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1000 AND MORE!

Gerard Faure
1, Parc de la Chateliere
38760 Varces Allieres et Risset
FRANCE

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Twenty one years after the search for my first asteroid, I saw the thousandth in 1996. Only four other observers, by their passion and their perseverance, are confirmed to have succeeded in visually spotting 1000 asteroids. Visual observation, by which the first minor planets were discovered, can yet improve our understanding of these tiny objects of our solar system.

Since the discovery of Ceres in 1801, there have been numerous observers who have visually detected asteroids among the stars, but few of them have reached 1000 different asteroids. To learn of these active observers, I have corresponded with Dr. Frederick Pilcher and sent nearly 40 letters to active observers in 12 countries. The *Minor Planet Bulletin* and the *Minor Planet Observer* have also published my call for information. As a result, I can reasonably assert that only five people have attained 1000 visual asteroid sightings prior to the end of 1997. These are: Paul G. Comba, G. Roger Harvey, Frederick Pilcher, Andrew Salthouse, and myself.

Frederick Pilcher, Illinois College, Jacksonville, USA, was the first who reached the 1000 plateau. Having obtained the *Ephemerides of Minor Planets* in 1968, he located his first asteroid (Pallas) on February 24 and 25, 1968 by its motion between stars and its absence on the *Atlas Eclipticalis*. He then ordered the *Falkauer Atlas* to identify minor planets more conveniently among fainter stars with a 25-cm Celestron telescope. In late 1973, he had observed 317 asteroids when he acquired a 35-cm Celestron telescope, also located at the Walter H. Balcke Observatory of Illinois College. This telescope enabled him, with the help of the Vehrenberg *Atlas Stellarum* (and despite city lights) to track asteroids as faint as magnitude V14.9. In the 1970's, Pilcher located several objects distant from their predicted positions by a few arcminutes to many tens of arcminutes by searching along the line of variation. He also drew lightcurves of several asteroids and noted a number of magnitude discrepancies. On January 2, 1981 he observed his 1000th different asteroid 750 Oskar, 13 years after first observing Pallas. In the 1980's, he used the *Lick Photographic Star Atlas* which, unlike the *Stellarum Atlas*, showed stars to and beyond the telescope limit for almost all fields in the sky. As of early April 1998, he has located 1780 minor planets, many of which he has seen many times. Frederick Pilcher, immortalized by the asteroid 1990, is well known for his activities as Recorder of the ALPO Minor Planet Section since 1983. He has written numerous papers in the *MPB* and each year publishes the report of asteroid observations by the ALPO members. He has also written the "Discovery Circumstances" section of the scholarly books, *Asteroids* and *Asteroids II*.

The second observer who reached 1000 visual asteroid sightings is G. Roger Harvey. Influenced by Dr. Jay U. Gunter and *Tonight's Asteroids*, Harvey observed his first asteroid 4 Vesta, in 1974, from his observatory, near Concord, in North Carolina, USA. Passion aroused quickly and he located 129 objects with his 25-cm telescope, then changed to a 51-cm telescope which allowed him to gain 1.5 magnitudes. On March 31, 1984 1847 Stobbe became his thousandth visual asteroid, less than 10 years after his start. Then, with a new 73-cm Newtonian, it took him only three years to see his second thousand, passing the 2000 mark on October 29, 1987 with 3250 Martebo. Five years later, he saw his 3000th visual object, (5189) 1990 UQ, on May 3, 1992. He accumulated asteroid observations including many Trojan and near-Earth objects. His farthest observed object is 2060 Chiron. He succeeded in recovering visually 2212 Hephaistos on December 16, 1987 at more than 1.1 minute of right ascension west of the predicted position. Harvey has also spotted hundreds of minor planets with true magnitudes fainter or brighter than those predicted. Now, light pollution at Concord is increasing, limiting his visual magnitude to 16.0 during clear nights. He moves from object to object by the coordinate circles and uses *Stellarum* charts with fainter stars from the *Lick Atlas*. He sometimes locates more than 20 asteroids per night, and many hundred objects during a typical year (374 in 1983). Once his targets are located, he returns to them twice in the night to confirm their motion. For his outstanding contribution, the IAU has honored him with the asteroid 4278 following the suggestion of J.U. Gunter and the agreement of B.J. Marsden. On May 15, 1998 his total was 3336 asteroids. Harvey holds by far the absolute record of different asteroids visually observed. When will he reach 4000?

Paul G. Comba is the third confirmed observer who has attained 1000 visual minor planet sightings. His first asteroid was 6 Hebe which he detected in September 1976. Most of his observations were made from Brookline, Massachusetts, USA, near Boston. He used a 8-cm spotting scope, a 15-cm refractor, a 20-cm Celestron, a 28-cm Schmidt-Cassegrain and telescopes of clubs, at Star Parties. In July 1992, Comba settled in Prescott, Arizona, USA, under clear skies. He bought a 46-cm NGT telescope with which he observed in June 1994 his thousandth visual asteroid 1018 Arnolda. He also

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visually observed 2060 Chiron in 1995 and currently reaches magnitude V15, his faintest being V15.8. His score, in late 1996, was 1288 visual objects. Comba had also undertaken, since July 1994, to do astrometric measures of his own photographic objects. Hundreds of these measures have been published in the *Minor Planet Circulars*, in addition to the discovery of an asteroid of mag. V16.5. In April 1996, Comba stopped his visual observations and launched into the realm of CCDs with an ST8 camera and the software *Astrometrica*. Since this year, he accumulated results of more than 5300 astrometric positions and 393 provisional designations for new discoveries, most of magnitude 18 or 19. Seven of them have now been numbered.

Two years after Paul Comba, I was the fourth observer and the first European to become a member of the "Millennium Club". I observed my first asteroid, 4 Vesta, with my 7x50 binoculars, in Casablanca, Morocco, on July 19, 1975 and two others with my 90-mm telescope, before my return to France in March 1976. In 1978, I purchased a 20-cm Celestron and in 1979, only with the *Becvar Atlas Eclipticalis* and some ephemerides of bright asteroids, I saw 16 objects. In 1980, I began to use the Vehrenberg *Falkauer Atlas* and the *EMP* in 1981, to increase the number of observable objects. With the C8 my limiting magnitude was V13.5 during clear nights in Grenoble, where from my balcony, asteroids were visible three hours, after their passage across the meridian. Nevertheless, I reached a total of 250 objects during 1983. In 1984 and 1985, I made numerous expeditions in mountains to altitudes of 600m to 2500m. Under the best circumstances, Trojan asteroids up to V15.7 were seen with my C8. During the years 1985 and 1986, I wrote the chronicle "Le monde des petites planetes" in the french review *Pulsar* and in 1986, I moved to Varces, 12km south of Grenoble. There, the C8 limiting magnitude of V14.6 permitted me to detect some hundred known asteroids in 6 years. In late 1992, I bought a computer, the GSC catalog and the *Superstar* software to draw charts to a limit of V16. Unfortunately, *Superstar* calculations were always imprecise. The ephemerides had to be calculated with the Russian *Ceres* software and the asteroid positions plotted manually on *Superstar* charts. Since 1995, I pushed the magnitude limit near V16.0 with my C8 from a new observation site, at an altitude of 1170m. I observed notably 7 Iris with the naked eye, 2060 Chiron and about 40 asteroids with magnitude discrepancies. I also saw my 1000th asteroid by confirming the motion of 309 Fraternitas on June 14, 1996. On May 17, 1998, my total was 1141 asteroids visually seen. Now, I map charts with the excellent *Guide* software, eventually completed by the fainter stars of the *Microsky Atlas*. I hope to make asteroid discoveries and lightcurve measurements with my new CCD camera ST6, in the future.

Recently, Andrew Salthouse, Millington, New Jersey, USA, became the fifth person to reach the 1000 asteroid mark visually. On November 3, 1997 he confirmed his thousandth minor planet by seeing the motion of (5847) 1989 YB. Ceres was his first asteroid observed in November 1965 with his 11-cm reflector. Later, he saw a handful of other tiny planets over the years, principally with a 25-cm reflector. He was up to 54 by the end of 1990. Richard Binzel of MIT suggested to him to obtain information on the *Minor Planet Observer* newsletter. Then, with the use of the *MPO* charts and with his new home-made 44.5-cm Dobsonian, Salthouse started to observe asteroids more seriously and attained the score of 1000 in less than seven years. His observation site is very light polluted and the best he can do with his instrument is V14.4. Despite this bad sky, he has seen a small number of Trojans and made more than 6000 asteroid observations. On May 4, 1998 his total number of minor planets was 1045.

Two other amateurs may join the "Millennium Club" before the year 2000: Ben F. Hudgens, Memphis, Tennessee, USA, using 25-cm and 33-cm telescopes, under a polluted sky; Lawrence Garrett, Burlington, Vermont, USA, using a 32-cm Newtonian and some smaller telescopes. At the end of 1997, they respectively have observed 879 and 691 minor planets.

Lastly, in the past, two other observers came close to 1000 different asteroids. The first is Ray E. Fabre from Aiae in Hawaii, USA, who used a 20-cm then 33-cm and finally 44-cm Newton telescopes. After 15 years of observations, he had made in 1986 more than 1100 successful observations concerning 892 objects when he apparently stopped his program.

The second observer was the famous Austrian professional astronomer Johann Palisa (1848-1925) who visually discovered 121 asteroids, some fainter than magnitude V15, between 1874 and 1923 with the use of stellar charts patiently elaborated. No other astronomer has visually discovered more asteroidal objects. He used a 15-cm instrument at Pola Observatory, on the Adriatic coast and thereafter a 68-cm telescope at Vienna Observatory. He made thousands of excellent micrometric measures of asteroid positions, notably for the follow-up of Heidelberg Observatory objects photographically discovered since 1891. Palisa probably observed most of the 1039 minor planets already numbered before his death, considering his long career, but it is doubtful that he had seen 1000 different asteroids. Some objects were lost or non-existent and at that time astronomical news did not quickly go round between world observatories. Orbital elements were also more imprecise than now. In order to know his score, one should analyze Palisa observation reports and *the Astronomische Nachrichten* until 1924. The answer is surely in Germany or in Austria. Perhaps a local *MPB* reader will release it one day?

With the advent of CCD cameras, another era has begun... taking over from that of photographic and visual observers for whom it took long years to reach 1000 asteroids, a number accessible by an amateur in one or two months with CCD cameras. Nevertheless, visual observers can continue useful work by effecting the watch of stellar occultations by asteroids and by the observation of minor planets to detect those which magnitudes V and H would be inaccurate, through the participation to the Magnitude Alert Project of Lawrence Garrett. The most significant discrepancies visually found between 1980 and 1997 are in the table below. This table shows the interest of this type of visual work on asteroids.

I thank all the people who have helped me in the preparation of this paper, particularly Dr. Pilcher for his valuable assistance. Finally, I hope that this article will arouse new amateur vocations for asteroid observations and searches, whether by visual or other techniques, and that discoveries will be numerous.

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TABLE I. SELECTION OF GREAT DISCREPANCIES OF MAGNITUDE SEEN VISUALLY FROM 1980 TO 1997

ASTEROIDS	DISCREPANCY OBSERVED ON MAG.V	DATES	NAME OF OBSERVERS	MAG. B(1,0) EMP 87	MAG. H EMP 88-91	MAG.H EMP 92-97	REMARKS
	(F=fainter/B=brighter than predicted in the annual EMP)						
316 GOBERTA	1.2 +B	88/11/11	PILCHER	11.5	11.52	9.8	CORRECTION ON EMP92
473 NOLLI	1.0 +F	88/02/10	HARVEY		10.0	12.3	CORRECTION ON EMP92
1206 NUMEROWIA	1.6 +F	89/10/22	HARVEY	12.4	9.48	11.2	CORRECTION ON EMP92
1212 FRANCETTE	2.0 +F	80/02/12	PILCHER	8.0	9.38	9.54	CORRECTION ON EMP87
	0.8 +F	83/08/09	FABRE				(VAR.>= 0,04 MAG)
	2.2 +F	85/10/10	HARVEY				
1293 SONJA	1.8 +F	92/11/08	HARVEY	15.4	14.0	12.0	ERROR ON EMP92
	1.3-1.6 +F	96/08/09	FAURE				
1656 SUOMI	1.0 +F	87/11/21	HARVEY	15.4	13.1	12.4	ERROR ON EMP87/92
	1.1 +F	96/02/24	FAURE				
1663 VAN DEN BOS	1.5 +B	90/11/12	HARVEY	14.9	13.7	12.2	CORRECTION ON EMP92
1890 KONOSHENKOVA	1.0 +F	95/12/21	HARVEY	12.6	11.2	10.8	ERROR ON EMP92 ?
2143 JIMARNOLD	2.5 +F	97/08/31	FAURE	15.3	14.1	11.2	ERROR ON EMP92
2183 NEUFANG	1.0 +F	90/06/20	HARVEY	12.6	11.4	11.5	VAR. > 0,1 MAG
2491 TVASHTRI	1.5 +F	87/01/03	HARVEY	14.6	13.74	13.68	
2791 PARADISE	1.3 +F	88/01/24	HARVEY	13.0	11.5	12.24	VAR. 0,25 MAG
3578 CARESTIA	1.8 +F	91/10/04	FAURE		10.5	8.1	ERROR ON EMP89
	1.9 +F	91/10/13	HARVEY				
	3.0 +F	96/07/22	GARRETT				ERROR ON EMP92
	3.1 +F	96/09/04	GARRETT				
3873 RODDY	1.4 +F	92/12/03	HARVEY		13.1	11.8	ERROR ON EMP92
	1.3-1.6 +F	96/06/11	FAURE				
4116 ELACHI	1.2 +F	94/03/16	HARVEY		13.30	13.0	
4729 1980 RO2	1.3 +B	90/10/17	HARVEY			13.1	
4744 1988 RF5	1.2 +F	91/01/26	HARVEY		11.6	10.9	ERROR ON EMP92 ?
5641 MC CLEESE	1.7 +F	95/03/25	HARVEY			12.7	
5905 1981 CJ1	1.1-1.4 +F	95/08/02	HARVEY			13.0	

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RECOVERIES, FOLLOW-UP OBSERVATIONS AND NUMBERING OF MINOR PLANETS

Paul G. Comba
1411 Galaxy Lane
Prescott AZ, 86303
e-mail: comba@northlink.com

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This paper discusses follow-up observations of previously discovered asteroids, and the development of strategies to enhance the effectiveness of observations from discovery to numbering.

A previous paper (Comba 1997) described the author's minor planet observing activities at Prescott Observatory during the first fully-instrumented year of operation. Starting in March, 1996, observations were made with a 46-cm f/4.5 reflector and an ST-8 CCD camera, and analyzed with the Astrometrica program. The net results were the discovery of 207 minor planets, plus several hundred astrometric observations of other asteroids. (The referenced paper gave 210 as the number of discoveries, but it was later found that 3 of them were duplicates.)

This paper discusses the recoveries and re-observations of a subset of the first year's discoveries, and presents some strategies intended to improve the effectiveness of observations, from discovery to the numbering of the asteroids.

Review of discovery process

1. An observer obtains astrometric observations of a moving object on two nearby nights and sends them to the Minor Planet Center (MPC). The MPC tries to determine whether the observations pertain to a known object. If no such identification can be made, the object is given a provisional designation, such as 1996 FP3. In either case, the observer is informed of the result. The receipt of a provisional designation may be considered a discovery in the extended sense.

2. If further observation of the object are submitted to the MPC in the following weeks, the MPC computes a more precise orbit. It may then happen that, upon further checking, the new object is found to be identical to a previously discovered one that was given a different designation. The MPC then declares one of the designations to be the principal one, and the corresponding observer gets credit for the discovery. The principal designation is awarded not necessarily to the first discoverer, but to the one who first supplies the observations from which a "reasonable" orbit is determined.

3. When a minor planet has been observed repeatedly at several oppositions, so that a very precise orbit can be computed, it gets numbered. In the strict sense, a discovery is recognized only when the planet's number and the discoverer's name are published in the Minor Planet Circulars. The requirements for numbering are discussed further below.

Follow-up on first year discoveries

Table I classifies the discoveries made in the first year and their subsequent history. The class labels are briefly described in the body of the table. L+ and L- refer to objects that were identified (linked) with earlier discoveries, and were credited to the author or to another discoverer respectively. The numeric class labels refer to the number of days from the first to the last observation during the discovery opposition. In general, the objects in the classes L+, L- and 50+ were brighter than visual magnitude 18.5 at discovery, while the others were fainter. Among the class L+ objects, 11 had been observed at one previous opposition, 8 at two, and 2 at three.

One column shows the number of objects that were recovered (the term applies to objects that have been observed at a single opposition) or re-observed at a later opposition; this number does not include those that were subsequently numbered. The "missed" objects were searched for repeatedly over a fairly wide area, hence their residuals (observed minus calculated) were probably 15 arc minutes or more. The "too faint" could not be reobserved because of their being too faint, too low in the sky, or in the Milky Way.

The single "too faint" object in the 50+ class was 1996 UJ, a Mars crosser that was at opposition in May 1998 at magnitude 21, declination -43, and in the Milky Way--a triple whammy. The 3 rediscoveries of class 30- were unplanned and made accidentally by other observers.

Figure 1 is a plot of the recovery R. A. residuals as a function of the observation arc length. The R. A. residuals were in all cases much greater than the Dec. residuals. It should be noted that many recoveries occurred well before opposition, when the objects had a smaller apparent motion and less time had elapsed since the previous opposition observations. The median residual for class 50+ objects is 1.3 arc minutes, and it is clear from Figure 1 that almost all these objects could have been recovered even with a camera/telescope having a rather small field, say 10 arc minutes.

In light of the first year's experience, an effort was made in the second year to increase the number of discoveries of brighter objects (magnitude less than or equal to 18.5). This was achieved in part by doing some searches with a smaller telescope, 25-cm f/4, which yields a field of 47x31 arc minutes. Brighter objects are more likely to have been observed before, or of being observable for 50 days or more. As a result, while the total number of discoveries declined to 175, the number of class L+ or 50+ objects increased to 51.

Optimal patterns of observations

Beginning observers and discoverers tend to make unnecessarily many observations. To define a sufficient but non-redundant pattern of observations, one must consider several issues. First, how many observations of the same field should be made on a given night? If the purpose is to discover new objects, the answer is two, and the images should preferably be

Table I. Disposition of first year discoveries

Class	Description	Total	Reobs/ recov	Reobs & numbered	Missed	Too faint
L+	Linked, credited to author	21	10	8		3
50+	Arc of 50 days or more	21	20			1
30-49	Arc of 30 to 49 days	9	3		3	3
30-	Less than 30 days, 3+ nights	76	3			
2N	2 nights	73				
L-	Linked, credited to others	7				

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taken over several fields in rotation, (e. g., 1 2 3 1 2 3). This insures a longer time interval between images of the same field, hence a better estimate of the proper motion of any object that may be discovered.

If the purpose is to observe a known object, the opinion of the experts (Bowell et al., 1989) is that "The measurement of three (or more) positions of a main-belt asteroid on the same night is usually a waste of time". The author examined a small sample (N=25) of triplets of his own observations, and found that in 80 percent of the cases they were so perfectly consistent that the third observation was indeed redundant. In the other 20 percent of the cases there may be a very small advantage in having three data points instead of two.

If one can blink a pair of images at the telescope, and finds two clear asteroid images, that should certainly settle the matter. However, if the images can be blinked only later, there are several reasons why a third image may be desirable:

1. It may happen, specially in a crowded star field, that one or even two asteroid images are too close to a star to be measurable. The third exposure is a form of insurance against this eventuality, specially desirable if the Moon or weather may interfere with re-observing the object in the near future.

2. CCD images tend to be noisy from cosmic-ray hits and other artifacts. In rare cases, it may take 3 images to unequivocably identify a moving object.

3. The marginal cost of obtaining and measuring the third image is rather small, if one figures the overhead involved in planning the observations, acquiring and centering the field at the telescope, and setting up the astrometry program.

In the unlikely event that one discovers a fast moving object and recognizes it at the telescope, it is important to make more observations, preferably spread out over several hours, and to measure and communicate them to the MPC as soon as possible.

With two observations of a newly discovered asteroid, one can compute its apparent daily motion by dividing the difference of of the coordinates at the two positions by the time difference, expressed as a fraction of a day. If the motion is retrograde, as is the case near opposition, this calculation overestimates the R.A. motion by about 2 or 3 time seconds, depending on the (unknown) distance of the asteroid, because of the parallax effect due to the Earth's rotation. This correction is independent of the time interval between the observations.

From the daily motion, one can get an estimate of the object's positions for the next several days. If the object is before opposition, where it appears to accelerate, the actual motion is likely to be slightly greater than the estimate; and viceversa after opposition.

After the two nights' observations are sent to the MPC, they compute a Vaisala orbit. This is an approximate orbit from which an ephemeris can be computed that gives reasonably good predictions for the next 10 to 15 days. The ephemeris can be obtained by subscribing to the MPC Computer Service or by connecting with the MPC web site at

http://cfa-www.harvard.edu/iau/MPEph/MPEph.html

To plan the next set of observations, two considerations apply. First, orbit computers find it very advantageous to have observations in pairs of nearby nights: this makes it possible to establish the reliability of the observations. Second, while an arc of 50 days has proved quite adequate to achieve a recovery, it is just as easy, with some planning, to stretch the same observations over 60 days. In that case, the MPC usually classifies the orbit as "long arc", computes ephemerides using perturbations (making them more precise), and publishes its U parameter (discussed below).

This prompts us to propose the following as the ideal observation schedule, counting the days from the day of discovery: (0 1 7 8 30 31 60 61). Of course the weather may interfere with the schedule, and the pair (7 8) may have to be moved forward on account of the Moon. If an asteroid has been previouly observed, the identification can often be made after the first 4 nights, making it then a multi-opposition object.

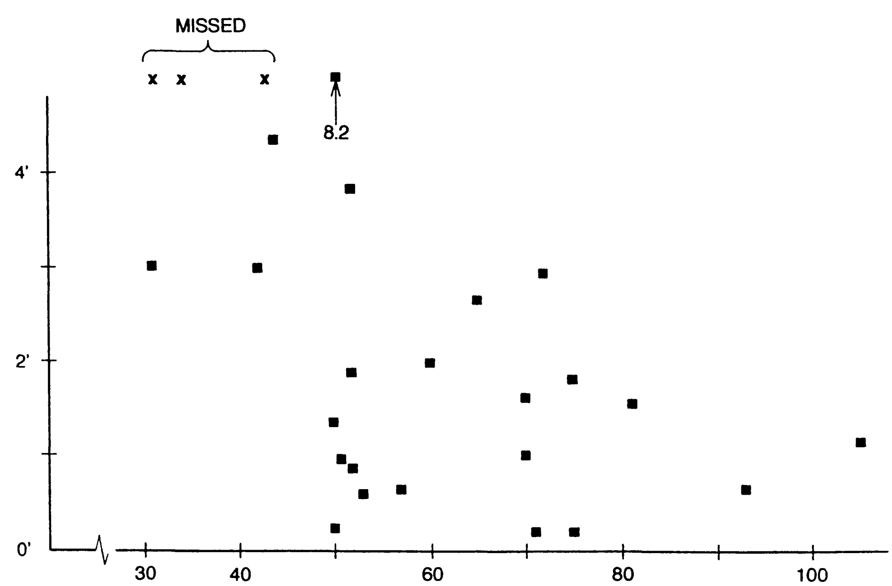

FIGURE 1. RECOVERY R. A. RESIDUALS (ARC MIN) vs OBSERVATION ARC (DAYS)

Multi-opposition objects and numbering

We assume that the goal of an asteroid observing program is to accumulate enough observations on individual asteroids so they can ultimately be numbered. To this end, it is useful to know the numbering rules. These rules, devised for the purpose of insuring that no numbered asteroid would ever be lost (as had happened in the past), have become stricter over the years. At the present time, they are essentially embodies into two parameters, U and J, derived from an asteroid's observations and orbital elements.

U (uncertainty) is explained in detail at the MPC website at

http://cfa-www.harvard.edu/iau/info/UValue.html

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U measures, on a logarithmic scale, the estimated position error per decade along the orbit, with U=0 indicating an error of 1 arc second and U=9 of half an orbit. The requirement for numbering is U<=2. Most long-arc asteroids have U=4 or 5 or occasionally 6. Most two-opposition objects have U=3 or 4. In practice, objects with U<=5 can be recovered without difficulty at the next opposition.

The parameter J is only partially explained in (Marsden 1996). It is a sum of several terms intended to weigh the number of oppositions at which an asteroid has been observed, the number of elapsed years, the number of observations at each opposition, and the spread of the observations. A score >=23 typically leads to numbering. The ideal pattern of observations at any opposition appears to be one pairs of nights in each of three lunations, which contributes 8 points to the sum J. In most cases, it takes observations at 4 or more oppositions before the requirements on U and J are met.

While this information is useful for planning an observing schedule, it is the author's opinion that a full description of the computation of J, and the publication of J alongside U in the Minor Planet Circulars, would be of interest to observers and would contribute to the avoidance of redundant observations.

A changing environment

The number of reported observations of minor planets has increased dramatically in recent months, as several programs have intensified the search for potentially hazardous near-earth objects. In May and June 1998 the Lincoln Laboratory Experimental Test Station in New Mexico reported twice as many observations as all the other observatories combined. Meanwhile, Lowell Observatory is gearing up for a very ambitious program (The Lowell Observer, 1998) whereby the entire accessible dark sky would be imaged three times per month to a limiting magnitude of 19.

How will these developments affect the amateur? One can expect, over a period of years, that the number of discoverable asteroids will diminish. With the plethora of expected observations, the concern for redundant observations will vanish, and the follow-up problem will be automatically solved--in most cases. Two niches where amateur will continue to make valuable contributions are the follow-up of (a) fast moving near-earth objects, and (b) objects that move out of the range of the automated observatories, e.g., to the deep southern sky.

For the near future, however, asteroid hunting remains a viable occupation.

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ASTEROID NEWS NOTES

David J. Tholen
Institute for Astronomy
University of Hawaii
Honolulu, HI 96822

Eight Hundred Twenty Three Newly Numbered Asteroids

Since the last installment of News Notes, 823 asteroids have been numbered to crash through the 9000 level and bring the numbered total to 9142. Non-main-belt objects among these include:

(8348)	1988 BX	Hungaria
(8355)	1989 RQ1	Mars crosser
(8373)	1992 AB	Mars crosser
(8376)	1992 OZ9	Hilda
(8404)	1995 AN	Hungaria
(8405)	1995 GO	Centaur
(8444)	1969 TR1	Mars crosser
(8482)	1988 RA11	Cybele
(8507)	1991 CB1	Apollo
(8550)	1994 PV24	Hilda
(8551)	1994 VC7	Hilda
(8566)	1996 EN	Apollo
(8567)	1996 HW1	Amor
(8651)	1989 YU5	Mars crosser
(8709)	Kadlu	Mars crosser
(8721)	AMOS	Hilda
(8743)	1998 EH12	Hilda
(8825)	1988 MF	Hungaria
(8913)	1995 YB2	Hilda
(8915)	1995 YK3	Hilda
(8917)	1996 EU2	Cybele
(8988)	1979 MA4	Cybele
(9023)	1988 RG1	L5 Jupiter Trojan
(9030)	1989 UX5	L5 Jupiter Trojan
(9058)	1992 JB	Apollo
(9068)	1993 OD	Mars crosser
(9069)	1993 OV	Hungaria
(9082)	1994 VR6	Mars crosser
(9084)	1995 CS1	Hungaria
(9121)	1998 DJ11	Hilda
(9142)	5191 T-3	L5 Jupiter Trojan

New Asteroid Names

The highest numbered asteroid that is also named is currently (8725) Keiko, while the lowest numbered asteroid that remains unnamed is (3109) 1974 DC. The previous holder of this distinction, (3081) 1971 UP, was finally named Martinuboh. The total of numbered but unnamed asteroids jumped from 2469 to 3122, so there are now 6020 named asteroids (not counting the unnumbered near-Earth object Hermes), which means there have been only 170 new names attached to numbered asteroids since the last installment of News Notes. I suspect that most of those names are not familiar to MPB readers, though I recognize some names of former or current scientists associated with my graduate institution, The University of Arizona's Lunar and Planetary Laboratory.

(6141)	Durda	Arizona
(7225)	Huntress	NASA Associate Adminis-trator for Space Science
(7231)	Porco	Arizona
(7355)	Bottke	Arizona
(7749)	Jackschmitt	last person to walk on the Moon

Planet Crossing Asteroid Update

The list below includes 132 discoveries since the last installment of News Notes. The trans-Neptunian population is now up to 68. The Lincoln Labs Experimental Test Site in New Mexico is now bearing the fruit of considerable development effort on fast-readout CCDs. They are covering enormous chunks of sky and finding more Earth-approaching objects than anyone else.

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Object	Category	Diam km	Date	Location	Discoverer(s)
1997 GA45	Pluto crosser	180.	Apr 03	Mauna Kea	Kavelaars et al.
1997 UF25	Pluto crosser	110.	Oct 26	La Palma	Fletcher et al.
1997 UG25	Pluto crosser	140.	Oct 26	La Palma	Fletcher et al.
1998 DK36	Apohele	0.038	Feb 23	Mauna Kea	Tholen et al.
1998 EP8	Amor	0.6	Mar 02	ODAS	Maury et al.
1998 EG14	Mars crosser	3.8	Mar 01	La Silla	
1998 FF2	Amor	0.6	Mar 20	Lincoln Lab	Blythe et al.
1998 FG2	Apollo	0.19	Mar 21	Tucson	Tucker
1998 FP2	Mars crosser	1.9	Mar 20	Lincoln Lab	Blythe et al.
1998 FX2	Amor	0.8	Mar 22	Lincoln Lab	Blythe et al.
1998 FL3	Apollo	0.15	Mar 22	Spacewatch	Scotti
1998 FW4	Apollo	0.6	Mar 20	Lincoln Lab	Blythe et al.
1998 FK5	Mars crosser	3.0	Mar 24	Lincoln Lab	Blythe et al.
1998 FL5	Apollo	0.19	Mar 22	Lincoln Lab	Blythe et al.
1998 FM5	Apollo	2.4	Mar 24	NEAT	Helin et al.
1998 FM9	Amor	0.48	Mar 24	Lincoln Lab	Blythe et al.
1998 FN9	Amor	0.24	Mar 24	Lincoln Lab	Blythe et al.
1998 FR11	Apollo	2.4	Mar 24	Lincoln Lab	Blythe et al.
1998 FS11	Mars crosser	0.48	Mar 24	NEAT	Helin et al.
1998 FC12	Mars crosser	3.8	Mar 25	NEAT	Helin et al.
1998 FG12	Apollo	0.24	Mar 24	Lincoln Lab	Blythe et al.
1998 FH12	Apollo	0.6	Mar 25	Lincoln Lab	Blythe et al.
1998 FF14	Apollo	0.30	Mar 24	Lincoln Lab	Blythe et al.
1998 FJ14	Mars crosser	1.5	Mar 22	Lincoln Lab	Blythe et al.
1998 FB41	Mars crosser	1.9	Mar 20	Lincoln Lab	Blythe et al.
1998 FL43	Mars crosser	8.	Mar 20	Lincoln Lab	Blythe et al.
1998 FB73	Mars crosser	1.5	Mar 29	ODAS	Maury et al.
1998 FH74	Apollo	3.0	Mar 31	Lincoln Lab	Blythe et al.
1998 FJ74	Amor	0.8	Mar 31	Lincoln Lab	Blythe et al.
1998 FX134	Amor	0.8	Mar 20	Lincoln Lab	Blythe et al.
1998 GH	Mars crosser	2.4	Apr 02	Lincoln Lab	Blythe et al.
1998 GK	Mars crosser	3.0	Apr 02	Lincoln Lab	Blythe et al.
1998 GC1	Amor	0.24	Apr 02	Lincoln Lab	Blythe et al.
1998 GL10	Amor	1.0	Apr 15	Lincoln Lab	Blythe et al.
1998 GM10	Mars crosser	0.8	Apr 15	Lincoln Lab	Blythe et al.
1998 GQ10	Mars crosser	3.0	Apr 04	Fair Oaks	
1998 HH1	Amor	0.10	Apr 17	Spacewatch	Larsen
1998 HK1	Amor	0.48	Apr 18	Lincoln Lab	Blythe et al.
1998 HL1	Apollo	0.6	Apr 18	Lincoln Lab	Blythe et al.
1998 HM1	Apollo	0.048	Apr 18	Spacewatch	Larsen
1998 HX2	Mars crosser	3.0	Apr 21	Lincoln Lab	Blythe et al.
1998 HE3	Aten	0.19	Apr 21	Tucson	Tucker
1998 HJ3	Apollo	0.8	Apr 19	Lincoln Lab	Blythe et al.
1998 HK3	Amor	1.2	Apr 20	Lincoln Lab	Blythe et al.
1998 HL3	Apollo	0.38	Apr 21	Lincoln Lab	Blythe et al.
1998 HM3	Amor	0.8	Apr 21	Lincoln Lab	Blythe et al.
1998 HN3	Amor	0.8	Apr 19	Spacewatch	Larsen
1998 HN4	Mars crosser	2.4	Apr 22	Spacewatch	
1998 HK7	Mars crosser	4.8	Apr 23	Lincoln Lab	Blythe et al.
1998 HP7	Mars crosser	3.0	Apr 23	Lincoln Lab	Blythe et al.
1998 HS7	Mars crosser	2.4	Apr 23	Lincoln Lab	Blythe et al.
1998 HF8	Mars crosser	0.8	Apr 19	Spacewatch	
1998 HG8	Mars crosser	1.0	Apr 21	Spacewatch	
1998 HZ12	Mars crosser	4.8	Apr 02	La Silla	
1998 HD14	Aten	0.24	Apr 25	NEAT	Helin et al.
1998 HR24	Mars crosser	2.4	Apr 24	Visnjan	
1998 HT31	Apollo	0.24	Apr 29	NEAT	Helin et al.
1998 HJ41	Amor	1.0	Apr 28	Lincoln Lab	Blythe et al.
1998 HK43	Mars crosser	2.4	Apr 25	Visnjan	
1998 HG48	Mars crosser	4.8	Apr 20	Lincoln Lab	Blythe et al.
1998 HG49	Amor	0.15	Apr 27	Spacewatch	Gehrels
1998 HH49	Apollo	0.19	Apr 28	Spacewatch	Gehrels
1998 HK49	Apollo	0.12	Apr 29	Spacewatch	Gehrels
1998 HL49	Apollo	1.2	Apr 30	Spacewatch	Scotti
1998 HP49	Mars crosser	1.9	Apr 30	NEAT	Helin et al.
1998 HH52	Mars crosser	4.8	Apr 30	LONEOS	
1998 HV78	Mars crosser	3.8	Apr 21	Lincoln Lab	Blythe et al.
1998 HJ89	Mars crosser	1.2	Apr 21	Lincoln Lab	Blythe et al.
1998 HU108	Mars crosser	1.5	Apr 23	Lincoln Lab	Blythe et al.
1998 HD124	Mars crosser	4.8	Apr 23	Lincoln Lab	Blythe et al.
1998 JU1	Mars crosser	6.	May 01	NEAT	Helin et al.
1998 JZ1	Mars crosser	3.0	May 01	NEAT	Helin et al.
1998 JH2	Amor	1.5	May 01	Spacewatch	Scotti
1998 JJ4	Mars crosser	3.0	May 15	Woomera	
1998 KH	Apollo	0.8	May 16	Lincoln Lab	Blythe et al.
1998 KC2	Mars crosser	2.4	May 22	Lincoln Lab	Blythe et al.
1998 KU2	Apollo	1.5	May 22	Lincoln Lab	Blythe et al.
1998 KV2	Amor	1.2	May 22	Lincoln Lab	Blythe et al.
1998 KD3	Apollo	0.24	May 24	Lincoln Lab	Blythe et al.
1998 KE3	Mars crosser	3.0	May 23	Lincoln Lab	Blythe et al.
1998 KF3	Amor	0.6	May 23	Lincoln Lab	Blythe et al.

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Object	Category	Diam km	Date	Location	Discoverer(s)
1998 KG3	Amor	0.12	May 22	Spacewatch	Scotti
1998 KM3	Apollo	0.48	May 24	Lincoln Lab	Blythe et al.
1998 KN3	Apollo	0.8	May 24	Lincoln Lab	Blythe et al.
1998 KO3	Apollo	0.5	May 24	Lincoln Lab	Blythe et al.
1998 KF6	Mars crosser	0.38	May 23	Lincoln Lab	Blythe et al.
1998 KH9	Amor	0.8	May 27	Lincoln Lab	Blythe et al.
1998 KJ9	Apollo	0.48	May 27	Lincoln Lab	Blythe et al.
1998 KK16	Mars crosser	1.2	May 22	Lincoln Lab	Blythe et al.
1998 KH17	Mars crosser	2.4	May 28	Lincoln Lab	Blythe et al.
1998 KJ17	Amor	0.08	May 28	Lincoln Lab	Blythe et al.
1998 KK17	Apollo	1.9	May 29	Lincoln Lab	Blythe et al.
1998 KY26	Apollo	0.030	May 28	Spacewatch	Gehrels
1998 KH56	Mars crosser	3.0	May 27	Lincoln Lab	Blythe et al.
1998 KK56	Mars crosser	1.9	May 27	Lincoln Lab	Blythe et al.
1998 KR61	Mars crosser	3.0	May 23	Lincoln Lab	Blythe et al.
1998 KY61	Pluto crosser	220.	May 29	Cerro Tololo	Jones et al.
1998 KG62	Pluto crosser	350.	May 29	Cerro Tololo	Jones et al.
1998 KR65	Pluto crosser	280.	May 29	Cerro Tololo	Jones et al.
1998 KS65	Pluto crosser	220.	May 29	Cerro Tololo	Jones et al.
1998 LD	Amor	0.30	Jun 03	Lincoln Lab	Blythe et al.
1998 LE	Apollo	0.30	Jun 04	Lincoln Lab	Blythe et al.
1998 MQ	Amor	1.9	Jun 18	LONEOS	Onken et al.
1998 MZ	Apollo	0.48	Jun 18	Spacewatch	Scotti
1998 MR2	Mars crosser	3.0	Jun 19	Lincoln Lab	Blythe et al.
1998 MS2	Amor	0.30	Jun 20	Catalina	Larson et al.
1998 ME3	Amor	0.6	Jun 19	Lincoln Lab	Blythe et al.
1998 MV5	Apollo	0.06	Jun 23	Lincoln Lab	Blythe et al.
1998 MW5	Apollo	0.6	Jun 24	Lincoln Lab	Blythe et al.
1998 MX5	Amor	1.0	Jun 24	Lincoln Lab	Blythe et al.
1998 ML14	Apollo	1.2	Jun 24	Lincoln Lab	Blythe et al.
1998 MM14	Mars crosser	0.8	Jun 24	Lincoln Lab	Blythe et al.
1998 MN14	Amor	1.0	Jun 25	Lincoln Lab	Blythe et al.
1998 MR17	Mars crosser	2.4	Jun 26	Lincoln Lab	Blythe et al.
1998 MP22	Mars crosser	4.8	Jun 24	Lincoln Lab	Blythe et al.
1998 ML24	Mars crosser	1.2	Jun 29	Spacewatch	
1998 MR24	Amor	0.6	Jun 30	Lincoln Lab	Blythe et al.
1998 MT24	Apollo	3.8	Jun 29	Lincoln Lab	Blythe et al.
1998 MJ30	Mars crosser	0.8	Jun 29	Spacewatch	
1998 MK30	Mars crosser	3.0	Jun 30	Lincoln Lab	Blythe et al.
1998 MA42	Mars crosser	2.4	Jun 26	Reedy Creek	
1998 MA44	Mars crosser	1.5	Jun 26	La Silla	
1998 ND	Mars crosser	3.8	Jul 01	LONEOS	
1998 NU	Amor	2.4	Jul 02	Spacewatch	Montani
1998 OH	Apollo	2.4	Jul 19	NEAT	Helin et al.
1998 OK1	Apollo	0.48	Jul 21	Lincoln Lab	Blythe et al.
1998 OR2	Amor	1.9	Jul 24	NEAT	Helin et al.
1998 OP4	Amor	0.06	Jul 27	Spacewatch	Scotti
1998 OS4	Mars crosser	0.6	Jul 26	LONEOS	Koehn
1998 OX4	Apollo	0.19	Jul 26	Spacewatch	Scotti
1998 PF	Mars crosser	6.	Aug 02	LONEOS	Onken
1998 PG	Amor	1.5	Aug 03	LONEOS	Onken

A June 24 Apollo discovery by the NEAT project, designated 1998 MY5, turned out to be the same object as 1994 CK1. The identification was made by J. Rogers.

The discoveries of some of the more shallow Mars crossers are not routinely annnounced on the Minor Planet Electronic Circulars, and the discoverer information does not appear in the Minor Planet Circulars, which explains the blank entries in the table above.

First Asteroid With Orbit Entirely Inside Earth's Orbit Found

As noted in the last installment of News Notes, the writer has initiated a program to search for asteroids with aphelion distances less than or equal to 1 AU. On February 23, R. Whiteley spotted a faint trail on images the writer had taken earlier in the evening. It was quite a catch, because the end of the trail fell into the gap between two of the CCDs in the 8192x8192 mosaic that we were using, and the beginning of the trail on the second exposure of the pair was still in the gap. Observations on the following night are consistent with a topocentric distance of about 0.04 AU at the time of the observations. Instrument problems prevented additional followup observations from being obtained, so the semimajor axis and eccentricity of the orbit are quite uncertain, but the geometry of the observations was such that the aphelion distance is rather well constrained to be about 0.980 AU. At the longitude of the object's aphelion, the Earth is at a distance of 0.989 AU, so the object, designated 1998 DK36, apparently has an orbit entirely inside the Earth's orbit, the first such object to be found. As such, it would not be found by any opposition search effort. Clearly, the NEO search community needs eyes in the back of its head, so to speak.

Being different from the Atens, Apollos, and Amors, a new term seems to be warranted to distinguish these objects. "Apohele" (pronounced ah-poe-hay-lay) has been suggested; it is the Hawaiian word for "orbit", and seems appropriate for an object with an apoapsis (the generic form of the specific term aphelion) closer to the Sun (helios, from the Greek) than the Earth's orbit. This term appears in the table above. The distinction between the various categories of Earth approaching asteroids are summarized in the following chart, where q refers to the perihelion distance and Q refers to the aphelion distance:

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semimajor axis less than 1 AU		semimajor axis greater than 1 AU	
Q < 0.983 AU	Q > 0.983 AU	q < 1.017 AU	q < 1.017 AU
"Apohele"	Aten	Apollo	Amor
approaches from inside	crosses the orbit of the Earth		approaches from outside

Lightning Strikes Twice: Tucker Wins Second Benson Prize

As reported in the last installment of News Notes, Jim Benson of the Space Development Corporation has put up $5,000 as prize money to encourage amateur astronomers to find Earth-crossing asteroids. The first ten amateur discoveries will each receive $500. The first discovery to qualify for the prize was the Aten-class object 1997 MW1, found last June 29 by Roy Tucker of Tucson, Arizona. The second discovery to qualify is the Apollo-class object 1998 FG2, also found by Tucker.

Tucker's discovery came on March 21 this year; his goal is to cut down on the nine-month interval between his NEO discoveries.

The Ramans Do Things In Threes

The title of this news item is taken from one of the great closing lines in science fiction. It seemed appropriate, because Mr. Tucker has also found Earth-crossing asteroids in threes. On April 21, he discovered 1998 HE3, an Aten-class object. Two of his three discoveries are members of the Aten group. It qualifies him for the third Benson Prize, and is so far the only person to win one.

Obviously, Tucker succeeded at his goal of cutting down on the interval between his NEO discoveries.

ASTEROID PHOTOMETRY OPPORTUNITIES NOVEMBER-JANUARY

Alan W. Harris
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109

Vincenzo Zappalà
Observatorio Astronomico di Torino
10025 Pino Torinese
Italy

The table below lists asteroids that come to opposition during the months of November through January that represent useful targets for photoelectric or CCD photometry observations. Observations are typically needed because the asteroid has either an unknown or ambiguous rotational period. 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. Question marks are used to denote uncertain or unknown values.

Now that many amateur and other small observatories have CCD capabilities, much fainter targets are accessible to them. Therefore, we have included a selection of fainter targets, down to opposition magnitude 15. Our emphasis among these fainter targets is to reach to the smallest size bodies possible within that magnitude limit. Thus the objects listed tend to be inner-belt asteroids, or even Mars or Earth-crossing objects, at unusually favorable oppositions. To achieve this, we filter the list of all oppositions to include those objects with H (absolute) magnitude >14.0 (roughly <5 km in diameter), but opposition V magnitude <15.0, and then further eliminate any objects for which adequate observations have already been made. Our criteria for the brighter objects remains the same: opposition V magnitude <12.0 and that the period is unknown, very uncertain, or ambiguously determined. We have dropped low phase angle as a criterion for inclusion, as it seems no one has responded to past listings suggesting phase relation observations.

Ephemerides for any solar system object can be calculated with the HORIZONS program; see the web page at http://ssd.jpl.nasa.gov/ . Finder charts for some of these asteroids may appear in the *Minor Planet Observer.* For information on this publication, contact: Brian D. Warner, Box 818, Florissant, CO 80816.

Asteroid		Opp'n Date	Opp'n V Mag	Per	Amp	
181	Eucharis	Nov 11	11.9	>24	0.1	PER
6485	Wendeesther	Nov 19	14.5	?	?	PER
	1996 FG3	Nov 25	14.3	?	?	PER
5732	1988 WC	Dec 11	14.4	?	?	PER
4558	Janesick	Dec 21	14.4	100	>0.1	PER
351	Yrsa	Jan 10	11.7	?	?	PER
206	Hersilia	Jan 27	12.0	7.33?	0.1	PER
240	Vanadis	Jan 28	11.7	?	?	PER

Asteroid Photometry Opportunities

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