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

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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 Administrator 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.

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.

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:

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

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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