



# THE BAA OBSERVERS' WORKSHOPS



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## Observing near Earth asteroids

by Roger Dymock



**Workshop No. 5:**  
**Nottingham 2004 April 24**

I explain to potential asteroid observers how they might progress from visual observing to CCD astrometry and photometry. The presentation covers my own experiences observing main belt asteroids and imaging near Earth asteroids. This presentation can be viewed in its entirety on my Near Earth Asteroid (NEA) website.<sup>1</sup> Links to the sites mentioned in this article and a fuller explanation of the methods described here can also be found on this website.

### What, when and why?

#### Beginning

After completing a basic astronomy course at the Hampshire Astronomical Group's observatory, a small group of attendees decided to continue observing on the evening previously set aside for the course. We would observe any objects of interest as described in magazines such as *Sky and Telescope*.

The first asteroid we observed was (4) Vesta – not terribly impressive, just another 'star', and we weren't even sure we were looking at the right object. A few nights later I received a phone call from one of the group to say that he had observed the asteroid again and it had moved, so we were observing the correct object after all. This was about the time asteroids were in the news due to the possibility of impacts wiping out large proportions of life on Earth, and I was hooked.

#### Equipment

My first telescope proper, purchased in 1996, was a Russian TAL 4.5-inch

(114mm) reflector. A good telescope but rather heavy, and it had to be stored in a corner of the lounge so that I could lift it out into the garden through the patio doors. The TAL was followed a year later by an Orion 10-inch (250mm) reflector. The difficulty of moving this fairly large telescope and other observing paraphernalia in and out of the house tended to limit my observing to evenings of absolutely certain clear skies, and thus a permanent outside location became a necessity. The 'Observapod' was constructed in 1999.<sup>2</sup> At this time I also made the move from visual to CCD observing (using a Starlight Express MX516 camera) and the observatory became even more necessary in order to be able to leave all the electronics permanently connected. The pod, telescope and associated equipment are shown in Figure 1.

Hardware requires software and my current packages are

- Megastar* for plotting asteroid tracks
- Astroart* for imaging and tracking
- Astrometrica* for astrometry
- AIP4WIN* for photometry
- Guide* for plotting astrometric measurements
- TAC32* for updating the PC clock from a GPS receiver.

The 'why' in the section title is 'Why in the name of sanity am I out here freezing my crown jewels off when I should be in a nice warm bed?' or 'Why does it always cloud over just as I have got everything set up?' or 'Why is it always

clear when there is a full Moon?' Some of this at least may soon change as I am in the process of setting up my study PC and observatory laptop for remote control of the telescope and CCD camera. While on the subject of cold nights it is worth mentioning that all my equipment is mains powered, since batteries are expensive and quickly die in the cold.

### Observing main belt asteroids

#### Magnitude estimates

This is probably the easiest way to start observing asteroids visually. To find them you need a star charting program such as *Megastar* and the latest orbital elements. These can be found on the Minor Planet Center (MPC)<sup>3</sup> or the Lowell Observatory<sup>4</sup> websites. The asteroid's magnitude can be estimated by comparing its

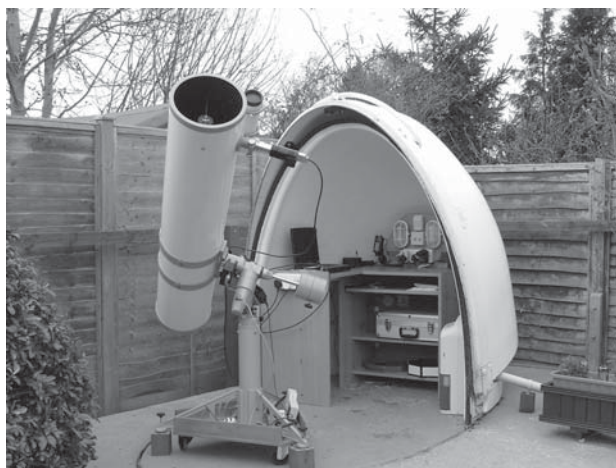


Figure 1. MPC observatory code 940.

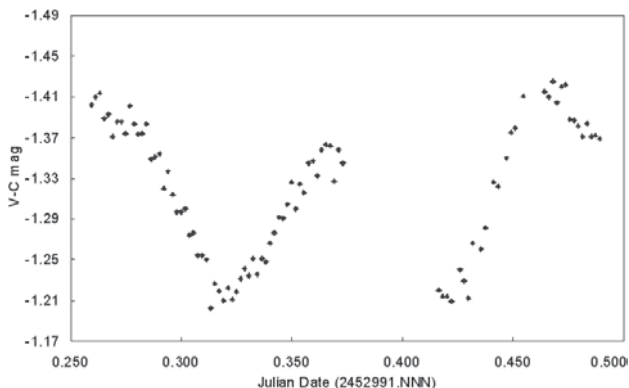


Figure 2. Light curve for the main belt asteroid (250) Bettina.

brightness with some or all of the stars in the field of view. Slightly defocusing helps with the comparison of stars which are almost the same magnitude as the asteroid. The Asteroids and Remote Planets Section (ARPS) Director, Andy Hollis, will be pleased to receive your estimates.

### Occultations

Occultations of stars by asteroids can also be observed, predictions being available from the International Occultation Timing Association.<sup>5</sup> If several observers time the same event the approximate shape of the asteroid can be determined.

### Light curves

Asteroids rotate, many in just a few hours. By obtaining CCD images over such a period and measuring the magnitude of the asteroid on each image a light curve can be obtained (Figure 2). Such data assist professional astronomers in determining the rotational period, pole orientation and shape of the asteroid.

## Imaging near Earth asteroids

### What and where?

I use the term ‘imaging’ because it is unusual to be able to observe these objects visually. One exception to this rule was 2002 NY40, but if you do see one the dinosaurs in Jurassic Park might well be running for cover again!

Asteroids are the leftovers from the creation of the solar system – the builders’ rubble – and come in three flavours, iron, stony and stony-iron. If you have purchased a new house you will know that builders leave all their rubbish in one place, namely your garden. However the builders of the solar system were much more even-handed and spread the rubble all over the

system. Moving outwards from the Sun we have near Earth asteroids, the main belt between Mars and Jupiter, Centaurs amongst the gas giant planets, the Edgeworth–Kuiper belt beyond Pluto and the far distant Oort Cloud, most of which are actually comets.

Near Earth asteroids inhabit a variety of orbits: Arjunas, always

closer to the Sun than the Earth; Atens, Earth crossers but spending most of their time inside the Earth’s orbit; Apollos, ditto but mostly outside; and Amors which are found between Earth and Mars.

### Obtaining an observatory code

#### Why do you need one?

The MPC issues an observatory code in recognition of the accuracy of your astrometry. Once you have such a code your observations of asteroids (or comets) may be submitted to the MPC.

Astrometry is the measurement of the position of an asteroid or any other astronomical object.<sup>6</sup> Accurate astrometry enables the orbit of an asteroid to be defined and subsequently refined. The longer the period of observation the better defined will be the orbit. (Initial orbit calculations, which by definition are not well defined, are often the source of media speculation as to possible impacts with newly-discovered NEAs.)

#### How do you get one?

There are three steps to obtaining an observatory code: imaging a number of suitable asteroids, measuring their positions on the images obtained and submitting those measurements to the MPC. I went about it as follows.

1. A planisphere was used to determine which constellations were best placed, i.e. in the SE to allow the maximum number of nights’ observation of a particular asteroid.
2. Six mid-numbered asteroids between magnitudes 14 and 16 were selected, using *Megastar* to plot their positions.
3. Imaging was spread over approximately six weeks during Oct/Nov 2000. Each

asteroid was imaged for a period of one hour on two different nights, approximately twelve images being obtained each hour.

4. Three images, approximately fifteen/ twenty minutes apart, were selected from each hour’s results and processed using COAA FITSX (I now use *Astrometrica*) to determine the positions of the asteroids.
5. The results were submitted by email to the MPC, and after a nail-biting few days I was assigned the observatory code 940. An observatory code is specific to an observer and location. Changes to either will require a new code.

### Imaging tips

Correct setup is all-important for accurate astrometry.

- PC clock set to correct time
- Good polar alignment → accurate tracking → sharp images
- Good focus → sharp images
- Correct exposure times → avoid saturation
- Application of dark frames and flat fields → sharp images

Do remember to autosave your images – it is no fun having nothing to show for an evening’s work.

### Processing tips

Image calibration, the application of dark frames and flat fields, will much improve the quality of the images and thus astrometric accuracy. It is worthwhile checking your results against the track predicted by *Megastar* or by the MPC Ephemeris Service before sending them to the MPC.

### Submission tips

The MPC now handles incoming reports automatically so it is very important to get

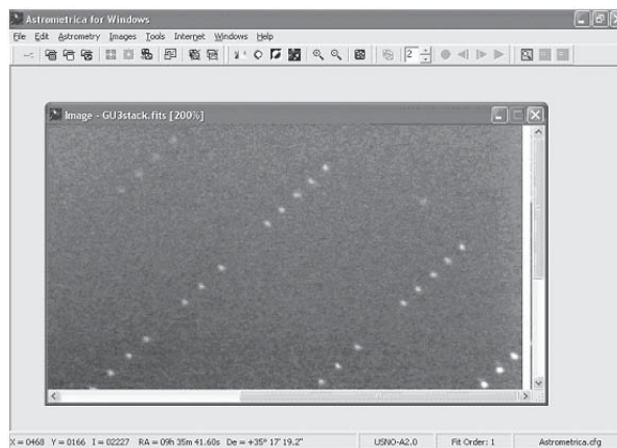


Figure 3. An *Astrometrica* Track and Stack composite image.

the format right. Details can be found on the MPC website.<sup>7</sup> I submit my observations as an email attachment generated using Microsoft *Notepad*. That email and attachment are then used as a template for future observations. Don't worry unduly about making a mistake – the MPC will put you right if needed.

## Follow-up, confirmation and discovery of near Earth asteroids

These three aspects of NEA observation have increasing degrees of difficulty. Only the first will be described in detail since this is the most straightforward and my setup is not really suitable for the others.

### Follow-up observations

The procedure for making such observations is:

1. Select a target. Suitable targets depending on the limiting magnitude of your setup and the region of the night sky available can be selected from the Spaceguard Priority List which can be accessed via the NEO Coordination System.<sup>8</sup>
2. Obtain orbital elements and an ephemeris from the MPC.<sup>9</sup> It is necessary to do this as orbital elements are continually being updated as the orbit becomes better defined. Choose the 'MPC-8' line option on the web page to obtain both elements and ephemeris.
3. Load the elements into *Megastar* and plot the predicted track. Any star charting program will suffice but I find *Megastar* easy to use.
4. Take the images. Image along the line of the predicted track as described under 'Obtaining an observatory code' above.

5. Calibrate and analyse the images. After the application of dark frames and flat fields Herbert Raab's superb *Astrometrica* software makes the next stage simple. NEAs move quite quickly and it is thus necessary to stack a number of short exposure images, taking the motion into consideration. *Astrometrica*'s Track and Stack feature allows this to be done with ease. The stars appear as lines of images and the asteroid as a single point (Figure 3).
6. Verify measurements. A useful check of your measurements can be made by loading them in to *Guide*. Assuming that the images have been obtained at regular intervals the plot should show equally spaced positions more or less in a straight line (Figure 4). The gaps are due to some images being discarded.
7. Submit results to the MPC. Results are submitted as previously described. Later you can check the Minor Planet Electronic Circulars (MPECs) and the Near Earth Dynamics website<sup>10</sup> to see if the measurements have been accepted.

### Confirmation and discovery

Details of recent discoveries can be found on the NEO Confirmation page.<sup>11</sup>

Although I have tried a couple of times to image asteroids listed on this page I have not been successful. The asteroids have either been too faint or too far from their predicted track. UK amateur Peter Birtwhistle has been very successful in this field and is highly regarded worldwide by both amateur and professional astronomers. To see how it is done visit his website.<sup>12</sup>

There are two other lists of potential targets on the NEO website, 'NEOs not seen recently' and 'Bright recovery opportunities' which are worth a visit by those who can image faint objects.

It is always worth checking your images to see if there are any moving objects other than the one you are looking for. This can be done by blinking the images – a series of four is preferable as this considerably lessens the chance of hot pixels or blemishes being mistaken for an asteroid. Peter Birtwhistle discovered 2004 DN25 in this way when imaging 2004 CK3. The MPC's MPChecker facility<sup>13</sup> can be used to eliminate known objects. However if it doesn't move and

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appears to be a new object you may have discovered a supernova, or even an asteroid which is heading straight for Earth!

### And finally...

Do make a start and share your observations with others, and don't be too worried about submitting them to the relevant organisation. There is a lot to learn (and money to spend) so take things a step at a time and don't be afraid to ask for help. And when you finally know it all, please do be prepared to help those who don't.

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## References and websites

- 1 NEA homepage: <http://homepage.ntlworld.com/roger.dymock/index.htm>
- 2 Dymock R., 'Observapod, a GRP observatory', *J. Brit. Astron. Assoc.*, **111**(4), 199 (2001)
- 3 Minor Planet Center: <http://cfa-www.harvard.edu/iau/mpc.html>
- 4 Lowell Observatory: [http://asteroid.lowell.edu/asteroid/loneos/loneos\\_disc.html](http://asteroid.lowell.edu/asteroid/loneos/loneos_disc.html)
- 5 IOTA, European section: <http://mpocc.astro.cz>
- 6 James N. D., 'An introduction to astrometry', *J. Brit. Astron. Assoc.*, **114**(1), 29 (2004)
- 7 MPC submission details: <http://cfa-www.harvard.edu/iau/info/OpticalObs.html>
- 8 NEO Coordination System: <http://spaceguard.esa.int/SSystem/SSystem.html>
- 9 Orbital elements: <http://cfa-www.harvard.edu/iau/MPEph/MPEph.html>
- 10 Near Earth Dynamics: <http://newton.dm.unipi.it/cgi-bin/neodyns/neoibo>
- 11 NEO Confirmation Page: <http://cfa-www.harvard.edu/iau/NEO/ToConfirm.html>
- 12 Peter Birtwhistle: <http://www.birtwhi.demon.co.uk/index.htm>
- 13 Minor Planet Checker: <http://scully.harvard.edu/~cgi/checkmp>

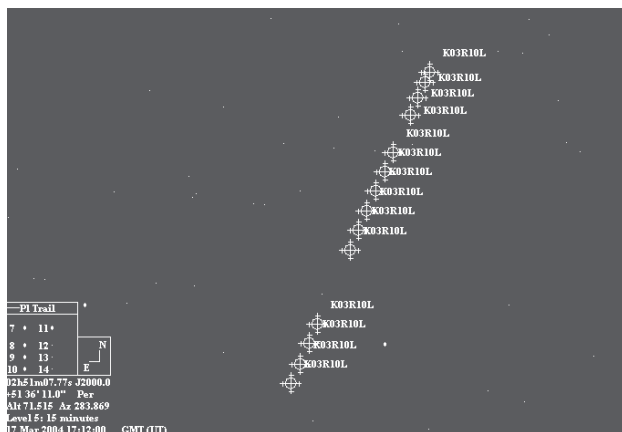


Figure 4. A plot of asteroid positions made by *Guide*.

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