Identification of Asteroids in the M65, M66, and NGC3628 Image: Poor Man's Astrometry

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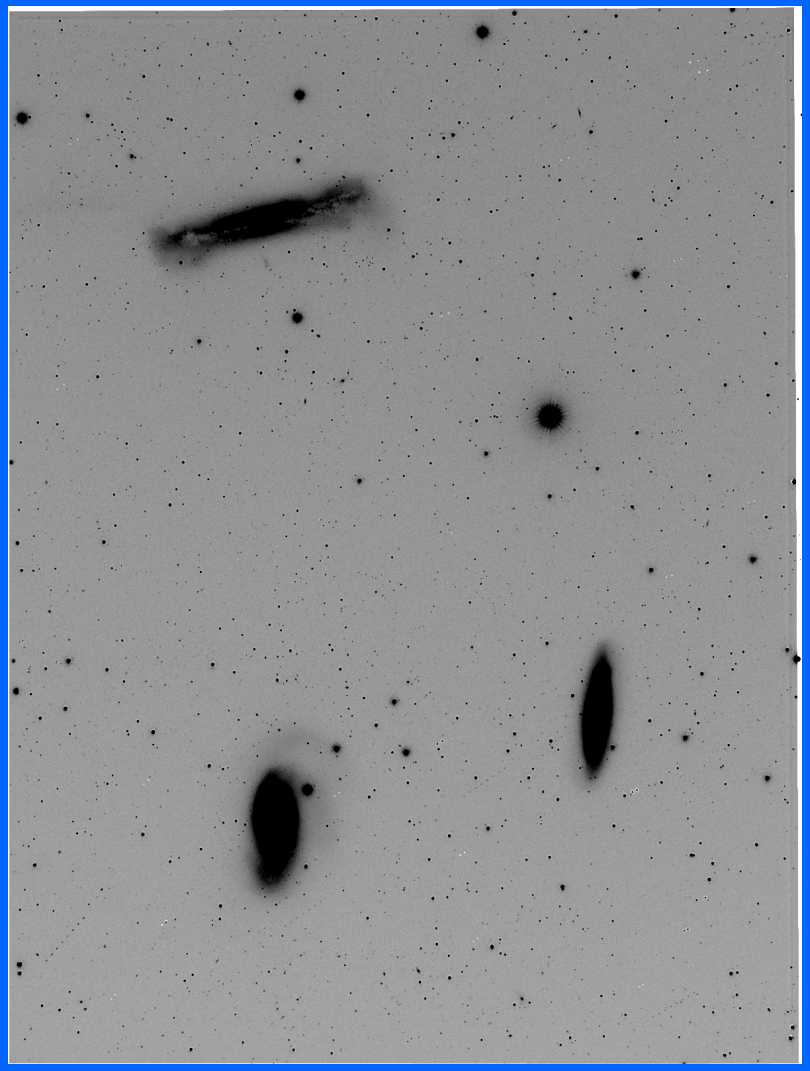
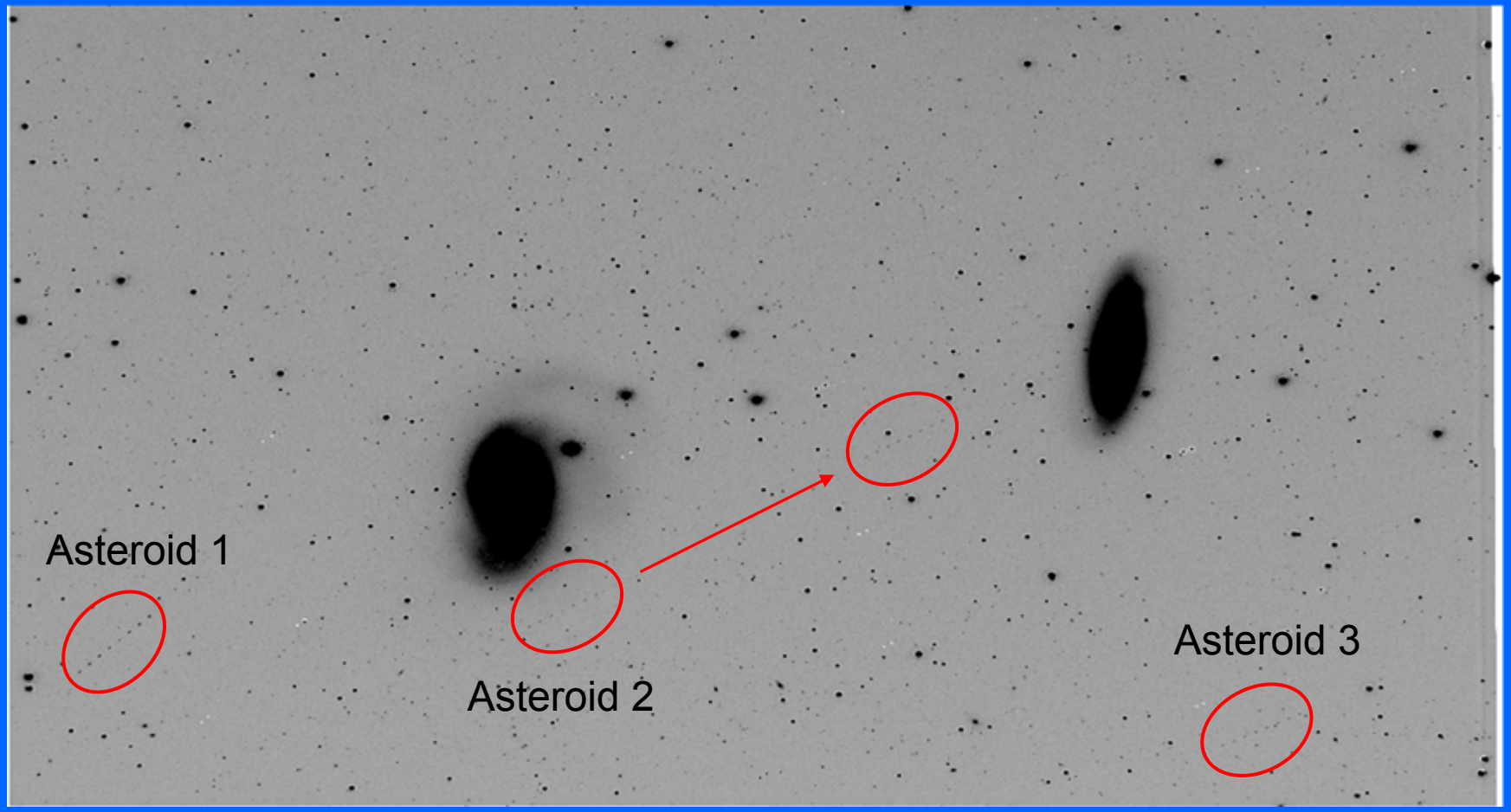
March 2007

M65, M66, and NGC3628: Composite of 30 5-minute exposures, taken over 2 nights (17-18 March 2007 UT), using a luminance filter



Closer inspection revealed 3 asteroids, one of which appeared on both nights of imaging

- Have I discovered new asteroids?



Asteroid Identification Requires Two Pieces of Information

1) Time
   - Universal time is incorporated in the image file
2) Location
   - Astrometry is the accurate measurement of the Right Ascension and Declination of objects in an image
   - But, my image files do not have RA and DEC information in them, so I only know relative positions, i.e., how many pixels apart objects are from each other
   - Using Palomar Sky Survey Plates of the region, which have location information encoded in them, I can determine the “exact” location of 2 reference stars

Asteroid 1: Reference Stars and Their Pixel Locations in My Image

Asteroid 1 Reference Stars and the Determination Pixel Scale

Star 1: 11h 21m 14.17s 12° 51' 36.98" Pixel (44, 1434)
Star 2: 11h 21m 01.51s 12° 54' 35.70" Pixel (121, 1358)

RA: Star 2 – Star 1= (1.51-14.17)/(121 - 44)

= -0.164 seconds/pixel

DEC: Star 2 – Star 1= $\frac{(54*60 + 35.70) – (51*60 + 36.98)}{(1358 – 1434)}$

= -2.352 arc seconds/pixel

- Relative to the known position of Star 1, I can calculate the asteroid position from its known pixel location

Asteroid 1: Estimated Locations

Star 1: 11h 21m 14.17s 12° 51’ 36.98” Pixels (44, 1434)

Time (UT)	Pixel Locations (RA, DEC)
04:46:56	(58, 1443)
09:55.52	(114, 1379)

RA = 11h 21m 14.17s + (-0.164)(58 – 44) = 11h 21m 11.86s

DEC = 12° 51’ 36.98” + (-2.352)(1443 – 1434) = 12° 51’ 15.6”

RA = 11h 21m 14.17s + (-0.164)(114 – 44) = 11h 21m 02.66s

DEC = 12° 51’ 36.98” + (-2.352)(1379 – 1434) = 12° 53’ 46.3”

MPChecker: Minor Planet Checker

Use the form below to prepare a list of known minor planets in a specified region. Notes on using this form are given at the bottom of this page.

If you wish to report the non-functioning of (or errors in) this service, please use this feedback form. But ensure that you have seen this note on computing limits before reporting anything.

Produce list | Clear/reset form

Date : 2007 03 18.20 UT

Produce list of known minor planets around:

(•) this J2000.0 position: R.A. = 11 21 11.86 Decl. = 12 51.26

or around ( ) these observations:

http://scully.cfa.harvard.edu/~cgi/CheckMP

MPChecker/CMTChecker/NEOChecker

Here are the results of your search(es) in the requested field(s):

The following objects, brighter than $V = 20.0$, were found in the 15.0-arcminute region around R.A. = 11 21 11.86, Decl. = +12 51.26 (J2000.0) on 2007 03 18.20 UT:

Object designation	R.A. (h m s)	Decl. (° ' ")	V	Offsets R.A.	Offsets Decl.	Motion/hr R.A.	Motion/hr Decl.
(10668) 1976 UB1	11 21 12.0	+12 51 15	15.9	0.0E	0.0S	25-	29+
(26420) 1999 XL103	11 20 16.0	+12 50 52	18.7	13.6W	0.4S	37-	13+

MPChecker/CMTChecker/NEOChecker

Here are the results of your search(es) in the requested field(s):

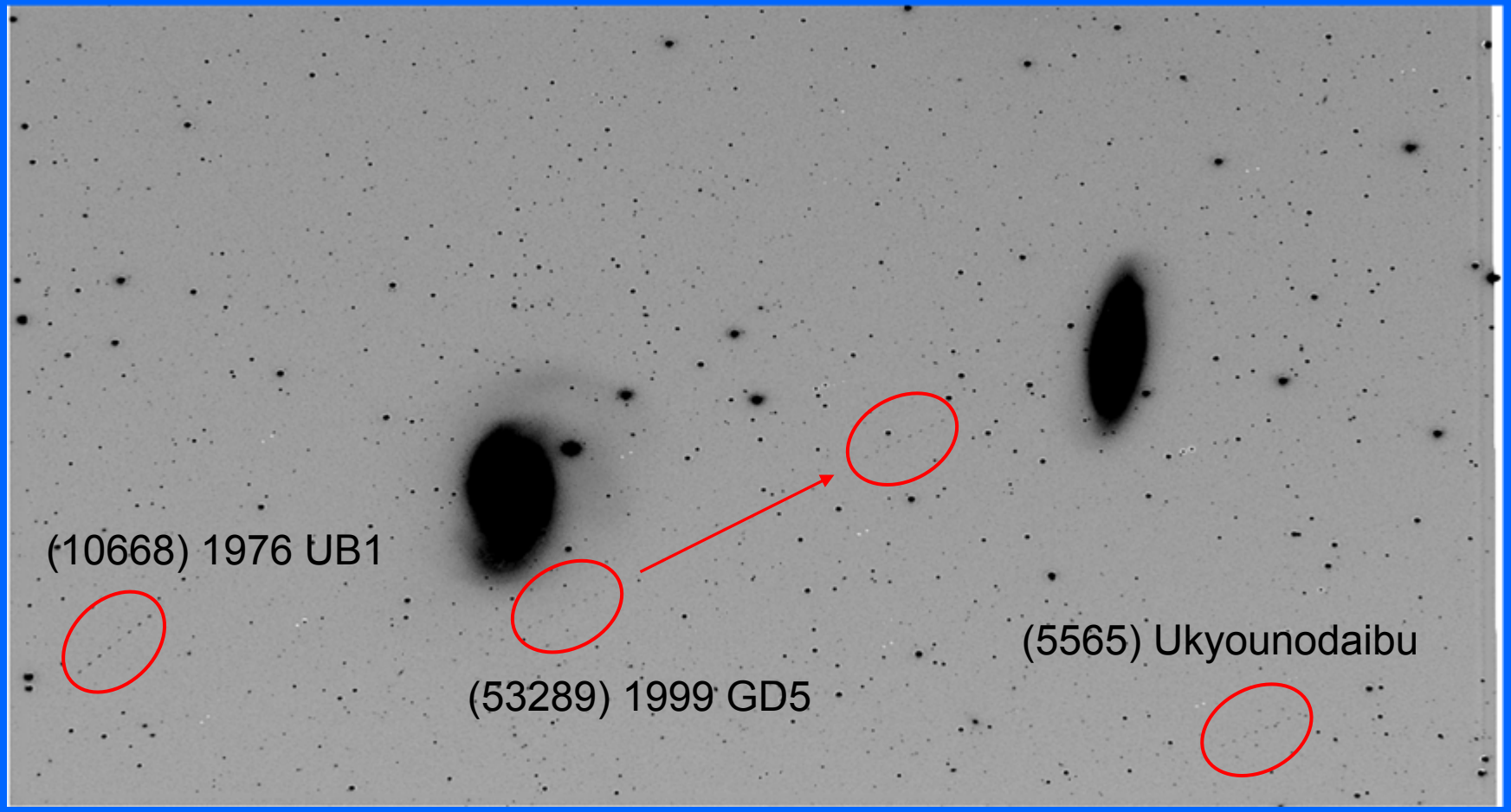
The following objects, brighter than $V = 20.0$, were found in the 15.0-arcminute region around R.A. = 11 21 03, Decl. = +12 53.8 (J2000.0) on 2007 03 18.41 UT:

Object designation	R.A. (h m s)	Decl. (° ' ")	V	Offsets R.A.	Offsets Decl.	Motion/hr R.A.	Motion/hr Decl.
(10668) 1976 UB1	11 21 03.2	+12 53 46	15.9	0.0E	0.0S	24-	29+
(26420) 1999 XL103	11 20 03.0	+12 52 02	18.7	14.6W	1.8S	36-	13+

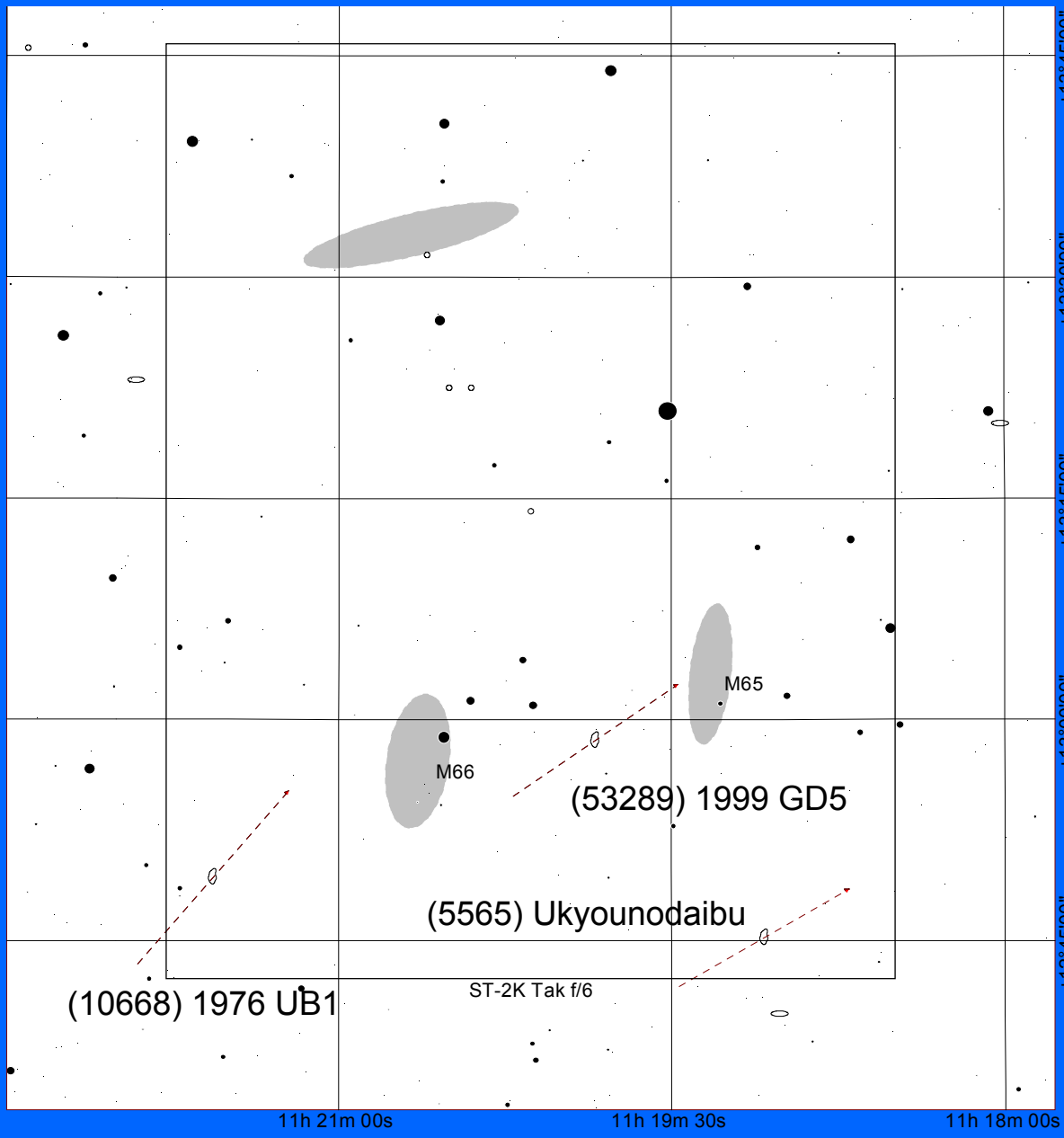
Asteroid Identification Using the Minor Planet Checker

Asteroid/Time	Estimated Location	Minor Planet Checker
(10668) 1976 UB1 (V15.9) 18 March 2007 04:46:56	11h 21m 11.9s 12º 51’ 16”	11h 21m 12.0s 12º 51’ 15”
18 March 2007 09:55:52	11h 21m 02.7s 12º 53’ 46”	11h 21m 03.2s 12º 53’ 46”
(53289) 1999 GD5 (V16.7) 17 March 2007 05:04:33	11h 20m 13.8s 12º 53’ 06”	11h 20m 13.4s 12º 53’ 09”
18 March 2007 09:55:52	11h 19m 19.0s 13º 02’ 24”	11h 19m 19.2s 13º 02’ 22”
(5565) Ukyounodaibu (V16.4) 18 March 2007 04:46:56	11h 18m 43.3s 12º 47’ 25”	11h 18m 43.3s 12º 47’ 25”
18 March 2007 09:55:52	11h 18m 33.3s 12º 48’ 50”	11h 18m 33.4s 12º 48’ 48”

By Checking My Estimated Asteroid Locations at the Beginning and End of Their Recoded Trails Against Candidate Objects From the MPC Database, I Have Conclusively Identified the Asteroids

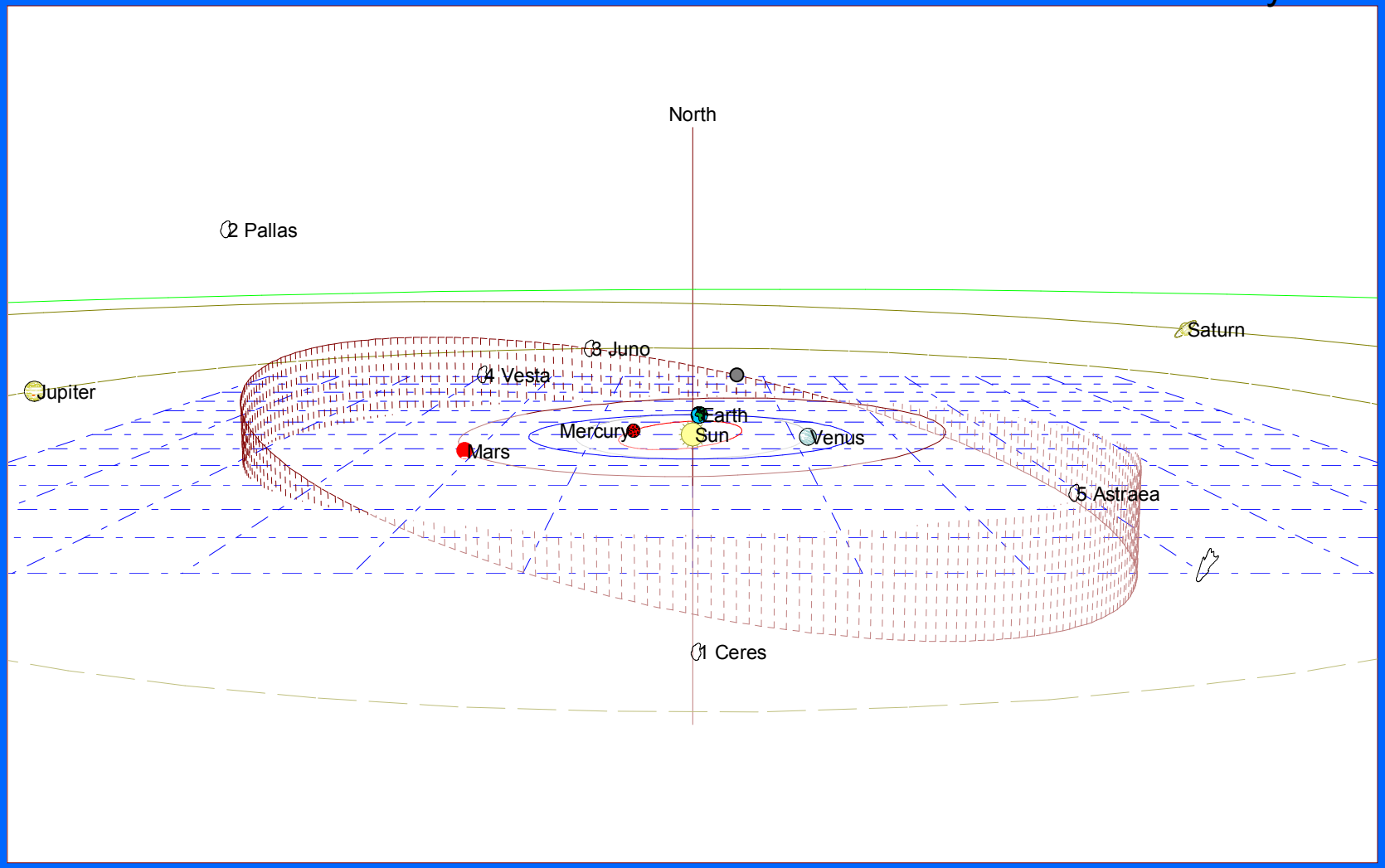


March 17, 2007 10:00PM PST (w/24 hour trails)



March 17, 2007 10:00PM PST

Period = 4.25 years



(10668)1976 UB1

Distance from Earth: 1.205653 astronomical units.
Distance from Sun: 2.185336 astronomical units.
Heliocentric: l:171.0779 b:4.3942 r:2.1853

Magnitude: 15.8
Rates ra: -0.0075 dec: 0.0082 (arc-secs/sec)
Magnitude: 15.8

10668 (1976 UB1)

Classification: Main-belt Asteroid **SPK-ID:** 2010668

[Ephemeris | Orbit Diagram | Orbital Elements | Physical Parameters | Discovery Circumstances]

[show orbit diagram]

Orbital Elements at Epoch 2454200.5 (2007-Apr-10.0) TDB
Reference: MPO65996 (heliocentric ecliptic J2000)

Element	Value	Uncertainty (1-sigma)	Units
e	0.1697354	n/a	
a	2.6250312	n/a	AU
q	2.1794705	n/a	AU
i	12.98531	n/a	deg
node	151.61239	n/a	deg
peri	30.97458	n/a	deg
M	357.53903	n/a	deg
t_p	2454211.1194971 (2007-Apr-20.61949710)	n/a	JED
period	1553.4601967	n/a	d
	4.25	n/a	yr
n	0.23174073	n/a	deg/d
Q	3.0705919	n/a	AU

Orbit Determination Parameters

# obs. used (total)	349
first obs. used	1952-??-??
last obs. used	2004-08-12
# oppositions	10
planetary ephem.	DE403
quality code	0
fit RMS	0.62
data source	MPC:mpn
producer	MPC

Additional Information

T_jup = 3.346

[Ephemeris | Orbit Diagram | Orbital Elements | Physical Parameters | Discovery Circumstances]

Physical Parameter Table

Parameter	Symbol	Value	Units	Sigma	Reference	Notes
absolute magnitude	H	13.2	mag	n/a	PDS3 (MPC 34736)	

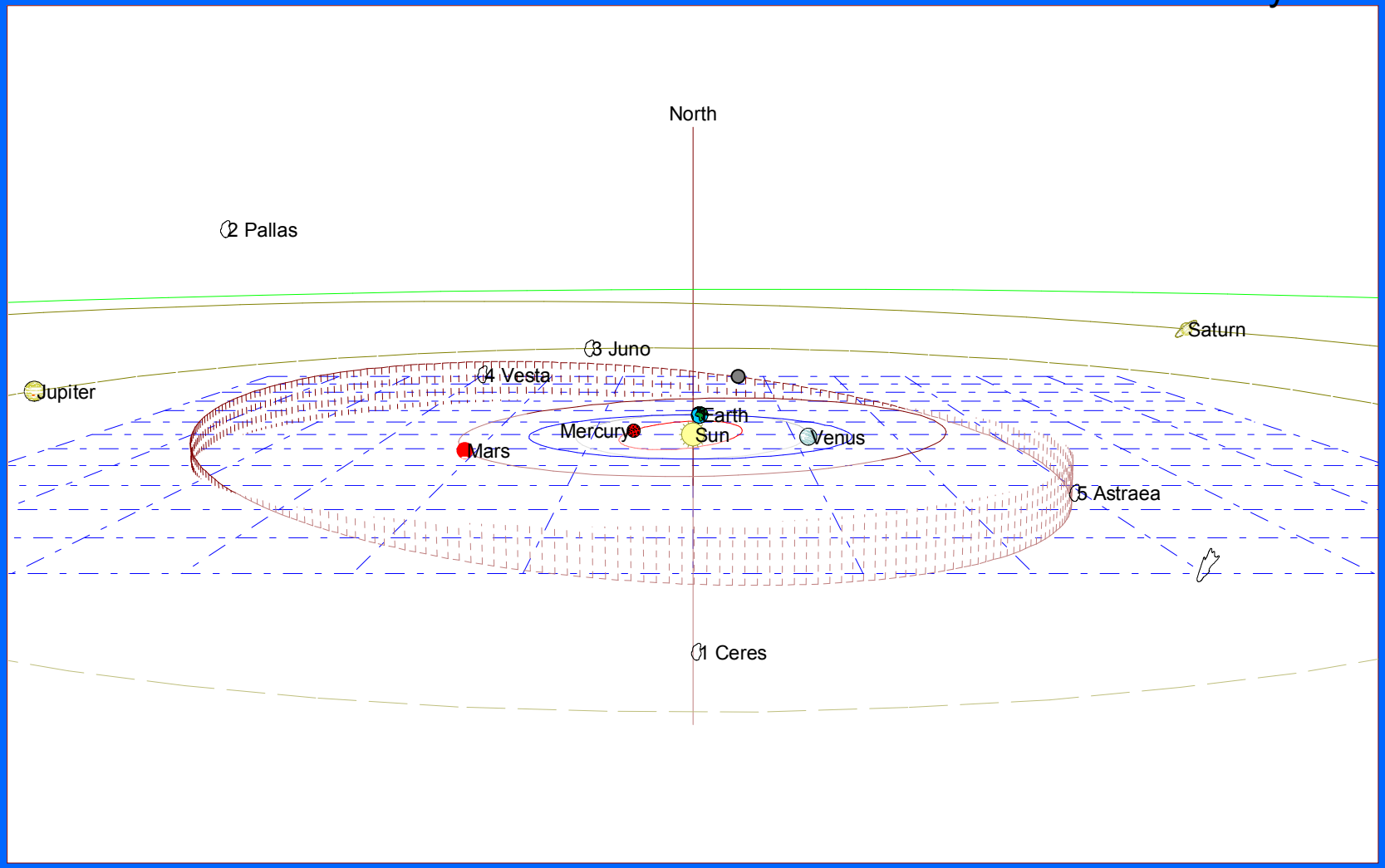
Alternate Designations

1976 UB1 = 1952 HD3 = 1990 FJ5 = 1994 DR

http://ssd.jpl.nasa.gov/sbdb.cgi

March 17, 2007 10:00PM PST

Period = 4.08 years



(53289)1999 GD5

Distance from Earth: 1.152611 astronomical units.
Distance from Sun: 2.131814 astronomical units.
Heliocentric: l:170.9618 b:4.2937 r:2.1318

Magnitude: 16.7
Rates ra: -0.0081 dec: 0.0053 (arc-secs/sec)
Magnitude: 16.7

53289 (1999 GD5)

Classification: Main-belt Asteroid **SPK-ID:** 2053289

[Ephemeris | Orbit Diagram | Orbital Elements | Physical Parameters | Discovery Circumstances]

[show orbit diagram]

Orbital Elements at Epoch 2454200.5 (2007-Apr-10.0) TDB
Reference: MPO110634 (heliocentric ecliptic J2000)

Element	Value	Uncertainty (1-sigma)	Units
e	0.1855665	n/a	
a	2.5530182	n/a	AU
q	2.0792635	n/a	AU
i	7.09987	n/a	deg
node	133.89195	n/a	deg
peri	4.68837	n/a	deg
M	27.87408	n/a	deg
t_p	2454085.1341287 (2006-Dec-15.63412871)	n/a	JED
period	1489.9761235	n/a	d
	4.08	n/a	yr
n	0.24161461	n/a	deg/d
Q	3.0267729	n/a	AU

Orbit Determination Parameters

# obs. used (total)	373
first obs. used	1999-??-??
last obs. used	2006-11-25
# oppositions	7
planetary ephem.	DE403
quality code	0
fit RMS	0.58
data source	MPC:mpn
producer	MPC

Additional Information

T_jup = 3.404

[Ephemeris | Orbit Diagram | Orbital Elements | Physical Parameters | Discovery Circumstances]

Physical Parameter Table

Parameter	Symbol	Value	Units	Sigma	Reference	Notes
absolute magnitude	H	14.2	mag	n/a	MPO110634	

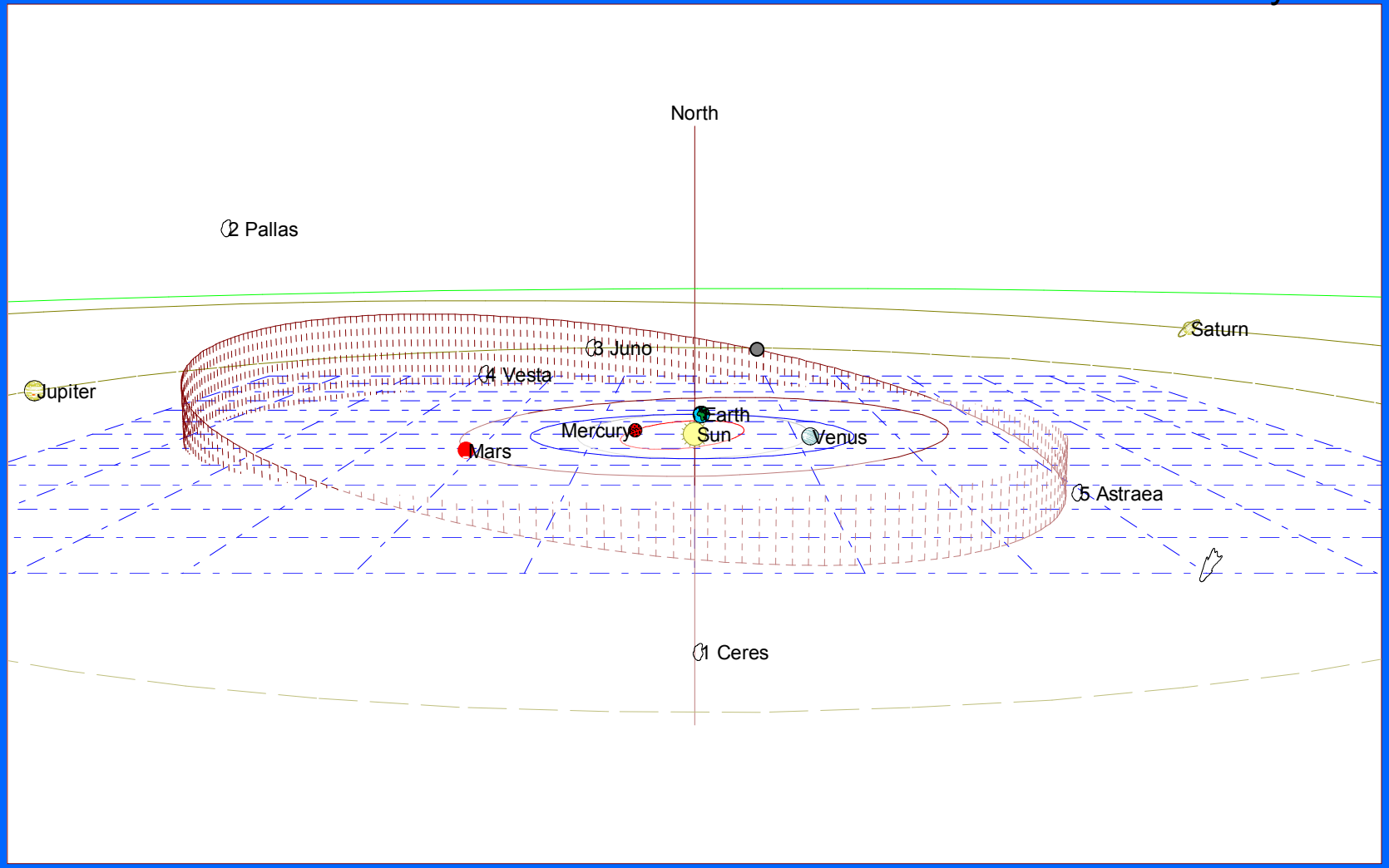
53289 (1999 GD5) Discovered 1999-Apr-07 by Shimizu, Y., Urata, T. at Nachi-Katsuura (905)

Reference: 20030216/Numbers.arc **Last Updated:** 2004-04-19

http://ssd.jpl.nasa.gov/sbdb.cgi

March 17, 2007 10:00PM PST

Period = 4.71 years



(5565)Ukyounodaibu

Distance from Earth: 2.087115 astronomical units.
Distance from Sun: 3.062379 astronomical units.
Heliocentric: l:169.2661 b:5.2262 r:3.0624

Magnitude: 16.2
Rates ra: -0.0082 dec: 0.0046 (arc-secs/sec)
Magnitude: 16.2

5565 Ukyounodaibu (1991 VN2)

Classification: Main-belt Asteroid **SPK-ID:** 2005565

[Ephemeris | Orbit Diagram | Orbital Elements | Physical Parameters | Discovery Circumstances]

[show orbit diagram]

Orbital Elements at Epoch 2454200.5 (2007-Apr-10.0) TDB
Reference: MPO47607 (heliocentric ecliptic J2000)

Element	Value	Uncertainty (1-sigma)	Units
e	0.2161894	n/a	
a	2.8088425	n/a	AU
q	2.2016005	n/a	AU
i	10.32079	n/a	deg
node	139.11466	n/a	deg
peri	265.02064	n/a	deg
M	108.18889	n/a	deg
t_p	2453683.7628510 (2005-Nov-09.26285100)	n/a	JED
period	1719.4498773	n/a	d
	4.71	n/a	yr
n	0.20936929	n/a	deg/d
Q	3.4160845	n/a	AU

Orbit Determination Parameters

# obs. used (total)	406
first obs. used	1952-??-??
last obs. used	2003-06-03
# oppositions	15
planetary ephem.	DE403
quality code	0
fit RMS	0.59
data source	MPC:mpn
producer	MPC

Additional Information

T_jup = 3.264

[Ephemeris | Orbit Diagram | Orbital Elements | Physical Parameters | Discovery Circumstances]

Physical Parameter Table

Parameter	Symbol	Value	Units	Sigma	Reference	Notes
absolute magnitude	H	11.8	mag	n/a	PDS3 (MPC 28113)	
SMASSII spectral type	spec_B	S		n/a	EAR-A-5-DDR-TAXONOMY-V4.0	based on a high-resolution spectrum

5565 Ukyounodaibu (1991 VN2) Discovered 1991-Nov-10 by Natori and Urata at Yakiimo

Reference: DISCOVERY.DB **Last Updated:** 2003-08-29

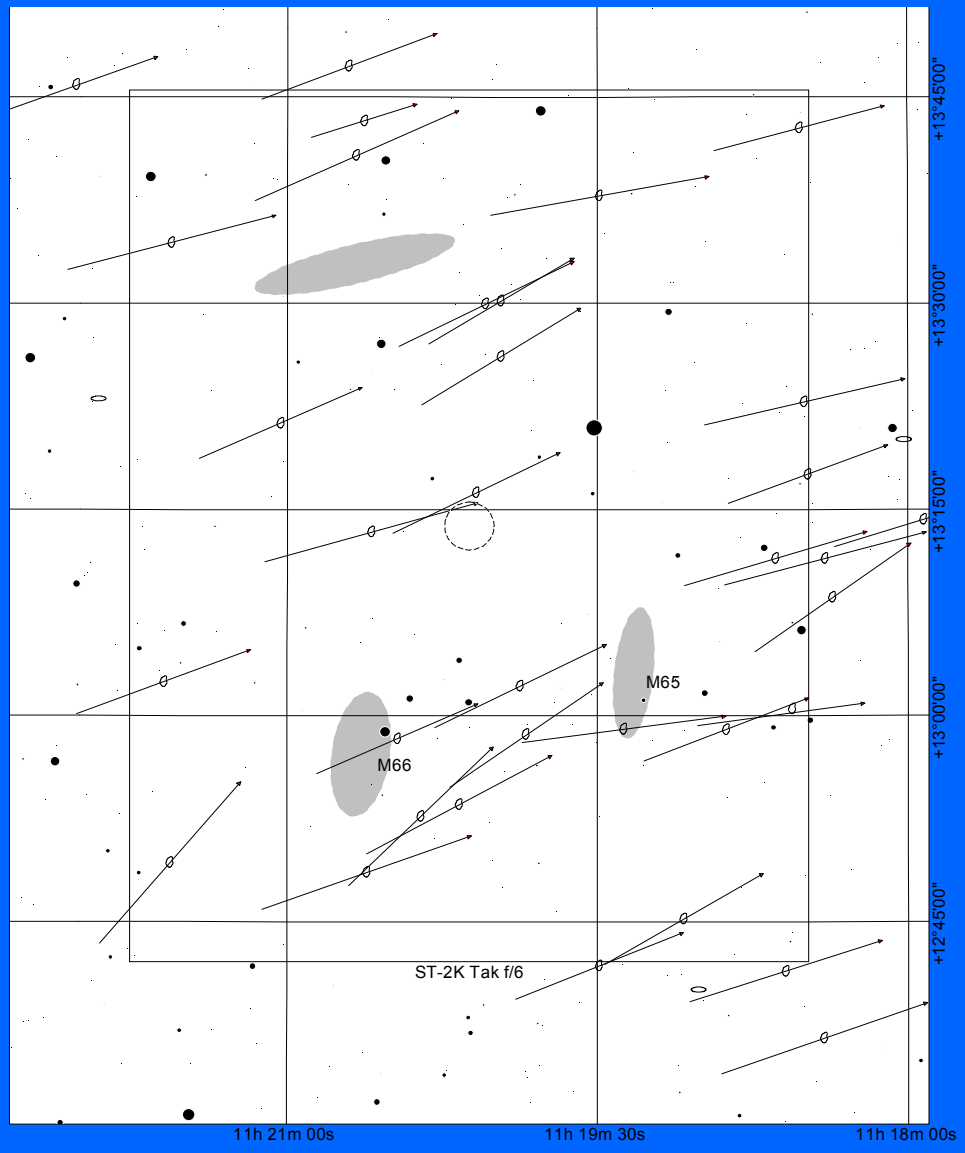
Alternate Designations

1991 VN2 = 1952 MA = 1962 PL = 1981 RB6 = 1988 CW

http://ssd.jpl.nasa.gov/sbdb.cgi

March 17, 2007 10:00PM PST (w/24 hour trails)

On this night there were over 30 known asteroids moving though the field of view



More Accurate Astrometry

- A simple method of astrometry has been successfully used to identify asteroids
  - However, according to the Guide to Minor Planet Astrometry* repeatable accuracy of <1” is needed
  - I have calculated the positions in terms of “plate coordinates,” rather, increased accuracy can be attained by transforming to “standard coordinates” which accounts for the fact that the CCD image is a flat representation of the celestial sphere
- See “The Handbook of Astronomical Image Processing” by R. Berry and J. Burnell for a discussion of more accurate astrometric formulae

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