

Near Earth Asteroid Observations

This project is intended to be conducted in small groups (two people). The objective of this project is to observe, record, measure and report the positions of a number of near Earth asteroids using predicted positions and brightness data from the IAU Minor Planet Center and the Tzec Maun Observatory (Cloudcroft, NM) robotic telescopes. Some of the early classroom exercises are designed to give students who attempt this activity sufficient background material. In order to do this project you will need to reserve time on one of the robotic telescopes, photographing the star fields where the selected asteroids are predicted to be found. Once the observations have been made the asteroids need to be identified and their positions and brightness' measured using Astrometrica (<http://www.astrometrica.at>). Finally, if the positions have been properly measured they will be reported to the IAU Minor Planet Center.

Prerequisites

This project assumes that you have completed the in-class CLEA exercise "Astrometry of Asteroids". A high speed Internet connection is preferred in order to control the Elk Creek Observatory and download the images. You will need an open phone line to the Elk Creek Observatory since not everything is automated at this time.

Required software

Astrometrica – You can download a 100 day evaluation version from <http://www.astrometrica.at/>. Wait until you are ready to start doing data analysis before getting and installing this software.

Internet browser –Firefox 1.5 and 2.0 work best. Internet Explorer 6 and 7 will work with some restrictions. Your instructor will provide you with the user Ids and passwords for the robotic telescopes.

The Tzec Maun Observatory has an interface that looks and functions very much like a planetarium program, which they call "Sky Chart". Objects can be selected by clicking on the object from the chart or you can enter an object name or coordinates in the "By Name" text field. To enter the coordinates of your asteroid enter them into the "By Name" field in the following format.

5h26m32s,10d26m25s
or
12.317,45.231

Note that you do NOT enter a plus sign for positive declination; doing so will lead to an error. If the declination is minus, then you DO use the minus sign:

5h26m32s,-10d26m25s

The first part is the right ascension (HMS) followed by the declination (DMS). There are no spaces. A more comprehensive list of ways to enter objects by name is available on the following link:

http://12.196.245.106/help/catalog_tips.htm.

Never click on an object that is below the horizon (green region on “Sky Chart”) as serious damage to the telescope can result.



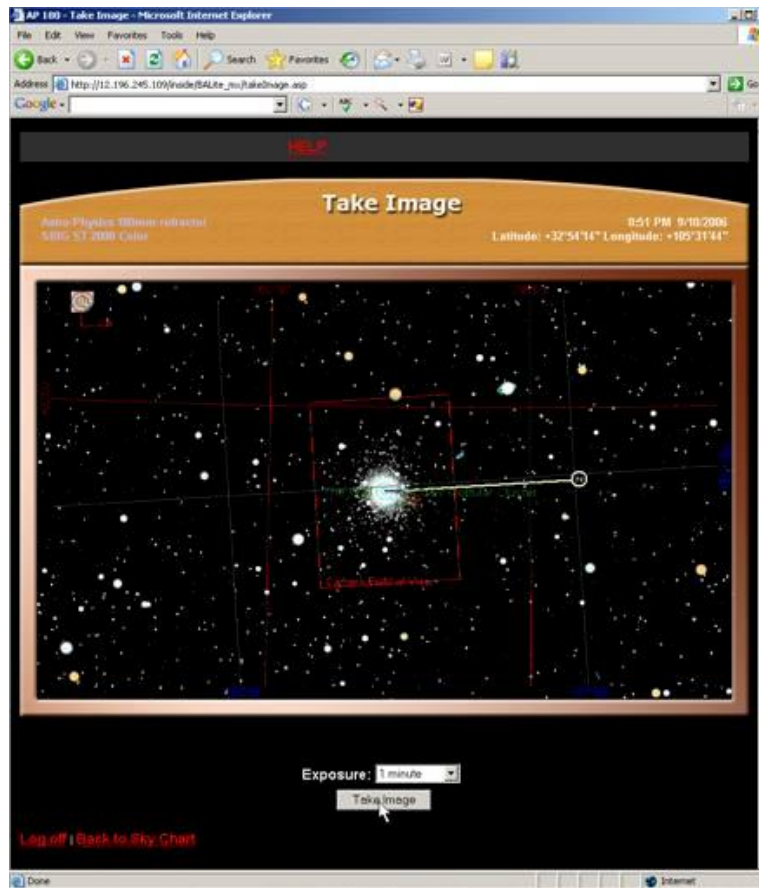
Tzec Mzun Telescope Interface

Telescope time on the Tzec Maun telescopes must be made through the Tzec Maun web site. Go to the telescope that you want to observe with and select the “Schedule

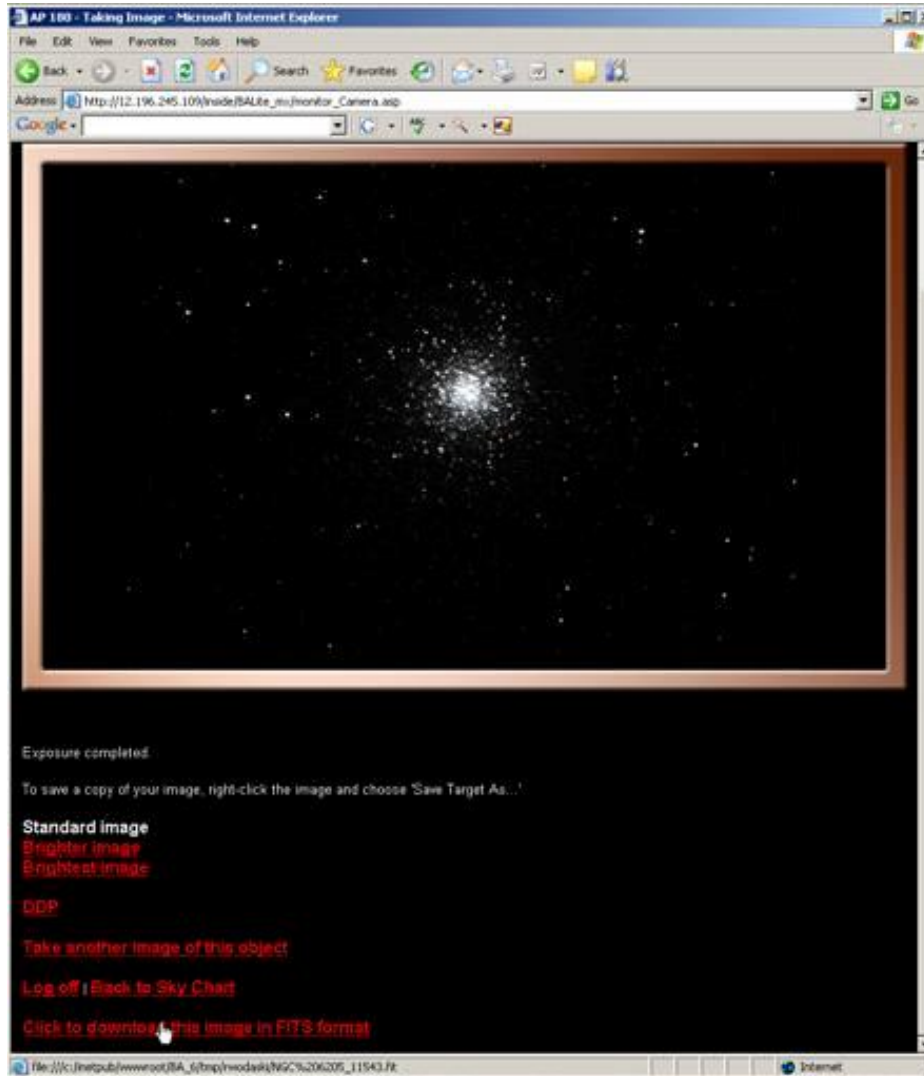
Telescope Time” Pick KCKCC from the list of schools and enter the user ID and password that your instructor will provide for you.

Image Acquisition

Capturing images with the Tzec Maun telescopes is very easy. After you have entered the coordinates in the “By Name” text field of the Sky Chart program and have slewed to the field you can set your exposure and take the image. Once the image has been acquired it will be displayed in the browser window. You will want to download the image in FITS format and then take another image.



Sky Chart Image Capture Screen



Sky Chart Image Display and Download Screen

Dark Frames

Dark frames are available from the Tzec Maun Observatory web site. You will find links to the dark frames on the Tzec Maun Observatory Wiki pages.

Flat Frames

Flat frames for the Tzec Maun telescopes can be requested from the telescope operator. Consult the Tzec Maun Observatory Wiki for information on requesting flat field frames.

Asteroid Observations

Planning

In order to observe an asteroid you need to know where to look. That is where Customizable Observable-Object Lists web site comes in handy (<http://cfa-www.harvard.edu/iau/lists/Customize.html>). This site allows you to generate lists of objects. On the first page of the customizable search you can accept the default parameters in the text fields. You will want to try the different options at the bottom of the page to see what asteroids are visible on the nights that you have scheduled time on a telescope.

Customize The Observable-Object Lists...

Some of the lists of observable objects on this website are rather long. This page allows you to customize certain observable lists to match your observing site. You may restrict the entries that are listed by sky position, solar elongation, magnitude and status of object. You are warned that certain combinations of selections will cause no objects to be listed.

Customize page

Reset form

RA limits to Decl. limits to

Elongation range to V magnitude range to

What kinds of objects are to be returned?

- Numbered objects
- Multi-opposition unnumbered objects
- Single-opposition unnumbered objects

Which page is to be customized?

- [Dates Of Last Observation Of NEOs](#)
 - [Dates Of Last Observation Of NEOs \(R.A. order\)](#)
 - [Bright NEO Recovery Opportunities](#)
 - [Faint NEO Recovery Opportunities](#)
 - [Dates Of Last Observation Of Unusual Minor Planets](#)
 - [Dates Of Last Observation Of Distant Objects](#)
 - [Dates Of Last Observation Of Distant Objects \(R.A. order\)](#)
-

To get started you will want to observe some of the brighter asteroids (magnitudes brighter than + 18) that are currently visible. You will want to observe on dark nights (near a new Moon). In general brighter asteroids can be picked up when a bright Moon is up but fainter asteroids will only be visible on dark moonless nights. The times generated by the Minor Planet Center Web site are in Universal Time.(UT). UT is ahead of us by 6 hours, so 9 PM CST on January 10 would be 0300 hours UT on January 11. The

following figure shows the query form. You will need to enter the date in the format indicated. You will then enter the number of intervals to print and the time interval. In the following example a 10-minute interval with 20 lines of output has been selected. The observatory code of 734 is for the Farpoint Observatory, located southwest of Topeka. Also, the motion of the asteroid will be displayed in arcseconds per minute rather than the default of arcseconds per hour. **Plan on generating ephemerides for your entire observing schedule.** In other words, if your scheduled time is from 8 PM to 10 PM on January 18 you need to generate ephemerides for 0200 to 0400 UT on January 19 (remember Universal Time is 6 hours ahead of CST).

Start date: (YYYY MM DD.dd form)

Number of dates to output:

Ephemeris interval: Ephemeris units: days hours minutes

Observatory code:

Display positions in: truncated sexagesimal or full sexagesimal or decimal units

Total motion and direction Separate R.A. and Decl. motions

Display motions as: "/min "/hr °/day

Full output Brief output

Minor Planet Ephemeris Service: Query Results

Below are the results of your request from the Minor Planet Center's Minor Planet Ephemeris Service. Ephemerides are for observatory code 734.

2007 AM

[Display all designations for this object](#)

Perturbed ephemeris below is based on 2-day-arc elements from [MPBC 2007-A48](#). Last observed on 2007 Jan. 10.

[Further observations?](#) NEO : Desirable at first ephemeris date

K07A00M																
Date	UT	R.A. (J2000)	Decl.	Delta	r	El.	Ph.	V	Sky Motion		Object		Sun	Moon		
	h m s								"/min	P.A.	Azi.	Alt.	Alt.	Phase	Dist.	Alt.
2007 01 13	000000	04 55 48.3	+21 01 17	0.212	1.159	142.7	30.9	19.9	3.53	291.8	272	+38	-07	0.36	143	-64
2007 01 13	001000	04 55 46.0	+21 01 30	0.212	1.159	142.7	31.0	19.9	3.54	291.7	274	+40	-09	0.36	143	-65
2007 01 13	002000	04 55 43.6	+21 01 43	0.212	1.159	142.7	31.0	19.9	3.54	291.7	276	+42	-11	0.36	143	-66
2007 01 13	003000	04 55 41.3	+21 01 56	0.212	1.159	142.7	31.0	19.9	3.54	291.6	277	+44	-13	0.36	143	-67
2007 01 13	004000	04 55 38.9	+21 02 09	0.212	1.159	142.6	31.0	19.9	3.55	291.6	279	+46	-15	0.36	143	-68
2007 01 13	005000	04 55 36.6	+21 02 22	0.212	1.159	142.6	31.0	19.9	3.55	291.5	281	+47	-17	0.36	143	-69
2007 01 13	010000	04 55 34.2	+21 02 36	0.212	1.159	142.6	31.0	19.9	3.55	291.5	283	+49	-19	0.36	143	-69
2007 01 13	011000	04 55 31.8	+21 02 49	0.212	1.159	142.6	31.0	19.9	3.55	291.4	285	+51	-20	0.36	144	-69
2007 01 13	012000	04 55 29.5	+21 03 01	0.212	1.159	142.6	31.0	19.9	3.56	291.4	288	+53	-22	0.36	144	-69
2007 01 13	013000	04 55 27.1	+21 03 14	0.212	1.159	142.6	31.1	19.9	3.56	291.3	290	+55	-24	0.36	144	-69
2007 01 13	014000	04 55 24.7	+21 03 27	0.212	1.159	142.5	31.1	19.9	3.56	291.3	293	+57	-26	0.36	144	-69
2007 01 13	015000	04 55 22.4	+21 03 40	0.212	1.159	142.5	31.1	19.9	3.56	291.2	296	+59	-28	0.36	144	-68
2007 01 13	020000	04 55 20.0	+21 03 53	0.212	1.159	142.5	31.1	19.9	3.56	291.2	299	+60	-30	0.36	144	-67
2007 01 13	021000	04 55 17.6	+21 04 06	0.212	1.159	142.5	31.1	19.9	3.56	291.1	302	+62	-32	0.35	144	-67
2007 01 13	022000	04 55 15.3	+21 04 19	0.212	1.159	142.5	31.1	19.9	3.56	291.1	306	+64	-34	0.35	144	-65
2007 01 13	023000	04 55 12.9	+21 04 32	0.212	1.159	142.5	31.1	19.9	3.56	291.0	310	+65	-36	0.35	144	-64
2007 01 13	024000	04 55 10.5	+21 04 44	0.212	1.159	142.5	31.1	19.9	3.56	291.0	314	+67	-38	0.35	144	-63
2007 01 13	025000	04 55 08.1	+21 04 57	0.212	1.159	142.4	31.2	19.9	3.56	291.0	319	+68	-40	0.35	144	-62
2007 01 13	030000	04 55 05.8	+21 05 10	0.212	1.159	142.4	31.2	19.9	3.56	290.9	325	+69	-42	0.35	145	-60
2007 01 13	031000	04 55 03.4	+21 05 23	0.212	1.159	142.4	31.2	19.9	3.56	290.9	331	+70	-44	0.35	145	-58

Observing Procedure

Apply for Telescope Time

You will need to apply for time on one of the robotic telescopes at the Tzec Maun Observatory. The Tzec Maun Observatory is located in the dark skies of New Mexico and has several small telescopes with CCD cameras available for use. They currently have four telescopes available (two seven inch, one eight inch and one 14 inch telescope) for student use. The AP 180, AP 206 or the Maksutov-Newtonian can be used for asteroid hunting.

Log into Remote Telescope

For the Tzec Maun Observatory the URL is <http://www.tzecmaun2.org/>. Click on the "Telescope Portal" link at the top of the web page. Use the "Schedule time" link on the portal page to reserve telescope time. You should plan on reserving time several days in advance.

Slew Telescope to First Asteroid

Enter the RA and Dec of your asteroid from the MPC query into the remote telescope interface. Use the coordinates from the MPC query that best matches the time you are observing.

Take Images

When you take an image you need to choose an exposure that is long enough to record the asteroid and faint surrounding stars. The AP 206 telescope using a three to four minute exposure will record stars down to 18th magnitude. You need to keep the angular speed of the asteroid in mind as well. If the asteroid is moving at 3 "/min you probably won't record it. At best you may record a faint elongated smudge. If you take too long of an exposure your asteroid may turn out as an elongated streak. You will want to try exposures of three or four minutes.

Download Images

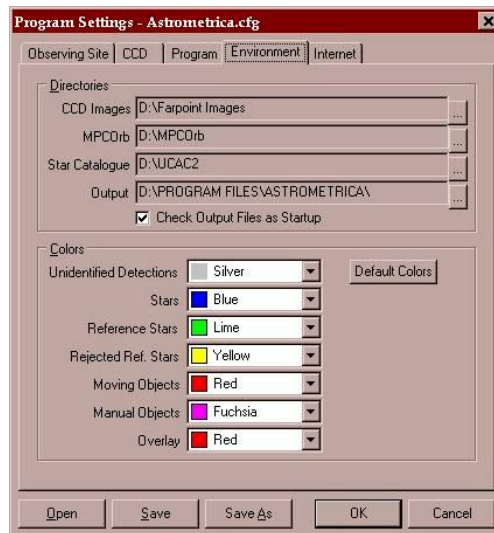
Once you have finished taking a series of images you will want to download the images to your PC. Place them in a folder that has the date as part of its name. For the date use the Universal Time when you took the images. For example if you observe at 9 PM on Jan 20th, 2007, the folder would be named 20070121 since the 9 PM CST on 01/20/2007 is 0300 UT on 01/21/2007 (CST is six hours behind UT).

Data Analysis

External Data Files

Astrometrica needs one of several stellar catalogs. It can work with the USNO-A2.0, USNO-B1.0, USNO-SA2.0 and UCAC 2 catalogs. The USNO-A2.0 catalog contains data on over 500 million stars and comes on 11 CDs. The USNO-B1.0 catalog contains data on over 1 billion stars and is available only via the Internet. The USNO-SA2.0 catalog is a subset of the USNO-A2.0 catalog and contains data on about 55 million stars of magnitude 16b to 19. The catalog with the best positional data is the UCAC 2 catalog, which fits on a single DVD disk. This is the catalog that you will be using. Copy the contents of the supplied DVD to your PC's hard drive or use the data directly from the DVD. The UCAC 2 catalog is not yet complete and does not cover any stars above declination +45 degrees. If you are observing in a region that is not covered by the UCAC 2 catalog Astrometrica will download the required reference stars from the USNO-B1.0 over the Internet, which will require an active Internet connection.

The Minor Planet Center asteroid database (MPCOrb) and the comet database will need to be downloaded from the Minor Planet Center. The address is "<ftp://cfa-ftp.harvard.edu/pub/MPCORB/>". You will want to download MPCORB.zip and use WinZip to unpack the data file. Also, download COMET.DAT from the same address. You need to place the files into a directory on your PC's hard drive. Next, you need to tell Astrometrica where the external data is located. Open Astrometrica's configuration dialog and select the "Environment" tab. Adjust the "MPCOrb" and "Star Catalog" settings to the locations where the data is to be found.



Astrometrica Configuration Dialog

The MPCOrb database needs to be periodically updated. It would be a good idea to update it whenever you observe.

Image Calibration

In Astrometrica open your master dark and flat frames, using the “Load Dark” and “Load Flat” buttons on the toolbar, and minimize them. Astrometrica will automatically calibrate your images while the dark and flat frames are open.

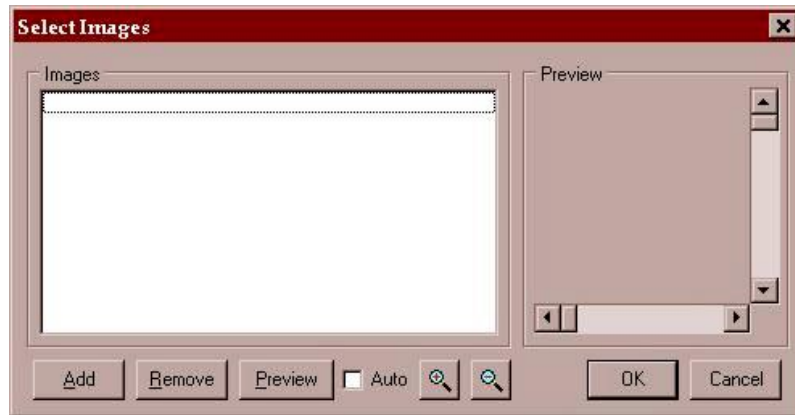
Stacking and Alignment

Click the “Stack and Track” button on the Astrometrica toolbar. The “Select Images” dialog will come up.

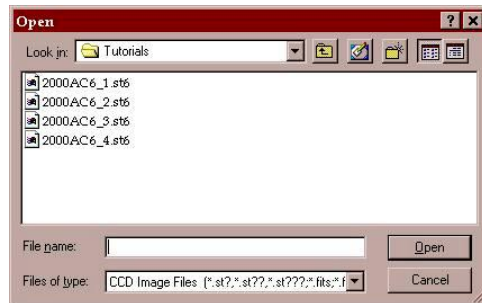


Astrometrica Toolbar

Click the “Add” button on the dialog, which will bring up the “Open” dialog. Select anywhere from three to six images (the shorter your exposure the more images you will want to select).



Stack and Track Select Dialog

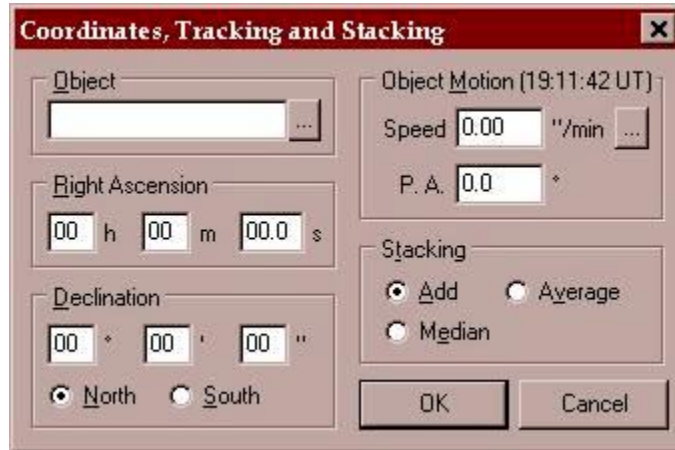


Add Dialog



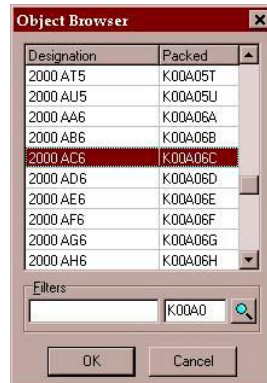
Selected Images in the Stack and Track Select Dialog

The selected images will now appear in the “Select Images” dialog. Click the “OK” button. After the images have loaded the “Coordinates, Tracking and Stacking” dialog will be displayed.



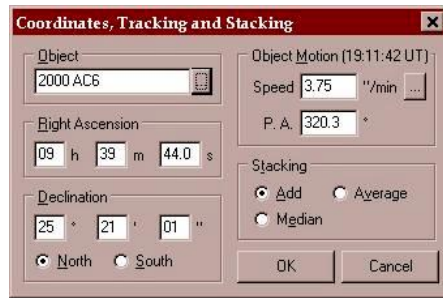
Coordinates, Tracking and Stacking Dialog

If your images are centered on a known asteroid you will want to select the asteroid from the MPCOrb database by selecting the browser button “[...]” next to the “Object” box. This will bring up the object browser. Enter the name or part of the name in the “Filters” box and click the search button. Find the asteroid in the list and select it. Click the “OK” button.



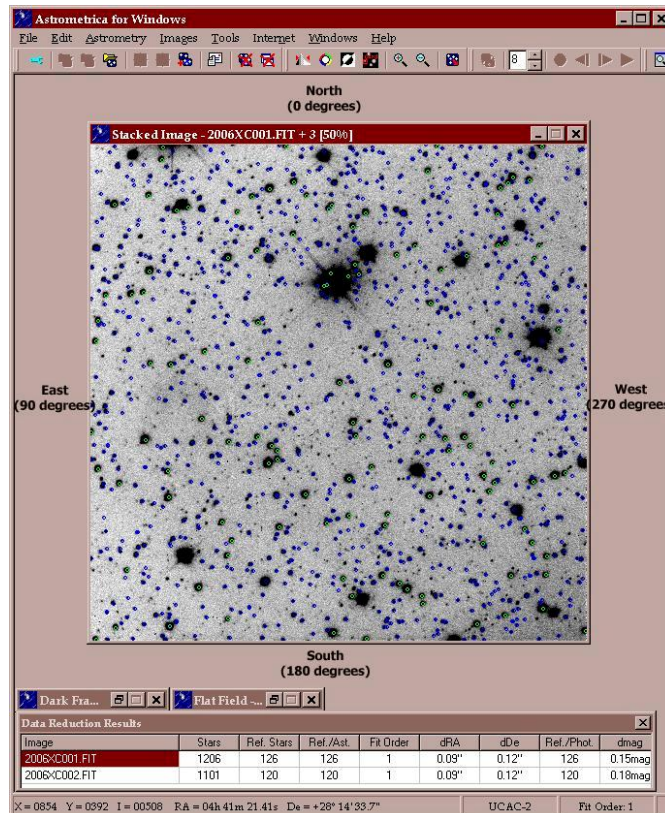
Object Browser Dialog

The “Object Browser” can filter asteroids by their designation (name) or their packed number. For example, “2000 AC6” is a designation while K00A06C the equivalent packed number. In the “Object Browser”, the left text field is for the designation while the right text field is for the packed number. When you have found your target in the “Object Browser” select it and click the “OK” button. You will be returned to the “Coordinates, Tracking and Stacking” dialog, and all of the fields will now be filled in.



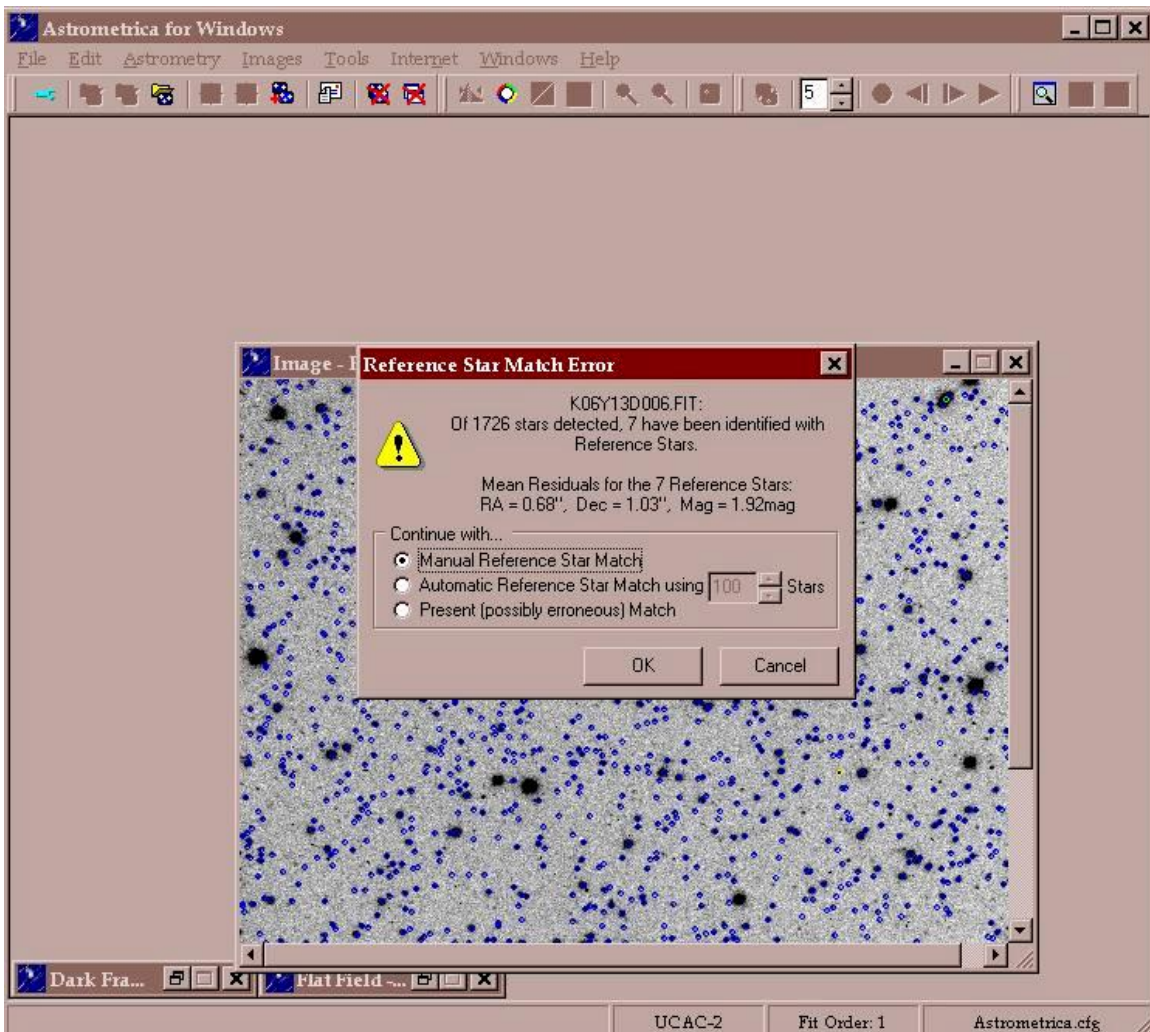
Filled in Dialog

Notice that the coordinates of the asteroid for the time when the image was taken are filled in as well as the speed in seconds of arc per minute and the direction, which is called the position angle (P. A.), that the asteroid is moving. The P. A. is measured from North (0 degrees) through East (90 degrees), then through South (180 degrees), then through West (270 degrees) and finally back to North. In the following example the image is oriented with North on the top and East to the left. Remember that right ascension increases to the East and declination increases to the North.

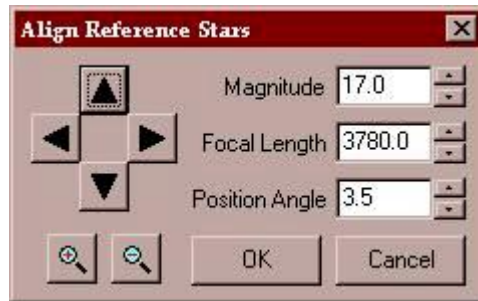


Position Angles

Keep in mind that the orientation of your images may be backwards from this example. You will need to know your camera's orientation. If you don't know it you can always try different camera orientation settings in Astrometrica's configuration dialog until it is able to get a good fix on the stars in your images or you can simply compare your images with a good star chart. Sometimes Astrometrica is not able to get a good fix on the stars in an image even when the orientation of the image is correct. Several things can cause this to happen. The coordinates that you told it are way off, the telescope focal length, which affects the image scale, in the settings is wrong, the camera position angle is slightly off, or the image orientation in the configuration settings is wrong. When one of these happens Astrometrica will display a dialog prompting giving you the option to try again with more reference stars or to do a manual alignment. It is probably a better idea to pick the manual alignment option.

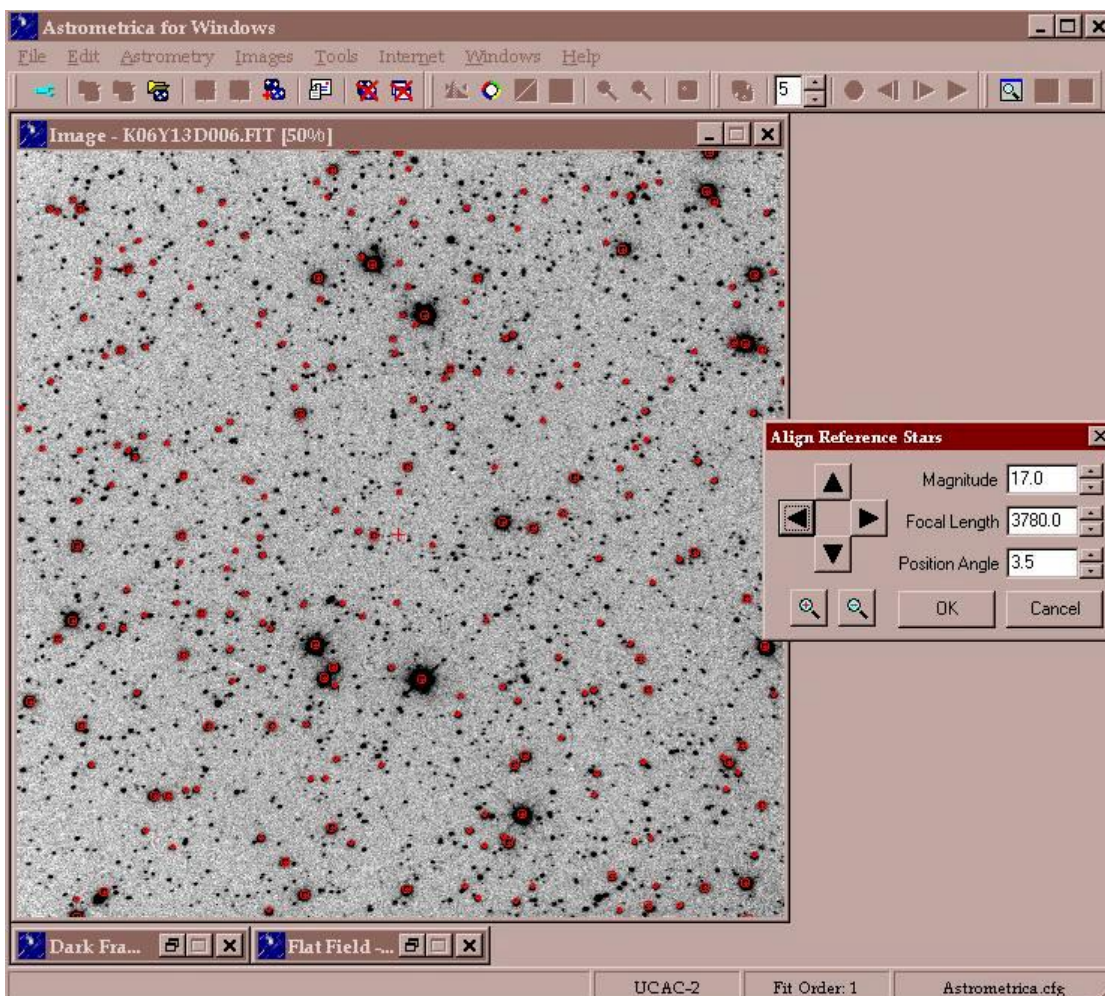


Star Alignment Error Dialog

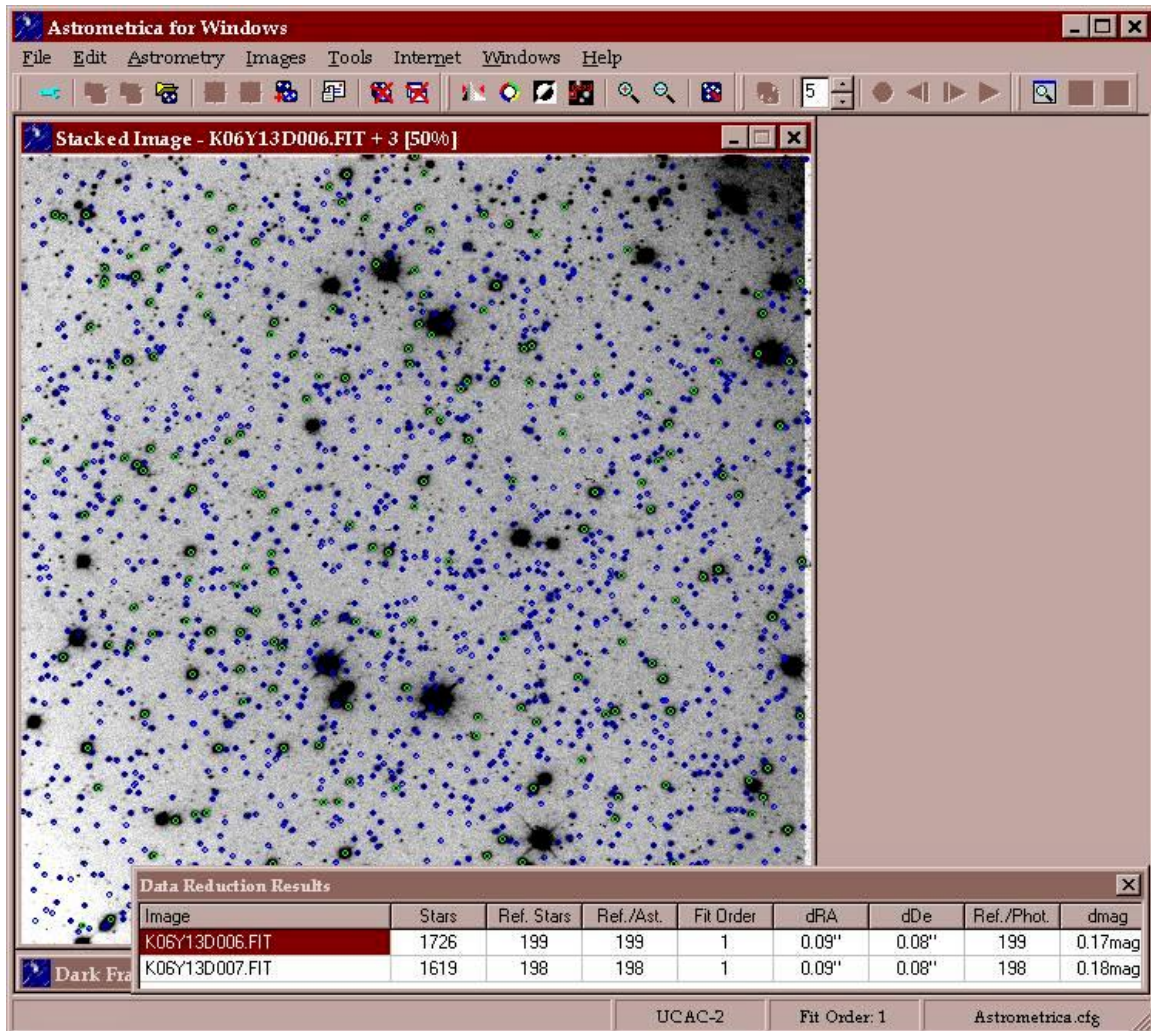


Manual Alignment Dialog

The alignment dialog allows you to adjust the number of reference stars with the magnitude adjuster. Increasing the magnitude will increase the number of reference stars. Generally, the more reference stars you can match with the better. If you are uncertain about the focal length or camera angle you can adjust those to see if you can match the red reference circles with the stars in the image. If the focal length and camera position angle are correct the red reference circles will be slightly offset from the stars in the image.



Manual Alignment

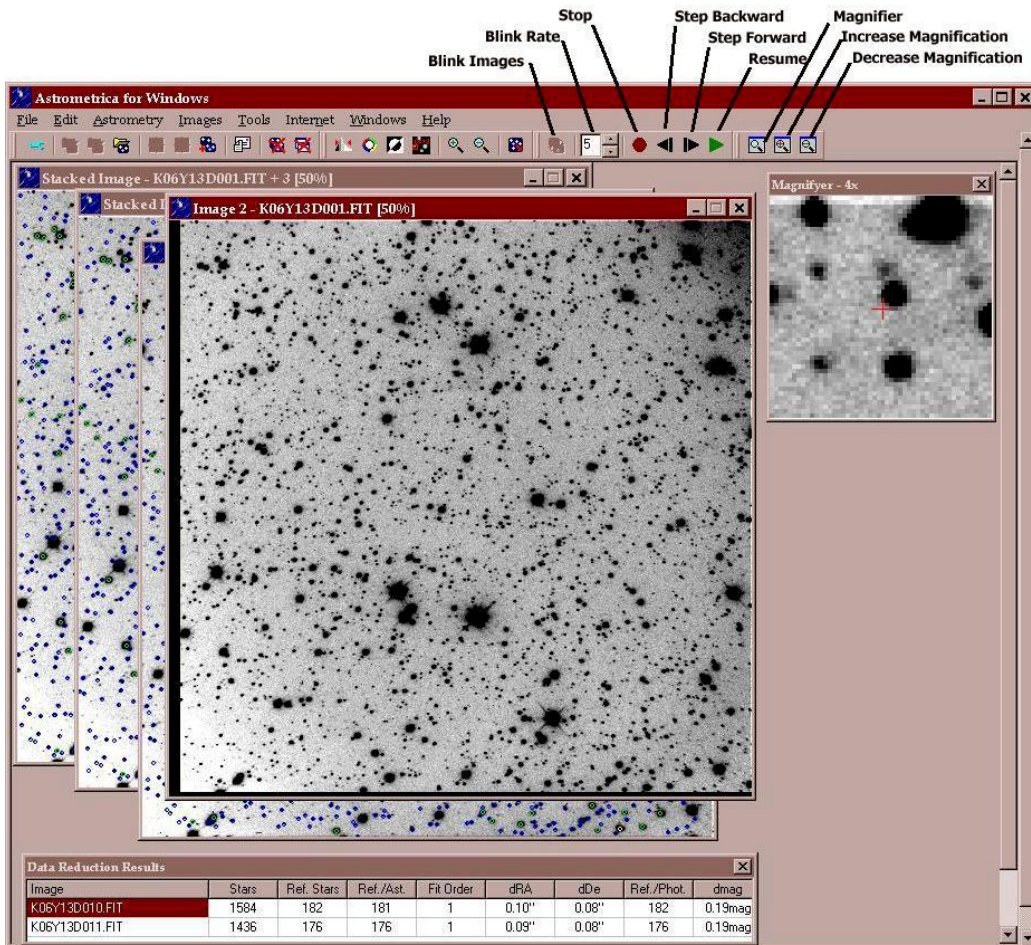


Successfully Aligned Image

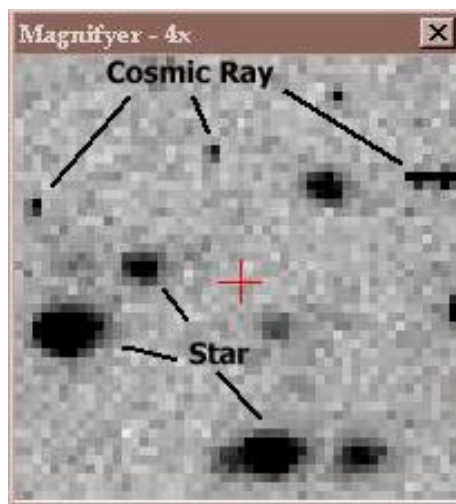
After you have aligned the red reference circles to the image Astrometrica will display the alignment results. You want to keep the residuals (dRA and dDe) down to around 0.10 seconds of arc or less. You will need to repeat the “Stack and Track” steps until you have at least three sets of stacked images.

Blinking Stacked Images

After you have stacked several sets of images you are ready to blink them. Click on the “Blink Images” button on the toolbar, which will bring up a new window that animates the images. Study the blinking images for several minutes and look for stellar looking images that move across the field. There will be a lot of dark specks that appear on the images at random, which are cosmic ray hits on the CCD chip. Cosmic ray hits do not have the soft edges that stars have. An asteroid in the field will look like a star (perhaps a bit elongated) moving across the field in a line and it will appear on each frame, while the cosmic ray hits will not appear on each frame. You can use the magnifier tool to get a better look at potential asteroids. Just move the mouse over the blinking image and the magnifier tool will enlarge that part of the image.



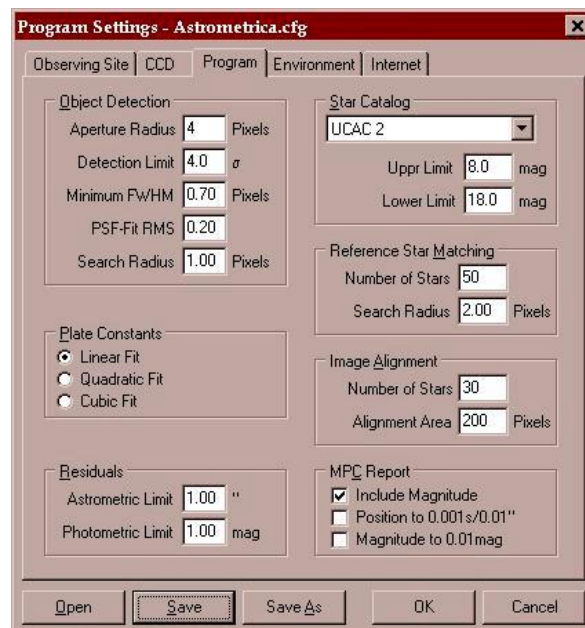
Blink and Magnifier Tools



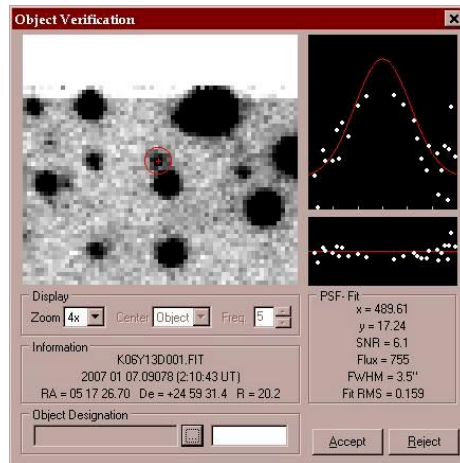
Cosmic Rays vs. Stars

Measuring Asteroid Coordinates

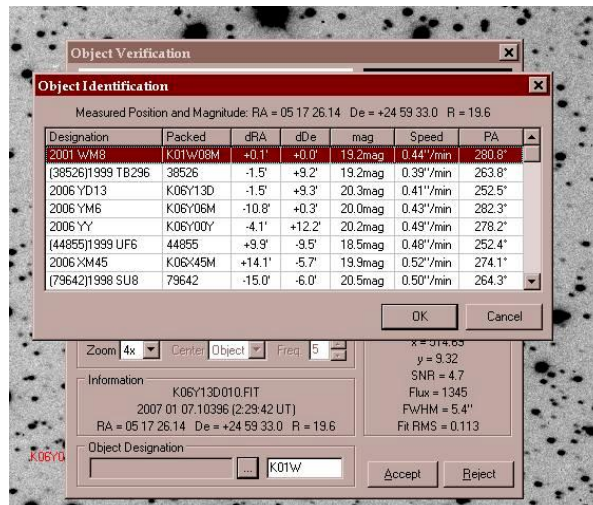
When you have positively identified an asteroid in the blinked images you need to measure the coordinates of the asteroid in each of the blinked frames. The best way to do this is to stop the blinking by clicking the “Stop” button on the toolbar and backup the blink sequence to the first image. Open the “Configuration” window and select the “Program” tab and make sure that you set the Aperture Radius to 4 pixels and save the settings. If the asteroid gets close to a star you may have to go back into the settings and reduce the radius to two or three pixels. If the asteroid passes in front of a star you can’t make any measurements while it is entangled with the star. To measure the position of an asteroid simply click on it and the “Object Verification” window will be displayed. The “Object Verification” window shows the selected position, which should be in the center of the asteroid. If the detection looks good then you need to supply the object’s identification. If you are measuring a known asteroid, enter part or all of the name in the text field at the bottom of the “Object Verification” window and click on the “Object Browser” button. Select the object’s name from the “Object Identification” window and click the “OK” button. Now the “Object Verification” is complete and to save the position click the “Accept” button. Repeat these steps for each frame. The results are stored in Astrometrica’s “MPC Report” file, which can be accessed from the “File” menu.



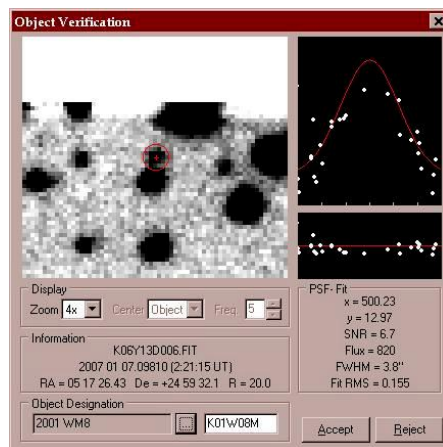
Object Detection Settings



Object Verification Window



Partial Name Entered for Packed Designation



Completed Object Verification Window

If the asteroid that you are measuring does not match anything in the Minor Planet database you need to make up a temporary name for it. I suggest using the following format.

“SSOONN”

The first two characters “SS” are the initials of the location. Use “TM” for Tzec Maun. “OO” are the initials of the observers’ last names, and NN is a numeric sequence (01, 02, 03, ...). The sequence would start on any given night with “01” for the first unknown object and would be incremented by one for each subsequent unknown. The Minor Planet Center will either match the object with a known asteroid or it will assign a new designation for it.

Report Submission

When you have completed your measurements you need to format your report(s) to the Minor Planet Center. Take your Astrometrica log and separate the main belt asteroids from any near Earth asteroids. If an asteroid you observed did not come from the Minor Planet Center’s NEO list assume it is a main belt asteroid. Any comets that you might have observed need to go into their own report.

From: Farpoint Observatory [fast@nekaal.org]
Sent: Sunday, January 07, 2007 1:18 AM
To: mpc
Cc: David Kolb; Dan Tibbets; Gary Hug
Subject: MB - 3 possible new MB and one nearby known MB

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COD 734
OBS D. Tibbets
MEA D. Kolb
TEL 0.7-m reflector + CCD
ACK MB Report file updated 2007.01.07 00:59:11
AC2 fast@nekaal.org
NET UCAC-2

```

Object Name	Date & Time	RA	Dec	Magnitude	Observatory Code
B9766	C2007 01 07.21671	06 40 31.20	+30 33 45.6	19.9 R	734
B9766	C2007 01 07.22403	06 40 30.97	+30 33 46.1	20.7 R	734
B9766	C2007 01 07.25331	06 40 29.10	+30 33 47.7	19.8 R	734
B9766	C2007 01 07.26137	06 40 28.56	+30 33 47.8	19.4 R	734
fptk01	C2007 01 07.21671	06 40 29.48	+30 33 15.3	20.0 R	734
fptk01	C2007 01 07.22403	06 40 28.98	+30 33 13.9	19.8 R	734
fptk01	C2007 01 07.23135	06 40 28.55	+30 33 13.6	19.8 R	734
fptk01	C2007 01 07.23867	06 40 28.04	+30 33 12.4	20.2 R	734
fptk01	C2007 01 07.24599	06 40 27.69	+30 33 11.5	20.3 R	734
fptk01	C2007 01 07.25331	06 40 27.28	+30 33 09.9	20.3 R	734
fptk02	C2007 01 07.21671	06 40 11.97	+30 39 27.1	20.4 R	734
fptk02	C2007 01 07.22403	06 40 11.55	+30 39 28.6	20.1 R	734
fptk02	C2007 01 07.23135	06 40 11.11	+30 39 30.4		734
fptk02	C2007 01 07.24599	06 40 10.29	+30 39 33.1	20.3 R	734
fptk03	C2007 01 07.21671	06 40 04.81	+30 48 46.9		734
fptk03	C2007 01 07.23867	06 40 03.29	+30 48 50.6	20.9 R	734
fptk03	C2007 01 07.24599	06 40 02.79	+30 48 51.2	20.8 R	734
fptk03	C2007 01 07.25331	06 40 02.27	+30 48 52.3	21.0 R	734
fptk03	C2007 01 07.26137	06 40 01.94	+30 48 54.4	21.3 R	734

Sample Report

All of the report header information can be entered into Astrometrica’s configuration dialog, which automatically gets added to the report. The ACK line needs to be edited so as to indicate the type of object being reported. Use “MB” to indicate a main belt object,

“NEO” for near Earth objects and COMET for comets. The reports should be mailed to mpc@cfa.harvard.edu. The Minor Planet Center does not like isolated reports being submitted. You should always observe objects on at least two nearly consecutive nights (within two or three days if possible).

From: Farpoint Observatory [fast@nekaal.org]
Sent: Monday, January 08, 2007 1:50 AM
To: David Kolb
Subject: MB 2nd night Followup of fptk02 and fptk03

COD 734
 OBS D. Tibbets
 MEA D. Tibbets
 TEL 0.7-m reflector + CCD
 ACK MB 2nd night Followup of fptk02 and fptk03 2007.01.08 00:36:49
 AC2 fast@nekaal.org
 NET UCAC-2

fptk02a	C2007	01	08.24529	06	38	56.73	+30	51	08.0			734
fptk02a	C2007	01	08.26284	06	38	55.61	+30	51	11.3	19.5	R	734
fptk02a	C2007	01	08.27016	06	38	55.23	+30	51	12.9	20.4	R	734
fptk03a	C2007	01	08.24529	06	39	13.36	+30	42	48.7	19.9	R	734
fptk03a	C2007	01	08.25406	06	39	12.82	+30	42	49.4	19.5	R	734
fptk03a	C2007	01	08.26284	06	39	12.30	+30	42	51.1	20.3	R	734
fptk03a	C2007	01	08.27016	06	39	11.95	+30	42	52.3	20.0	R	734

Sample Follow-up Report

From: Farpoint Observatory [fast@nekaal.org]
Sent: Saturday, January 06, 2007 10:58 PM
To: CBAT
Cc: Dan Tibbets; Gary Hug; davidkolb@sbcglobal.net
Subject: COMET FOLLOW-UP

COD 734
 OBS G. Hug D. Tibbet
 MEA D. Kolb
 TEL 0.7-m reflector + CCD
 ACK COMET Report file updated 2007.01.06 22:41:10
 AC2 fast@nekaal.org
 NET UCAC-2

0178P	C2007	01	07.17097	07	33	48.26	+23	33	51.2	18.8	N	734
0178P	C2007	01	07.17536	07	33	48.00	+23	33	52.6	19.1	N	734
0178P	C2007	01	07.17976	07	33	47.74	+23	33	54.9	18.5	N	734

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Sample Comet Follow-up Report

Expectations

You will be expected to make successful observations on at least six nights. The more nights on the telescopes you get the better your chances of perhaps stumbling upon an unknown asteroid.

You need to keep a journal of all of you planning activities and work including the printed ephemerides of the asteroids from the Minor Planet Center, times and dates of your observations, telescopes used, images, e-mails, and Astrometrica output. Use the attached observing log forms to keep a record of your observations. The printed material can be kept in a notebook. The images, including any calibration frames need to be kept

on suitable storage media such as a flash drive or CD. **Keep backups of everything!**
Your journal and images will be submitted at the end of the semester. Keep a duplicate copy for yourself.

Assessment

Number of observing sessions: 25%

Quality of planning and observations: 25%

Record keeping (completeness of observing logs): 25%

Team Effort (if working in a team): 25%

If working individually the first three assessments will count 33% each.

Total Point Value: 50

Discussion Questions

1. Which of the following asteroids would you be able to get a more precise measurement of the position. An asteroid moving across the field at 20 arc seconds per minute or an asteroid moving at one arc second per minute?
2. Why is it harder to find asteroids on a night with a full moon?
3. Why is it important to get at least two and preferably three observations of an asteroid?

