

PHASE ANGLE DEPENDENCE OF BRIGHTNESS AS A TOOL FOR TAXONOMIC CLASSIFICATION OF ASTEROIDS: CASE FOR ASTEROIDS (723) HAMMONIA AND (16551) 1991 RT14. V. G. Shevchenko^{1,2}, I. G. Slyusarev^{1,2}, I. N. Belskaya^{1,2}, V. A. Checha², Yu. N. Krugly¹, V. G. Chiorny¹, ¹Astronomical Institute of Kharkiv V. N. Karazin National University, Sumska Str. 35, Kharkiv 61022, Ukraine, ²Department of Astronomy and Space Informatics of Kharkiv V. N. Karazin National University, Svobody sq. 4, Kharkiv 61022, Ukraine, shevchenko@astron.kharkov.ua

Introduction: Asteroid albedos obtained from the infrared surveys by WISE [1-3] and AKARI [4] point out a presence of small-sized (< 50 km) high and moderate albedo asteroids in the outer part of the main belt. Moreover DeMeo & Carry [5] based on the SDSS colors and albedos have estimated a significant mass fraction of such asteroids in the outer part of the main belt. Since the SDSS colors [8] and radiometric albedos may contain rather large observational errors for faint (small-sized) asteroids, an independent check of taxonomic classification is needed. For example, Marsset et al. [9] performed the spectral observations of some moderate albedo asteroids of Hilda group and Jupiter Trojans. They have not found essential distinctions in spectral properties of the observed moderate-albedo asteroids and those of the low-albedo population which suggest their similar surface composition and possible errors in the determined values of albedos.

As it was shown by Belskaya & Shevchenko [10] and Shevchenko et al. [11, 12] asteroid taxonomical classification can be made using their phase angle dependences of brightness. Asteroids of low, moderate and high albedo classes show distinct differences in linear slopes and amplitudes of the opposition effect (OE). Such classification was performed by Oszkiewicz et al. [13] for large numbers of asteroids from the MPC dataset based on the G_{12} parameter of the new magnitude system. Since these data have low accuracy in magnitudes the determined classes can be utilized only for statistical purposes. To obtain more precise classification magnitudes versus phase angles should be measured with an accuracy of 0.02-0.03 mag.

The present work is devoted to check the taxonomical classifications of the selected asteroids from the outer part of the main belt. Below we discuss new photometric observations of two asteroids, namely (723) Hammonia and (16551) 1991 RT14 which let us to measure their magnitude-phase dependences and to check their taxonomical classifications.

Observations and Results: CCD photometry of these asteroids was made using the 0.7-m reflector of the Chuguevskaya Station of the Astronomical Institute of Kharkiv V. N. Karazin National University in September-November 2014. The observations were

carried out mainly in the V and R photometric bands of the standard Johnson-Cousins photometric system. The method of CCD observations and data reduction is explained in [12]. Some results obtained for these asteroids are given below.

(723) Hammonia. The asteroid has an orbit with a semimajor axis of 2.99 AU and a small eccentricity. Initially (723) Hammonia was classified by Bus & Binzel [14] as the C-type asteroid, but its albedos obtained from WISE [1], AKARI [4], and IRAS [15] infrared surveys equal to 0.35, 0.29, and 0.18, respectively, contradict this classification. We observed the asteroid for 17 nights in 2014 to obtain a good quality magnitude-phase relation. We obtained the composite lightcurve with the rotation period of 5.4349 ± 0.0015 hours and the maximal amplitude of 0.08 ± 0.02 mag. The average color index V-R is equal to 0.34 mag. The lightcurve was used to take correctly into account lightcurve variations in the magnitude-phase relation. The magnitude-phase relation of (723) Hammonia is shown in Figure 1.

(16551) 1991 RT14. The asteroid has an orbital semimajor axis of 2.77 AU with an eccentricity of 0.11. The values of B-V and V-R colors estimated from SDSS asteroid data [8] are equal 0.46 and 0.44 mag, respectively. The value of B-V color differs greatly from the average values of the main asteroid types [16], and most likely it is an erroneous value. Our observations were performed for six nights and we obtained the rotation period (16.193 ± 0.005 h), the color index V-R (0.49 mag), and the magnitude-phase relations. Our value of V-R is slightly higher than the value obtained from the SDSS data and is typical for moderate albedo asteroids [16].

Discussion: We present the magnitude-phase relations in the V and R bands for the observed asteroids in Fig. 1. The magnitude-phase dependence for (16551) 1991 RT14 were shifted along the magnitude scale on 3.27 mag. One can see that the phase curve behaviours are very similar for these two asteroids. Both asteroids show an opposition effect typical for moderate-albedo asteroids. For comparison we plotted in Fig.1 the magnitude-phase relations of some S-type asteroids, namely (20) Massalia [17], (79)

Euryome [18], and (243) Ida [19]. They show a good agreement with the observed asteroids. It indicates that the asteroids (723) Hammonia and (16551) 1991 RT14 are most likely belong to the S-type asteroids.

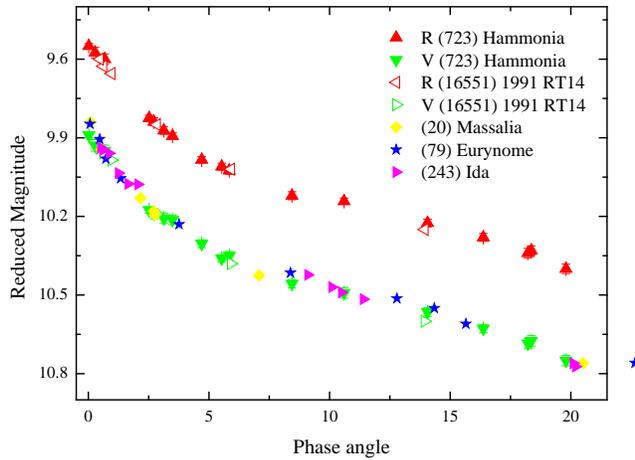


Fig. 1. Magnitude-phase dependence of (723) Hammonia and (16551) 1991 RT14 in the VR bands. The magnitude-phase relations of (20) Massalia [17], (79) Euryome [18], and (243) Ida [19] were plotted for comparison.

The figure 2 shows a relationship of the OE amplitude versus the linear slope (the data are taken from [10] and our new data are added). The studied asteroids (723) Hammonia and (16551) 1991 RT14 lie inside the region of S and M taxonomic classes (as defined in Tholen’s taxonomy). It gives a strong evidence that these asteroids are moderate albedo objects.

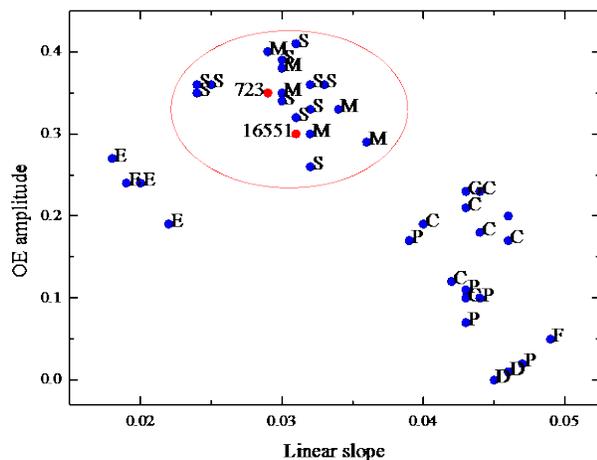


Fig. 2. The relationship of the OE amplitude and the linear slope for asteroids of different types (defined by letters).

Conclusions: Based on photometric observations of asteroids (723) Hammonia and (16551) 1991 RT14 carried out in September–November 2014 we measured their rotation periods and magnitude-phase angle dependences down to the extremely small phase angles less than 0.5 deg in the V and R bands. The obtained dependences are similar to the magnitude phase angle dependences of moderate albedo asteroids. These data undoubtedly indicate that the asteroids have moderate-albedo surfaces. The result has demonstrated that the phase angle dependence of brightness can be used as a tool for a preliminary taxonomic classification of asteroids.

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