The Comets of 1993

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A report of the Comet Section (Director: J. D. Shanklin)

This report is the fourth in the present annual series[1,2,3] which gives for each comet: the discovery details, orbital data and general information, magnitude parameters and BAA comet section observations. Further details of the analysis techniques used in this report are given in an earlier paper[4]. Ephemerides for the comets predicted to return during the year can be found in the ICQ Handbook[5]. Analysis of the observations of the degree of condensation (DC) suggests that observers need to study the figures in the Section Handbook.

Table 1. Orbital data for the comets of 1993[6]

Comet				T	q	e	P	ω	Ω	i
a	A1	Mueller	1994 I	94 Jan 12.8834	1.937531	1.001779		130.6569	144.7224	124.8778
b		87P/Bus	1994 XVI	94 June 28.1444	2.183112	0.374643	6.52	24.4040	182.2214	2.5730
c		9P/Tempel 1	1994 XIX	94 July 3.3085	1.494152	0.520255	5.50	178.9021	68.9853	10.5519
d	F1	Mueller	1992 XX	92 Aug 4.5903	5.900821	1.005641		62.0038	77.5149	53.9402
e	F2-Q	D/Shoemaker-Levy 9	1994 X	94 Mar 30.2298	5.379401	0.207429	17.7	355.0085	220.9268	5.8232
f		37P/Forbes	1993 IV	93 Mar 14.6322	1.446844	0.568049	6.13	310.5365	334.4555	7.1591
g		44P/Reinmuth 2	1994 XVIII	94 June 29.6759	1.893065	0.464111	6.64	45.8765	296.1700	6.9819
h	K1	Shoemaker-Levy	1994 IV	94 Feb 2.0272	4.849239	1.000298		232.4553	30.3282	67.7670
i		17P/Holmes	1993 VII	93 Apr 10.7467	2.176756	0.410415	7.09	23.2227	328.0461	19.1704
j		42P/Neujmin 3	1993 XVI	93 Nov 13.0380	2.001304	0.586031	10.6	147.0117	150.4254	3.9869
k		61P/Shajn-Schaldach	1993 XVII	93 Nov 15.9828	2.344551	0.387678	7.49	216.5548	166.8929	6.0772
l	K2	P/Helin-Lawrence	1993 XI	93 June 30.3660	3.090216	0.308874	9.45	163.7345	92.0350	9.8831
m	M1	110P/Hartley 3	1994 XII	94 May 20.6289	2.461212	0.317011	6.84	168.4240	287.8817	11.6956
n		36P/Whipple	1993 XXXII	94 Dec 22.4272	3.093878	0.258714	8.53	201.8754	182.4952	9.9271
o		76P/West-Kohoutek-Ikemura	1993 XXI	93 Dec 25.3476	1.576783	0.543283	6.41	359.9771	84.1677	30.5410
p	Q1	Mueller	1994 IX	94 Mar 26.2797	0.967275	1.000278		261.0330	193.7890	105.0260
q	U1	112P/Urata-Niijima	1993 XII	93 July 13.5783	1.456645	0.587865	6.64	21.4823	31.9126	24.2141
r	U2	113P/Spitaler	1994 III	94 Jan 28.2341	2.133112	0.422316	7.10	50.2072	14.5125	5.7724
s	W1	P/Mueller 5	1994 XXV	94 Sep 12.0365	4.250042	0.260543	13.8	30.0045	100.6624	16.4657
t	X1	P/Kushida-Muramatsu	1993 XIX	93 Dec 10.1499	2.745172	0.277295	7.40	348.2876	93.7118	2.3670
u	X2	114P/Wiseman-Skiff	1993 IX	93 June 4.3173	1.509225	0.567806	6.53	171.9101	271.6565	18.1856
v	Y1	McNaught-Russell	1994 XI	94 Mar 31.0970	0.867641	0.993512		353.4698	166.3593	51.5868

The epoch of the elements for each comet is the Julian Date ending in zero, closest to the date of perihelion. New style designations for the comets are also given.

The elements for 1993e are for fragment Q.

Table 2. List of visual observers

Andre J Ayme de Rosamond	Australia
Sally Beaumont	Windermere, Cumbria
John E. Bortle	U.S.A.
Eric Broens	Belgium
Paul Camilleri	Australia
Matyas Csukas	Romania
Haakon Dahle	Norway
Alfons Diepvens	Belgium
Steve Evans	Towcester, Northants
James Fraser	Alness, Rossshire
Gordon Garradd	Australia
Bjoern Haakon Granslo	Norway
Werner Hasubick	Germany
Roberto Haver	Italy
Paul Haworth	Ravensthorpe, Northants
Lars Trygve Heen	Norway
Guy M. Hurst	Basingstoke, Hampshire

Albert F. Jones	New Zealand
Graham Keitch	Manaton, Devon
Attila Kosa-Kiss	Romania
James Lancashire	Cambridge
Andreas Lauvstad	Norway
Martin Lehky	Czech Republic
Oernulf Midtskogen	Norway
Herman Mikuz	Slovenia
Raymond Minty	Banff, Scotland
Roy W. Panther	Walgrave, Northampton
Alfredo Jose Serra Pereira	Portugal
Gary Poyner	Birmingham
Richard W Schmude	U.S.A.
David A. J. Seargent	Australia
John Seach	Australia
Jonathan D. Shanklin	Cambridge
Christopher E. Spratt	Canada
Tony Tanti	Malta
Melvyn D. Taylor	Wakefield, Yorkshire
Maura Tombelli	Italy
Frank Ventura	Malta
Peter F. Williams	Australia
Graham W. Wolf	New Zealand
C Wyatt	Australia
Mauro Vittorio Zanotta	Italy

Table 3. List of astrometric, CCD and Photographic Observers

Observer	Site	IAU Station No
Ron Arbour	South Wonston, Hants	
Andrea Boattini	Italy	108/552
Cecil Gilbert	Newcastle upon Tyne	
Bev Ewen-Smith	Portugal	
Werner Hasubick	Germany	
Nick James	Chelmsford, Essex	970
Martin Lehky	Czech Republic	
Brian Manning	Stakenbridge, Worcs	494
Jean-Claude Merlin	France	504
Herman Mikuz	Slovenia	106
Roy Mitchell	Eglinton, Co Londonderry	
Martin Mobberley	Galleywood, Suffolk	477/480
Bob Neville	Greens Norton, Northants	967
David Strange	Worth Matravers, Dorset	
Alex Vincent	Worthing, Sussex	
Peter Wroath	Newbury, Berks	

Table 4. Magnitude parameters of comets observed by the comet section.

A correction for aperture of 0.0033 mm^{-1} and the observer corrections derived in previous papers[1,2,3,4,7,8] have been applied and the H1 value is reduced to zero aperture. No comet had a sufficiently large coma to warrant including the coma correction. In addition to BAA/TA observations, some observations obtained from the internet have been used to augment the data available for the analyses.

	Comet	No	ΔR AU	H1	dev	K1	H10	dev	H15	dev
a	Mueller	833	1.9-4.5	5.5±0.1	0.6	6.9±0.2	4.3±0.1	0.7	2.4±0.1	1.0
c	9P/Tempel 1	206	1.5-2.0	5.2±0.3	0.6	23.4±1.2	8.1±0.1	0.7	7.0±0.1	0.6
e	D/Shoemaker-Levy 9	6	5.5				2.1±0.1	0.3	-1.6±0.1	0.3
g	44P/Reinmuth 2	5	1.9-2.3				9.8±0.4	0.8	8.3±0.4	0.9
m	110P/Hartley 3	2	2.6				8.1±0.1	0.1	6.0±0.1	0.1
o	76P/West-Kohoutek-Ikemura	4	1.6				12.0±0.2	0.4	11.0±0.2	0.3
p	Mueller[a]	303	1.0-3.3	7.4±0.1	0.7	6.6±0.3	6.3±0.1	0.9	4.7±0.1	1.3
r	113P/Spitaler	1	2.2				11.5		9.8	
v	McNaught-Russell[b]	773	0.9-1.5	8.6±0.1	0.8	7.7±0.6	8.7±0.1	0.8	8.9±0.1	0.8
	29P/Schwassmann-Wachmann 1	14	6.0-6.1				0.5±0.1	0.5	-3.4±0.1	0.5

a. Comet Mueller faded dramatically about a month after perihelion and the values given here apply up to 1994 April 20 only.

b. CCD and photographic magnitudes were not used in the analysis because they are substantially fainter than visual estimates for this comet.

The magnitude of the comets can be calculated from the equation:

$$m = H1 + 5.0 * \log(\Delta) + K1 * \log (r)$$

For most comets there are insufficient observations to calculate K1 accurately and so a value of 10 or 15 is assumed, which gives the constant H10 or H15 respectively. The formal error is given for each coefficient, followed by the rms deviation of the observations from the fitted curve.

The comets with year letter designations

a Mueller (1993 A1, 1994 I)

On January 2.4, Jean Mueller discovered a 15.5^m comet with the 1.2-m Oschin Schmidt on Mt Palomar during the course of the 2nd Palomar Sky Survey (PSSII) [IAUC 5657, 1993 January 4]. The comet was approaching opposition and still over a year from perihelion, moving slowly north west in Ursa Major.

After discovery the comet continued moving westwards into Lynx, where it completed its retrograde loop in early May. It then moved back into Ursa Major, crossing into Ursa Minor and reached its highest declination in mid October. Heading south east, it passed through Draco and Cygnus, reaching perihelion in Pegasus on 1994 January 12. Its motion south east slowed and when last seen in mid April it had reached the border of Pisces and Aquarius.

Section observations span the range T-371 to T+96 days. Herman Mikuz was able to secure images[9] of the comet almost immediately after the discovery announcement, making it 14^m on January 6 with his 0.20-m Schmidt and ST-6 CCD system. Werner Hasubick was able to photograph it at the end of February, but the first visual observation was not made until late April when Martin Lehky obtained visual estimates of 12.6 with a 0.20-m refractor. It was a low circumpolar object for mid latitude Northern hemisphere observers from mid-May until mid-August. Oernulf Midtskogen picked it up at 12.0^m on August 14 with his 0.32-m reflector x130. As it moved towards the pole and brightened, more observations were made. Jonathan Shanklin made it 11.1 on September 24 with the Thorrowgood 0.20-m refractor at the University of Cambridge. By mid October it had brightened further and had a larger coma diameter; Roy Panther estimating it at 9.8 with a coma diameter of 8' on October 18 in his 0.25-m reflector x35. A photograph by Martin Mobberley taken on October 16 was published in the Journal[10]. It was at its brightest in November, with Sally Beaumont estimating it at 8.7 in her 0.13-m refractor on November 20. It had faded a little by December and was moving south, but had developed a short tail. Nick James photographed it on December 4th[11]. James Lancashire observing with the Thorrowgood telescope x40 on December 11 estimated it at 9.2 with a 0.1° tail in pa 30°. Around perihelion in January it was becoming much harder

to observe, low in the twighlight, but Graham Keitch, observing under the clear skies of Dartmoor was able to follow it until early February; his last observation, with 25x150B on 1994 February 7, making it 9.6. After this only one further observation was received, though the ephemeris predicts that it should have been observable for some time from the southern hemisphere. Paul Camilleri, observing from Cobram, Victoria, Australia made it 10.5 in 20x80B on April 19.

The coma diameter increased from around 1' at discovery to 7' a little before closest approach to the earth in 1993 November (three months before perihelion), shrinking again to around 2' three months after perihelion. In real terms this corresponds to an increase from 150,000 km at discovery, to a broad maximum of around 400,000 km between 150 days before (T-150) and 25 days after perihelion (T+25). There is no significant pattern to the DC observations, with observers reporting values between 0 and 9. Generally the DC was around 3 to 4. The wide scatter in DC observations suggests that observers were not reporting this correctly. Sketches of representative DC values are given in the Section Handbook, and these are also available on the Section web page. A short tail was observed from T-150 to T. Maximum observed length of around 0.2° occurred at T-50, corresponding to a real length of 0.02 AU.

Table 5. Ephemeris for comet Mueller 1993a

Magnitudes calculated from $m = 5.7 + 5.0 * \log(\Delta) + 7.7 * \log(r)$
Latitude: 53.0°N Longitude: 0.0°W

Day	R.A. (2000.0)	Dec	Mag	Δ	R	Observable	Elong
	hh mm.m	°.mm		A.U.	A.U.	hh.mm to hh.mm	°
1993 January							
2/ 3	9 46.1	47.11	13.7	3.79	4.57	20.48 to 6.40	138
12/13	9 32.7	49.52	13.5	3.65	4.48	19.30 to 6.36	144
22/23	9 15.3	52.23	13.4	3.55	4.40	18.09 to 6.29	145
1993 February							
1/ 2	8 54.3	54.35	13.3	3.49	4.31	18.11 to 6.16	142
11/12	8 30.7	56.15	13.2	3.46	4.22	18.28 to 6.01	135
21/22	8 6.4	57.20	13.1	3.47	4.13	18.46 to 5.42	126
1993 March							
3/ 4	7 43.4	57.50	13.1	3.51	4.05	19.04 to 5.01	116
13/14	7 23.3	57.52	13.1	3.57	3.96	19.22 to 4.05	106
23/24	7 7.2	57.34	13.0	3.64	3.87	19.42 to 3.09	96
1993 April							
2/ 3	6 55.3	57.06	13.0	3.71	3.78	20.03 to 2.16	86
12/13	6 47.3	56.33	13.0	3.79	3.70	20.25 to 1.26	77
22/23	6 42.9	56.02	12.9	3.85	3.61	20.49 to 0.40	69
1993 May							
2/ 3	6 41.4	55.35	12.9	3.91	3.52	21.14 to 23.59	60
12/13	6 42.3	55.15	12.8	3.95	3.43	21.42 to 23.23	53
22/23	6 45.3	55.03	12.7	3.97	3.35	22.11 to 22.50	46
1993 June							
1/ 2	6 50.1	54.60	12.6	3.96	3.26	Not Observable	41
11/12	6 56.3	55.06	12.5	3.94	3.18	Not Observable	36
21/22	7 3.7	55.22	12.4	3.88	3.09	Not Observable	34
1993 July							
1/ 2	7 12.3	55.49	12.3	3.81	3.01	Not Observable	33
11/12	7 21.8	56.28	12.1	3.70	2.92	Not Observable	34
21/22	7 32.4	57.21	12.0	3.58	2.84	1.45 to 1.55	38
31/32	7 44.0	58.32	11.8	3.43	2.76	21.49 to 21.50	
						0.21 to 2.24	42
1993 August							
10/11	7 56.8	60.02	11.6	3.26	2.68	21.20 to 2.50	47

20/21	8	11.1	61.58	11.3	3.07	2.60	20.51 to	3.15	54
30/31	8	27.5	64.24	11.1	2.87	2.53	20.23 to	3.38	60
1993 September									
9/10	8	47.6	67.27	10.8	2.66	2.46	19.55 to	3.59	67
19/20	9	14.6	71.15	10.6	2.45	2.39	19.28 to	4.19	74
29/30	9	58.0	75.52	10.3	2.25	2.32	19.03 to	4.38	81
1993 October									
9/10	11	33.1	80.51	10.0	2.06	2.26	18.39 to	4.55	88
19/20	15	28.4	82.32	9.7	1.90	2.20	18.17 to	5.13	94
29/30	18	25.9	76.25	9.5	1.78	2.14	17.58 to	5.30	97
1993 November									
8/ 9	19	33.1	66.52	9.4	1.72	2.10	17.42 to	5.46	98
18/19	20	8.2	56.29	9.3	1.72	2.05	17.29 to	6.02	95
28/29	20	31.8	46.30	9.3	1.78	2.01	17.21 to	1.59	
							6.01 to	6.16	88
1993 December									
8/ 9	20	50.2	37.40	9.4	1.89	1.98	17.17 to	23.53	81
18/19	21	5.7	30.15	9.5	2.03	1.96	17.18 to	22.32	72
28/29	21	19.5	24.14	9.6	2.19	1.95	17.24 to	21.27	62
1994 January									
7/ 8	21	32.0	19.23	9.8	2.36	1.94	17.34 to	20.30	53
17/18	21	43.7	15.29	9.9	2.52	1.94	17.47 to	19.38	44
27/28	21	54.6	12.19	10.1	2.66	1.95	18.02 to	18.50	36
1994 February									
6/ 7	22	4.9	9.42	10.2	2.79	1.96	Not Observable		27
16/17	22	14.6	7.30	10.3	2.89	1.99	Not Observable		20
26/27	22	23.8	5.35	10.4	2.96	2.02	Not Observable		15
1994 March									
8/ 9	22	32.5	3.51	10.5	3.00	2.05	Not Observable		14
18/19	22	40.6	2.14	10.6	3.02	2.10	Not Observable		18
28/29	22	48.0	0.37	10.6	3.00	2.15	Not Observable		26
1994 April									
7/ 8	22	54.7	-1.02	10.7	2.96	2.20	Not Observable		34
17/18	23	0.5	-2.50	10.7	2.89	2.26	Not Observable		43
27/28	23	5.2	-4.51	10.8	2.80	2.32	Not Observable		52
1994 May									
7/ 8	23	8.6	-7.11	10.8	2.69	2.39	Not Observable		62
17/18	23	10.5	-9.56	10.8	2.57	2.46	Not Observable		72
27/28	23	10.3	-13.13	10.7	2.44	2.53	Not Observable		83
1994 June									
6/ 7	23	7.6	-17.07	10.7	2.32	2.61	Not Observable		95
16/17	23	1.6	-21.43	10.7	2.20	2.68	Not Observable		107
26/27	22	51.6	-26.57	10.7	2.11	2.76	Not Observable		120
1994 July									
6/ 7	22	36.8	-32.38	10.8	2.06	2.84	Not Observable		132
16/17	22	16.5	-38.22	10.8	2.05	2.93	Not Observable		143
26/27	21	50.8	-43.36	11.0	2.09	3.01	Not Observable		150
1994 August									
5/ 6	21	21.1	-47.51	11.2	2.18	3.09	Not Observable		149
15/16	20	50.1	-50.51	11.4	2.32	3.18	Not Observable		142
25/26	20	21.3	-52.38	11.6	2.50	3.26	Not Observable		132

Fig 1
Orbit diagram

Fig 2

Observed light curve

Fig 3
Coma diameter

Fig 4
Alex Vincent slide

Fig 5
Bob Neville photo

b 87P/Bus (1994 XVI)

Recovered by James V Scotti of the Lunar and Planetary Laboratory, University of Arizona with the 0.91-m Spacewatch CCD telescope at Kitt Peak (SWT) on January 1.2, just past opposition in Taurus [IAUC 5696, 1993 January 22]. The comet was 22nd magnitude and still over 18 months away from perihelion. The comet was only predicted to reach 16^m and no section observations were made.

When discovered at Siding Spring in 1981, on a UK Schmidt plate taken for asteroid search purposes, the comet was 16.5^m. It was a fairly favourable return, and similar to the present one. It was perturbed into its present orbit following a very close approach to Jupiter in 1952 which swapped the perihelion of the previous orbit to the aphelion of the new one. Next century a further encounter with Jupiter will increase the perihelion distance from 2.2 to 3.6 AU.

c 9P/Tempel 1 (1994 XIX)

Recovered nearly 18 months before perihelion by James Scotti with the SWT on January 21.2 at 21st magnitude. The comet was just past opposition on the borders of Auriga and Gemini [IAUC 5698, 1993 January 27]. This was a favourable apparition of a short period comet first observed in 1867, but which was lost between 1879 and 1967 following an encounter with Jupiter in 1881 which increased the perihelion distance from 1.8 to 2.1 AU. Further encounters in 1941 and 1953 put q back to 1.5 AU and calculations by Brian Marsden allowed Elizabeth Roemer to recover it in 1967. Alternate returns are favourable, but pertubations will once again increase the perihelion distance in the middle of the next century.

Section observations span the range T-147 to T+61 days. In early March 1994 the comet began its retrograde loop in Virgo, which it completed in May, heading south and east through the zodiacal constellations of Libra, Scorpius and Saggitarius which it entered in October.

Herman Mikuz picked it up with his CCD system on 1994 March 5 and Graham Keitch found it visually with 25x150B a day later. It was 13.2 in the CCD system, but visually was nearly two magnitudes brighter at 11.4. It slowly brightened: James Lancashire made it 10.5 with the Thorrowgood on April 14. Closest approach to the Earth occurred in early May when most observers were estimating it at around 9^m - 11^m. Attila Kosa-Kiss estimated it at 10.1 on May 5 in his 0.16-m reflector x54 and Werner Hasubick observing on June 1 with 25x100B made it 9.5. It continued brightening towards perihelion in early July, but was becoming harder to observe from the UK. Jonathan Shanklin made the last UK observation with his 0.33-m reflector x85 on July 1 when it was approximately 10.1. After this it become a southern hemisphere object, Graham Wolf being able to follow it until September 2 when it was 10.5 in his 0.21-m reflector x105.

The coma diameter increased from around 1' in early March to 4' in early June, after which it decreased rapidly to 1' in early July. In real terms this corresponds to an increase from 50,000

km to 150,000 km. Again there is no clear pattern to the DC, with observers reporting values between 1 and 7 throughout the apparition. Overall there is an indication that it increased from 2 at T-120 to 4 at T-60, reducing back to 2 at perihelion.

Table 6. Ephemeris for comet P/Tempel 1 1993c

Magnitudes calculated from m = 5.4 + 5.0 * Log(Δ) + 25.0 * Log(r)
Latitude: 53.0°N Longitude: 0.0°W

Day	R.A. hh mm.m (2000.0)	Dec °.mm	Mag	Δ A.U.	R A.U.	Observable hh.mm to hh.mm	Elong °
1994 March							
8/ 9	13 34.0	10.41	12.1	0.97	1.87	22.16 to 5.09	146
18/19	13 33.0	11.35	11.6	0.88	1.82	21.11 to 4.44	153
28/29	13 28.7	12.21	11.1	0.80	1.77	20.08 to 4.18	159
1994 April							
7/ 8	13 21.8	12.45	10.7	0.75	1.72	20.13 to 3.51	160
17/18	13 13.4	12.33	10.3	0.71	1.68	20.36 to 3.23	156
27/28	13 5.4	11.34	9.9	0.69	1.63	21.01 to 2.55	148
1994 May							
7/ 8	12 59.5	9.45	9.7	0.69	1.60	21.27 to 2.26	140
17/18	12 57.2	7.11	9.5	0.70	1.57	21.56 to 1.57	132
27/28	12 59.1	4.00	9.3	0.71	1.54	22.26 to 1.29	125
1994 June							
6/ 7	13 5.4	0.23	9.3	0.74	1.52	22.54 to 0.41	119
16/17	13 15.8	-3.30	9.3	0.78	1.50	23.15 to 23.49	113
26/27	13 30.0	-7.32	9.3	0.82	1.50	Not Observable	108
1994 July							
6/ 7	13 47.6	-11.33	9.5	0.87	1.49	Not Observable	104
16/17	14 8.1	-15.27	9.6	0.93	1.50	Not Observable	101
26/27	14 31.2	-19.06	9.9	0.99	1.51	Not Observable	98
1994 August							
5/ 6	14 56.6	-22.26	10.2	1.07	1.53	Not Observable	95
15/16	15 24.0	-25.21	10.5	1.15	1.56	Not Observable	92
25/26	15 52.8	-27.47	10.9	1.24	1.59	Not Observable	89
1994 September							
4/ 5	16 22.8	-29.43	11.3	1.33	1.62	Not Observable	87
14/15	16 53.5	-31.08	11.7	1.44	1.66	Not Observable	84
24/25	17 24.4	-32.02	12.2	1.56	1.71	Not Observable	81

Fig 6
Orbit diagram

Fig 7
Observed light curve

Fig 8
Coma diameter

d Mueller (1993 F1, 1992 XX)

Jean Mueller discovered a 17^m comet on a 75 minute exposure plate taken with the 1.2-m Oschin Schmidt during PSSII on March 19.3 [IAUC 5723, 1993 March 24]. The comet was near opposition and nine months past perihelion, moving slowly west on the borders of Ursa Major and Draco. It faded after discovery.

e D/Shoemaker-Levy 9 (1993 F2, 1994 X)

The story of the demise of this celebrated comet is well recorded in the Journal[12,13,14], TA[15] and elsewhere. Discovered by the team of Carolyn S and Eugene M Shoemaker and David H Levy (SLT) during the search for near earth asteroids with the 0.46-m Palomar Schmidt (PS) as a 14th magnitude 'string of pearls' [IAUC 5725, 1993 March 26], it spectacularly ended its life in a series of impacts with the planet Jupiter in July 1994.

Images of the comet were received from several observers[16,17], but reduced magnitude estimates were much rarer. Mikuz obtained estimates of around 14^m between 1993 April 1 and 1993 June 19 with his CCD system. Tombelli was able to observe the comet visually with his 0.44-m reflector x222 on April 24, making it 13.5.

f 37P/Forbes (1993 IV)

The comet was recovered as it emerged from solar conjunction by G Lowe with the 0.33-m astrograph at Perth Observatory on March 21.8. The discovery was reported by former Section Director, Michael P Candy, on IAUC 5728 [1993 March 28]. The comet was at 14^m close to perihelion in Sagittarius.

At a good return the comet can be a 10th magnitude object, however this return was not a favourable one and no section observations were reported. Discovered in 1929 by A F I Forbes during a routine comet search with a 0.20-m reflector from Harmanus, South Africa, the comet's orbit has been fairly stable this century. An encounter with Jupiter in 1990 started progressive changes, though there is little immediate change in the perihelion distance.

g 44P/Reinmuth 2 (1994 XVIII)

Recovered by James Scotti with the SWT on February 26.5 at 22nd magnitude whilst still 16 months from perihelion. It was past morning quadrature on the borders of Libra and Centaurus [IAUC 5772, 1993 April 22]. Section observations span the range T+41 to T+156 days.

The orbit is relatively stable and the comet was discovered in 1947 and has been seen at every return since, though it only occasionally gets as bright as it did at this one.

Mikuz, observing in mid August 1994 with his CCD system made the comet 15^m. In mid October 1994 Werner Hasubick was able to obtain photographs of the comet, when it was 13.5^m. Mikuz made a final observation in early December when it was again 15^m.

h Shoemaker-Levy (1993 K1, 1994 IV)

Discovered by the SLT with the 0.46-m PS on May 23.2 at photographic magnitude 16.5. [IAUC 5803, 1993 May 25]. When discovered the comet was past opposition in Centaurus, moving very slowly south west. It was a very distant comet and faded after discovery.

i 17P/Holmes (1993 VII)

Recovered by Tsutomo Seki at Geisei, Japan with his 0.6-m reflector at photographic magnitude 18 on May 24.8 in Pisces as the comet emerged from conjunction [IAUC 5804, 1993 May 26].

When discovered in 1892 by E Holmes while observing M31 with a small reflector from London, the comet was brighter than M31 which was close by. It was evidently in outburst and one photograph showed a double nucleus, perhaps showing a similar event to that which occurred in P/Schwassmann-Wachmann 3 in 1995. In 1899 and 1906 it was only 14 - 15 magnitude and was lost for the next seven returns until recovered by Elizabeth Roemer following a prediction by Brian Marsden. The orbit is relatively stable at the moment with occasional distant encounters with Jupiter changing the perihelion distance a small amount. For the last few returns it has been no brighter than 17^m.

j 42P/Neujmin 3 (1993 XVI)

Recovered by James Scotti with the SWT on May 25.3 at 21st magnitude when it was just past opposition in Libra [IAUC 5805, 1993 May 27]. The comet was only predicted to reach 16^m and no section observations were made.

The comet was perturbed into its present orbit after a close approach to Jupiter in 1850 which reduced the perihelion distance from 2.7 to 2.1 AU. Discovered in 1929, it has been missed at alternate apparitions ever since. The pre 1850 orbit is almost identical to that of 53P/Van Biesbroeck and it is probable that the two comets split from a common parent in 1849 prior to the encounter.

k 61P/Shajn-Schaldach (1993 XVII)

Recovered by James Scotti with the SWT on May 27.4 at 20th magnitude when it was nearing morning quadrature on the borders of Pisces and Aquarius [IAUC 5807, 1993 May 28].

The comet was discovered in 1949, following a close approach to Jupiter in 1946 which converted the perihelion of the old orbit into the aphelion of the new one. It wasn't recovered in 1957 or 1964, but a prediction by Brian Marsden enabled to be recovered in 1971. Although at discovery it reached 12^m it has not done as well on subsequent returns.

l P/Helin-Lawrence (1993 K2, 1993 XI)

Discovered by Eleanor F Helin and Kenneth J Lawrence with the PS on May 17.4 at magnitude 16.5 when at opposition and near perihelion in Ophiuchus. [IAUC 5810, 1993 June 2]. It faded after discovery.

m 110P/Hartley 3 (1993 M1, 1994 XII)

Recovered when still 11 months from perihelion by James Scotti with the SWT on June 23.4 at magnitude 19.5. It was emerging from conjunction on the borders of Aries and Pisces [IAUC 5826, 1993 June 29]. Section observations span the range T-153 to T-110 days.

This was the first return of the comet, which was discovered with the UK Schmidt telescope from Siding Spring in February 1988 and it reached perihelion 0.25 days later than predicted by Dan Green in the ICQ Handbook for 1993. It was perturbed into its present orbit following an encounter with Jupiter in 1949.

Mikuz observed the comet on 1993 December 18 and 1994 January 30 with his CCD system, when the comet was around 15^m.

n 36P/Whipple (1993 XXXII)

Recovered by James Scotti with the SWT on June 25.4 at 21st magnitude when it was nearing opposition in Aquila [IAUC 5827, 1993 June 30].

The comet is in a somewhat chaotic orbit and experiences quite large changes in perihelion distance due to slow encounters with Jupiter. It was discovered in 1933 after an approach to Jupiter in 1922 reduced the perihelion distance to 2.5 AU. Only 13^m at discovery, it has never been brighter than this, and a subsequent encounter with Jupiter in 1981 has pushed q back out to 3.1 AU.

o 76P/West-Kohoutek-Ikemura (1993 XXI)

Recovered by James Scotti with the SWT on July 20.5 at 20th magnitude when it was nearing morning quadrature in Eridanus [IAUC 5832, 1993 July 23]. Section observations cover the range T-37 to T+36 days.

The comet was discovered in 1975 following a very close encounter with Jupiter in 1972 which produced one of the largest reductions of perihelion distance on record, reducing q from 5.0 to 1.4 AU. Lubos Kohoutek was actually taking a confirmation plate for a second comet (75P/Kohoutek) discovered 18 days earlier and then lost. Although 12^m at the discovery apparition, it is another comet which has not done so well on subsequent returns.

Mikuz observed the comet between 1993 November 17 and 1994 January 30 using his CCD system. The comet was near perihelion and between mag 13 and 15.

p Mueller (1993 Q1, 1994 IX)

Jean Mueller discovered a 14.5^m comet on a plate taken with the 1.2-m Oschin Schmidt during PSSII on August 16.4 [IAUC 5846, 1993 August 18]. The comet was past morning quadrature and seven months from perihelion, moving slowly north east on the borders of Perseus and Andromeda. Its motion slowly accelerated as it passed through Pegasus but slowed again as it passed through Aquarius, reaching perihelion in Sculptor. It began to accelerate again and passed through Phoenix, Eridanus, Horologium, Pictor and was last seen in Puppis. Section observations cover the range T-218 to T+48 days.

The comet was essentially a northern hemisphere object prior to perihelion and a southern hemisphere object after perihelion. Mikuz was able to image the comet as early as 1993 August 20 when it was 14^m , but visual observation did not begin to any great extent until October. Graham Keitch made it 11.5 on October 9, with a weakly condensed 2' diameter coma in 25x150B. Martin Mobberley photographed it on October 17^{10}. It slowly brightened and Keitch made it 10^m by mid January. Moving south, and heading towards perihelion on March 26, it was in solar conjunction until early April when it was picked up by David Seargent at mag 8.7 on April 1 in 15x80B. It continued to brighten and Albert Jones made it 7.2 on April 11 in his 78-mm refractor x30, with a 2' diameter, moderately condensed coma. After this it faded rapidly and became much more diffuse, Jones making the final observation on 1994 May 13 when it was 10.8 in his 0.32-m reflector x63, with a 1' diameter coma and DC1. It seems likely that activity switched off as the decline is much more precipitate than that predicted by the light curve. Exposures taken by A C Gilmore (Mount John University Observatory, New Zealand) on May 4.4 showed a diffuse, roughly parabolic patch with no hint of the condensation that was visible on April 14.3. SWT exposures taken by Robert Jedicke

on June 2.2 showed an elliptical diffuse image, with a total coma magnitude near 10.5, but any remaining nucleus must have been fainter than about 18.5. [IAUC 6004, 1994 June 8].

The comet never approached the earth or sun much closer than 1 AU and throughout the apparition the coma diameter remained small. It increased from around 0.4' to reach a peak of 3' in mid November, slowly declining to 1' in 1994 May. In real terms the diameter increased from 50,000 km to a peak of 200,000 km. Again a wide range of DC vaues was reported (0 - 9). The data are consistent with DC3 throughout the apparition, perhaps declining a little towards the end.

Table 7. Ephemeris for comet Mueller 1993p

Magnitudes calculated from m = 7.9 + 5.0 * Log(Δ) + 7.3 * Log(r)
Latitude: 53.0°N Longitude: 0.0°W

Day	R.A. hh mm.m (2000.0)	Dec °.mm	Mag	Δ A.U.	R A.U.	Observable hh.mm to hh.mm	Elong °
1993 August							
10/11	1 47.7	49.33	14.3	3.18	3.39	22.53 to 2.50	93
20/21	1 42.8	49.59	14.0	2.93	3.28	21.45 to 3.15	101
30/31	1 33.8	50.08	13.7	2.68	3.17	20.35 to 3.38	110
1993 September							
9/10	1 20.3	49.48	13.4	2.44	3.05	19.55 to 3.59	119
19/20	1 2.1	48.45	13.0	2.21	2.94	19.28 to 4.19	128
29/30	0 39.9	46.38	12.7	2.01	2.82	19.03 to 4.38	136
1993 October							
9/10	0 15.5	43.11	12.4	1.84	2.70	18.39 to 4.55	142
19/20	23 51.5	38.13	12.1	1.72	2.58	18.17 to 4.38	143
29/30	23 30.2	31.56	11.8	1.63	2.46	17.58 to 3.12	138
1993 November							
8/ 9	23 13.4	24.50	11.6	1.60	2.34	17.42 to 1.45	128
18/19	23 1.5	17.36	11.5	1.61	2.22	17.29 to 0.22	115
28/29	22 54.3	10.47	11.3	1.66	2.10	17.21 to 23.03	102
1993 December							
8/ 9	22 51.2	4.42	11.2	1.73	1.97	17.17 to 21.50	89
18/19	22 51.5	-0.33	11.1	1.80	1.85	17.18 to 20.43	77
28/29	22 54.6	-5.03	11.0	1.88	1.72	17.24 to 19.40	66
1994 January							
7/ 8	23 0.0	-8.58	10.8	1.95	1.60	17.34 to 18.41	55
17/18	23 7.3	-12.27	10.6	1.99	1.48	Not Observable	46
27/28	23 16.3	-15.40	10.4	2.02	1.37	Not Observable	37
1994 February							
6/ 7	23 26.8	-18.45	10.2	2.01	1.26	Not Observable	30
16/17	23 38.9	-21.53	9.8	1.98	1.16	Not Observable	25
26/27	23 53.0	-25.10	9.5	1.90	1.08	Not Observable	24
1994 March							
8/ 9	0 9.7	-28.44	9.2	1.79	1.01	Not Observable	27
18/19	0 30.7	-32.43	8.9	1.64	0.98	Not Observable	33
28/29	0 58.8	-37.14	8.6	1.47	0.97	Not Observable	41
1994 April							
7/ 8	1 39.9	-42.15	8.4	1.28	0.99	Not Observable	50
17/18	2 45.2	-47.16	8.2	1.09	1.04	Not Observable	60
27/28	4 27.9	-49.46	8.2	0.95	1.12	Not Observable	70
1994 May							
7/ 8	6 31.7	-45.16	8.3	0.90	1.21	Not Observable	79
17/18	8 9.1	-34.29	8.7	0.96	1.32	Not Observable	84
27/28	9 11.2	-23.28	9.3	1.12	1.43	Not Observable	84

1994 June							
6/ 7	9 51.8	-15.07	9.9	1.34	1.55	Not Observable	81
16/17	10 20.7	-9.21	10.5	1.60	1.67	Not Observable	76
26/27	10 43.2	-5.24	11.1	1.87	1.79	Not Observable	70

Fig 9
Orbit diagram

Fig 10
Observed light curve

Fig 11
Coma diameter

Fig 12
Ron Arbour image

q 112P/Urata-Niijima (1993 U1, 1993 XII)

Recovered by James Scotti with the SWT on October 20.5 at magnitude 19.5 when it was emerging from conjunction in Leo Minor [IAUC 5882, 1993 October 21].

This was the first return of the comet which was discovered at a very favourable return in 1986, following an encounter with Jupiter in 1982/83. The predicted ephemeris required a correction of +0.24 days. The return was a poor one and the comet was not expected to exceed 19^m.

r 113P/Spitaler (1993 U2, 1994 III)

On October 24.3 James Scotti found a 17^m comet with the SWT moving west on the borders of Pisces and Aries. He suggested that it might be P/Spitaler, which had not been seen since its discovery apparition in 1890. Syuichi Nakano had predicted that it might return to perihelion on October 4.0 and the comet was close to the line of variation for $\Delta T = +108.7$ days. Computation by Brian Marsden confirmed the identity. [IAUC 5885, 1993 October 28]. It was near opposition.

At its discovery the comet reached 12^m in a very favourable apparition, however the present magnitude suggests that it may have been in outburst. The orbit is comparatively stable and was well enough determined that it should have been recovered if the discovery magnitude had been typical. Richard Buckley had made a prediction for its return in 1979 in the BAA Journal[18] commenting that of all the 'missing comets' he was considering, it had one of the better chances of recovery.

Martin Mobberley obtained an astrometric CCD image[19] of the comet using his 0.47-m reflector at Galleywood, Chelmsford on 1993 November 12, when it was about 17^m. The comet was then 77 days before perihelion.

s P/Mueller 5 (1993 W1, 1994 XXV)

Jean Mueller discovered an 18^m comet on a plate taken with the 1.2-m Oschin Schmidt during PSSII on November 20.4 [IAUC 5891, 1993 November 21]. The comet was approaching opposition and ten months from perihelion, moving slowly north east in Gemini. It is a distant, short period comet, which encountered Jupiter in 1964.

t P/Kushida-Muramatsu (1993 X1, 1993 XIX)

Yoshio Kushida and Osamu Muramatsu of Yatsugatake South Base Observatory, Japan, photographically discovered a 16.5^m comet on December 8.7 using a 0.25-m f/3.4 reflector. At discovery the comet was moving east and was diffuse with a central condensation and a coma of about 1'-2' diameter. [IAUC 5903, 1993 December 12]. The comet was near opposition in Taurus and at perihelion and faded after discovery.

u 114P/Wiseman-Skiff (1993 IX)

Suspected weak images of this comet on CCD frames were obtained by B. Schmidt with the Multiple-Mirror Telescope at Mt. Hopkins on February 2. They were confirmed with an independent recovery by Jim Scotti in Spacewatch images obtained by Tom Gehrels at Kitt Peak on December 16 (low altitude, twilight, rather poor seeing), after which Scotti found the comet on a single frame obtained on December 10. On December 16, the 21^m comet showed a coma 13" in diameter, with a faint 0'.34 tail in p.a. 286°. [IAUC 5908, 1993 December 16]. The comet was emerging from conjunction, moving south east on the borders of Corvus and Hydra.

A close approach to Jupiter in 1984 diverted the comet into its present orbit and it was discovered in December 1986. This was the first return of the comet and the predicted ephemeris required a correction of -0.08 days. The 6.5 year period means that alternate returns are unfavourable and this was a poor one.

v McNaught-Russell (1993 Y1, 1994 XI)

Robert H. McNaught discovered a 17^m comet on a U.K. Schmidt Telescope plate taken by Kenneth S. Russell on December 17.5. The comet showed a coma of diameter 8" and a very faint tail 10" long in p.a. 20°. [IAUC 5910/5911, 1993 December 18]. The comet was at evening quadrature, moving west in Horologium and three months from perihelion. The comet has a long period of around 1500 years. Calculations by Nakano and Hasegawa [IAUC 5943, 1994 March 2] suggest a possibility that the comet may be identical with one seen in 574, though the residuals are over a degree.

Section observations cover the range T-103 to T+90 days. The comet moved along Eridanus and reached perihelion in Taurus. It continued moving rapidly north through Auriga and Camelopardalus, reaching its highest northern declination in Draco and was last seen in Hercules.

Early visual observations showed that the comet was much brighter than expected from the discovery photographs, once again showing that it is worth attempting visual observation of comets which have only been observed photographically or with CCD detectors by large aperture telescopes. Because of the large discrepency between visual and CCD/photographic magnitudes for this comet, only observations in the range T-46 to T+74 have been used in the analysis of the light curve. Other comets imaged during the year have not shown such a large discrepancy, so this may reflect an unusual emission spectrum as the coma is not markedly unusual.

Initially a southern hemisphere object it was not observed visually until mid February, though in retrospect the light curve suggests that it could have been observed several weeks earlier. Albert Jones, observing from Stoke, New Zealand, made the comet 10.6 in his 0.32-m

reflector x100 on February 15. It brightened rapidly and moved north and Jonathan Shanklin was able to pick it up low in the evening twighlight on March 16 when it was about 7.3 in 10x80B. A few observers were able to glimpse it during the BAA Winchester weekend (March 25 - 27), despite the light of a full moon. As it moved higher in the sky more observers were able to find it and peak brightness was reached in early April; Guy Hurst observing on April 3 made it 6.9 in 15x80B. A short tail became apparent: Atilla Kossa-Kiss observing on April 4 estimated it at 1.5° long in pa 50. Several observers obtained photographs around this time[20,21,22]. By mid April it was already fading, Melvyn Taylor making it 8.0 in 16x80B on the 18th. As it faded it became less condensed; Werner Hasubick observing on May 14 estimating it at 9.7, DC2 in 25x100B with a 3' diameter coma. A few observers followed it into June, Jonathan Shanklin making it 11.5 on the 5th in his 0.33-m reflector x 85. Mikuz was able to find it with his CCD system on June 30, measuring the magnitude at 15.2, considerably fainter that predicted by the visual light curve.

The coma diameter increased from 2' in February to around 10' in early April, declining to 1' by mid June. Many observers did report diameters greater than 10' in early April, some up to 22'; this may imply a faint outer coma, but more probably there was confusion between the coma and tail. The true diameter increased from around 100,000 km in February to 200,000 km in early April, declining back to 100,000 km in June. The DC figures again show a wide range (0 - 8), but the mean curve shows a clear increase from DC2 at T-45 to DC4 at T, becoming very diffuse (DC0) by T+60. The tail appeared between T-10 and T+40, with a maximum observed length of 1.5° just after perihelion, corresponding to a true length of only 0.01 AU.

Table 8. Ephemeris for comet McNaught-Russell 1993v

Magnitudes calculated from m = 9.0 + 5.0 * Log(Δ) + 8.5 * Log(r)
Latitude: 53.0°N Longitude: 0.0°W

Day	R.A. (2000.0)	Dec (2000.0)	Mag	Δ	R	Observable	Elong
	hh mm.m	°.mm		A.U.	A.U.	hh.mm to hh.mm	°
1994 January							
7/ 8	2 40.9	-54.26	11.6	1.44	1.65	Not Observable	83
17/18	2 37.1	-52.17	11.2	1.35	1.52	Not Observable	79
27/28	2 38.9	-49.28	10.7	1.25	1.39	Not Observable	76
1994 February							
6/ 7	2 46.1	-45.54	10.1	1.14	1.27	Not Observable	73
16/17	2 58.5	-41.20	9.5	1.01	1.15	Not Observable	70
26/27	3 15.7	-35.13	8.9	0.87	1.04	Not Observable	68
1994 March							
8/ 9	3 37.2	-26.27	8.1	0.72	0.96	Not Observable	66
18/19	4 2.7	-13.01	7.4	0.58	0.90	19.32 to 20.03	63
28/29	4 32.4	7.29	6.9	0.49	0.87	19.52 to 21.58	60
1994 April							
7/ 8	5 8.0	33.14	6.9	0.47	0.88	20.13 to 0.36	61
17/18	5 56.2	55.31	7.4	0.53	0.93	20.36 to 3.23	66
27/28	7 13.4	69.37	8.1	0.65	1.00	21.01 to 2.55	71
1994 May							
7/ 8	9 20.7	76.02	8.8	0.78	1.10	21.27 to 2.26	75
17/18	11 39.2	76.05	9.5	0.92	1.22	21.56 to 1.57	78
27/28	13 7.6	72.47	10.2	1.05	1.34	22.26 to 1.29	81
1994 June							
6/ 7	13 57.7	68.26	10.8	1.18	1.46	22.54 to 1.03	83
16/17	14 29.5	63.49	11.3	1.31	1.59	23.15 to 0.46	85
26/27	14 52.7	59.08	11.8	1.44	1.72	23.17 to 0.49	87
1994 July							
6/ 7	15 11.4	54.29	12.3	1.58	1.85	22.58 to 1.11	88
16/17	15 27.9	49.56	12.7	1.72	1.98	22.32 to 1.40	89

Fig 13
Orbit diagram

Fig 14
Observed light curve

Fig 15
coma diameter

Fig 16
DC

Fig 17
Bev Ewen-Smith isophote

Fig 18
Alex Vincent slide

Fig 19
Sally Beaumont drawing April 08.88

Fig 20
Roy Mitchell image

Other comets

29P/Schwassmann-Wachmann 1

Mikuz continued studying the comet with his CCD system, finding it in outburst at up to 13^m in February[23], March, April, late October - November and December. During its February outburst Jean-Claude Merlin photographed it on February 15[24] and Werner Hasubick on February 26. Somewhat dissapointingly no section observers followed it visually, though observations were reported on IAUC.

Infra-red observations on October 22, November 11 and 12 by M C Senay and David Jewitt with the JCMT on Mauna Kea suggested a CO production rate of 2000 kg s^{-1}, which is sufficient to drive the observed dust activity in the comet [IAUC 5929, 1994 February 4]. This was the first direct evidence that activity in comets beyond the orbit of Jupiter can be powered by carbon monoxide.

McNaught-Tritton 1978 G2 (1978 XXVII)

On IAUC 5866 [1993 September 18] Rob McNaught reported finding an image of a comet on a UK Schmidt which confirmed an earlier image reported on IAUC 5471 [1992 March 10]. It was subsequently found on other plates taken at Siding Spring in 1978 April and 1980 January. The comet, which has a large perihelion distance of 6.3 AU did not receive an old style year letter, but was assigned a perihelion number for 1978.

Comets not recovered

D/Lovas 2 1986 W1

Predicted to be at perihelion in early June, the return was a little unfavourable, but it should have attained about 15^m at a reasonable elongation.

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Figure Captions:

Figure 1. The orbit of comet Mueller 1993a. a) Viewed from the north ecliptic pole. The orbits of the earth and Jupiter are shown for scale. The shaded part of the comet's orbital plane lies above the ecliptic. b) Viewed from the ascending node of the comet's orbit looking towards

the sun. From this viewpoint the orbit appears as a straight line, showing the inclination of the comet's orbit. c) Viewed from a rotating reference frame, centred on the earth with the sun at top. In this frame the true distance to the comet is shown but the angular elongation from the sun is viewed from the ecliptic pole; the 6 o'clock position corresponds to the comet at opposition and the 3 o'clock position to the comet at morning quadrature. The path is shown dashed when it lies below the ecliptic. The comet was discovered at T-375; observations used in the analysis cover the range T-371 to T+96.

Figure 2. The observed magnitude of comet 1993a. The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1993 January. The scatter is accentuated by the mix of visual and CCD observations.

Figure 3. The coma diameter of comet 1993a. The lower panel shows the observed coma diameter in arc minutes and the upper panel the true diameter in 100,000 km.

Figure 4. Comet Mueller 1993a photographed by Bob Neville on 1993 October $18^{d}\ 20^{h}\ 23^{m}$ with 0.30-m, f5 reflector, exposure 10 minutes on T-Max 400 developed for 7 minutes in D-19.

Figure 5. Comet Mueller 1993a photographed by Alex Vincent on 1993 December $4^{d}\ 20^{h}\ 30^{m}$ using a four minute exposure on Fujichrome 400 slide film at the prime focus of a 0.3-m f5 reflector.

Figure 6. The orbit of comet Tempel 1 1993c. a) Viewed from the north ecliptic pole. b) Viewed from the ascending node of the comet's orbit looking towards the sun. c) Viewed from the rotating reference frame. Observations used in the analysis cover the range T-147 to T+61.

Figure 7. The observed magnitude of comet 1993c. The curve is a best fit over the apparition, with no corrections applied. Tick marks indicate the first of each month from 1994 January.

Figure 8. The observed coma diameter of comet 1993c. The tick marks indicate the first of each month from 1994 March. The lower panel shows the observed coma diameter in arc minutes and the upper panel the true diameter in 100,000 km.

Figure 9. The orbit of comet Mueller 1993p. a) Viewed from the north ecliptic pole. b) Viewed from the ascending node of the comet's orbit looking towards the sun. c) Viewed from the rotating reference frame. The comet was discovered at T-222; observations used in the analysis cover the range T-218 to T+48.

Figure 10. The observed magnitude of comet 1993p. The curve is a best fit over the apparition, with no corrections applied. The comet's activity declined dramatically after 1994 April. Tick marks indicate the first of each month from 1993 August.

Figure 11. The coma diameter of comet 1993p. The lower panel shows the observed coma diameter and the upper panel the true diameter in 100,000 km. Tick marks indicate the first of each month from 1993 August.

Figure 12. Comet Mueller 1993p imaged by Ron Arbour on 1993 November $14^{d}\ 22^{h}\ 07^{m}$.

Figure 13. The orbit of comet McNaught-Russell 1993v. a) Viewed from the north ecliptic pole. b) Viewed from the ascending node of the comet's orbit looking towards the sun. c) Viewed from the rotating reference frame. The comet was discovered at T-103; observations used in the analysis cover the range T-46 to T+74.

Figure 14. The observed magnitude of comet 1993v. The curve is a best fit over the apparition, with no corrections applied. Photographic and CCD observations lie much below the visual light curve. Tick marks indicate the first of each month from 1993 December.

Figure 15. The coma diameter of comet 1993v. The lower panel shows the observed coma diameter and the upper panel the true diameter in 100,000 km. Tick marks indicate the first of each month from 1994 February.

Figure 16. The DC of comet 1993v. The curve is a best fit 2nd order regression with 95% confidence limits.

Figure 17. Comet McNaught-Russell 1993v imaged by Bev Ewan-Smith on 1993 April 2^{d} 20^{h} 58^{m} using a 0.3-m reflector and 120 second integration on an ST4 CCD.

Figure 18. Comet 1993v drawn by Sally Beaumont on 1993 April 8.88 using 0.13-m refractor x20.

Figure 19. Comet 1993v photographed by Alex Vincent on 1994 April 11^{d} 21^{h} 15^{m} using a five minute exposure on Fujichrome 400 slide film at the prime focus of a 0.3-m f5 reflector.

Figure 20. Comet 1993v imaged by Roy Mitchell on 1994 April 13^{d} 21^{h} 56^{m} using a 0.25-m f4.5 reflector and 20 second integration on an ST4 CCD.