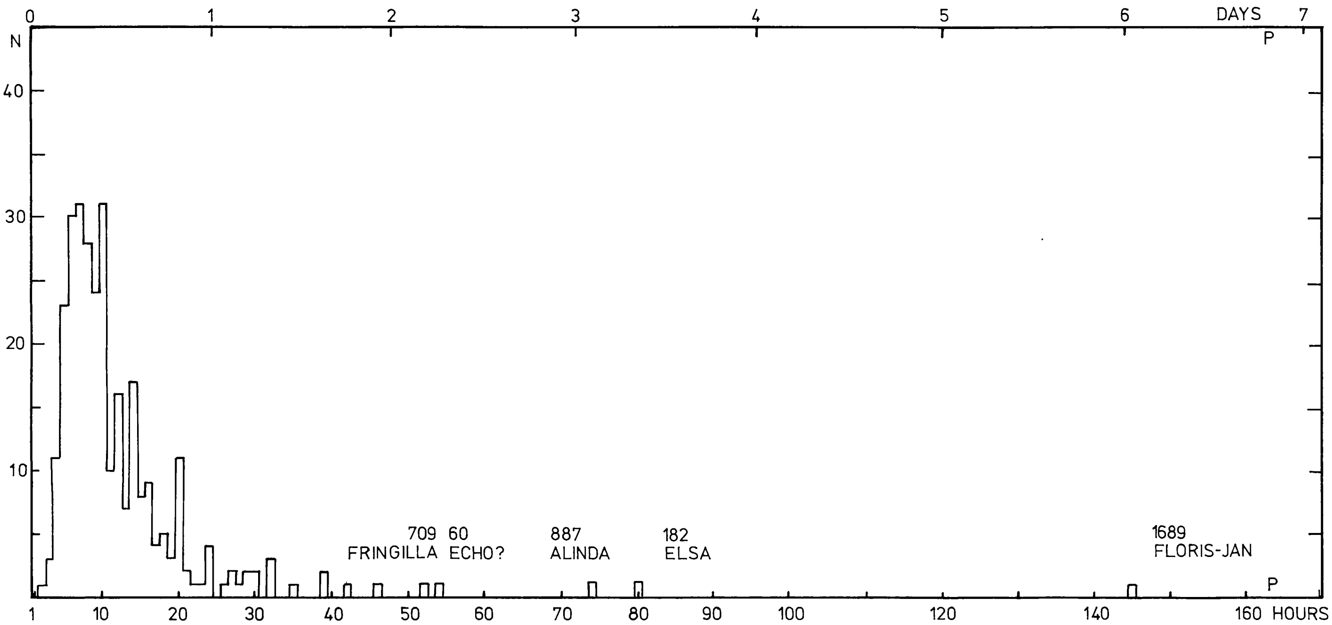


Fig. 6. Histogram of 300 asteroid rotation periods, as published until beginning of 1982; numbers and names for slowly spinning asteroids with P longer than 50 h are given. The exceptionally long rotation period $P = 145^{\mathrm{h}}.0$ for 1689 Floris-Jan becomes evidently clear

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