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Rotation period and lightcurve analysis of selected asteroids

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Abstract. Some observational programs, like the Small Telescope Science Program, are an effort of advanced observers, private and professional observatories to cover major astronomical events or to provide continuous or long term monitoring, when there is little or no professional scope time available. Variable stars, asteroids and comets are the preferred target of these kinds of activities.
Here I report the results of the ALP (Asteroid Lightcurve Program) at my backyard observatory. A 210 mm Dall-Kirkham telescope at f/11.5 was fitted with a Starlight-Xpress SXV-H9 CCD Camera. The observational goal was to determine unknown rotation period of Main Belt asteroids or to refine on it when it was uncertain. I choose only asteroids that had a visible magnitude of 15 or brighter for good signal-to-noise ratio.
Some asteroids were observed in support of VLTI or radar observations. Differential photometry was used in any case. A set of nearly 20 reliable lightcurves were obtained with well defined rotation period and amplitude.
A small subset shows peculiar features in the lightcurve so it would be interesting to remeasure these objects under different viewing/illumination conditions.

Key words. lightcurve – asteroid

1. Introduction

There has been a considerable qualitative leap in asteroid photometry, like for all the astrophysics areas, with the introduction of solid state detectors, the so called Charge Coupled Devices or CCDs. Waiting for the launch of GAIA mission, that probably will revolutionize by quantities and qualities the knowledge about asteroids, the photometric observations from the Earth carry on to be a fundamental tool because allow us to obtain valuable information in a quite simple way also with off-the-shelf instruments.

Nowadays it is possible to study asteroids of 14^{th} magnitude using a 20 cm aperture telescope, with a good precision and reliability grade whereas, before the coming of CCDs, it would have been necessary a telescope with a much larger aperture. In Fig. 1 it is reported a significant example of the results that it is possible to obtain in support of observations at the limit of current resources (Delbó et al., 2006).

2. Importance of lightcurves

From the analysis of a lightcurve it is possible to deduce the rotation period of the asteroid that, in general, rotates around a fixed axis, showing to the observer the surfaces of maxi-

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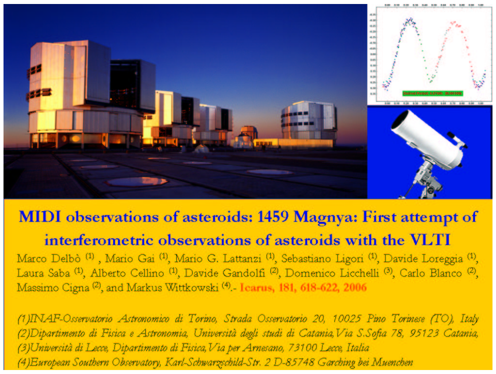

Fig. 1. A good example of collaborative project using both small and professional telescopes.

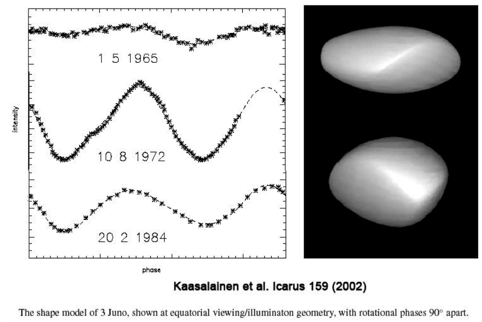

Fig. 2. 43 Ariadne asteroid lightcurves and the three-dimensional model obtained by Kaasalainen et al. (2002) with the inversion technique.

mum and minimum area in a cyclical way. A sufficient number of lightcurves, obtained with observations at different ecliptic longitudes and given out in three or four apparitions, allows us to determine the direction of the rotation axis. Besides, it permits to build a three-dimensional model rather detailed, on a large scale, of the asteroid shape using the mathematical technique of lightcurve inversion. The reason because it is necessary to observe the object under different perspectives, is that in this way the side and grazing lighting points out, thanks to light and shade, the possible shape irregularities, at least on macroscopic scale.

In Fig. 2 are shown three of the 43 Ariadne asteroid lightcurves used by the authors to obtain the three-dimensional model (Kaasalainen et al., 2002), with the inversion technique of a considerable number of lightcurves acquired in different epochs.

3. Observation and data reduction

My backyard observatory is located in a very small, but light polluted town, in the South of Italy, at about 145m above the sea level. Observations were made using a 210mm f/11.5 Dall-Kirkham telescope and a Starlight SXV-H9 CCD camera. To obtain the maximum S/N ratio, all asteroid photometry data were taken using an IDAS clear filter. Image acquisition and standard calibrations were done using Astroart, published by MSB Software. Photometric measurements and light curves were prepared using MPO Canopus, published by BDW Publishing. Differential photometry was used in any case. In general, the complete data set was preserved until the last analysis stage, only deleting badly cloud-affected data after completing the period analysis.

Asteroids, located at least at an elevation angle of about 30° at the beginning of the observations, were selected using The Sky, published by Software Bisque. I choose only asteroids that had a visible magnitude of 15 or brighter for good signal-to-noise ratio. Then the asteroids were cross-checked with the Harris and Warner's lightcurve parameter list (Harris and Warner, 2005). I tried to observe only asteroids that have uncertain published results (code 2).

In principle, to obtain a good lightcurve it is sufficient an hundred of points with a good distribution in the period. Nevertheless, certainly it would be better to have more points, both to evidence possible morphological irregularities and to minimize the errors in the measurements due, for example, to the worsening weather conditions during the observations. A lot of asteroids rotate in periods included between 6 and 12 hours, so three or four nights of measurements are sufficient to determine the period with good precision. However, it is appropriate to add a fourth session in few days to obtain a better accuracy. Usually, the lightcurve has a sinusoidal trend with two max-

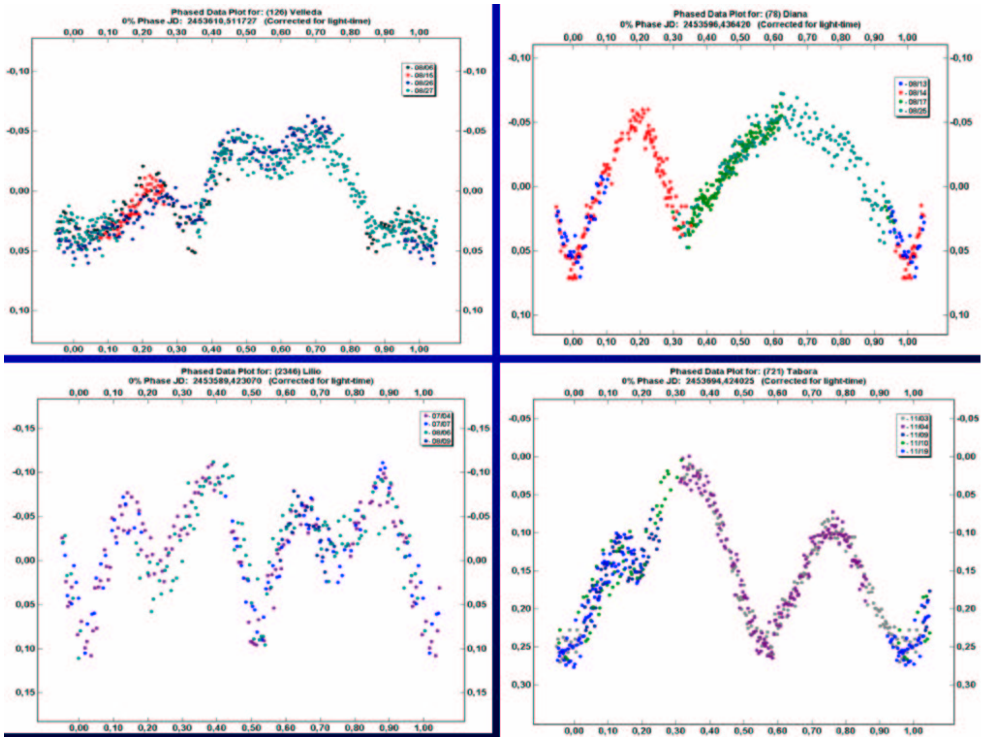

Fig. 3. Some of the most interesting studied asteroids (126 Velleda, 78 Diana, 2346 Lilio, 721 Tabora from left to right). The features in the lightcurves indicate probable irregularities in the shape or, as in the case of 2346 Lilio, the possible binariety of the object.

imum and two minimum, often with different height and depth, but sometimes the curves have knees and indentations according to the complex impact evolution of some asteroids.

Sometimes, the definition of the period is a really trouble and it is necessary to do measures over more nights to resolve the problem. As a matter of fact, it can happen that the asteroid is binary, so that different periods or eclipses overlap in the lightcurve. A sign could be the presence of more extreme points for cycle than two.

An asteroid in the list of suspicious binaries, that exhibits four maximum and minimum for cycle, is 2346 Lilio. It could be also a single ellipsoidal object but very misshaped.

Macroscopic irregularities in the shape are evident also in 126 Velleda. Certainly, it will be interesting to study in depth these objects during the next apparitions, when the different geometric lighting conditions could evidence these or others characteristics in the lightcurves, and then to provide more information about their morphology.

4. Conclusions

The present technological level of the solid state detectors permits to start up, with off-the-shelf instruments, research programs inconceivable up to few years ago. A good parameter that illustrates the qualitative improvement is the comparison with the dimension of the instrument used to obtain the previously reported rotation periods of some of the listed asteroids (see Tab. 1): ESO telescopes with an aperture of one meter or more 20 years ago,

Table 1. List of the studied asteroids. The asteroids in bold font are characterised by rotational periods different from those previously published.

Asteroid	Previously reported Rotation Period (hr)	Revised Rotation Period (hr)
78 Diana	7.225	7.300 ± 0.001
126 Velleda	5.364	7.300 ± 0.001
300 Geraldina	6.818	6.842± 0.001
453 Tea	6.4	6.812 ± 0.001
454 Mathesis	7.075	8.378 ± 0.001
522 Helga	3.4	8.126 ± 0.001
565 Marbachia	5.084	4.587 ± 0.001
573 Recha	6.53	7.164 ± 0.001
629 Bernardina	4	3.763 ± 0.001
705 Erminia	7.22	53.96 ± 0.001
714 Ulula	6.998	6.998 ± 0.001
721 Tabora	8	7.982 ± 0.001
1304 Arosa	4.67	7.749 ± 0.001
1547 Nele	7.081	7.100 ± 0.001
1600 Vyssotsky	3.2	3.201 ± 0.001
2346 Lilio	1.547	3.029 ± 0.001
6974 1992 MC	-	2.423 ± 0.001

and that used in this work. In few years, big surveys will provide great quantities of photometric data about the asteroid population but, in the meantime, it is possible to give an effective contribute also working with small telescopes at private observatories in urban environmental or using the educational facilities present in much Universities.

References

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Kaasalainen, M. et al. 2002, Icarus, 159