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The stellar occultation by Makemake on 2011 April 23

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Abstract

We have taken advantage of a stellar occultation by the dwarf planet Makemake on 2011 April 23, to determine several of its main physical properties. We present results from a multisite campaign with 8 positive occultation detections from 5 different sites, including data from the 8-m VLT and 3.5-m NTT telescopes in Chile, which have very high temporal resolution. Because the star was significantly fainter than Makemake (setting a record in the magnitude of a star whose occultation has been detected), the occultation resulted in a drop of just ~0.3 mag in the lightcurves. From the lightcurves we have been able to determine the size and shape of the body, its geometric albedo and constraints on its atmosphere.

1. Introduction

There are currently 5 dwarf planets recognized as such by the Astronomical Union: Ceres, Pluto, Eris, Makemake, and Haumea. The latter four are plutonian dwarf planets. These dwarf planets are large and important objects whose study is difficult because of their considerable distances to the sun. Pluto is the best known of all of them, thanks in part to its early discovery in 1930. Stellar occultations by Pluto, have provided important pieces of information on this object, especially on its atmosphere (e.g. [1] and references therein). We intended to take advantage of possible stellar occultations by the dwarf planet (136472) Makemake (also known as 2005FY$_9$) in order to derive basic physical properties and gain substantial knowledge on this dwarf planet. However, successfully observing occultations by Transneptunian Objects (TNOs) is very difficult because of their small angular diameters, the high uncertainties in their orbits and the uncertainties in star positions. The process from initial prediction to successful observation of an occultation by a TNO requires a huge effort. Until very recently, and despite intense efforts, no occultations by TNOs other than Pluto had ever been recorded. In approximately one year, and prior to the Makemake event, four such occultations have been detected ([2],[3],[4],[5],[6]). This indicates that the technique is becoming mature enough to be a key research tool for the Trans-Neptunian Region in the future.

1.1 Prediction of the event

The potential occultation of the faint star NOMAD 1181-0235723 by Makemake was predicted in 2010 following the same methods described in [7]. The initial occultation prediction was not encouraging: it indicated that Makemake's shadow would miss the Earth by around 1000km on April 23rd at approximately 1:30 UT. Although this initial prediction did not cause any enthusiasm, careful astrometric refinement of the star's position and that of Makemake (from two different telescopes on several nights, two weeks before the event) changed the initial view. The new prediction showed that the shadow path of the occultation would finally fall on

South America (fig. 1). The star magnitude in V band was around 18.2, whereas Makemake's magnitude was estimated to be around 17.2. Therefore, the expected brightness drop was around ~0.3 mag. Thus, the observation of the occultation seemed difficult, but feasible.

2. Observations

A large observational campaign was arranged involving 15 telescopes. The occultation was successfully recorded from the 3.5m NTT telescope and the 0.6m TRAPPIST telescope at La Silla, the 0.84m telescope at Cerro de Armazones Observatory, the 8m VLT (Unit 3) at Paranal Observatory, the 0.4m ASH2 and 0.5m telescopes at S. Pedro de Atacama Observatory, as well as the 0.6m Carl Zeiss telescope in Pico dos Dias Observatory. A variety of instruments were used, but all of them were imaging devices from which synthetic aperture photometry was obtained in several wavelength ranges, as a function of time. The time resolution in the photometry was diverse, ranging from 0.272s to 15s. The resulting lightcurves were analyzed to derive 5 occultation chords.

3. Discussion

The size and shape that we can derive from the 5 different occultation chords will be given at the meeting, after the ingress and egress times from the lightcurves are carefully fitted. At the time of this writing only very coarse values can be given, because the event took place only one month prior to the deadline for abstract submissions. The same is true for constraints on the atmosphere. We will also provide the final shadow path on Earth and other side-products like albedo.

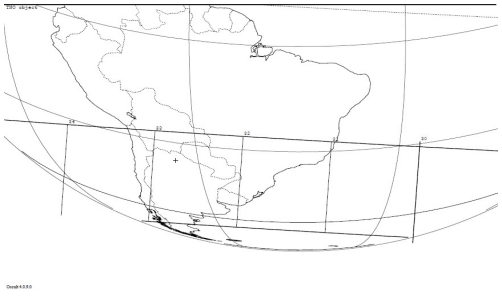

Figure 1: Map of the region of the Earth where Makemake's shadow path was expected to fall (from astrometric followup two weeks prior to the event).

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