Photometry of super fast rotating, near-Earth asteroid 2022 AB

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Introduction

2022 AB is a very small (~100-m) near-Earth asteroid belonging to the Aten group. This object was first observed at GINOP-KHK in Piszkesteto on 2 January 2022[1] and it passed the Earth at a distance of 3,700,000 km (9.6 lunar distances) on 20 January. The next such close approach of this asteroid (9.2 lunar distances) will take place in 2069.

What distinguishes this object is the very favorable geometry of observation during this close-up. Until 26 January, the phase angle changed in the range of 0.3°-85.5°, reaching a magnitude of $V = 16.4$ near the opposition according to JPL HORIZONS[2]. Observations of the asteroid at such a wide range of the phase angle, and in particular the opposition effect, allow for the accurate determination of the phase curve and the absolute magnitude H.

Our campaign started on 4 January and until 26 January, we observed 2022 AB using small (no larger than 2-m) telescopes located in USA, Canada, Spain, UK, Italy, South Africa, Poland, Ukraine, Romania, South Korea and Australia. Among other things, we used the global LCOGT[3] telescope network, which reacts in real time to adverse weather and technical conditions at individual nodes of the network, choosing the proper telescope for the moment. We collected a very large amount of useful data. Due to the fact that we have just finished our observation campaign, we are at the stage of preliminary work. And here we only present preliminary results regarding the rotation period, colour indices, taxonomy and effective diameter. We organized a similar observation campaign for 2021 DW_1 in March 2021. At that time, we even successfully obtained a rotation axis and a 3D shape model of the asteroid[4][5][6].

Rotation period

We collected a lot of photometric data. Based on the lightcurves we have initially analyzed, we can say that the rotation period is approximately 182 ± 1 s.
In connection with the topic of the Workshop, we would like to mark the usefulness of using small telescopes in observing fast-rotating asteroids on the example of our first observations of 2022 AB on 5 January, when object was faint, average brighness $V = 18.4$ mag (based on the calibration of our observations). We used 0.7-m RBT/PST2 telscope, 5-s exposures (to be able to detect very short rotation periods) and so-called clear filter (to collect as much light as possible at such a short exposure time).

During 1.5 hours of observations, we collected data from almost 30 rotations, which at around 0.5 mag amplitude allowed us to create a quite accurate composite lightcurve with Fourier series fit fourth-order.

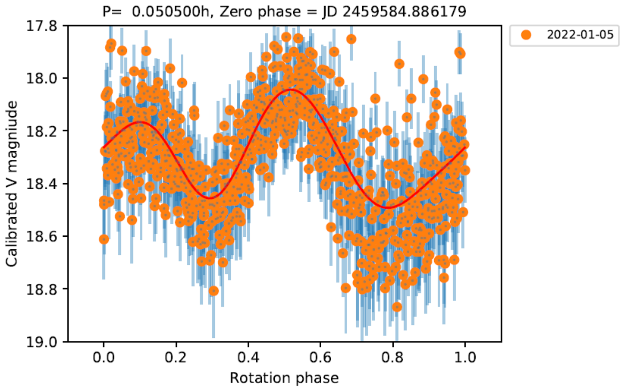


Figure 1: Example of composite lightcurve of 2022 AB with 4 order Fourier series fit.

Colour indices

To determine the colour indices, we also collected photometric data in the Johnson-Cousins B, V, R and I bands. The observations were made on a few telescopes at different times. Here, we present the preliminary results based on data from South Korea 1-m telescope (DOAO) taken between 3:20 pm and 6:56 pm UTC on 11 January. We divided the observations into two sets. The first with an exposure time of 10s and the second with an exposure time of 18s. In each of the sets, we used a series of I, R, V observations, each for 25 min (set 1) or 20 min (set 2), and B for 42 or 40 min. Using solar analogs, we transformed the brightness in BVRI into Sloan g'r'i'z' bands, respectively. Then, knowing the rotation period, we composited the lightcurves to determine the shifts between the lightcurves in the given bands.

Due to changes in the geometry of observations, we have prepared composited lightcurves separately for both set. The results are consistent within the uncertainty.

The results for sets 1:

$g' - r' = 0.352 \pm 0.016$,

$r' - i' = 0.160 \pm 0.012$,

$i' - z' = 0.081 \pm 0.011$,

and set 2:

$g' - r' = 0.346 \pm 0.013$,

$r' - i' = 0.165 \pm 0.012$,

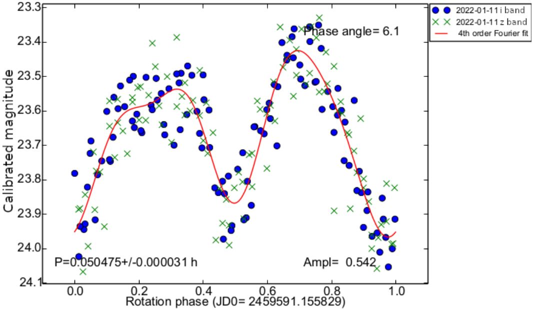
$i' - z' = 0.066 \pm 0.018$

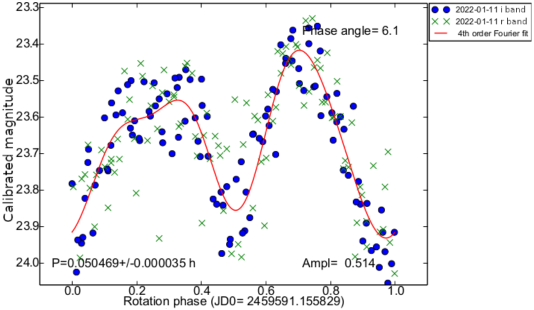
We give the average values of the obtained colour indicies:

$g' - r' = 0.348 \pm 0.011$,

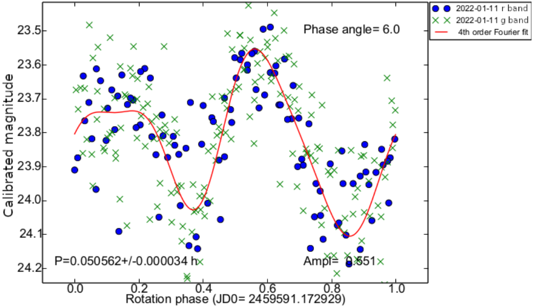
$r' - i' = 0.162 \pm 0.009$,

$i' - z' = 0.077 \pm 0.010$





Composite lightcurves for set 1,
top left: lightcurves in i (dots)
and z band (crosses),
top right: i and (dots) and r (crosses) bands,
bottom: r (dots) and g (cross) bands.



Taxonomy

To determine the taxonomic class of 2022 AB, we converted the colour indices to the reflection coefficients R_r, R_i and R_z, normalized to the reflection values in the g band, using the formula[7]:

$$R_f = 10^{-0.4[(f-g)-(f_\odot - g_\odot)]}$$

where g and $g_\odot$ are the g magnitudes of the asteroid and Sun, and f and $f_\odot$ are the magnitudes in some other band.

We assumed the solar colours $(i-g)_\odot = -0.55 \pm 0.03$ mag, $(r-g)_\odot = -0.45 \pm 0.02$ mag and $(z-g)_\odot = 0.61 \pm 0.04$ mag[8].

Our reflectivities results: $R_\mathrm{g} \equiv 1$,
$R_\mathrm{r} = 0.911 \pm 0.019$,
$R_\mathrm{i} = 0.965 \pm 0.029$,
$R_\mathrm{z} = 0.980 \pm 0.040$.

Next, we compared them with spectra of different taxonomic classes, as given by [7].
Our results are the best match for Cb class.

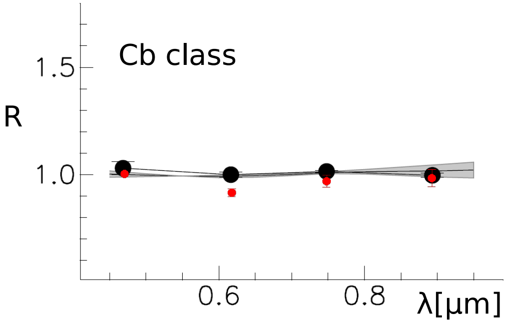


Figure 2: Plot of reflectivities R_g,R_r,R_i,R_z of Cb class asteroids (black dots) and 2022 AB (red dots). Data for the Cb class were taken from [7]. The gray area represents the class dispersion.

Diameter

We can determine the effective diameter knowing the absolute magnitude H and albedo p_V according to the equation[9]:

$$D_{\mathrm{eff}} = 1329 \times 10^{(-H/5)} \times p_{\mathrm{V}}^{(-1/2)}$$

In the near future we are going to find H value from the phase curve, but for now we used the approximate $H = 23.6 \pm 0.36$ given by JPL[2].
Albedo for Cb class asteroids:
$p_{\mathrm{V}} = 0.059 \pm 0.027$[10],
hence
$D_{\mathrm{eff}} = 0.104 \pm 0.029\,\mathrm{km}$

Summary

We observed the asteroid 2022 AB in January 2022. Based on some of the photometric data we have collected, we present preliminary results: rotation period $P = 182\,\mathrm{s}$, colour indices: $g' - r' = 0.348 \pm 0.011$, $r' - i' = 0.162 \pm 0.009$, $i' - z' = 0.077 \pm 0.010$, taxonomic class: Cb, diameter $D_{\mathrm{eff}} = 104 \pm 29\,\mathrm{m}$. We expect to provide more accurate results based on all the data collected in the near future.

Acknowledgements

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References

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