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# Observations of Stellar Occultations by Dwarf Planets and TNOs - International Campaigns

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## Abstract

Observations of stellar occultation by dwarf planets and TNOs are a powerful possiblity, to gain scientific data about these objects. This includes a precise information about their shapes and the determination of a possible atmosphere. Small to medium sized telescopes, either at fixed sites or mobile ones, equipped with cameras with integrating video or digital read out and precise timing circuitry as well are necessary. High precise astrometry beforehand (last minute astrometry) is very often the only way to minimize negative results. A strong cooperation between amateur- and professional astronomers is needed for successful campaigns. Results of observation campaigns for (50000) Quaoar, Pluto and Triton will be presented.

## 1. Introduction

Starting from lunar and minor planet occultation observations as a "training field" the obervation of dwarf planets and TNOs is a much more challenging project. The small angular size needs high precision astrometry. the recording of stars with magnitudes between 11mag and down to 18 or 19mag (V or R Band) with exposure times less than 5 seconds is necessary. Either video equipment with integrating CCD systems or real digital cameras in combination with precise timing will give sufficient signal to noise ratios to cover these occultations. After lightcurve analysis of many occultation stations, from the different chords the shape of these bodies can be determined, which is the only precise way at the moment. If present, atmospheres with a surface pressure down to about $10^{-4}$ Pa could be detected.

## 2. Materials and Methods

### 2.1 Telescopes and Cameras

In general, objects such as dwarf planets and TNOs have extremely small angular sizes, occultations of relatively faint stars have to be observed, in order to have enough events to observe. Typical objects are stars fainter than about 13th magnitude. Considering a relative velocity of the occulting object and the star with respect to the observer of around 20 km/sec, exposure times can be relatively long, for large objects even up to 5 sec per data point. In tests it could be shown, that for a typically dark site (sky background less than $20^{m}$/arcsec$^{2}$) a 40 cm telescope and a CCD camera with a standard chip can reach in 1 second 17mag.

### 2.2 Timing circuitry

The correct time is very essential in order to synchronize all observations from different sites for a final analysis. Either GPS timing of the camera itself or of the computer used for data acquisition or a timing protocol over the internet (NTP) can be used. In some countries there exist radio controlled clocks, such as the DCF77 stations of the Physikalisch

Technische Bundesanstalt (PTB) in Germany. The timing precision should be better than +/- 0.1 second.

### 2.3 Astrometry

High precision astrometry in the 10 mas range is required. In most cases this can only be guaranteed by professional groups such as [1].

### 2.4 Determination and distribution of predictions

If astrometry is provided, the occultation track on earth can be calculated, very often using the WINOCCULT program system written by D Herald, Australia. The prediction charts have to be distributed over internet home pages, such as http://www.iota-es.de or by direct mailing lists (Planoccult).

### 2.5 Post event analysis

Images and video recordings have been analysed using various free software packages, such as IRIS and MIDAS. Using reference stars in the images, a possible change of light transmisson in the earth's atmosphere (aerosols due to clouds etc.) has been compensated as much as possible and lightcurves have been extracted with exact timings. If possible, atmospheric data can be evaluated using model fits.

## 3. Results of recent campaigns

### 3.1 (50000) Quaoar 2011

A large campaign for an occultation of 2UCAC 26029329 (13m3 in V Band) by (50000) Quaoar has been organized in Europe. Problems resulted from the morning sky (sun for Germany only about 7 to 10 degrees below the horizon). Northern of a line southern Ireland to southern Slovakia all stations were clouded out, south of this line only a "miss" could be observed. Another campaign for a 17th mag star on May 14th, 2011 did only show negative results.

### 3.2 Occultations by Pluto (2010)

A large campaign with about 30 stations has been organized for a Pluto event with the star 2UCAC 24920649 (11mag) on the 14th of February 2010 in central Europe. Due to severe weather problems in nearly all Europe at that time only 3 stations got results. Another bright occultation by Pluto for the southern hemisphere of the earth occurred on the 4th of July, 2010. Positive lightcurves have been recorded from South Africa, Namibia and Argentine. Lightcurves have been extracted.

### 3.3 Occultation by Triton (2008)

On May 21st of 2008 an occultation of a 13m5 star by Triton was observed successfully from Namibia and Reunion. Lightcurves could be extracted and give information about the faint atmosphere.

## 6. Summary and Conclusions

We have shown, that even with small to medium sized telescopes, distributed about large areas of the world, successful observations of occultations by dwarf planets and TNO's are possible. Prerequisite is a high precision astrometry to avoid too many misses. Stars as faint as 17th to 18th magnitude (in V or R Band) can be used aA&A 515, A32 (2010)s objects with integration times of up to 5 seconds at sufficiently dark observing sites. Triton and Pluto occultations have provided lightcurves of relatively high quality, which show the thin atmosphere of both bodies.


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## References


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