British Astronomical Association
BRITAIN'S LEADING ORGANISATION FOR OBSERVATIONAL ASTRONOMY

Observing Projects with Asteroid-Comet Connections

(A joint meeting of the **BAA Comet Section** and **Asteroids & Remote Planets Section**)

An audience of nearly 70 assembled in the Berrill Lecture Theatre at the Open University in Milton Keynes on 2012 October 6 for a discussion meeting covering observation of comets and asteroids. The meeting was organised by ARPS Director Richard Miles, who selected the venue and arranged speakers, adopting a format of many short talks. This report gives a brief summary of the talks and discussion, and a shorter version appears on p.10-12 of the Comet Section newsletter, *The Comet's Tale* (Issue No.32, published in 2013 January)

The speakers outside the Berrill Building at the Open University
(photo: David Briggs)
(left to right: S. Duddy, G. Williams, L. Buzzi, S. Lowry, G. Relf, R. Dymock, R. Miles, S. Green, E. Ansbro, J. Shanklin and N. James

Richard Miles, Director of ARPS, began proceedings with a talk on:

Icy asteroids and rocky comets: an introduction

Brian Marsden had noted in 1969 that 28P/Neujmin and 49P/Arend-Rigaux might be transition objects. At that time it was thought that comet orbits were unstable whilst asteroid orbits were stable, but subsequent research has changed the picture. Our knowledge of comets and asteroids has expanded exponentially since that time and we now know of many examples of transition objects such as asteroids exhibiting some form of coma, and apparently dormant comets.

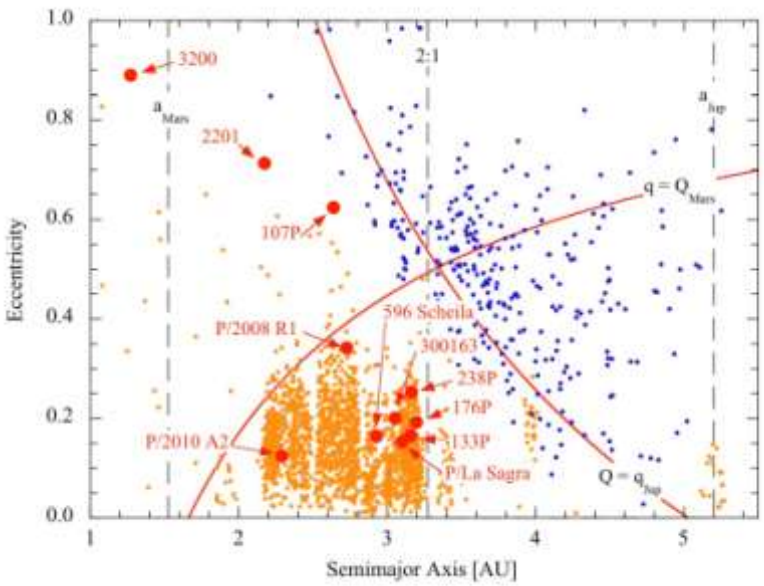


Figure 1: From David Jewitt, *"Main Belt Comets"*

The distribution of the mass-losing asteroids is shown, including their relation to the asteroids (orange dots) and classical comets (blue dots).

Jonathan Shanklin, Director of the Comet Section, followed with an introduction to:

Comets, quasi-comets and the Comet Section

He began with a short introduction to the Section, then moved on to describe how Section visual observations of *Rosetta* target 67P/Churyumov-Gerasimenko had been used to construct light curves. It is a relatively "new" periodic comet having entered the present orbit in 1959, and the perihelion distance of the comet has varied slightly since the discovery apparition. The comet is usually intrinsically at its brightest some 40 days after perihelion, and seems to be intrinsically brighter when the perihelion distance is smaller. He then gave an overview of the prospects for the two potential "Great" comets of 2013, 2011 L4 (PanSTARRS) and 2012 S1 (ISON). One memorable observation that he had made concerned 1998 K5 (LINEAR), which appeared nearly asteroidal during a close approach to the Earth, but become more diffuse as its distance increased. He also drew attention to the point that comets could outburst at more or less any time, so that an apparently dead asteroidal object could suddenly show its cometary nature. He noted several recent comets that had originally been designated as asteroids, and also several asteroids which had cometary orbits. Comet 2P/Encke will be the focus for a Comet Section observing campaign in 2013.

Simon Green, Senior Lecturer in Planetary and Space Sciences at the OU spoke about:

Sample return from asteroids and comets

He began by asking the question of, "Why study asteroids and comets?" They retain information about the early solar system; comets from the outer part, asteroids from the inner part. They also contain material that pre-dates the solar system. They show how planets form. They create an impact hazard, but may have seeded life. Space missions allow direct resolution of craters, activity etc. We have imaged around a dozen objects. Each one tells us something new. Comets are hard to get to and are active. *Stardust* collected 4mg of material whilst doing a flypast, but *Rosetta* will land and do in-situ observations, which is much more difficult. Stardust particles include high temperature grains which are crystalline, which implies a high temperature origin, so there must have been some mixing between inner and outer solar system. The *Rosetta* instrumentation is a compromise – its resolution is limited, and uses 20 year old technology to answer a 20 year old question. We really need samples in laboratories and take time for detailed analysis, and also store samples for future technology. Whilst meteorites are samples of asteroids, they are difficult to compare as asteroids are subject to space weathering. Fragile objects don't survive entry through Earth's atmosphere. The Tagish Lake meteorite samples, even though collected and bagged very quickly after their fall, were contaminated by skidoo exhaust. Even more fragile specimens would not survive re-entry. Hayabusa did pick up grains from S-type asteroid (25143) Itokawa, but we need to go to a primitive asteroid. The NASA mission OSIRIS-REx will be launched in 2016 to carbonaceous asteroid (101955). *Marco Polo* is an ESA mission to return 100g from a near-Earth asteroid. Samples will tell us much about processes.

Stephen Lowry, Lecturer in Astronomy and Astrophysics at the University of Kent, covered:

YORP and other perturbation effects affecting asteroids and comets

He works on a range of programs from ground based observation, space telescope and space missions. Solar radiation can change the rotation of an asymmetric body by reflection, and also by absorption and re-emission of thermal radiation. This also changes the object's surface properties. The effect is demonstrated by the Koronis family, which have their rotation axes aligned into two groups. YORP can create monolithic fast rotators, fission effects and tumbling slow rotators. The Yarkovsky effect can change the orbit, e.g. (6489) Golevka, as can outgassing. YORP can explain the shape of small rubble pile asteroids and their binary nature by acting over millions of years, e.g. the "diamond" shape of (2867) Steins. Radar images confirm several similar objects. We see an evolution of the spin rate in 2000 PH5 over five years which matches that expected from YORP. His group is carrying out a program at ESO over four years to make further detections. YORP might create tails or a coma if it leads to rotational break-up.

Sam Duddy, Post-Doctoral Research Associate at the University of Kent, extended this theme with a talk on:

Characterisation of unbound asteroid pairs

Asteroids larger than a few hundred metres don't rotate faster than 2 – 5 hours. This implies that there is a limit on the bulk density which is much smaller than that of meteorites, which implies voids or fissures. Some may be 70% empty space. Radar shows some contact binaries. Itokawa may also be a contact binary. YORP spin-up takes material from the poles to the equator and spins it off. This drift would take place over long timescales, but could occur in discrete surface landslides, which could create a coma. The spun-off material can accumulate to create a satellite. Alternatively a rapidly spinning sphere can disrupt. On occasion a binary can become unbound, particularly if the ratio of relative masses is less than 0.2. At least 35 MBA pairs may have this origin. He is doing a spectroscopic survey to see if they have a similar composition, and have found several that show similar spectra. A few don't, but this could be a snapshot effect of looking at different ends.

Nick James then spoke on:

Methods common to observing comets and asteroids

He uses a C11, with a 72mm f/6 Megrez refractor to give wide-field imaging for his work. Moving objects need different comparison stars each night. He uses *Astrometrica* as it is one of the best programs ever written. It does astrometry and stacking. Astrometry is very important for NEOs, e.g. to decide radar targets. We need cometary photometry to predict future brightness, but CCD photometry of comets is much harder. What is the reported magnitude? – nuclear, central, total coma? Ideally it needs something like *Astrometrica*. There is a utility called FoCAs, which looks at the *Astrometrica* log file and can give box magnitudes out to 60" in 10" steps. The scatter is quite small between observers. Alternatively you could curve fit the coma and integrate. A comet with a tail creates further problems. For a bright object, taking 1/3 second images and stacking is a good technique. *KPhot* is a DOS program that gives a total magnitude.

The final speaker of the morning session was **Graham Relf**, from the BAA Computing Section, who described:

New observing aids for asteroids and comets on the Computing Section website

Various applets have been written for the website. There is a quick look at "The solar system – what's observable?" – clicking near an object gives further information, and scope to generate

a finding chart. There are also options to add objects such as asteroids, comets including the Kreutz search area and relevant charts. Messier objects have also been added. There are charts for all the brighter or unusual comets. Dedicated webpages have been set up for asteroids attaining mag 12.0 or brighter at opposition with charts for each, and for asteroid appulses where two objects brighter than mag 15.0 approach closer than 0.1° (1-day ephemeris). [Comment: A new observing programme to detect rotationally-induced colour changes by studying asteroid pairs which can be imaged in a single CCD field of view is anticipated].

During the lunch break there was an opportunity to view several poster displays that had been brought along, including a display by members of the local **Milton Keynes Astronomical Society**, an item on the closest approaching comets by Kenelm England, and a display of the work of ARPS members.

The afternoon session began with **Roger Dymock** describing:

Project Alcock: Encouraging comet observations, imaging and discovery

The idea of the project was to get people out looking at comets, where there is a whole range of possible opportunities. Local societies have members who are keen to follow more serious projects. He presented a matrix showing what was possible with different types of instrument. Roger acknowledged that many useful ideas were gleaned from Martin Mobberley's book, "Hunting and Imaging Comets".

Activity \ Method	Visual/ Binos	Visual/ telescope	CCD imaging	DSLR imaging	Webcam imaging	On-line images
Observing known comets	x	x	x	x	x	
Observing comets of particular interest	x	x	x	x	x	
Follow-up obs of newly discovered comets			x			
Asteroids that might be comets			x			
Recovery of returning periodic comets			x			
Discovering comets	x	x		x		x
Discovering sungrazers			x			x

Luca Buzzi had specially come from Italy for the meeting and told us about:

Finding comets amongst the asteroid population: Project T3

He is co-ordinator of the T3 Project, which was launched in 2006. The Tisserand parameter **Tj** was defined by Francois-Felix Tisserand in the second half of the 18th century. Usually **Tj** for comets is less than 3, but MBC have it greater than 3. There are normally about 30 observable objects that are sufficiently bright and un-numbered. To detect potential cometary activity needs good seeing, a sufficient exposure time to get a good signal to noise ratio and flat and dark fields. Having taken an image the object needs to be checked for a coma compared to stellar images. The Project has found 10 objects that turned out to be comets. They mostly use amateur telescopes, but have access to some professional telescopes, e.g. Faulkes.

By co-incidence **Gareth Williams**, Associate Director of the Minor Planet Center, was in Milton Keynes for his PhD viva. He described the subject of his PhD:

Improving the absolute magnitudes: Correcting the astrophotometry

MPC minor planets magnitudes are often too bright and accurate to ±0.5. The MPC H photometric magnitudes are offset by about -0.5 at 14th magnitude, and a standard value of the

slope parameter, G is used. Historically astrometry was most important, and there was a massive change in accuracy between 1945 and 1990. Now it is time to improve the photometry. Magnitudes are different from different stations, even for asteroids, and often by a magnitude or more. Catalogue magnitudes are often different as well. What was needed was a UBVRI catalogue to 20th magnitude, so he constructed one. He then derived a correction for each astrometric catalogue. This was used to revise *WISE* albedos, and now the majority of asteroids have albedos less than 0.55, though a few problems remain. A paper is in preparation, and public release will occur after submission of his thesis. Funding of the MPC was by subscription, but NASA had given full funding a few years ago.

Eamonn Ansbro concluded the first afternoon session, with a talk on:

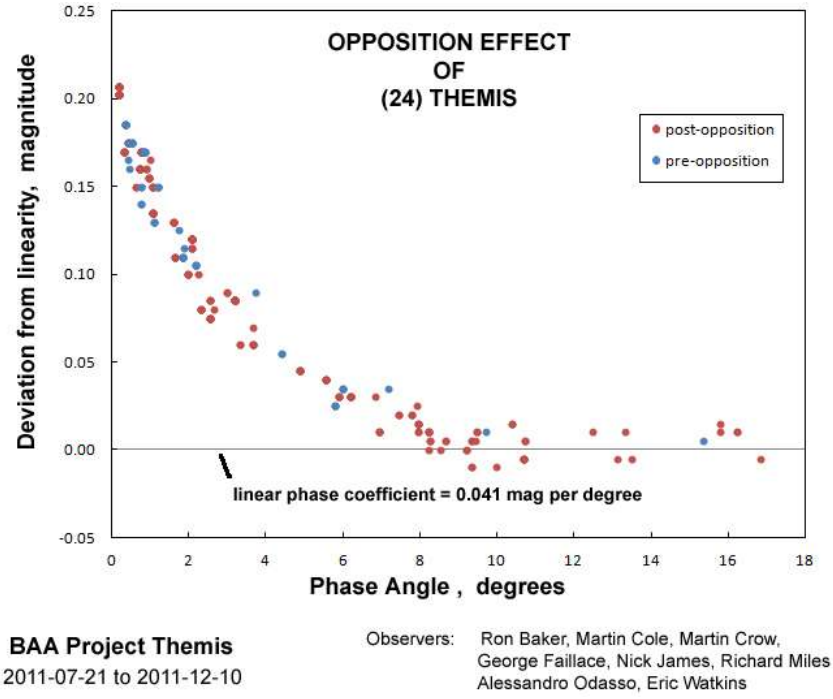
Detecting TNOs by occultation methods

There are four classes of Trans-Neptunian Objects – classical (ecliptic), scattered disc, resonance (Neptune) and oddities. To get full information on size distribution down to 10km would require surveys down to 30th magnitude. The occultation technique could go further. It needs a star with a small angular diameter. Diffraction effects can enhance the apparent size of the TNO. Using a two colour system allows discrimination of occultation events.

After tea, **Richard Miles** gave two short presentations, first on the theme of:

Frosty asteroids and Project Themis

A *Nature* paper had reported on the detection of ice on (24) Themis. Asteroids brighten above the standard log r rate at low phase angle, to give an opposition brightness surge, which depends on the nature of the surface regolith. The size of the effect increases with the albedo, but there is some scatter.

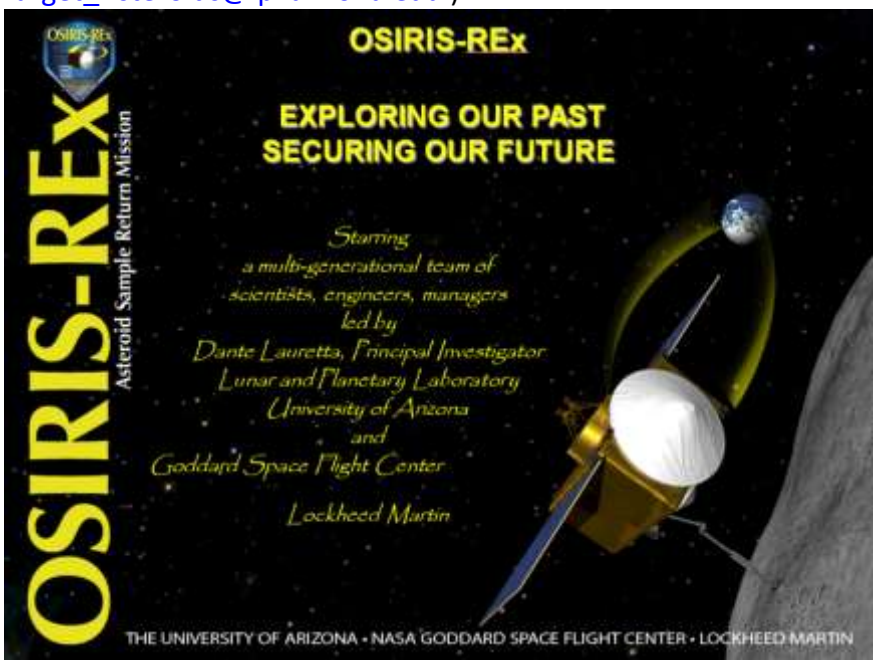


He has preliminary data for 14 asteroids, but using the APASS catalogue will give better results. (7102) Neilbone was found to have a very small opposition effect. Detection needs good photometry, hence the need for APASS. He has tested APASS against a widefield frame taken using a 105mm aperture f/2.8 Canon lens with an SXVR-H18 camera and V filter from which magnitudes were derived using *Astrometrica* and the CMC14 catalogue showing no significant discrepancy greater than +/-0.02 mag down to 14.5.

Richard followed up with:

Target Asteroids for Spacecraft: Observing opportunities for amateurs

OSIRIS-Rex has a target of (101955) 1999 RQ36. A "*Citizen Science Project*" has been set up, overseen by Carl Hergenrother and Dolores Hill of the University of Arizona, to encourage amateurs to provide observations of potential target asteroids (contact: Target_Asteroids@lpl.arizona.edu).



Only around 300 asteroids have reasonable orbits for a sample return, 27 are greater than 200m and five are carbonaceous. (101955) might be YORP shaped. *Hayabusa II* is going to 1999 JU3. The *Marco Polo* target is 1996 FG3, which is a binary, but has a relatively high delta V. There may be others that are more suitable, but spectral information is lacking. Josh Hopkins of Lockheed-Martin has asked for follow-up astrometry and photometry of selected targets during favourable observing windows. Some objects on the NEO Confirmation Page also prove to be suitable mission targets and require follow-up observations over the days following their discovery. In a subsequent discussion, Simon Green referred to 2008 EV5 as a potential alternative target for the *Marco Polo* mission.

Graham Relf has a background in image processing. He showed an image of 2009 P1 (Garradd) which had 600 stars in the frame, but these need removing for photometry. He has written an app to set the stars to background levels, which gives better contours. There was a discussion on coma fitting – visual observers don't often need to take this into account, but removing stars is quite important for fainter CCD objects where stars form a greater percentage of the background.

Gareth Williams said that two pre-discovery positions of 2012 S1 (ISON) had allowed him

to do a full orbit solution, which was essentially parabolic, i.e. 1/a (orig) is essentially 0.

The meeting venue worked extremely well proving to be a great success, linking professional and amateur astronomers, and providing much time for mutual discussion. There will be many opportunities for amateurs to contribute to professional research on these small solar-system bodies in future

Richard Miles
Director, Asteroids and Remote Planets Section

Jonathan Shanklin
Director, Comet Section