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ON THE REDISCOVERY OF ASTEROIDS

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The history of the discovery and rediscovery of a typical asteroid is described. Some general ideas on the attribution of asteroids are outlined.

On the 8th of August 1986, an asteroid was secured on plates taken with the old 50/90 Potsdam Schmidt, at the Bulgarian National Observatory at Rozhen, near Smoljan, not far away from the Greek border. The asteroid received from the Minor Planet Center, the provisional designation 1986 PM4 (MPC 11217). During a second observing run, the following September, at the same observatory, a new asteroid was discovered, that received the provisional designation 1986 RS (MPC 11217). It turned out that the asteroid 1986 RS is identical with the asteroid 1986 PM4 (F. N. Bowman, E. W. Elst, B. G. Marsden, MPC 11723).

With seven astrometric positions and an arc of 30 days, an orbit calculation was done by Bardwell, MPC 11722, and this is shown in column a of Table I. E. Goffin at Agfa Gevaert, was able to identify the asteroid with asteroids that have been observed in the past (MPC 11830):

* 1986 PM_4= 1930 UF_1= 1934 NK = 1957 JC_1= 1972 QP = 1979 BQ_1= 1986 RS

From all the available positions a more reliable orbit was calculated (Goffin, MPC 11830, shown in Table I, column b).

Last January 1988, I recovered the asteroid 1986 PM4 on plates taken with the Grand Schmidt at the observatory of Haute Provence, Southern France (MPC 12902).

Which is the best orbit? Is it the first one or the second one? Let us look a little more carefully at the ephemerides calculated from both sets of orbital elements (Table I). It is clear that from the ephemerides, calculated from the first set of orbital elements, it would have been rather difficult to recover the asteroid. (Table II).

Let us now have a look at some particular Minor Planet Circulars. The object 1984 SE3 (MPC 12320) was discovered by Skiff, rediscovered by Debehogne at ESO in 1984, and recovered by myself at ESO in 1987 (Table III). Another example of discovery and rediscovery we find in MPC 12317, where the object 1983 RT3 was discovered by Debehogne at ESO and rediscovered by Elst at the same observatory in 1987.

1986 PM4 = 1986 RS

	a	b
Epoch	1986 08 18.0	1987 07 24.0
M	358.23	67.08121
n	0.2047	0.20976097
a	2.8513	2.805305
e	0.1400	0.1559491
Peri	38.72	43.87790
Node	291.08	289.31681
Incl.	8.64	8.12938

Table I: Orbital elements of 1986 PM4. Column "a" contains the elements published by Bardwell in MPC 11722; column "b", those by Goffin in MPC 11830.

1986 PM4 (Bardwell)	alpha = 04h59m44.69s delta = +27d02m05.1s
1986 PM4 (Goffin)	alpha = 05h29m41.14s delta = +26d08m06.6s
Astrometric Pos. (Elst)	alpha = 05h29m37.01s delta = +26d08m17.0s
Epoch	1988 Jan. 21.86510

Table II: Ephemerides from two different sets of orbital elements.

I'm always impressed by the work of the Minor Planet Center, by the correct attribution of the discovered objects to the real discoverers, but some questions may arise (cfr. Table III). Sometimes even an arc of only three days may be sufficient to "discover" the discoverer. However, in most cases, a long arc is necessary to find out the real discoverer.

Permit me to quote some words Dr. Marsden wrote me some time ago, concerning almost the same problem:
"I appreciate that it is awkward when an astronomer goes to observe from a distant location but has to do his measurements when he gets back home. However, most minor-planet observers do still observe from close to home, and even some of those who travel far away have been trying to make arrangements to get measurements made near the telescope. If astronomers want to be sure to get credit for their discoveries, they should try to include in their programs and budgets some facility for getting quick measurements. Like so much else nowadays, it is a competitive situation, and some are going to move ahead while others get left behind. On the other hand, it is certainly my impression that, while an individual observer might miss some discoveries, he gains others, and each observer statistically gets about as many discoveries as is consonant with his effort he puts into his observing and measuring."

I think, it must be possible to have better communication between the different observatories where the discoveries are made, in order not to duplicate the work. It is due to observers like the carefully working H. Debehogne and others, with their long arcs, we are able to retrace the object in the past and may attribute the asteroid to the real discoverer. Too long we have observed and reobserved the same objects without knowing that they were the same asteroids. A good example of this point we may find in last batch of February (MPC 12788), where the asteroid 1931 FM, discovered by C.W. Tombaugh in 1931, has got 13 different provisional designations:

1931 FM= A909 HE= 1925 BF= 1929 WA_1= 1955 MR= 1957 WH_1= 1959 EC_1= 1963 WD= 1977 KR= 1978 NM_2= 1982 DQ_4= 1985 UD_4= 1987 BK

The last designation 1987 BK got it through the observations at the Uccle observatory.

That international collaboration exists, is proven by the many observations that were made from the Apollo-object 1987 SB, discovered by Elst, Ivanova and Shkodrov, at the Bulgarian National Observatory, last September 1987. This particular object has been observed at Palomar, Rozhen, Oak Ridge, ESO, Lowell and Kitt Peak, for which I should like to thank all the concerned observers.

Acknowledgements

My participation at the Asteroids II Conference, Tucson during March 1988, was made possible by means of a traveling fund from the National Scientific Fund Organisation, Belgium, for which I should like to express my warm gratitude.

Date	Obs	dα	dδ	Date	Obs	dα	dδ
500125	012	108-	72	840929	809	0.4-	0.0
500128	760	0.9+	2.1-	840929	809	0.3-	0.0
500128	760	1.0-	0.6+	840930	809	0.0	0.1-
730329	805	0.9-	0.6-	840930	809	0.0	0.1+
840922	809	0.4-	0.4+	840930	809	0.0	0.2-
840922	809	0.2-	0.2+	841001	809	0.2-	0.1-
840922	809	0.1-	0.3+	841001	809	0.0	0.2-
840923	809	0.7-	0.2+	841001	809	0.4+	0.3-
840923	809	0.4-	0.2+	860403	054	1.9-	1.8+
840923	809	0.2-	0.4+	890405	054	0.4-	1.1+
840924	809	0.6-	0.1+	860409	688	4.0-	0.7+
840924	809	0.6-	0.3-	860409	688	1.4+	1.6-
840924	809	0.4-	0.3-	860410	054	1.4+	1.3
840926	809	0.5-	0.0	870821	809	0.4+	1.5-
840926	809	0.1+	0.0	870821	809	0.1+	1.1-
840926	809	0.3+	0.2+	870821	809	0.4+	0.8-
840927	809	0.1-	0.1+	870822	801	0.3+	0.1-
840927	809	0.1+	0.1+	870825	809	0.0	0.5-
840927	809	0.0	0.1-	870825	809	0.4+	0.9-
840928	809	0.7-	1.0+	870825	809	0.6+	1.0-
840928	809	0.1+	1.1+	870827	809	1.8+	1.2-
840928	809	0.5+	1.4+	870828	809	0.6-	1.3+
840928	688	0.8+	1.3-	870828	809	0.8+	1.6+
840928	688	1.6+	1.0-	870828	809	2.3+	1.4+
840928	809	0.9+	0.3-	870829	809	3.1-	0.2-
840928	809	0.6+	0.7-	870829	809	3.9-	0.5+
840928	809	1.0+	1.1-	870829	809	2.6-	1.0+
840929	809	0.6-	0.1-				

Table III: The observations (residuals) of the asteroid 1984 SE3 (3706).

V+B PHOTOELECTRIC PHOTOMETRY OF ASTEROID 114 KASSANDRA

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Photoelectric observations of the asteroid 114 Kassandra were made from Estación de Altura "El Leoncito" (Ex Yale Southern Station) of Félix Aguilar Observatory during the 1988 apparition. The determined synodic rotational period, lightcurve amplitude and average B-V color are: P=10.758±0.004 hours, Δm=0.25±0.01, B-V=0.78±0.014. B-V color changes of ~0.04 magnitude were observed to repeat consistently with rotational phase and this is interpreted as evidence for albedo spots on the asteroid's surface.

Observations

In early 1988 the asteroid 114 Kassandra was favorably placed for photoelectric study. Observations of this minor planet were conducted by the authors as part of a program directed toward the study and determination of the synodic rotational periods of asteroids. The described photometric study was conducted from Estación de Altura "El Leoncito" of Félix Aguilar Observatory (San Juan, Argentina).

The photometric measurements were made using the V and B filters of a cooled photon counting photometer equipped with a RCA 31034 photomultiplier tube attached to the 0.76-m Cassegrain telescope. The photometric data were recorded using a Commodore 64 microcomputer which was interfaced with the photometer.

A nearby comparison star of spectral class G (when possible) was selected to minimize the effects of color dependent variations in the atmospheric extinction between the asteroid and comparison star. In this special case we used for comparison a standard star of the nearby Selected Area 104 (Landolt 1973) which was within one degree of the asteroid. This election facilitated the subsequent standardization and reduced the correction for differences in atmospheric extinction to less than 0.01 magnitude.

During each observing night and for both colors, 30 second photometric integrations were used on the asteroid and comparison star, and 15 seconds on the sky. The standard observing procedure followed was to initially obtain photometric measurements of the comparison star and the sky background. These measurements were followed by a single 30 second integration of the asteroid and a 15 second integration of the sky, after which this comparison star-asteroid photometric sequence was repeated. Magnitude measurements of 114 Kassandra are subject to an average uncertainty of 0.01 magnitude in both colors. Typically 6 to 9 photometric measurements of the asteroid in each color were obtained during each hour of the observing run. During each night the raw photometric data were stored in a computer disk file and a hard copy was produced.

Results

114 Kassandra was discovered on July 23, 1871 by C.H.F. Peters. 114 Kassandra is listed by Bowell et al. (1979) as a C type asteroid with a diameter of 131 Km. Harris and Young (1983) reported a possible period of 20 hours with an amplitude >0.17 magnitude. However, no lightcurve was published and these authors considered their result to be highly uncertain. Photometric observations of this asteroid were conducted using the 0.76-m Cassegrain telescope at Yale Southern Station of Félix Aguilar Observatory on the nights of April 22, 23, and 26, 1988 UT, on which 41, 46, and 32 photometric measurements were made in each color, respectively. Observational circumstances are shown in Table I.

On the basis of the photometric data obtained during these three nights of observation it was determined that a synodic rotational period of 10.758±0.004 hours best conformed to the observations. Composite lightcurves for V and B-V based upon this rotational period are shown in Figures 1 and 2, respectively. In the construction of these composite lightcurves, variations in the V magnitude and B-V color on different nights due to changing asteroid heliocentric and geocentric distance as well as changing phase angle were adjusted by sliding up and down the nightly lightcurves. The gap between 5:05 and 6:10 in the April 23 lightcurve is due to a close appulse between the asteroid and a 13 magnitude background star at 3:05 UT, April 23.

The lightcurve of 114 Kassandra shows two maxima and two minima per rotational cycle, all well defined, with a lightcurve amplitude of 0.25±0.01 magnitude. The asteroid was observed to be brighter during one lightcurve maximum than at the other. A lightcurve with a single maximum and minimum per rotational cycle yielding a rotational period of 5.379 hours is viewed by the authors as being unlikely.

We found that the average B-V color of 114 Kassandra is 0.78±0.014, which is consistent with the value reported by Bowell et al. (1979). It is important to note the sharp maximum at 4:15 UT

Date	R.A. (1950)	Dec.	Long (1950)	Lat	Ph	Comp
4/22	$12^h41.7^m$	0°38.8'	189.325°	4.726°	9.3	SA104-654
4/23	12 41.1	0 43.7	189.155	4.742	9.8	" "
4/26	12 39.4	0 57.4	188.673	4.785	11.1	" "

Table I. Observational circumstances for 114 Kassandra.

and minima at 6:30, 7:30 and 8:30 UT in the B-V lightcurve. These changes are observed to recur at the same rotational phases and probably represent true variations due to albedo changes.

Acknowledgement

The authors wish to thank Ing. José A. López and the staff of Félix Aguilar Observatory for the observing time and kindness during the course of this research program.

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Harris, A.W. and Young, J.W. (1983). "Asteroid Rotation IV. 1979 Observations". *Icarus* 54, 59-109.

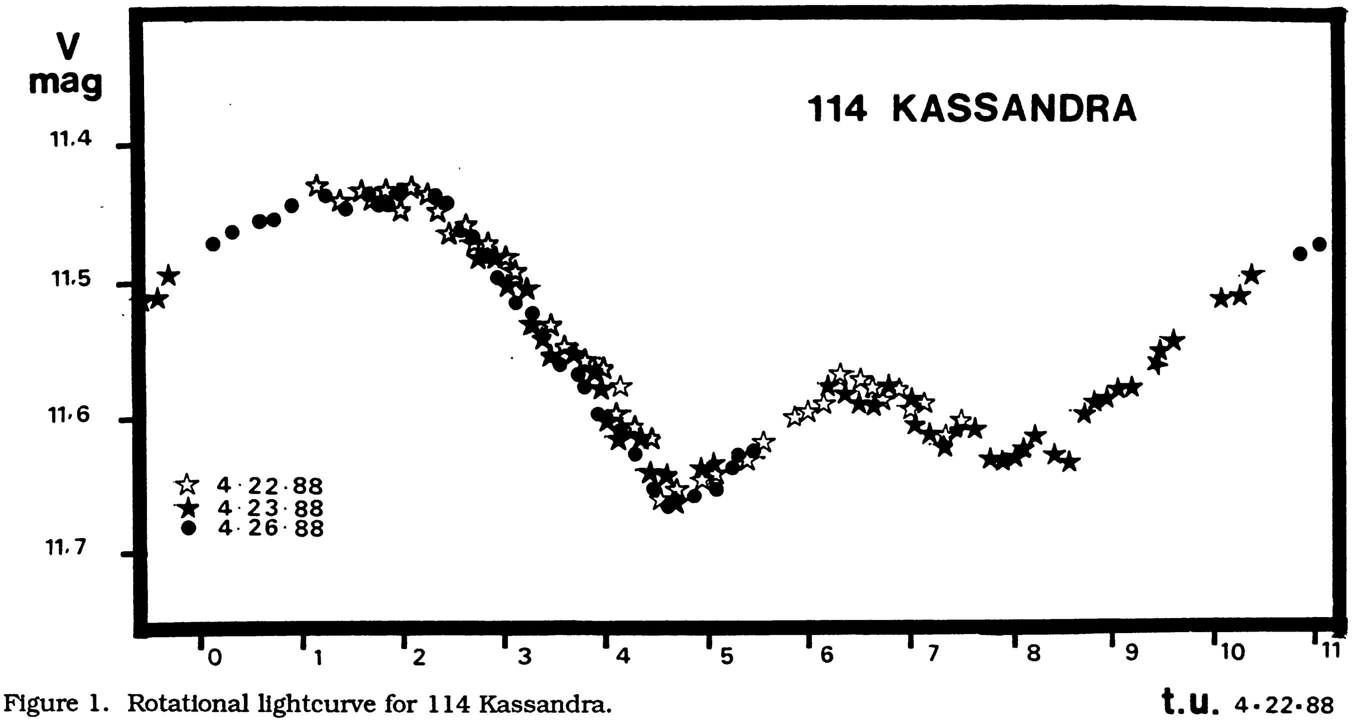

Figure 1. Rotational lightcurve for 114 Kassandra.

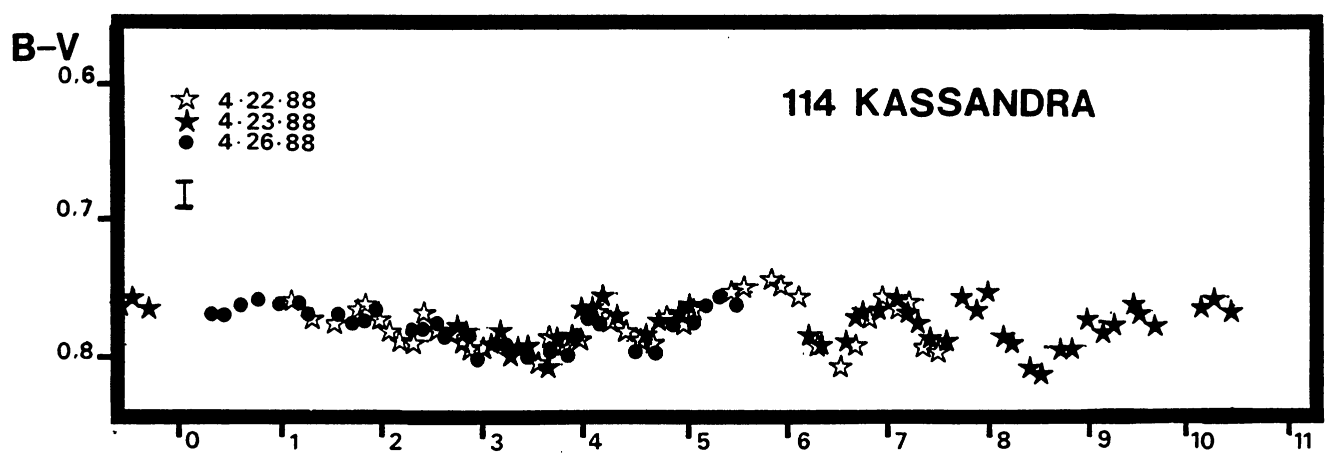

Figure 2. B-V lightcurve for 114 Kassandra. A one-sigma error bar is shown at left.

PHOTOELECTRIC PHOTOMETRY OPPORTUNITIES NOVEMBER-JANUARY

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The table below lists asteroids which come to opposition during the months of November through January that represent useful targets for photoelectric photometry observations. Observations are needed because the asteroid has either an unknown or ambiguous rotational period or because the asteroid will be observable at a very low phase angle. The table also includes asteroids which are candidates for pole determinations (see the article by Di Martino and Zappalá in issue 12, No. 1), are targets for radar observations (see the article by Ostro in *MPB* 10, No. 4), or are subjects for shape modelling (see the article by Davis and Binzel in *MPB* 14, No. 3). The table gives (in order of opposition dates) the asteroid number and name, opposition date, opposition V magnitude, the rotational period (in hours), the estimated lightcurve amplitude (in magnitudes), and the designation PER if observations are needed to determine the rotational period. AMB implies that previous period determinations have given ambiguous results and these alternate periods are listed in the table. PHA indicates observations of the phase curve are desired because the asteroid will be at an unusually low phase angle, POL indicates the asteroid is a pole position candidate, RAD indicates the asteroid is a planned radar target, and MOD denotes an asteroid at a critical longitude for shape modelling. Question marks are used to denote uncertain or unknown values. An outline of recommended observing procedures in given in *MPB* 11, No. 1, page 7. Also recommended is the book *Solar System Photometry Handbook* (see the review by Tholen in *MPB* 11, No. 4). Ephemerides for all of the asteroids in the table are included in this issue. Some of these may appear on finding charts in *Tonight's Asteroids* prepared by Mr. Joseph F. Flowers, Route 4 Box 446, Wilson, NC 27893, USA.

Asteroid	Opp'n Date	Opp'n V Mag	Per	Amp	
674 Rachele	Oct 25	11.0	16.6	0.15	PER
751 Faina	Nov 23	11.3	?	?	PER
41 Daphne	Jan 10	11.7	5.988	0.3	MOD
39 Laetitia	Jan 13	10.2	5.138	0.3	MOD

Photoelectric Photometry Opportunities

DATE	R.A. (1950) HR	MIN	DEC. DEG	MIN	MAG V	PHASE ANGLE
Minor Planet 39 Laetitia						
1988 Nov 30	8	7.56	+ 9	7.4	10.79	16.9
Dec 10	8	5.07	+ 9	2.4	10.62	14.4
20	8	0.11	+ 9	11.4	10.45	11.3
30	7	53.05	+ 9	34.8	10.28	7.9
1989 Jan 9	7	44.56	+10	11.6	10.13	4.7
19	7	35.58	+10	59.2	10.11	3.9
29	7	27.12	+11	53.6	10.28	6.6
Feb 8	7	20.11	+12	50.6	10.48	10.0
18	7	15.23	+13	46.5	10.69	13.0
Minor Planet 41 Daphne						
1988 Nov 30	7	52.25	+ 0	45.5	12.36	15.8
Dec 10	7	49.22	+ 0	7.1	12.15	13.9
20	7	43.89	- 0	16.7	11.94	11.5
30	7	36.58	- 0	22.2	11.74	9.2
1989 Jan 9	7	27.90	- 0	7.1	11.59	7.5
19	7	18.72	+ 0	28.7	11.54	7.7
29	7	10.02	+ 1	23.1	11.60	9.6
Feb 8	7	2.74	+ 2	31.7	11.72	12.4
18	6	57.61	+ 3	49.1	11.85	15.2
Minor Planet 674 Rachele						
1988 Sep 11	2	28.42	+ 1	57.4	11.81	16.1
21	2	25.79	+ 1	44.8	11.59	13.4
Oct 1	2	20.60	+ 1	28.6	11.36	10.2
11	2	13.17	+ 1	12.6	11.13	6.7
21	2	4.16	+ 1	1.3	10.96	4.1
31	1	54.51	+ 0	59.4	10.99	5.4
Nov 10	1	45.35	+ 1	10.4	11.14	8.9
20	1	37.68	+ 1	36.6	11.31	12.7
30	1	32.25	+ 2	18.2	11.48	16.0
Minor Planet 751 Faïna						
1988 Oct 11	4	27.58	+ 8	19.8	12.10	20.6
21	4	24.72	+ 8	41.6	11.87	17.1
31	4	18.41	+ 9	10.2	11.64	12.8
Nov 10	4	9.19	+ 9	48.0	11.41	8.2
20	3	58.13	+10	36.0	11.22	4.4
30	3	46.72	+11	33.9	11.34	5.8
Dec 10	3	36.52	+12	40.4	11.62	10.1
20	3	28.78	+13	53.7	11.90	14.4
30	3	24.23	+15	11.8	12.18	18.0