# Physical Studies of Asteroids – an Observing Programme at ESO

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## Introduction

The majority of the asteroids are small and tiny bodies orbiting the sun between Mars and Jupiter. One can estimate the total number of asteroids with diameters greater than 1 km to be more than 700,000. Compared to the major planets, the thermal and geological evolution of the asteroids has been modest. Observing asteroids gives us thus not only clues to the origin and evolution of the asteroids, but also to that of the planetary system.

This article attempts to give a short description of the programme "Physical Studies of Asteroids" for which the major part of the observations is conducted at ESO, La Silla. One part of the programme deals with detailed studies of rather bright asteroids, aiming at a better understanding of rotational properties, shapes, compositional types and other physical parameters essential for studies of asteroids. Correlations between rotation period and size, period and compositional type, shape and size, and properties of family asteroids, are some of the problems studied with the aid of photoelectric UBV photometry. Another part of the programme deals with the properties of the very small asteroids, which have sizes of only a few kilometres. How have these been formed? Are they collisional products or do they more resemble the original planetesimals? What is their history of evolution? The ESO Schmidt telescope has been used to study these questions.

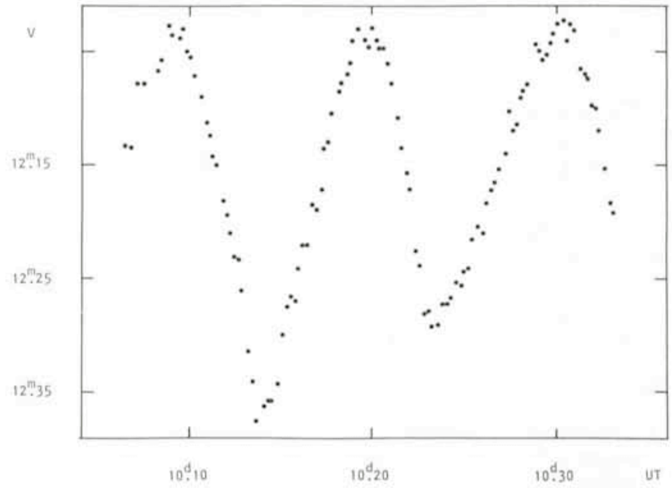


Fig. 1: *Photoelectric lightcurve of the asteroid 250 Bettina observed with the ESO 50 cm telescope on September 10, 1980. The observed V magnitude is plotted versus universal time. 250 Bettina has a rotation period of $5^h1$.*

## Studies of Bright Asteroids

Figure 1 presents a lightcurve of the asteroid 250 Bettina, obtained during September 1980 with the ESO 50 cm telescope. If we assume that the lightcurve shows two maxima and two minima per rotation cycle (the normal triaxial model that seems to work quite well for more than 90 % of the asteroids), thus supposing that the change of brightness depends on the shape of the asteroid rather than on variations of the albedo over the surface, we get for 250 Bettina a period of $5^h1$. Only one asteroid, Vesta, has a lightcurve indicating that the change in brightness depends on variations of the albedo over the surface of the asteroid. Some asteroids have lightcurves showing three maxima and minima per rotation cycle and they

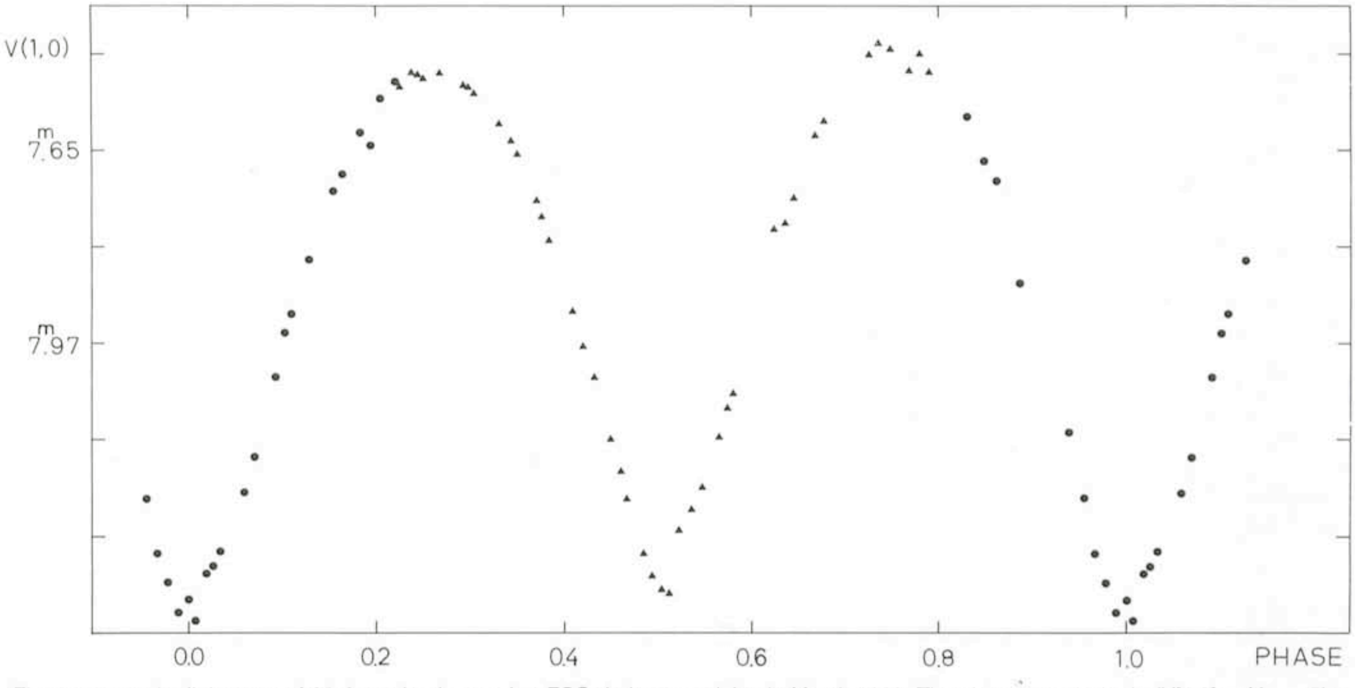


Fig. 2: *composite lightcurve of 63 Ausonia observed at ESO during two nights in March 1980. The absolute magnitude ($V[1,0] = V_{obs} - 5 \log [r \cdot \Delta] - 0^m035 \cdot$ phase angle) is plotted versus phase. The amplitude of $0^m95$ is remarkably large for an asteroid with a diameter of nearly 100 kilometres. 63 Ausonia has a period of $9^h3$.*

are thus of a somewhat more complicated shape than the normal triaxial model.

Figure 2 displays a composite lightcurve of 63 Ausonia, observed in March 1980 with the ESO 50 cm telescope. Ausonia is nearly 100 km in diameter and the lightcurve amplitude, $0^{m}.95$, is remarkably large for an asteroid of this size. No other main-belt asteroid this big has such an irregular shape.

UBV observations of asteroids provide us not only with information about the rotation periods and shapes, but give also information about the composition of the material on the asteroids' surfaces. Most asteroids can be divided into a few distinct compositional types from their UBV colours. The most common types are: *C* (carbonaceous chondrites), *S* (silicaceous) and *M* (metallic). Of the asteroids greater than 50 km in diameter, 76 % are of type *C*, 16 % of type *S*, 5 % of type *M*. From the colour indices B-V=$0^{m}.70$ and U-B=$0^{m}.27$ we can classify 250 Bettina to be of a compositional type close to *M*. Because of the small number of *M* asteroids, only a few have been observed so far, but there are indications that the asteroids of type *M* have a faster spin than the other asteroids. The reason for this may be that they have a greater density. Another asteroid of this type, also observed at ESO in September 1980, 201 Penelope, has a period of about 4 hours.

During four observing runs at ESO a total of 15 asteroids have so far been observed long enough to make it possible to determine their rotation periods. Table 1 summarizes very briefly some of the results obtained during the first three observing runs. During August/September 1980 about 20 lightcurves were observed of the asteroids 33, 101, 201, 250, 386 and 432.

The ESO 50 cm telescope has proved to be very efficient for this type of observations. The accurate setting of the telescope makes finding charts unnecessary, accurate coordinates taken from the yearly volume of the *Ephemerides of Minor Planets* is

*Table 1. Physical data for some of the observed asteroids*

| Asteroid | Period | Amplitude | B-V | U-B | Type |
|---|---|---|---|---|---|
| 63 | $0^{d}.3873$ | $0^{m}.95$ | $0^{m}.92$ | $0^{m}.53$ | S |
| 64 | $0^{d}.365$ | $> 0^{m}.44$ | $0^{m}.74$ | $0^{m}.28$ | CME |
| 85 | $0^{d}.2864$ | $0^{m}.16$ | $0^{m}.67$ | $0^{m}.30$ | C |
| 95* | $0^{d}.3620$ | $0^{m}.25$ | — | — | — |
| 133* | $0^{d}.5293$ | $0^{m}.25$ | $0^{m}.90$ | $0^{m}.51$ | S |
| 135 | $0^{d}.429$ | $0^{m}.17$ | $0^{m}.70$ | $0^{m}.28$ | CME |
| 218* | $0^{d}.268$ | $0^{m}.22$ | $0^{m}.86$ | $0^{m}.44$ | S |
| 485* | $0^{d}.7331$ | $0^{m}.12$ | $0^{m}.85$ | $0^{m}.43$ | S |
| 683* | $0^{d}.1801$ | $0^{m}.12$ | $0^{m}.69$ | $0^{m}.31$ | C |
| 792* | $0^{d}.382$ | $0^{m}.62$ | $0^{m}.71$ | $0^{m}.21$ | M |

* Observer M. Carlsson

enough for having the asteroid more or less in the diaphragm after setting the telescope. Since the telescope is computer-controlled, it is possible to observe quite fast; during September 1980 it was thus possible to observe the asteroids 33 Polyhymnia, 101 Helena and 386 Siegena more or less simultaneously during the same night. 101 Helena seems to have a period close to $24^{h}$ but the other two rotate faster.

## Studies of Small Unnumbered Asteroids

Most of the plate material was collected with the Schmidt telescope at ESO during 5 nights in 1978–1980. Many plates of the same field in the ecliptic, taken during the same night, make it possible to obtain photographic lightcurves of a large number of small unnumbered asteroids. Kodak plates of type 098–04, combined with the Schott filter GG 495, give a limiting magnitude of V~$18^{m}$ (exposure time 5–6 minutes). The unnumbered asteroids are found on a plate with long exposure time, thus

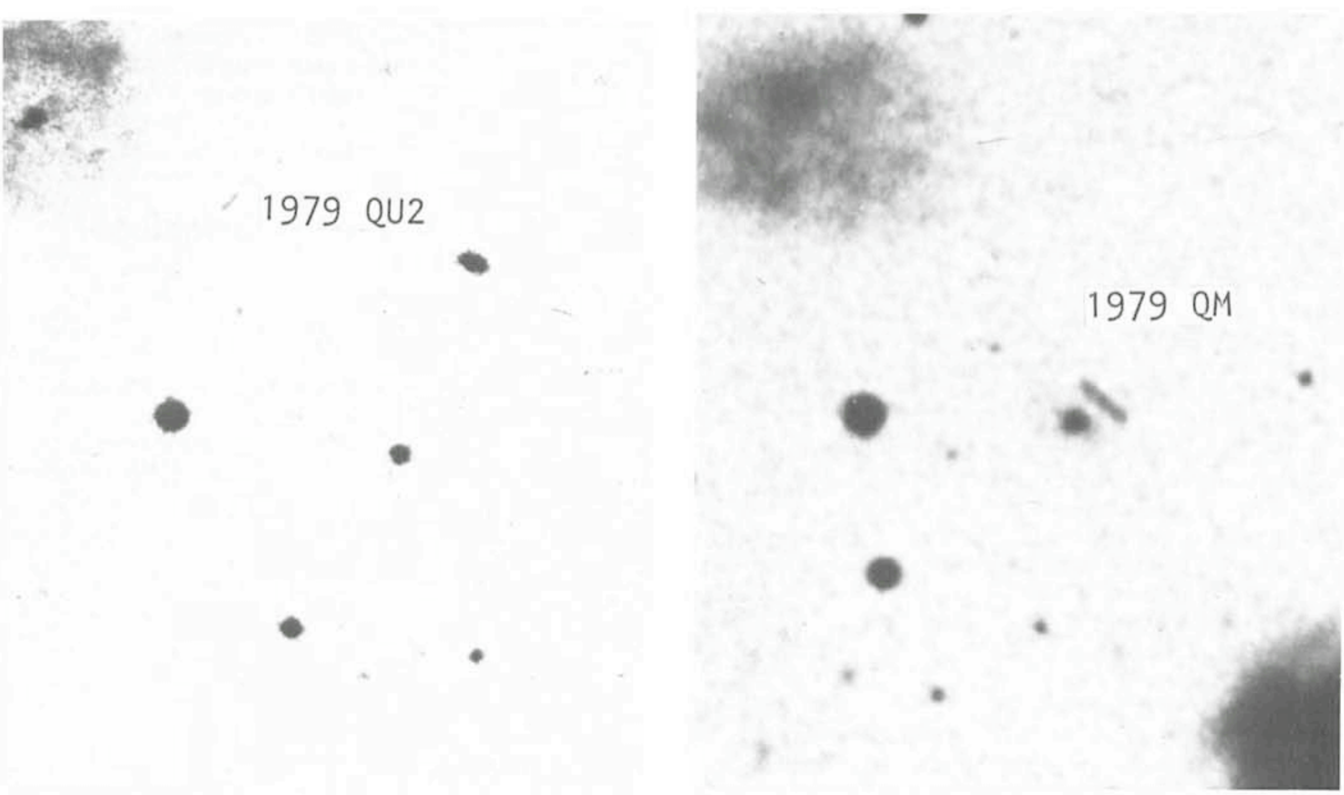


Fig. 3: *Two out of several hundreds of asteroids found during the work. The asteroid 1979 QM is probably an Amor asteroid. The large diffuse spots are just ink dots marking the asteroids' trails.*

making it quite easy to pick out the trails of the asteroids among the round images of the stars. This has given for each of the observed fields almost 150 newly discovered asteroids. Figure 3 is a copy of a part of a plate taken during August 1979. The figure shows the trail of an ordinary main-belt asteroid, 1979 QU2, and that of a faster-moving object, probably an Amor asteroid (an asteroid with perihelion well inside the orbit of Mars).

Additional plates are taken for positions in order to derive orbital elements, and thus distances, and, from that, estimates of the diameters of the asteroids. The positions on some of the plates from 1979 were measured with the ESO Optronic machine, giving nearly 800 positions of some 140 newly discovered asteroids. Since this part of the programme still is in a preliminary phase, it is too early to draw any conclusions about the physical nature of the small asteroids.

# Mapping the Southern Sky with the ESO 1 m Schmidt Telescope

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To any astronomer, professional or amateur, the Palomar Observatory Sky Survey (shortly POSS) is a well-known and useful tool. The whole northern sky is photographed and prints from these photographs are available in the libraries of nearly all important observatories and astronomical institutes in the world.

Such a collection of photographs represents a sort of inventory of the universe, at least of the part accessible with our present instrumentation. In a simple way, this photographic inventory serves just to see what we have in the sky. What stars, clusters, nebulae, galaxies are there? Later, having done a selection, astronomers may concentrate on single objects or classes of objects for a deeper detailed investigation.

It is not necessary to explain here at long the importance and usefulness of the Palomar Sky Survey. In a certain sense it has become a "classic" already and has set a landmark and a high level in the field of sky mapping. Its only disadvantage, if one may say so, is the fact that it is limited to the northern hemisphere.

So, since the end of the fifties when the POSS had been finished and distributed to the astronomers, there has been the wish and the need to have a similar atlas of the southern sky.

One large obstacle to such an atlas was the fact that there was no adequate instrument available in the south for making the survey.

The instrument best fitted for such a photographic survey is a wide-angle camera with the following three important specifications:

(1) as already mentioned, it should have a wide field, otherwise it would be necessary take thousands of plates to cover a certain range of the sky, instead of only a few hundred;
(2) it should be powerful in "light-catching", in order to reach faint objects, or, roughly spoken, it should look into the sky as deep as possible;
(3) and the plate scale should be reasonably large as for extended objects, galaxies for instance, a fair resolution would help the user of the survey to try a first morphological classification of the objects.

The instrument of best choice is then, in consequence, a Schmidt camera.

There have been Schmidt cameras in operation in the south since long, but of smaller size and not as powerful as the Palomar Schmidt telescope. Once the northern atlas had been completed, one wished of course not only just a continuation to the south but a continuation which would be compatible. That means: the same field size, or nearly the same, the same limiting magnitude, or better if possible, and the same scaling in order to have comparable overlapping fields.

During the seventies, two large Schmidt telescopes came into operation; they had exactly the same scale as the Palomar Schmidt (1 mm = ~ 67 arcseconds) and fulfilled also the specifications of power and field size. These are the United Kingdom Schmidt telescope, based in Australia, and the ESO 1 m Schmidt telescope on La Silla. Both telescopes are now engaged in producing maps of the southern sky similar to the great example the Palomar Survey has set.

The laborious task has been distributed in such a way that both telescopes are busy with maps of different colours. ESO has taken the part of producing an atlas in the RED range, which is being realized on the fine grain KODAK IIIa-F emulsion behind a filter RG 630. In this way, a band-pass is defined from

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## Optical Jets in Galaxies

**List of Topics**

- Introduction: Jets and other evidence for outflow in active galaxies
- The ST – important parameters for planning observations
- Imaging observations of optical emission from jets
- Spectroscopic evidence for collimated outflow in active galaxies
- The M87 jet
- Centaurus A
- QSO jet: 3C 273 and other QSO jets
- Coma A
- Radio emission from jets
- X-ray emission from jets
- Relevant theoretical aspects
- Discussion
- Concluding remarks

Organizers: F. Macchetto, ESTEC — G. Miley, Leiden — M. Tarenghi, ESO.