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An extensive photometric study of the dwarf planet Makemake

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Abstract

We will present a photometric study of the dwarf planet Makemake based on new observational data obtained between 2006 and 2017 using 0.7 to 3.6-m telescopes around the world. Based on this extensive dataset we derive a high precision rotational period estimate. The resulting lightcurve has a small peak-to-peak amplitude variability, that implies an almost spherical shape or an elongated object in a pole-on orientation. Multi-colour observations allowed us to measure surface colours of Makemake. The magnitude phase dependence slope is quite low and is similar to other bodies with methane ice-rich surfaces. Combining our and literature data we tested Makemake for the existence of long-term brightness variations, and searched for the signs of a satellite.

1. Introduction

Dwarf planet (136472) Makemake is one of the largest and brightest known Transneptunian objects (TNOs) [4], [6]. The existence of strong methane absorption bands in Makemake's spectrum suggests that its surface is dominated by methane ice and its irradiation products (e.g. [1], [8]).
Previous photometric investigations proposed a few possible rotational periods: 11.24 h or its double value 22.48 h was suggested in [5], 7.77 h value was proposed by [2] and later preferred by the authors of [10], although other possible period aliases were also detected.
Further photometric observations are needed not only for precise measuring of rotational period, but also, if possible, for the photometric detection of the newly discovered Makemakean satellite [7].

2. Observations and data reduction

The observations were carried out during 53 nights between 2006 and 2017. We used ten middle-sized telescopes at different observational sites, namely, the 3.6-m Telescopio Nazionale Galileo (Spain), the 2.6-m Shain Telescope at Crimean Astrophysical Observatory (Ukraine), the 2.5-m Isaac Newton Telescope at Roque de los Muchachos Observatory (Spain), the 2.0-m telescope at Terskol Observatory (Russia), the 1.5-m telescope at Sierra Nevada Observatory (Spain), the 1.2-m telescope at Calar Alto Observatory (Spain), the 1.0-m Zeisse 1000 telescope at Simeiz Observatory (Ukraine), the 1.0-m East and West telescopes at Tien Shan Astronomical Observatory (Kazakhstan), the 0.7-m telescope at Abastumani Astrophysical observatory (Georgia), and the 0.7-m telescope at Chuguev Observatory of V. N. Karazin Kharkiv National University (Ukraine). All the measurements were made using standard Johnson-Cousins photometric system in BVRI broad-band filters or using no filter at all. Most part of the observational data was obtained in R filter. Image reduction procedure was performed in a standard way

which includes dark and/or bias subtraction and flat-field correction. For majority of data only differential photometry was performed, but during some nights the absolute calibration was also made.

3. Main results

A thorough analysis of the large amount of photometric data allowed us to find the rotational period of Makemake with a very good precision. The calculated peak-to-peak lightcurve amplitude is very small (A = 0.037 mag) and can be associated with almost spherical shape or almost polar aspect of Makemake during the observations.

The knowledge of sidereal rotational period allowed us to recalculate the values of absolute magnitude and geometric albedo of Makemake.

From the multi-colour observations we measured surface colours, that appeared to be in agreement with previously reported values as well as with spectral results [3], [9]. The magnitude phase function was measured in the phase angle range of 0.5-1.1^{o} and is similar to other methane ice-rich bodies such as Pluto and Eris.

By using our and literature data we also tested Makemake for the changes in brightness lightcurve amplitude and absolute magnitude with time. Finally, we analyzed the expected influence of the discovered satellite and discuss the possible existence of another satellite(s).

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